INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal- 500 043, Hyderabad, Telangana

APPLIED PHYSICS
COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**				
2	Course Title	**Applied Physics**				
3	Course Code	AHSD07				
4	Class / Semester	I / I				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	-	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		-	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 64		Tutorials: Nil		Practical: Nil	
10	Course Coordinator	Dr. Rizwana				
11	Date Approved by BOS	24 August 2023				
12	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD07.pdf				
13	Course Prerequistes	**Level UG/PG**	**Course Code**	**Course Title**	**Semester**	
		Intermediate	-	-	-	

14. Course Overview
The aim of this course is to promote understanding of fundamental knowledge in physics needed for the future technological advances. The concepts covered are in the fields of solid state physics, modern physics, superconductors and nanoscience. This knowledge helps to develop the ability to apply the principles in many advanced technological sectors such as nanotechnology, optical fiber communication, quantum technology etc.

15. Course Objectives:

The students will try to learn:

I	Fundamental concepts needed to explain a crystal structure in terms of atom positions, unit cells, and crystal symmetry.
II	Basic formulations in wave mechanics for the evolution of energy levels and quantization of energies for a particle in a potential box with the help of mathematical description.
III	The metrics of optoelectronic components, lasers, optical fiber communication and be able to incorporate them into systems for optimal performance.
IV	The appropriate magnetic, superconducting and nanomaterials required for various engineering applications.

16. Course Outcomes:

After successful completion of the course, students should be able to:

S.No	Course outcome description
CO 1	Use the general rules of indexing of directions and planes in lattices to identify the crystal systems and the Bravais lattices.
CO 2	Extend the principles of dual nature of matter and Schrodinger wave equation to a particle enclosed in simple systems.
CO 3	Analyze the concepts of laser with normal light in terms of mechanism for applications in different fields and scientific practices.
CO 4	Comprehend the knowledge on functionality of components in optical fiber communication system by using the basics of signal propagation, attenuation and dispersion.
CO 5	Gain knowledge on properties of magnetic and superconducting materials suitable for engineering applications.
CO 6	Formulate the principle factors, fabrication, characterization techniques and the applications of nanomaterials.

17. Mapping of topic learning outcomes (TLO) to course outcomes

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
1	Space lattice, Basis, unit cell, lattice parameters	TLO 1	Recollect the basic properties of crystallography and crystal structures.	CO 1	Remember
2	Crystal systems	TLO 2	Classify various crystal systems in terms of unit cell dimensions and crystallographic axes.	CO1	Understand
3	Bravais lattices	TLO 3	Draw the Bravais lattice structures formed in seven crystal systems.	CO1	Understand

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
4	Simple cubic, Body centered cubic, Face centered cubic structures	TLO 4	Explain different crystal structures and determine their packing fractions.	CO1	Understand
5	Planes in a crystal	TLO 5	Identify different planes that can be formed in the crystal structure.	CO1	Apply
6	Interplanar distance	TLO 6	Determine the expression for interplanar spacing in orthogonal crystal system.	CO1	Apply
7	Waves and particles	TLO 7	Explainthe concept of dual nature of matter and light radiation.	CO2	Understand
8	de broglie hypothesis, Matter waves	TLO 8	Extend the debroglie hypothesis to the concept of matter waves.	CO2	Understand
9	Davisson and Germers experiment	TLO 9	Describe how Davisson and Germer experiment explained the existence of matter waves.	CO2	Understand
10	Schrodinger time independent wave equation	TLO 10	Discuss the Schrodinger time independent wave equation associated with matter waves.	CO2	Understand
11	Physical significance of wave function	TLO 11	Analyze the physical significance of wave function associated with matter waves.	CO2	Apply
12	Infinite square well potential	TLO 12	Apply Schrödinger's wave equation for energy values of a free particle confined in one dimensional potential square well.	CO2	Apply
13	Characteristics of lasers	TLO 14	Discuss the basic concepts of laser light sources.	CO3	Understand
14	Spontaneousand stimulated emission of radiation	TLO 15	Obtain the relation between Einstein coefficients associated with absorption, spontaneous emission and stimulated emission.	CO3	Apply
15	Lasing action	TLO 16	Explain the concepts involvedin producing lasing action.	CO3	Understand
16	Ruby and He-Ne lasers	TLO 17	Describe in detail the principle and working of Ruby and He-Ne lasers.	CO3	Understand
17	Applications of lasers	TLO 18	Identify the engineering applications of lasers in different fields.	CO3	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
18	Principle and construction of an optical fiber	TLO 19	Illustrate the principle and construction of optical fibersused in communication system.	CO 4	Understand
19	Acceptance angle, Numerical Aperture	TLO 20	Derive the expressions for the acceptance angle and numerical aperture of an optical fiber.	CO 4	Understand
20	Types of optical fibers, Single mode, multimode, step index, graded index	TLO 21	Discuss different types of optical fibers based on refractive index profile and modes of propagation.	CO 4	Understand
21	Optical fiber communication system	TLO 22	Elucidate the block diagram of fiber optic communication system.	CO 4	Apply
22	Applications of optical fibers	TLO 23	Enlist the applications of optical fibers.	CO4	Remember
23	Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility,	TLO 24	Acquire knowledge of basic terms related to magnetic materials.	CO 5	Understand
24	Origin of magnetic moment, Bohr magneton	TLO 25	Describe magnetic moment in an atom in termsof Bohr magneton.	CO 5	Understand
25	Classification of dia, para and ferro magnetic materials on the basis of magnetic moment	TLO 26	Classify different magnetic materials based on electron theory.	CO 5	Understand
26	Hysteresis curve	TLO 27	Examine the spontaneous magnetization in ferromagnets based on orientation of domains.	CO 5	Understand
27	Superconductivity, general properties	TLO 28	Recall he definition of superconductivity based on resistance.	CO 5	Remember
28	Meissner effect	TLO 30	Explain the Meissner effect related to superconductors.	CO 5	Understand

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
29	Effect of magnetic field	TLO 31	Analyze the effect of magnetic field on superconductors.	CO 5	Apply
31	BCS theory	TLO 33	Elucidate the concept of flux quantization and BCS theory.	CO 5	Apply
32	Applications of superconductors	TLO 34	Discuss the applications of superconductors.	CO 5	Understand
33	Nanoscale	TLO 35	Recall the definition of nano scale and nanotechnology.	CO 6	Remember
34	Quantum confinement	TLO 36	Explain the quantum confinement factor of nanomaterials.	CO 6	Understand
35	Surface to volume ratio	TLO 37	How the surface to volume ratio changes when particle size is reduced to nano scale.	CO 6	Understand
36	Bottom-up fabrication: sol-gel, precipitation, combustion methods, top-down fabrication: ball milling, physical vapor deposition, chemical vapor deposition	TLO 38	Discuss different methods of preparation of nanomaterialssuch as sol-gel, precipitation, and combustion, ball milling, physical vapor deposition and chemical vapor deposition.	CO 6	Understand
37	Characterization techniques: x-ray diffraction, transmission electron microscopy	TLO 39	Acquire the knowledge of different characterization techniques such as X-ray diffraction, Scanning Electron Microscopy and Transmission Electron Microscopy.	CO 6	Understand
38	Applications of nanomaterials	TLO 40	Discuss the applications of nanomaterialsin different engineering fields.	CO 6	Understand

18. Employability Skills

Project based skills: Applied physics for engineering students develop experimental skills, mathematical and problem solving abilities, required to carry out research and development in a large number of specialties.

19. Content Delivery / Instructional Methologies:

✓	Power Point Presentation	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

21. Course content - Number of modules: Five

MODULE I	**CRYSTAL STRUCTURES**	**Number of Lectures: 12**
	Introduction, space lattice, basis, unit cell, lattice parameter, Bravais lattices, crystal systems, structure and packing fractions of simple cubic, body centered cubic, face centered cubic crystals, directions and planes in crystals, Miller indices, separation between successive [h k l] planes.	
MODULE II	**QUANTUM PHYSICS**	**Number of Lectures: 12**
	Waves and particles, de Broglie hypothesis, matter Waves, Davisson and Germer's experiment, Heisenberg's uncertainty principle, Schrödinger's time independent wave equation, physical significance of the wave function, infinite square well potential.	

MODULE III	**LASERS AND FIBER OPTICS**	**|Number of Lectures: 15**
	Characteristics of lasers, spontaneous and stimulated emission of radiation, population inversion, lasing action, Ruby laser, He-Ne laser and applications of lasers. **P**rinciple and construction of an optical fiber, acceptance angle, numerical aperture, types of optical fibers (Single mode, multimode, step index, graded index), optical fiber communication system with block diagram and applications of optical fibers.	
MODULE IV	MAGNETIC AND SUPERCONDUCTING PROPERTIES	| Number of Lectures: 12
	Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility, origin of magnetic moment, Bohr magneton, classification of dia, para and ferro magnetic materials on the basis of magnetic moment. Superconductivity, general properties, Meissner effect, effect of magnetic field, type-I & type-II superconductors, BCS theory, applications of superconductors.	
MODULE V	NANOTECHNOLOGY	| Number of Lectures: 13
	Nanoscale, quantum confinement, surface to volume ratio, bottom-up fabrication: sol-gel, precipitation, combustion methods, top-down fabrication: ball milling, physical vapor deposition, chemical vapor deposition, characterization techniques: x-ray diffraction, transmission emission microscopy, applications of nanomaterials.	

TEXTBOOKS

1. Arthur Beiser, Shobhit Mahajan and Rai Choudhary, *Concepts of Modern Physics,* , Tata McGraw Hill, 7th Edition, 2017.

REFERENCE BOOKS:

1. H J Callister, *A Textbook of Materials Science and Engineering,* , Wiley Eastern Edition, 8th Edition, 2013.
2. Halliday, Resnick and Walker, *Fundamentals of Physics,* , John Wiley Sons,11th Edition, 2018.
3. Charles Kittel, *Introduction to Solid State Physics,* , Wiley Eastern, 2019.
4. S.L. Gupta and V. Kumar, *Elementary Solid State Physics,* ,Pragathi Prakashan, 2019.
5. K K Chattopadhyay and A N Banerjee, *Introduction to Nanoscience and Nanotechnology,* , Prentice Hall India, 2nd Edition, 2011.

Electronic Resources:

1. NPTEL :: Physics - NOC:Quantum Mechanics I
2. NPTEL :: Physics - NOC:Introduction to Solid State Physics
3. NPTEL :: Physics - NOC:Solid State Physics
4. https://nptel.ac.in/courses/104104085
5. NPTEL :: Metallurgy and Material Science - NOC:Nanotechnology, Science and Applications

Material Online:

1. Course template
2. Tutorial question bank
3. Definition and terminology
4. Tech-talk topics
5. Assignments
6. Model question paper - I
7. Model question paper - II
8. Lecture notes
9. Early learning readiness videos (ELRV)
10. Power point presentations

22. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
Discussion on OBE			
1	Discussion on Outcome Based Education, CO, POs and PSOs		
Content Delivery (Theory)			
1	Introduction, space lattice	CO 1	T1; R1
2	Basis, unit cell, lattice parameter	CO 1	T1; R1
3	Crystal systems	CO 1	T1; R1
4	Bravais lattices	CO 1	T1; R1
5	Simple cubic structure	CO 1	T1; R1
6	Body centered cubic structure	CO 1	T1; R1
7	Face centered cubic structure	CO 1	T1; R1
8	Directions and planes in crystals	CO 1	T1; R1
9	Miller indices	CO 1	T1; R1
10	Separation between successive [h k l] planes	CO 1	T1; R1
11	Introduction to Quantum Physics	CO 2	T1; R1, R2
12	Wave-particle duality of radiation	CO 2	T1; R1, R2
13	de broglie hypothesis and de broglie wavelength	CO 2	T1; R1, R2
14	Properties of Matter waves	CO 2	T1; R1, R2
15	Davisson and Germer's experiment	CO 2	T1; R1, R2
16	Schr¨odinger time independent wave equation	CO 2	T1; R1, R2
17	Physical significance of wavefunction	CO 2	T1; R1, R2
18	Particle in a one-dimensional potential box	CO 2	T1; R1, R2
19	Characteristics of laser, Spontaneous and Stimulated emis sion	CO 3	T1; R3, R4
20	Metastable state, Population inversion, Lasing action	CO 3	T1; R3, R4
21	Ruby laser	CO 3	T1; R3, R4

S.No	Topics to be covered	CO's	Reference
22	He-Ne laser, Applications of LASER	CO 3	T1; R3, R4
23	Principle and construction of optical fibers	CO 4	T1; R3, R4
24	Acceptance angle, Acceptance cone, Numerical Aperture	CO 4	T1; R3, R4
25	Types of optical fibers	CO 4	T1; R3, R4
26	Optical fiber communication system, Applications of optical fibers	CO 4	T1; R1, R2
27	Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility	CO 5	T1; R1
28	origin of magnetic moment, Bohr magneton	CO 5	T1; R1
29	Diamagnetic and Paramagnetic materials	CO 5	T1; R1
30	Ferromagnetic materials	CO 5	T1; R1
31	Hysteresis curve	CO 5	T1; R1
32	Superconductivity, general properties	CO 5	T1; R1
33	Meissner effect, effect of magnetic field	CO 5	T1; R1
34	type-I & type-II superconductors	CO 5	T1; R1
35	BCS theory	CO 5	T1; R1
36	applications of superconductors	CO 5	T1; R1
37	Nanoscale, quantum confinement, surface to volume ratio	CO 6	T1; R4
38	bottom-up fabrication: sol-gel, precipitation, combustion methods	CO 6	T1; R4
39	top-down fabrication: ball milling, physical vapor deposition, chemical vapor deposition	CO 6	T1; R4
40	characterization techniques: x-ray diffraction, transmission electron microscopy, applications of nanomaterials	CO 6	T1; R4
Problem Solving/Case Studies			
1	Packing fraction	CO 1	T1; R1
2	Miller indices	CO 2	T1; R1
3	Interplanar spacing	CO 2	T1; R1
4	de broglie wavelength	CO 2	T1; R1, R2
5	Energies associated with one dimensional potential box	CO 2	T1; R1, R2
6	Wavelength and Energy bandgap, Divergence	CO 3	T1; R3, R4
7	Relative population of two states, Number of photons emitted	CO 3	T1; R3, R4
8	Acceptance angle and Numerical Aperture	CO 4	T1; R1
9	Magnetic moment, Magnetic induction, Permeability	CO 5	T1; R1
10	Intensity of magnetization, Magnetic susceptibility	CO 5	T1; R1
11	Critical temperature	CO 5	T1; R4
12	Critical field	CO 5	T1; R4
13	Surface to volume ration	CO 6	T1; R4
14	Particle size	CO 6	T1; R4
15	Debye Scherrer method	CO 6	T1; R4

S.No	Topics to be covered	CO's	Reference
Definition and Terminology			
1	Crystal structures	CO 1	T1; R1
2	Quantum physics	CO 2	T1; R1, R2
3	Lasers and fiber Optics	CO 3	T1; R3, R4
4	Magnetic and superconducting properties	CO 4	T1; R1
5	Nanotechnology	CO 5	T1; R4
Tutorial Question Bank			
1	Crystal structures	CO 1	T1; R1
2	Quantum physics	CO 2	T1; R1, R2
3	Lasers and fiber Optics	CO 3	T1; R3, R4
4	Magnetic and superconducting Properties	CO 4	T1; R1
5	Nanotechnology	CO 5	T1; R4

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Program Outcomes	
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	AAT

3 = High; 2 = Medium; 1 = Low

25. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	-	-

3 = High; 2 = Medium; 1 = Low

26. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	-	-

27. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Illustrate** the different crystal structures based on arrangement of atoms in a unit cell, calculate their packing fraction and use those expressions to integrate with other engineering disciplines.	3
	PO 2	**Explain** the given **problem statement** and formulate lattice parameters and miller indices of a crystal from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of packing fraction.**	4
CO 2	PO 1	**Outline** drawbacks of classical mechanics, basic principles **dual nature** of matter wave, **derive** mathematical wave equation of matter waves and come to **conclusion** of quantization of energy used in quantum dots.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	**Explain** the given **problem statement** and formulate quantum confinement problems related to particle enclosed in small dimension from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of result**s.	4
	PO 4	**Identify** the use of these semiconductors under study and their conduction mechanism for the **research based knowledge** and **technological development**.	2
CO 3	PO 1	**Compare** the concepts of laser and normal light in terms of mechanism and **working principle** for applications in different fields and scientific practices.	3
	PO 2	**Explain** different components involved in **laser system** by using the **basics** of absorption, emission and amplification of light radiation.	4
CO 4	PO 1	**Gather** the knowledge on functionality of components in optical fiber communication system by using the basics of signal propagation, attenuation and dispersion.	3
	PO 2	**Explain** functionality of components in optical fiber communication **system** by using the **basics** of signal propagation, attenuation and dispersion.	4
	PO 4	**Identify the given problem** and **formulate** expressions for acceptance angle and numerical aperture with the given **information** and **data** by applying principles of information of propagation through optical waveguides.	2
CO 5	PO 1	**Utilize** spin and orbital motion of electrons in determining **magnetic moment** of materials in terms of Bohr magneton materials having specific **engineering applications**.	3
CO 6	PO 1	**Illustrate** the different principal factors affecting particle size, calculate their surface to volume ratio and use those expressions to integrate with other engineering disciplines.	3
	PO 2	**Explain** the given **problem statement** and formulate fabrication, characterization of nanomaterials provided **information** and **data** in reaching substantial conclusions by the **interpretation of application in different fields.**	4

28. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	40	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	10	-	2	-		-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	1	-		-	-	-	-	-	-	-	-	-

31. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Viva-voce	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

32. ASSESSMENT METHODOLOGY INDIRECT:

-	Assessment of mini Projects by Experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	Graduates who have specialized in physics provide a unique component of the technical workforce. They are able to attack a wide variety of problems with their problem-solving skills and grasp of the principles of physics,. A well-trained physicist is capable of moving quickly among different technical areas, particularly into areas so new that they have not yet evolved into an engineering discipline.
5	GENDER EQUALITY	

6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on 24 August 2023 .

Signature of Course Coordinator **HOD, CSE(DS)**
Dr. Rizwana, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

OBJECT ORIENTED PROGRAMMING
COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**				
2	Course code	**ACSD01**				
3	Course Title	**OBJECT ORIENTED PROGRAMMING**				
4	Class / Semester	I / I				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 0 hours		Practical: – hours	
10	Course Coordinator	Dr. M V Krishna Rao				
11	Date Approved by BOS	28/08/2023				
12	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse				
13	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		-	-	-	-	

14. Course Overview

The course provides a solid foundation in object-oriented programming concepts in using them. It includes concepts object-oriented concepts such as information hiding, encapsulation, and polymorphism. It contrasts the use of inheritance and composition as techniques for software reuse. It provides an understanding of object-oriented design using graphical design notations such as Unified Modelling Language (UML) as well as object design patterns.

15. Course Objectives:

The students will try to learn:

I	The fundamental concepts and principles of object-oriented programming in high-level programming languages.
II	Advanced concepts for developing well-structured and efficient programs that involve complex data structures, numerical computations, or domain-specific operations.
III	The design and implementation of features such as inheritance, polymorphism, and encapsulation for tackling complex problems and creating well-organized, modular, and maintainable code.
IV	The usage of input/output interfaces to transmit and receive data to solve real-time computing problems.

16. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	**Interpret** the features of object-oriented programming languages, comparison, and evolution of programming languages.
CO 2	**Model** the real-world scenario using class diagrams and exhibit communication between objects.
CO 3	**Estimate** the need for special functions for data initialization.
CO 4	**Outline** the features of object-oriented programming for binding the attributes and behavior of a real-world entity.
CO 5	**Use** the concepts of streams and files that enable data management to enhance programming skills.
CO 6	**Develop** contemporary solutions to software design problems using object-oriented principles.

17. Topic Learning Outcome (TLOs):

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
1	Objects and legacy systems	1	**Summarize** fundamental concepts of programming through a procedural approach.	CO 1	Understand
		2	**Differentiate** between OOP and other programming paradigms such as procedural programming.	CO 1	Understand
2	Object-oriented programming	3	**Gain knowledge** to design and implement software solutions using OOP principles.	CO 1	Remember

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		4	**Discuss** applications of OOP in software development, graphical user interface development, and mobile application development.	CO 1	Understand
3	Abstraction: Levels of abstraction	5	**Identify** the data components and behaviors of multiple abstract data types.	CO 1	Remember
		6	**Apply** techniques of decomposition to break a program into smaller pieces.	CO 1	Apply
		7	**Implement** a coherent abstract data type with loose coupling between components and behaviors.	CO 6	Apply
4	Classes and objects: Fields, methods, messages	8	**Interpret** knowledge by defining classes and creating instances to represent and interact with real-world entities or concepts.	CO 2	Understand
		9	**Instantiate** objects from classes to understand the relationship between classes and objects.	CO 2	Remember
5	Access specifiers: public, private, protected	10	**Enumerate** access specifiers' visibility and accessibility of class members (variables and methods) within different parts of a program.	CO 2	Remember
6	Class diagrams	11	**Create and interpret** class diagrams to visually represent classes, relationships, and interactions.	CO 2	Apply
7	Encapsulation	12	**Review** the encapsulation principle by specifying who can access and modify class members.	CO 3	Remember
		13	**Implement** encapsulation by using access modifiers (public, private, protected) to control access to class members.	CO 2	Apply
		14	**Use** static fields to keep a count of the number of objects that have been instantiated or to store a value that must be shared among all instances.	CO 6	Apply

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
8	Special member functions: Constructors, destructors	15	**Select** the constructor methods in initializing object attributes when instances are created.	CO 3	Remember
		16	**Illustrate** destructors to manage resources and perform cleanup operations in the classes such as closing files, releasing locks, or cleaning up cached data.	CO 6	Apply
9	Overloading: Functions, operators, constructors	17	**Express** the behavior of operators of a class that enriches programming skills in various ways that are both intuitive and flexible.	CO 3	Understand
		18	**Infer** that data is in a compatible format for specific operations or assignments to avoid unexpected behavior or data loss.	CO 3	Understand
		19	**List** the types of inheritance to facilitate code reuse, organization, and hierarchy for modeling complex systems.	CO 4	Remember
10	Inheritance: Subclasses, and method overriding	20	**Use** subclassing to design class hierarchies that allow code to be reused for distinct subclasses.	CO 4	Apply
		21	**Identify** the type of inheritance to create specialized classes that inherit the properties and behaviors of more general classes.	CO 4	Remember
11	Virtual functions	22	**Demonstrate** code flexibility using virtual functions to work with different types of objects through a common interface.	CO 4	Understand
12	Polymorphism	23	**Review** polymorphism on different derived classes to be treated as objects of their common base class.	CO 4	Remember
		24	**Understand and demonstrate** polymorphic behavior through function overriding and function overloading.	CO 4	Understand

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
13	Streams and files	25	**Illustrate** console input and output to create applications that interact with users, and process data.	CO 5	Understand
		26	**Label** objects to store them in files and deserialize them to recreate objects from files.	CO 5	Remember
		27	**Demonstrate** file-handling operations to enrich programming capabilities to create more sophisticated applications that interact with and manipulate external data sources effectively.	CO 5	Understand
		28	**Use** output with manipulators and predefined manipulatorsfor formatting input and output data.	CO 6	Apply
14	Command line arguments	29	**Interpret** software systems and applications to configure and control via command-line arguments.	CO 5	Understand

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - The tech industry evolves rapidly, and staying up-to-date with the latest programming languages, frameworks, and development practices is crucial. Combining OOP skills with a commitment to continuous learning demonstrates a student's dedication to staying relevant in a dynamic field.
2. Project-based skills - Creating projects that utilize OOP principles allows a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how OOP concepts work in practice.

19. Content Delivery / Instructional Methologies:

✓	Power Point Presentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definitions and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE:

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given in the first two modules. Each question carries 12 marks. There could be a maximum of two sub-divisions in a question.

21. Course content - Number of modules: Five

MODULE I	**Object-oriented concepts** | **Number of Lectures: 09**
	Objects and legacy systems, procedural versus Object-oriented programming, top-down and bottom-up approaches and their differences, benefits of OOP, applications of OOP, and features of OOP. **Abstraction:** Layers of abstraction, forms of abstraction, abstraction mechanisms.
MODULE II	**Classes and objects** | **Number of Lectures: 09**
	Classes and objects: Object data, object behaviors, creating objects, attributes, methods, messages, creating class diagrams. **Access specifiers and initialization of class members:** Accessing members and methods, access specifiers - public, private, protected, memory allocation. Static members, static methods.
MODULE III	**Special member functions and overloading** | **Number of Lectures: 09**
	Constructors and destructors: Need for constructors and destructors, copy constructors, dynamic constructors, parameterized constructors, destructors, constructors and destructors with static members. **Overloading:** Function overloading, constructor overloading, operator overloading - rules for overloading operators, overloading unary and binary operators, friend functions.

MODULE IV	**Inheritance and polymorphism**	**Number of Lectures: 09**
	Inheritance: types of inheritance, base class, derived class, usage of final, ambiguity in multiple and multipath inheritances, virtual base class, overriding member functions, order of execution of constructors and destructors. **Polymorphism and virtual functions:** Virtual functions, pure virtual functions, abstract classes, introduction to polymorphism, static polymorphism, dynamic polymorphism.	
MODULE V	**Console I/O and working with files**	**Number of Lectures: 09**
	Console I/O: Concept of streams, hierarchy of console stream classes, unformatted I/O operations, managing output with manipulators. **Working with files:** Opening, reading, writing, appending, processing, and closing different types of files, and command line arguments.	

TEXTBOOKS

1. Matt Weisfeld, *The Object-Oriented Thought Process*, Addison Wesley Object Technology Series, 4th Edition, 2013.

REFERENCE BOOKS:

1. Timothy Budd, *Introduction to object-oriented programming*, Addison Wesley Object Technology Series, 3rd Edition, 2002.
2. Gaston C. Hillar, *Learning Object-Oriented Programming*, Packt Publishing, 2015.
3. Kingsley Sage *Concise Guide to Object-Oriented Programming*, Springer International Publishing, 1st Edition, 2019.
4. Rudolf Pecinovsky, *OOP - Learn Object Oriented Thinking and Programming*, Tomas Bruckner, 2013.
5. Grady Booch, *Object-oriented analysis and design with applications*, Addison Wesley Object Technology Series, 3rd Edition, 2007.

MATERIALS ONLINE:

1. https://docs.oracle.com/javase/tutorial/java/concepts/
2. https://www.w3schools.com/cpp/
3. https://www.edx.org/learn/object-oriented-programming
4. https://www.geeksforgeeks.org/introduction-of-object-oriented-programming/

22. Course plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
Discussion on Outcome Based Education, CO, POs, and PSOs			
CONTENT DELIVERY (THEORY)			
1	Objects and legacy systems	CO 1	T1, Pg: 05
2	Object-oriented programming	CO 1	T1, Pg: 06
3	Procedural versus object-oriented programming	CO 1	T1, Pg: 07, R4: Pg: 13
4	Top-down and bottom-up approaches and their differences	CO 1	R5: 1.5
5	Benefits and applications of OOP	CO 1	R5: 1.6
6	Features of OOP	CO 1	T1, Pg: 12
7	Abstraction and layers of abstraction	CO 1	R1: 2.1
8	Forms of abstraction	CO 1	R1: 2.2
9	Abstraction mechanisms	CO 1	R1: 2.3
10	Object data, object behaviors, creating objects	CO 2	T1, Pg:12, 13
11	Attributes, methods, messages	CO 2	T1, Pg:19, 20
12	Classes	CO 2	T1, Pg: 17
13	Creating class diagrams with examples	CO 2	T1, Pg: 20
14	Accessing members	CO 2	R5: 3.1
15	Accessing methods	CO 2	R5: 3.2
16	Access specifiers - public, private, protected with examples	CO 2	T1, Pg: 188
17	Memory allocation	CO 2	T1, Pg: 90
18	Static members, static methods	CO 2	T1, Pg: 90
19	Constructors need constructors and destructors	CO 3	T1, Pg: 71
20	Copy constructors with examples	CO 3	R1: 15.1
21	Dynamic constructors with examples	CO 3	R1: 15.3
22	Parameterized constructors and destructors	CO 3	R1: 15.3.1
23	Constructors and destructors with static members	CO 3	R1: 15.3.2
24	Function overloading, constructor overloading	CO 3	R1: 15.3.2
25	Operator overloading - rules for overloading operators	CO 3	R1: 15.3.2
26	Overloading unary and binary operators	CO 3	R1: 15.3.2
27	Friend functions	CO 3	R1: 15.3.2
28	Inheritance and types of inheritance	CO 4	T1, Pg: 153
29	Base class, derived class, usage of final	CO 4	T1, Pg: 45
30	Ambiguity in multiple and multipath inheritance	CO 45	T1, Pg: 136

S.No	Topics to be covered	CO's	Reference
31	Virtual base class, overriding member functions	CO 4	T1, Pg: 137
32	Order of execution of constructors and destructors	CO 4	T1, Pg: 28 R1: 14.1
33	Virtual functions, pure virtual functions	CO 4	T1, Pg: 28
34	Abstract classes	CO 4	T1, Pg: 21
35	Introduction to polymorphism	CO 4	T1, Pg: 21
36	Static polymorphism, dynamic polymorphism.	CO 4	T1, Pg: 21
37	Concept of streams, hierarchy of console stream classes.	CO 5	T1, Pg: 225
38	Unformatted I/O operations	CO 5	T1, Pg: 221
39	Managing output with manipulators and predefined manipulators.	CO 5	T1, Pg: 225
40	Data streams, the opening of a file	CO 5	R1: 2.5
41	Reading/writing a character from/into a file	CO 5	T1, Pg: 225
42	Appending into a file	CO 5	T1, Pg: 232
43	Processing and closing files	CO 6	T1, Pg: 227
44	Different types of files and file systems.	CO 5	T1, Pg: 226
45	Command line arguments	CO 5	T1, Pg: 228
46	Question bank discussion	CO 6	T1
47	Question bank discussion	CO 6	T1
48	Question bank discussion	CO 6	T1
PROBLEM SOLVING/ CASE STUDIES			
1	Design a class to represent books with attributes like title, author, and ISBN. Create a class for library patrons with borrowing history and due dates. Implement methods to borrow and return books, tracking availability, and due dates.	CO 1	
2	Design a class for products with properties like name, price, and description. Develop a shopping cart class that allows users to add and remove products. Use objects to create an interactive shopping experience with calculated totals.	CO 1	
3	Create a class for students with attributes like name, age, and enrolment status. Design a class for courses with properties like title, instructor, and schedule. Implement methods to enroll students in courses and track their progress.	CO 1	
4	Design a class representing a geometric shape (e.g., circle, rectangle). Use the const keyword to declare methods that provide information about the shape without modifying its properties.	CO 2	

S.No	Topics to be covered	CO's	Reference
5	Design a university class with nested classes for departments and courses. Utilize nested classes to represent the hierarchical structure of the university's organization.	CO 2	
6	Design a class representing employees with attributes like name, employee ID, and position. Use a constructor to initialize employee information when an object is created. Implement a destructor to handle any cleanup tasks or logging when an employee object is destroyed.	CO 2	
7	Implement a class for complex numbers with overloaded operators for addition, subtraction, multiplication, and division. Allow users to perform arithmetic operations on complex numbers using intuitive syntax.	CO 3	
8	Design a class for representing dates and overload comparison operators. Allow users to compare dates and determine their chronological order.	CO 3	
9	Create a utility to convert measurements between different units (e.g., inches to centimeters, pounds to kilograms). Utilize type conversion to handle unit conversions based on user input.	CO 3	
10	Design a base class Character with virtual functions for movement, attack, and interaction. Implement derived classes PlayerCharacter and EnemyCharacter that override the virtual functions. Use polymorphism to handle interactions between various characters in the game.	CO 4	
11	Create a base class Employee with virtual functions for calculating salary and displaying information. Implement derived classes RegularEmployee and ContractEmployee that override the virtual functions.	CO 4	
12	Design classes representing accounts (e.g., savings, checking) and customers. Use encapsulation to hide sensitive data and provide methods to deposit, withdraw, and check balances. Apply inheritance to create specialized account types, such as VIP accounts with additional features.	CO 4	
13	Develop an application to manage tasks and to-do lists. Use console stream classes to display tasks, prompt users for new tasks, and mark tasks as completed. Enable users to save and load their to-do lists to/from text files using file stream classes.	CO 5	
14	Create a calculator application that performs basic arithmetic operations. Utilize console stream classes to prompt users for operands and operators, and display the calculation results.	CO 5	

S.No	Topics to be covered	CO's	Reference
15	Create a utility that parses and analyzes log files. Read log files, extract relevant information, and present summaries. Use file streams to process large log files efficiently.	CO 5	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to programming and object legacy.	CO 1	
2	Constructor and destructor.	CO 2	
3	Operator overloading.	CO 3	
4	Data hiding.	CO 4	
5	Command line arguments.	CO 5	
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Classes and objects.	CO 1	
2	Constructors and destructors.	CO 2	
3	Overloading a unary and binary operator using friend function and member function.	CO 3	
4	Ambiguity in derived classes for multipath inheritance.	CO 4	
5	Console stream classes.	CO 5	

23. Program outcomes and Program specific outcomes:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

24. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE
PO 2	**Problem analysis:** Identity, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE

PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and Environmental considerations.	3	CIE/SEE
PO 5	**Modern Tool Usage:** Create, select and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3	CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Tech talk/Definitions and terminology
PO 12	**Life-Long Learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/SEE

25. How program-specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	3	Tech talk /Definitions and terminology/ Assignments
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	3	Tech talk /Definitions and terminology/ Assignments

3 = High; 2 = Medium; 1 = Low

26. Mapping of each CO with PO(s), PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	✓	-	-	-	-	✓	-	-	✓	-	-
CO 2	✓	✓	✓	-	✓	-	-	-	-	✓	-	-	✓	-	✓
CO 3	✓	-	✓	-	✓	-	-	-	-	-	-	-	✓	-	✓

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 4	✓	-	✓	-	✓	-	-	-	-	✓	-	✓	✓	-	✓
CO 5	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	✓	-	✓

27. Justifications for CO – PO / PSO mapping - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of object-oriented programming while evaluating mathematical expressions in program statements. These concepts provide insight into expression evaluation by applying the principles of mathematics and science.	3
	PO 5	With the help of modern engineering tools, we can easily understand the basic concept of objects and classes while evaluating mathematical expressions in program statements.	1
	PO 10	Extend the knowledge of object-oriented programming to communicate effectively with the engineering community.	1
	PSO 1	Understand features of procedural as well as object-oriented programming while writing and analyzing computer programs in the areas related to Machine Learning, Big data, and Artificial Intelligence.	4
CO 2	PO 1	By applying the knowledge of mathematics, science, and engineering fundamentals we can effectively use the properties of OOP.	3
	PO 2	Apply nested classes in problem identification, statement, and validation.	5
	PO 3	Apply constructors and destructors to investigate and understand different complex engineering problems efficiently.	8
	PO 5	Apply static members to model complex engineering activities.	1
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	Apply features of procedural as well as object-oriented programming while writing and analyzing computer programs in the areas related to machine learning, big data, and artificial intelligence.	5
	PSO 3	Acquire the knowledge of object-oriented concepts to build statistical models used in data analytics in application domains of engineering and information systems.	2
CO 3	PO 1	Summarize indexing and slicing mechanisms for extracting a portion of data in a sequence using principles of mathematics, and engineering fundamentals.	8
	PO 3	Demonstrate the importance of indexing mechanisms in sequences while developing solutions for complex engineering problems and design systems using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	6
	PO 5	Demonstrate overloading operators with the usage of modern tools.	1
	PSO 1	Summarize indexing mechanisms to design and develop efficient real-time computational problems.	6
	PSO 3	Infer sufficient knowledge of container data types and apply it in real-time for data management tasks.	2
CO 4	PO 1	Demonstrate different modules/packages in object-oriented programming while developing solutions using the fundamentals of mathematics, science, and engineering.	3
	PO 3	Understand the usage of modules/packages while developing solutions for complex engineering problems and design systems using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	8
	PO 5	Interpret different string functions by using modern tools.	1
	PO 10	Extend the focus to understanding the usage of modules/packages and communicating effectively with the engineering community.	2
	PO 12	Summarize string handling functions that involve manipulating and managing text or character data for tasks like data validation, formatting, and communication.	7
	PSO 1	Demonstrate different modules to understand, design, and analyze computer programs in reducing the time and space complexities of various applications with a focus on data science domain.	5

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 3	Illustrate modern computer tools in implementing online and offline data streaming applications with a focus on unstructed data.	2
CO 5	PO 1	Make use of parameter passing and different types of arguments in user-defined functions to design efficient modular programs by applying the knowledge of mathematics, science, and Engineering fundamentals.	3
	PO 2	Apply modular programming concepts for problem identification, formulation, and data collection.	8
	PO 3	Select a strong foundation for writing efficient modular programs using parameter-passing mechanisms for career building by understanding the requirements and communicating effectively with the engineering community.	7
	PO 5	Develop different functions by using modern tools.	1
	PSO 1	Develop design and analyze object-oriented programming in parameter and arguments in methods for modular programming in general and data management in specific.	6
CO 6	PO 1	Apply scientific principles and methodologies, mathematical principles, and other engineering disciplines for procedural and object-oriented programming.	3
	PO 2	Apply object-oriented concepts in problem identification, statement, and validation.	7
	PO 3	Identify the need for object-oriented concepts while developing solutions for complex engineering problems and design systems using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	7
	PO 5	Develop object-oriented principles using modern tools.	1
	PO 10	Apply the knowledge of object-oriented programming to communicate effectively with the engineering community.	2
	PO 12	Identify the need for object-oriented principles for the preparation and the ability to engage in independent and lifelong learning	6
	PSO 1	Focus on writing programs using procedural and object-oriented concepts for applications such as computational geometry, machine learning, big data, and artificial intelligence by understanding and applying the engineering principles of learning.	6
	PSO 3	Acquire the knowledge of object-oriented concepts to build statistical models used in data analytics in application domains of engineering and information systems.	2

28. Total count of key competencies for CO – PO / PSO mapping:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	3	-	-	-	-	1	-	-	3	-	-
CO 2	3	2	3	-	3	-	-	-	-	3	-	-	3	-	3
CO 3	3	-	3	-	3	-	-	-	-	-	-	-	3	-	3
CO 4	3	-	3	-	3	-	-	-	-	2	-	3	3	-	3
CO 5	3	2	3	-	3	-	-	-	-	-	-	-	3	-	-
CO 6	3	3	3	-	3	-	-	-	-	2	-	3	3	-	3

29. Percentage of key competencies CO – PO / PSO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	20	0.0	0.0	66.6	0.0	0.0
CO 2	100	50	80	0.0	100	0.0	0.0	0.0	0.0	60	0.0	0.0	83.3	0.0	100
CO 3	100	0.0	60	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	100
CO 4	100	0.0	80	0.0	100	0.0	0.0	0.0	0.0	40	0.0	88	83.3	0.0	100
CO 5	100	80	70	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	0.0
CO 6	100	80	70	0.0	100	0.0	0.0	0.0	0.0	40	0.0	75	100	0.0	100

30. Course articulation matrix PO / PSO mapping:

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0$\leq$ C$\leq$ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	3	-	-	-	-	1	-	-	3	-	-
CO 2	3	2	3	-	3	-	-	-	-	3	-	-	3	-	3
CO 3	3	-	3	-	3	-	-	-	-	-	-	-	3	-	3
CO 4	3	-	3	-	3	-	-	-	-	2	-	3	3	-	3
CO 5	3	2	3	-	3	-	-	-	-	-	-	-	3	-	-
CO 6	3	3	3	-	3	-	-	-	-	2	-	3	3	-	3

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
TOTAL	18	7	15	-	18	-	-	-	-	8	-	6	18	-	12
AVERAGE	3	2.3	3	-	3.0		-	-	-	2.0	-	3.0	3.0	-	3.0

31. Assessment methodology - Direct:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Definitions and Terminology	✓	Tech talk / 5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓	Tech Talk	✓

32. Assessment methodology - Indirect:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write a brief description of the course and its relevance to SDGs.

1		
2		
3		

4	QUALITY EDUCATION	**Quality education:** Guarantee an education system that is both inclusive and fair, offering high-quality learning experiences and lifelong opportunities accessible to all.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, innovation, and infrastructure:** Strong OOP skills enable to design and development of services like microservice architecture, cloud computing, machine learning, and AI integration in a modular and maintainable way, contributing to a more flexible and scalable infrastructure.
10	REDUCED INEQUALITIES	

11	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable cities and communities:** OOP skills can develop software solutions that contribute to urban sustainability, improve quality of life, and address challenges like smart city solutions, energy efficiency and monitoring, waste management systems, public transportation optimization, environmental sensor networks, education, and awareness faced by modern cities.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 28-08-2023.

Signature of Course Coordinator **HOD CSE,DS**
Dr. M V Krishna Rao, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**				
2	Course Title	**MATRICES AND CALCULUS**				
3	Course Code	AHSD02				
4	Program	B.Tech				
5	Semester	I Semester				
6	Regulation	BT23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	1	4	-	-
8	Type of course (**Tick type of course**)	Core ✓	Professional Elective -	Open Elective -	VAC -	MOOCs -
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 16 hours		Practical: 0 hours	
11	Course Coordinator	Mr. P. Shantan Kumar				
	Course Instructor	Mr. P. Shantan Kumar				
12	Date Approved by BOS	23 August 2023				
13	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD02.pdf				
14	Course Prerequistes -	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		10+2	-	-	Basic Principles of Algebra and Calculus	

15. Course Overview

This course is a foundation for all engineering branches. It includes concepts of Matrices, Eigen Values, Eigen Vectors, Functions of Single, Several Variables, Fourier Series and Multiple Integrals. This course is applicable for simulation, colour imaging processing and optimal solutions in all engineering problems.

16. Course Objectives:

The students will try to learn:

I	The Concept of the rank of a matrix, eigen values, eigen vectors and solution of the system of linear equations.
II	The Geometrical approach to the mean value theorems and applications.
III	The Fourier series expansion in periodic and non-periodic intervals.
IV	The Evaluation of multiple integrals and applications.

17. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	**Determine** the rank and solutions of linear equations with elementary operations.
CO 2	**Utilize** the Eigen values, Eigen vectors for developing spectral matrices.
CO 3	**Make use of** Cayley-Hamilton theorem for finding powers of the matrix.
CO 4	**Interpret** the maxima and minima of given functions.
CO 5	**Apply** the Fourier series expansion of periodic functions for harmonic series.
CO 6	**Determine** the volume of solid bounded regions by using the integral calculus.

18. Topic Learning Outcome (TLOs):

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
1	Rank of a matrix	1	**Calculate** the rank of a matrix by using determinants	CO 1	Apply
		2	**Calculate** the rank of a matrix by using elementary operations	CO 1	Apply
2	Inverse of a matrix by Gauss-Jordan method	3	**Compute** the inverse of the given matrix by elementary operations	CO 1	Apply
3	System of non-homogeneous equations	4	**Identify** the use of matrix theory to solve the system of linear equations in various engineering problems	CO 1	Apply
		5	**Examine** the system of homogeneous equations by its augmented form	CO 1	Apply
		6	**Examine** the system of non homogeneous equations for its augmented form	CO 1	Apply
4	Characteristic equation	7	**Recall** the concepts of characteristic equations of matrices	CO 2	Remember
5	Eigenvalues and Eigenvectors	8	**Recall** the concepts of eigenvalues for future engineering applications	CO 2	Remember
		9	**Recall** the concepts of eigenvectors for future engineering applications	CO 2	Remember

S.No	**Topic(s)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
		10	**Utilize** the characteristic polynomials to compute the eigenvalues and eigenvectors	CO 3	Apply
6	Cayley-Hamilton theorem, Diagonalization of a matrix	11	**Make use of** the Cayley-Hamilton to find inverse of a matrix	CO 3	Apply
		12	**Make use of** the Cayley-Hamilton to find powers of a matrix	CO 3	Apply
		13	**Make use of** the Cayley-Hamilton to find diagonalization of a matrix	CO 3	Apply
7	Continuous functions	14	**Explain** the geometrical interpretation of continuous functions on closed and bounded intervals	CO 4	Understand
8	Mean value theorems	15	**Interpret** the mean value theorems on bounded functions	CO 4	Understand
9	Partial differentiation	16	**Recall** the partial differentiation for the functions of several variables	CO 4	Remember
10	Jacobian transformations	17	**Make use of** Jacobian transformations for the functions are to be dependent or independent	CO 4	Apply
11	Maxima and minima of a function	18	**Identify** the maxima and minima of a function with several variables by using partial derivatives	CO 4	Apply
12	Euler coefficients	19	**State** the Euler coefficients for Fourier expansion of periodic functions in a given interval	CO 5	Remember
13	Fourier series in periodic interval	20	**Extend** the Fourier series of given functions in a given periodic interval (-π, π)	CO 5	Understand
		21	**Extend** the Fourier series of given functions in a given periodic interval (0,2π)	CO 5	Understand
14	Fourier series in non -periodic intervall	22	**Compute** the Fourier series of given functions in non-periodic interval (0,2l)	CO 5	Apply
15	Half- range Fourier series	23	**Extend** the half- range Fourier series expansions of a function in a given periodic interval (0,π)	CO 5	Apply
		24	**Extend** the half- range Fourier series expansions of a function in a given arbitrary interval (0, l)	CO 5	Apply

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
16	Double integrals	25	**Solve** the double integrals of functions in given constant limits	CO 6	Apply
		26	**Solve** the double integrals of functions in cartesian coordinates with given limits	CO 6	Apply
		27	**Solve** the double integrals of functions in polar coordinates with given limits	CO 6	Apply
17	Change order of integration	28	**Identify** the change order of integration of double integrals in cartesian form	CO 6	Remember
18	Triple integrals	29	**Calculate** the triple integrals of function in given constant limits	CO 6	Apply
		30	**Calculate** the triple integrals of function in cartesian coordinates with given limits	CO 6	Apply

19. Employability Skills

1. **Linear Algebra:** Employability/ Skill development: Apply the concepts of Linear Algebra in programming languages
2. **Matrices and Differential Calculus:** Employability/ Skill development: Uses the basic of matrices and Calculus calculation concept in the field of Engineering
3. **Integral Calculus:** Employability/ Skill development: Uses the concept of definite integral in engineering problems
4. **Multivariable calculus:** Employability/ Skill development: Can solve the different Multivariable calculus

20. Content Delivery / Instructional Methologies:

✓	Power Point Pressentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE :

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

22. Course content - Number of modules: Five

MODULE I	**MATRICES** ‘ | **Number of Lectures: 09**
	Rank of a matrix by echelon form and normal form; inverse of non-singular matrices by Gauss-Jordan method; system of linear equations: solving system of homogeneous and non-homogeneous equations.
MODULE II	**EIGEN VALUES AND EIGEN VECTORS** | **Number of Lectures: 10**
	Eigen values; Eigen vectors and their properties (without proof); Cayley-Hamilton theorem (without proof), verification; finding inverse and power of a matrix by Cayley-Hamilton theorem; diagonalization of a matrix.
MODULE III	**FUNCTIONS OF SINGLE AND SEVERAL VARIABLES .** |**Number of Lectures: 10**
	Mean value theorems: Rolle’s theorem; Lagrange’s theorem; Cauchy’s theorem-without proof. Functions of several variables: Partial differentiation; Jacobian; functional dependence; maxima and minima of functions of two variables and three variables; method of Lagrange multipliers.
MODULE IV	**FOURIER SERIES** | **Number of Lectures: 09**
	Fourier expansion of periodic function in a given interval of length 2π; Fourier series of even and odd functions; Fourier series in an arbitrary interval; half-range Fourier sine and cosine expansions.
MODULE V	**MULTIPLE INTEGRALS** | **Number of Lectures: 10**
	Evaluation of double integrals (cartesian and polar coordinates); change of order of integration (only cartesian coordinates); evaluation of triple integrals (cartesian coordinates).

Text Books

1. B. S. Grewal, “*Higher Engineering Mathematics*”, Khanna Publishers, 44/e, 2017.
2. Erwin Kreyszig, “*Advanced Engineering Mathematics*”, John Wiley & Sons, 10/e, 2011.

ReferenceE Books:

1. R. K. Jain and S. R. K. Iyengar, "*Advanced Engineering Mathematics*", 3/ed Narosa Publications, 5th Edition , 2016.
2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas,, "*Calculus*", Uma Publications, 13/e Edition,Pearson Publishers, 2013.
3. N.P. Bali and Manish Goyall "*A text book of Engineering Mathematics*", Laxmi Publication, Reprint, 2008.
4. Dean G. Duffy, "*Advanced Engineering Mathematics with MATLAB*", PCRC Press
5. Peter O'Neil, "*Advanced Engineering Mathematics*", Cengage Learning.
6. B.V. Ramana, "*Higher Engineering Mathematics*", McGraw Hill Education

Electronic Resources:

1. https://onlinecourses.nptel.ac.in/noc23_ma88/preview
2. https://onlinecourses.nptel.ac.in/noc23_ma86/preview
3. https://www.efunda.com/math/math_home/math.cfm
4. https://www.ocw.mit.edu/resourcs/#Mathematics
5. https://www.sosmath.com
6. https://www.mathworld.wolfram.com

Materials Online:

1. Course template
2. Tech-talk topics
3. Assignments
4. Definition and terminology
5. Tutorial question bank
6. Model question paper – I
7. Model question paper – II
8. Lecture notes
9. Early lecture readiness videos (ELRV)
10. Power point presentations

23. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Theory of Matrices: Types of Real Matrices	CO 1	T1:2.4 R3:3.11
2	Elementary Operations: Elementary Row and Column Transformations	CO 1	T1:2.7.2 R3:3.34
3	Rank of a Matrix by Echelon Form	CO 1	T1:2.7.4 R3:3.38
4	Rank of a Matrix by Normal Form	CO 1	T1:2.7.7 R3:3.38
5	Inverse of a Matrix by Gauss-Jordan Method	CO 1	T1:2.7.6 R3:3.37
6	Solving system of Non-Homogeneous equations	CO 1	T1:2.10.1 R3:3.39
7	Solving system of Homogeneous equations	CO 1	T1:2.10.3 R3:3.39
8	Solving system of Non Homogeneous equations(Unknown Values)	CO 1	T1:2.10.3 R3:3.39
9	Eigen Values of a Matrix	CO 2	T1:2.13.1 R3:3.46
10	Eigen Vectors of a Matrix	CO 2	T1:2.13.2 R3:3.47
11	Properties of Eigen values and Eigen Vectors of a Matrix Problems	CO 2	T1:2.14 R3:3.47
12	Cayley-Hamilton Theorem- Statement, Verification	CO 3	T1:2.15 R3:3.48
13	Applications of Cayley – Hamilton: Finding Inverse and Powers of a Matrix	CO 3	T1:2.15 R3:3.48
14	Diagonalization of Matrix by Linear Transformation	CO 3	T1:2.16.1 R3:3.49
15	Linear Dependence and Independence of Vectors	CO 3	T1:2.3 R3:3.2
16	Mean Value Theorems:1: Rolle's Theorem	CO 4	T1:4.3.1 R6:2.1
17	Mean Value Theorems:2: Lagrange's Theorem	CO 4	T1:4.3.2 R6:2.2
18	Mean Value Theorems:3: Cauchy's Theorem	CO 4	T1:4.3.3 R6:2.3

S.No	Topics to be covered	CO's	Reference
19	Functions of Several Variables: Partial Differentiation	CO 4	T1:5.2 R3:5.1
20	Jacobian Transformations	CO 4	T1:5.7.1 R3:5.10
21	Functional Dependence	CO 4	T1-5.7.4 R3:5.11
22	Maxima and Minima of Functions with Two Variables	CO 4	T1:5.11.1 R3:5.13
23	Maxima and Minima of Functions with Three Variables	CO 4	T1-5.11.1 R3:5.14
24	Method of Lagrange Multipliers	CO 4	T1-5.12 R3:5.15
25	Euler Coefficeients for Fourier Expansion of Periodic Function in a Given Interval of Length ($-\pi,\pi$),($0,2\pi$)	CO 5	T1-10.2 R3:10.3
26	Fourier Series of Even Functions in a Given Interval of Length $(-\pi, \pi)$	CO 5	T1-10.6.1 R3:10.3
27	Fourier Series of Odd Functions in a Given Interval of Length $(-\pi, \pi)$	CO 5	T1-10.6.2 R3:10.3
28	Fourier Series of Neither Functions in a Given Interval of Length $(-\pi, \pi)$	CO 5	T1-10.6.2 R3:10.3
29	Fourier Series in an Arbitrary Interval (0,2l)	CO 5	T1-10.6.1 R3:10.6
30	Fourier Series in an Arbitrary Interval (-l,l)	CO 5	T1-10.6.2 R3:10.6
31	Half- Range Fourier Sine Expansions in a Given Interval of Length ($0,\pi$)	CO 5	T1-10.7 R3:10.7
32	Half- Range Fourier Cosine Expansions in a Given Interval of Length ($0,\pi$)	CO 5	T1-10.7 R3:10.7
33	Double Integrals in Constant Limits	CO 6	T1-7.1 R3:6.1
34	Double Integrals in Variable Limits	CO 6	T1-7.1 R3:6.2
35	Double Integrals in cartesian coordinates (Area enclosed by plane curves)	CO 6	T1-7.4 R3:6.2
36	Double Integrals in polar coordinates	CO 6	T1-7.3 R3:6.3
37	Change of order of integration (only Cartesian form)	CO 6	T1-7.2 R3:6.4
38	Triple Integrals in Constant Limits	CO 6	T1-7.5 R3:6.5
39	Triple Integrals in Variable Limits	CO 6	T1-7.5 R3:6.5

S.No	Topics to be covered	CO's	Reference
40	Double and Triple Integrals	CO 6	T1-7.1 R3:6.5
	PROBLEM SOLVING/ CASE STUDIES		
1	Rank of the Matrix by Echelon and Normal Form	CO 1	T1-2.7 R3:3.38
2	Homogeneous and Non Homogeneous Equations	CO 1	T1-2.10 R3:3.39
3	Eigen Values and Eigen Vectors of the Matrix	CO 2	T1-2.13 R3:3.46
4	Eigen Values and Eigen Vectors of the Matrix	CO 2	T1-2.16 R3:3.49
5	Cayley Hamilton Theorem Problems	CO 3	T1-2.15 R3:3.48
6	Powers of the Matrix by Cayley Hamilton Theorem	CO 3	T1-2.15 R3:3.48
7	Powers of the Matrix by Cayley Hamilton Theorem	CO 4	T1-4.3 R6:2.1
8	Jacobians, Functional Relationship	CO 4	T1-5.7 R3:5.10
9	Maxima and minima problems	CO 4	T1-5.11 R3:5.13
10	Fourier Series expansion of Periodic Function in a Given Interval of Length 2π	CO 5	T1-10.2 R3:10.3
11	Fourier Expansion of Periodic Function in a Given Interval of Length $(-\pi, \pi)$	CO 5	T1-10.6 R3:10.3
12	Fourier Series in an Arbitrary Interval (-l,l), Fourier Sine, Cosine Series in Interval (0,l)	CO 5	T1-10.6 R3:10.6
13	Finding Double Integrals in Cartesian and Polar Coordinates	CO 6	T1:7.1 R3:6.1
14	Change of order of integration	CO 6	T1-7.2 R3:6.4
15	Triple Integrals	CO 6	T1-7.5 R3:6.5
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
1	Rank of a Matrix, Homogeneous and Non-Homogeneous equations	CO 1	T1-2.7 R3:3.39
2	Eigen Values and Eigen Vectors, Diagonalization	CO 2, CO3	T1-2.13 R3:3.46
3	Mean Value Theorems, Jacobian Transformations, Functionally Dependent and Independent	CO 4	T1-4.3 R6:2.1
4	Fourier Series (Even, Odd, Neither Functions)	CO 5	T1-10.2 R3:10.3

S.No	Topics to be covered	CO's	Reference
5	Multiple Integrals (Double and Triple)	CO 6	T1-7.1 R3:3.6.1
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Matrices	CO 1	T1-2.4 R3:3.11
2	Eigen Values and Eigen Vectors	CO 2, CO 3	T1-2.13 R3:3.46
3	Functions of Several Variables	CO 4	T1-5.2 R3:5.1
4	Fourier Series	CO 5	T1-10.2 R3:10.3
5	Multiple Integrals	CO 6	T1-7.1 R3:6.1

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Program Outcomes	
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-

PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	-	-

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

28. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain the role of rank and inverse of real and complex matrices in solving complex engineering problems by using elementary transformation methods (principles of mathematics).	2
CO 2	PO 1	Determine the Eigen values, Eigen vectors, Spectral matrix complex engineering problems modelled by matrices with help of Characteristic Equation (principles of mathematics).	2
	PO 2	Model the problem into matrices, prepare precise statement of the problem and apply the concepts of Eigen values and Eigen vectors to develop the solution and interpret, validate the results through proper documentation.	6
CO 3	PO 1	Make use of Cayley Hamilton theorem for finding positive and negative powers of the matrix and apply them in the complex engineering problems modelled by matrices (principles of mathematics).	2
CO 4	PO 1	Explain the mean–value theorems for the single variable functions and the extreme values for functions of several variables apply them in the complex engineering problems Partial derivatives of (principles of mathematics).	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 1	Build the Fourier series expansion for the complex engineering problems modelled by given periodic, even and odd functions in various intervals with the help of Fourier coefficients formulae (principles of mathematics).	2
	PO 2	Model the problem with the help of suitable periodic functions, prepare precise statement of the problem and apply Fourier series expansions to develop the solution and interpret, validate the results through proper documentation..	6
CO 6	PO 1	Determine the solution of complex engineering problems modelled by Double and Triple Integrals by using substitution method and principles of mathematics.	2
	PO 2	Model the problem with the help of ordinary integrations, prepare precise statement of the problem and apply on double and triple integrations by method of ordinary integration and other analytical methods to develop the solution and interpret, validate the results through proper documentation.	6

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.6	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	60	-	-	-	-	-	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	9	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech-Talk / 5 Minutes Video	✓	Open Ended Experiments	-
Definitions and Terminology	✓	Quiz	✓	Assignments	✓

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

34. Relevance to Sustainability goals:

Brief description about the course and how its relevance to SDGs.

Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it.

×	NO POVERTY	-
×	ZERO HUNGER	-
×	GOOD HEALTH AND WELL-BEING	-
✓	QUALITY EDUCATION	**Quality Education:** Minimizing school dropout: The teaching of mathematics plays an important role in the implementation of sustainable education to achieve future goals: to make learning mathematics more relevant and applicable, as well as to support the development of 21st century skills.
×	GENDER EQUALITY	-
×	CLEAN WATER AND SANITATION	-
×	AFFORDABLE AND CLEAN ENERGY	-
×	DECENT WORK AND ECONOMIC GROWTH	-
×	INDUSTRY, INNOVATION AND INFRASTRUCTURE	-
×	REDUCED INEQUALITIES	-
×	SUSTAINABLE CITIES AND COMMUNITIES	-

×	RESPONSIBLE CONSUMPTION AND PRODUCTION	-
×	CLIMATE ACTION	-
×	LIFE BELOW WATER	-
×	LIFE ON LAND	-
×	PEACE, JUSTICE AND STRONG INSTITUTIONS	-
×	PARTNERSHIPS FOR THE GOALS	-

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD**
Mr. P.Shantan Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ENGINEERING CHEMISTRY
COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**				
2	Course Title	**ENGINEERING CHEMISTRY**				
3	Course Code	AHSD03				
4	Program	B.Tech				
5	Semester	I Semester				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 64 hours		Tutorials: .... hours		Practical: .... hours	
11	Course Coordinator	Dr.V Anitha Rani				
12	Date Approved by BOS	24/08/2023				
13	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD03.pdf				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		.Intermediate		I	Basic principle of chemistry	
		B.Tech		I	XXXX	

15. Course Overview

The course focuses on the fundamental concepts of chemistry to impart knowledge on applications of chemical sciences in engineering and technology. It deals with topics such as electrochemical principles in batteries, techniques to control corrosion, alternative sources of energy and water purification process. The significance of advanced materials and their usage in industrial, commercial and social sectors for sustainable development.

16. COURSE OBJECTIVES:

The students will try to learn:

I	The concepts of electrochemical principles and causes of corrosion in the new developments and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards complexometric method.
III	The properties, separation techniques of natural gas and crude oil along with potential applications in major chemical reactions..
IV	The different types of materials with respect to mechanisms and its significance in industrial applications.

17. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Implement** the principles of electrochemical systems to control the corrosion in metals.
CO 2	**Analyze** the basic properties of water for its usage in domestic and industrial purposes.
CO 3	**Use** complexometry for calculation of hardness of water to avoid industrial problems.
CO 4	**Extend** the applications of polymers based on their degradability and properties..
CO 5	**Choose** the appropriate fuel based on their calorific value for energy efficient processes.
CO 6	**Predict** the knowledge on viability of advanced materials for technological improvements in various sectors.

18. Topic Learning Outcome (TLOs):

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
1	Galvanic cell	TLO 1	Recall the oxidation and reduction reactions by observing the chemical changes in a cell.	CO 1	Remember
		TLO 2	Explain the operation of electrochemical cell to produce electrical energy from spontaneous redox reactions..	CO 1	Understand
		TLO 3	Use electrochemical principles in batteries.	CO 1	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
2	Electrolytic cell	TLO 4	Illustrate the process of electrolysis by using electrical energy for non-spontaneous chemical reactions..	CO 1	Understand
		TLO 5	Use electrolysis process in separating or obtaining pure elements from ores.	CO 1	Apply
3	Electrochemical series	TLO 6	Interpret the degree of reactivity of electrodes based on activity series table with standard hydrogen electrode.	CO 1	Understand
		TLO 7	Use standard reduction potential data to determine the relative strength of oxidizing and reducing agents.	CO 1	Apply
4	Zinc-air battery	TLO 8	Discuss the chemical reactions in Zinc and oxygen to produce electrical energy.	CO 1	Understand
5	Lead-Acid battery and Li-ion battery	TLO 9	Relate the relationship between charge produced and the amount of product formed for both electrochemical cell and electrolytic cells.	CO1	Understand
6	Causes of corrosion	TLO 10	Recall the corrosion process in metals in presence of environment.	CO 1	Understand
7	Chemical Corrosion	TLO 11	Interpret the oxidation and reduction reactions on the surface of metal in presence of oxygen to form metal oxide in presence of oxygen.	CO 1	Understand
8	Electrochemical corrosion	TLO 12	Illustrate the electrochemical corrosion of metals in acidic and alkaline environment.	CO1	Understand
9	Cathodic protection	TLO 13	Use sacrificial anodes to control corrosion inmetal structures.	CO1	Apply
10	Galvanizing, Tinning	TLO 14	Make use of metallic coatings and coating deposition technologies to prevent corrosion in metals	CO1	Apply
11	Electroplating	TLO 15	Use the process of electrolysis in industries to prevent corrosion in metals.	CO1	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
12	Treatment methods of potable water, Ion-exchange process and Reverse osmosis	TLO 16	Estimate the different water treatment methods to use in industries and domestic purpose.	CO2	Understand
13	Expression of hardness	TLO 17	Select the CaCO3 equivalents to express the total, temporary and permanent hardness of water.	CO3	Apply
14	Complexometry method	TLO 18	Make use of complexometry method to calculate the hardness of water	CO3	Apply
15	Types of polymerization	TLO 19	Relate the addition and condensation polymerization process to synthesize the polymers	CO4	Understand
16	Synthetic polymers	TLO 20	Explain the properties of polymers from organiccompounds.	CO4	Understand
17	Applications of polymers	TLO 21	Use polymers in various sectors based on their properties.	CO4	Apply
18	Classification of fuels	TLO 22	Classify the different types of fuels based their physical state of aggregation.	CO5	Understand
19	Analysis of coal	TLO 23	Demonstrate the qualitative and quantitative analysis of coal to prevent problems inindustries.	CO 5	Understand
20	Refining of petroleuml	TLO 24	Illustrate the fractions of crude oil by fractional distillation process.	CO 5	Understand
21	Demonstrate the qualitative and quantitative analysis of coal to prevent problems inindustries.	TLO 25	Develop the work energy relations and apply to connected systems.	CO5	Understand
22	Gaseous fuels	TLO 26	Use Liquefied petroleum gas and Compressed natural gas in various sectors.	CO 5	Apply
23	Calorific value of fuels	TLO 26	Use the Dulong's formula to find the highercalorific value and lower calorific value of fuels	CO 5	Apply
24	Combustion of fuels	TLO 27	Use theoretical calculation of amount of air required for combustion of fuels.	CO 5	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
25	Synthesis of Nanomaterials	TLO 28	Enhance the understanding of nano-structural materials	CO 6	Apply
26	Nanomaterials	TLO 29	Enhance the use of nanomaterials as a complex materials and structures in buildings.	CO 6	Apply
27	Smart materials	TLO 30	Recognize the importance and applications of smart materials.	CO 6	understand
28	Thermoresponse materials	TLO 31	Identify the importance and benefits of thermoresponse materials	CO 6	understand
29	Setting and hardening of cement	TLO 32	Relate the chemical reactions in setting and hardening of cement	CO 6	understand
30	Mechanism of lubrication	TLO 33	Discuss the mechanism of lubrication processapplied under different load, pressure andtemperatureconditions	CO6	understand

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Project based skills Engineering chemistry for students based on qualitative and quantitative analysis of experimental skills.

20. Content Delivery / Instructional Methologies:

✓	Power Point Pressentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	✓	Mini Project	✓	Videos

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

22. COURSE CONTENT-Number of Modules:Five

MODULE I	**BATTERIES CHEMISTRY AND CORROSION** | Number of Lectures: 13
	Introduction to electrochemical cells: electrolytic cell, Galvanic cell; electrochemical series and its applications; Batteries: classification of batteries, construction, working and applications of Zinc-air battery, Lead-acid battery, Li-ion battery, applications of Li-ion battery to electric vehicles; Corrosion: causes and effects of corrosion, theories of chemical and electrochemical corrosion, mechanism of electrochemical corrosion; Corrosion control methods: cathodic protection, sacrificial anode and impressed current methods; Metallic coatings: Galvanization and tinning; electroplating of Copper.
MODULE II	**WATER AND ITS TREATMENT** **| Number of Lectures: 13**
	Hardness Introduction: Hardness of water, causes of hardness; types of hardness, temporary and permanent hardness, expression and units of hardness; estimation of hardness of water by complexometric method; potable water and its specifications, steps involved in the treatment of water, disinfection of water by chlorination and ozonization;external treatment of water; ion-exchange process; desalination of water: reverse osmosis, numerical problems.
MODULE III	**POLYMER TECHNOLOGY** **. |Number of Lectures: 13**
	Polymers: classification of polymers; types of polymerization-addition, condensation polymerization withexamples. Plastics: thermoplastic and thermosetting plastics; preparation, properties and engineering applications of PVC, Nylon6,6 and Bakelite; Biodegradable polymers: polylactic acid and polyvinyl alcohol and theirapplications. Elastomers: Introduction to natural rubber, vulcanization of natural rubber, preparation, properties and engineering applications of Buna-S and Thiokol rubber.
MODULE IV	**ENERGY SOURCES** **| Number of Lectures: 13**
	Introduction to fuels; classification of fuels; Solid fuels: coal; analysis of coal, proximate and ultimate analysis and their significance; Liquid fuels: petroleum and its refining; Gaseous fuels: composition, characteristics and applications of natural gas, LPG and CNG; Alternative and non-conventional sources of energy: solar, wind and hydropower advantages and disadvantages. Calorific value of fuel: HCV and LCV, Dulongs formula, calculation of air quantity required for complete combustion of fuel, numerical problems

MODULE V	**ENGINEERING MATERIALS** | **Number of Lectures: 12**
	Nanomaterials: introduction, preparation of nanoparticles by sol-gel method, chemical reduction method, applications of nanomaterials. Smart materials and their engineering applications: shape memory materials, poly L-lactic acid. Thermoresponse materials: Polyacryl amides, Poly vinyl amides. Cement: composition of Portland cement, setting and hardening of cement. Lubricants: characteristics of a good lubricant, mechanism of lubrication, thick film, thin film and extreme pressure lubrication; properties of lubricants: viscosity, Redwood viscometer, flash and fire point, cloud and pour point.

TEXTBOOKS

1. Jain and jain, Monika jain , "*Engineering Chemistry* ", Dhanpat Rai Publishers, 17th Edition, 2022.

REFERENCE BOOKS:

1. Shashi chawla& *Engineering Chemistry*", 1th Edition, 2017.
2. jaya sree Reddy, "*Engineering Chemistry*", wiley Publications, 2023.
3. S.S Dara "*Engineering Chemistrys. chand*"12th Edition, 2018.
4. Nitin K Puri "*Nanomaterials Synthesis Properties And Applications*", I K international publishing house pvt Ltd, 1st edition 2021.
5. S. Bhavikatti, "*Engineering Chemistry*", New Age International, 5th Edition, 2020.
6. R. C. Hibbler, "*Engineering Chemistry*", Pearson Press, 2021.

MATERIALS ONLINE:

1. Lecture notes, ELRV videos and power point presentations
2. Answers / solutions to all questions / problems in the textbook
3. Online exercises
4. Problems and solutions in files

23. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Electrochemical cells (Galvanic cell), electrolytic cell	CO 1	T1:6.1, R1:7.4,8
2	Electrochemical series and its applications	CO 1	T1: 6.7, R1:10
3	Batteries, classification of batteries	CO 1	T2:5.10 R1:1.15
4	Construction, working and applications of Zinc-air battery	CO 1	T1:3.13, R1:23.1
5	Construction, working and applications of Lead-acid storage battery	CO 1	T1:3.13,R1:23.2
6	Construction, working and applications of Li-ion battery, applications of Li-ion battery to electric vehicles	CO 1	T1:3.14 , R1:24
7	Corrosion, causes and effects of corrosion, chemical corrosion	CO 1	T1:3.20, R1:1.2
8	Electrochemical corrosion, mechanism of electrochemical corrosion	CO 1	T1:3.21, R1:2.1
9	Cathodic protection, sacrificial anode and impressed current methods	CO 1	T1:3.22, R1:6.4
10	Metallic coatings, Galvanization and tinning, electroplating of Copper.	CO 1	T1:3.23, R1:6.3,6.6
11	Hardness of water, causes of hardness, disadvantages of hard water	CO 2	T1:2.1, R1:4
12	Types of hardness, temporary and permanent, expression and units of hardness	CO 2	T1:2.1, R1:5.3
13	Estimation of hardness of water by complexometric method	CO 3	T1:2.6, R1:6.1
14	potable water and its specifications, steps involved in the treatment of water, disinfection of water by chlorination and ozonization	CO 2	T1:2.6.5, R1:14
15	External treatment of water, ion-exchange process	CO 3	T1:2.8, R1:12.3
16	Desalination of water, reverse osmosis	CO 3	T1:2.10.2, R1:17.4
17	Classification of polymers; types of polymerization-addition, condensation polymerization with examples.	CO 4	T1: 3.5, R1: 3

S.No	Topics to be covered	CO's	Reference
18	Plastics, thermoplastic and thermosetting plastics	CO 4	T1:1.4, R1: 2.10
19	Preparation, properties and engineering applications of PVC	CO 3	T1:3.5, R1: 7.2
20	Preparation, properties and engineering applications of Nylon 6,6 s	CO 4	T1: 3.12, R1:7.7 5.1.2
21	Preparation, properties and engineering applications of Bakelite	CO 4	T1:3.14, R1: 3.2.3
22	Biodegradable polymers, polylactic acid and polyvinyl alcohol and their applications.	CO 4	T1:3.14, R1: 3.2.3
23	Elastomers, vulcanization of natural rubber	CO 4	T1: 3.15, R1:6.1
24	Preparation, properties and applications of Buna-s and Thiokol rubber.	CO 4	T1: 3.22, R1: 6.7
25	Classification of fuels, analysis of coal, proximate analysis of coal and their significance	CO 5	T1:4.2, R1: 2.1, 7.1,7.2
26	Ultimate analysis of coal and their significance	CO 4	T1:4.4.1, R1:7.1,7.2
27	Liquid fuels, petroleum and its refining	CO 5	T1:4.5.2, R1:15.2
28	Composition, characteristics and applications of natural gas, LPG and CNG	CO 5	T1:4.6, R1:9.1,9.2
29	Alternative and non-conventional sources of energy: solar, wind and hydropower advantages and disadvantages.	CO 4	T1:4.6, R1:9.8
30	Calorific value of fuel: HCV and LCV, Dulongs formula,	CO 5	T1:4.8, R1: 4.1
31	Calculation of air quantity required for complete combustion of fuel, numerical problems.	CO 5	T2:16.9 R1:8.11.2
32	Nanomaterials, preparation of nanoparticles by sol-gel method	CO 6	T1: 6.0, R1: 1
33	Preparation of nanoparticles by chemical reduction method and applications of nanomaterials.	CO 6	T1: 6.1, R1:11
34	Smart materials and their engineering applications, shape memory materials, Poly L-Lactic acid.	CO 6	T1: 6.1 R2:12.24
35	Thermoresponse materials, Polyacryl amides, Poly vinyl amides.	CO 6	T1: 6.1
36	Cement, composition of Portland cement	CO 6	T1: 5.1.2, R1: 3.2
37	Setting and hardening of cement.	CO 6	T1: 5.1.3, R1: 3.3
38	Lubricants, characteristics of a good lubricant	CO 6	T1: 3.24, R1: 3,5

S.No	Topics to be covered	CO's	Reference
39	Mechanism of lubrication, thick film, thin film and extreme pressure lubrication	CO 6	T1: 3.24, R1: 3,5
40	properties of lubricants, viscosity, flash and fire point, cloud and pour point	CO 6	T1: 3.25, R1: 7 R1: 7
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on temporary and permanent hardness in Degree French and ppm	CO 3	T1:2.1, R1:5.4
2	Problems on temporary, permanent and total hardness in ppm and Degree Clark	CO 3	T1:2.1, R1:5.4
3	Problems on the temporary, permanent and total hardness of water in Degree French and Degree Clark.	CO 3	T1:2.1, R1:5.5
4	Problems on the temporary, permanent and total hardness of water in Degree Clark and Mg/L.	CO 3	T1:2.1, R1:5.5
5	Problems on the total hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
6	Problems on the temporary hardness and permanent hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
7	Problems on the temporary hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
8	Problems on the permanent hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
9	Problems on the higher and lower calorific values of the fuel.	CO5	T1:4.8, R1:4.3
10	Problems on the gross and net calorific values of the fuel.	CO 5	T1:4.8, R1:4.3
11	Problems on HCV and LCV (polar coordinates).	CO 5	T1:4.8, R1:4.3
12	Problems on GCV and NCV	CO 5	T1:4.8, R1:4.3
13	Problems on calculation of air quantity required for complete combustion of coal	CO 5	T1:4.9, R1:10.2
14	Problems on complete combustion of fuel in air	CO 5	T1:4.9, R1:10.2
15	Problems on calculation of air quantity required for complete combustion of fuel	CO 5	T1:4.9, R1:10.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions & terminology discussion onbatteries chemistry and corrosion	CO 1	T1:6.1, R1: 7.4,1.2
2	Definitions & terminology discussion on water and its treatment	CO 2, CO3	T1:2.1, R1:5.3
3	Definitions &terminology discussion on polymer technology	CO 3, CO 4	T1: 3.5, R1: 7.2

S.No	Topics to be covered	CO's	Reference
4	Definitions &terminology discussion on energy sources	CO 5	T1:4.2, R1:2.1
5	Definitions & terminology discussion on engineering materials	CO 6	T1: 6.0, R1: 11,3,3.2
	DISCUSSION OF TUTORIAL QUESTION BANK		
1	Question bank discussion on batteries chemistry and corrosion	CO 1	T1:6.1, R1: 7.4,1.2
2	Question bank discussion on water and its treatment	CO 2, CO 3	T1:2.1, R1:5.3
3	Question bank discussion on polymer technology	CO 4	T1: 3.5, R1: 7.2
4	Question bank discussion on energy sources	CO 5	T1:4.2, R1:2.1
5	Question bank discussion on engineering materials	CO 6	T1: 6.0, R1: 11,3,3.2

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 7	**Environment and sustainability**understand the impact of the professional engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	Seminar / Conferences / Research papers

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation..	-	
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	-	

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	✓	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-		-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-		-	-
CO 4	✓	-	-	-	-	-	✓	-	-	-	-			-	-
CO 5	✓	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-

28. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using principles of science for solving engineering problems.	2
	PO 7	Use metallic coatings to control the corrosion in metals and know the impact in socio economic and environmental contexts for sustainable development..	2
CO 2	PO 1	Explain the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using principles of science for solving engineering problems.	2
CO 3	PO 1	Explain the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using principles of science for solving engineering problems.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science..	2
CO 4	PO 1	Explain the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using principles of science for solving engineering problems.	2
	PO 7	Use biodegradable polymers to reduce the soil pollution and know the impact in socio economic and environmental contexts for sustainable development..	2
CO 5	PO 1	Explain the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using principles of science for solving engineering problems.	3
	PO 2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science.. .	2
	PO 7	Use biodegradable polymers to reduce the soil pollution and know the impact in socio economic and environmental contexts for sustainable development.	2
CO 6	PO 1	Explain the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using principles of science for solving engineering problems.	2
	PO 7	Use biodegradable polymers to reduce the soil pollution and know the impact in socio economic and environmental contexts for sustainable development.	2

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	2	-	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 5	3	2	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 6	2	-	-	-	-	-	2	-	-	-	-	-	-	1	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	33.3	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-	-	-		-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	33.3	-
CO 5	100	20	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 6	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % $<C<$ 60% –Moderate

1-5 $<C\leq$ 40% – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	3	-	-	-	-	-	-	1	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	3	-	-	-	-	-	3	-	-	-	-	-	-	1	-
CO 5	3	1	-	-	-	-	3	-	-	-	-	-	-	1	-
CO 6	3	-	-	-	-	-	3	-	-	-	-	-	-	1	-
TOTAL	18	2	-	-	-	-	12	-	-	-	-	-	-	5	-
Average	3	1	-	-	-		3	-	-	-	-	-	-	-	-

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	Water purification can help to decrease dangerous bacteria and other chemicals that can weaken the immune system by removing pollutants and impurities. This may assist stay in good health and lowers chance of illness.
4	QUALITY EDUCATION	The fundamental principles of water treatment and its applications in industry, apply electrochemical principle in batteries
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	Safe and readily available water is important for public health, domestic use, food production or recreational purpose.countries' economic growth and can contribute greatly to poverty reduction.

7		Affordable electricity is provided by clean energy sources such as solar, wind and hydropower.
8		
9		
10		
11		Renewable energy systems for sustainable cities
12		Renewable energy systems for sustainable cities
13		Non-renewable energy resources release harmful greenhouse gases into the atmosphere, creating the greenhouse effect which causes global warming.

14		
15		The biodegradable plastics material focuses on creating a more sustainable and greener world with a smaller environmental imprint.
16		
17		

Approved by: Board of Studies in the meeting conducted on21-August-2023 .

Signature of Course Coordinator **HOD,CSE(DS)**
Dr.V.Anitha Rani, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

APPLIED PHYSICS LABORATORY
COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="4">CSE (DATA SCIENCE)</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="4">Applied Physics Laboratory</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="4">AHSD09</td></tr>
<tr><td>4</td><td>Program</td><td colspan="4">B.Tech</td></tr>
<tr><td>5</td><td>Semester</td><td colspan="4">I Semester</td></tr>
<tr><td>6</td><td>Regulation</td><td colspan="4">BT-23</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Practical Hours</td><td>Credits</td></tr>
<tr><td colspan="3">48</td><td>1</td></tr>
<tr><td>8</td><td>Course Offered</td><td colspan="2">Odd Semester ✓</td><td colspan="2">Even Semester ×</td></tr>
<tr><td>9</td><td>Course Coordinator</td><td colspan="4">Dr. Surya Sharma N V</td></tr>
<tr><td>10</td><td>Date Approved by BOS</td><td colspan="4">24/08/2023</td></tr>
<tr><td>11</td><td>Course Webpage</td><td colspan="4">www.iare.ac.in/B.Tech. Course Syllabus BT23 -CSE/—-</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">Course Prerequistes</td><td>Level UG/PG</td><td>Course Code</td><td>Course Tittle</td><td>Semester</td></tr>
<tr><td>Intermediate</td><td>-</td><td>-</td><td>-</td></tr>
</table>

13. Course Overview

The aim of the course is to provide hands on experience for experiments in different areas of physics. This laboratory includes experiments involving electromagnetism and optoelectronics. This also develops student's expertise in applying physical concepts to practical problem and apply it for different applications.

14. COURSE OBJECTIVES:

The students will try to learn:

I	Familiarize with the lab facilities, equipment, standard operating procedures..
II	About the different kinds of functional magnetic materials which paves away for them to use in various technical and engineering applications..
III	The analytical techniques and graphical analysis to study the experimental data for optoelectronic devices.
IV	The application characteristics of lasers and its propagation in optical fibre communication.

15. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the type of semiconductor using the principle of Hall effect and also determine the energy gap and resistivity of a semiconductor diode using four probe method.
CO 2	**Illustrate** principle, working and application of wave propagation and compare the results of frequency with theoretical harmonics and overtones.
CO 3	**Investigate** the energy losses, curie temperature and properties associated with a given Ferro magnetic material
CO 4	**Examine** launching of light through optical fiber from the concept of light gathering capacity of numerical aperture and determine the divergence of Laser beam
CO 5	**Graph** V-I /L-I characteristics of various optoelectronic devices like Light Emitting diode, Solar cell at different intensities to understand their basic principle of functioning as well as to infer the value of Planck's constant
CO 6	**Analyse** the variation of magnetic field induction produced at various points along the axis of current carrying coil.

16. Employability Skills

1. **Project based:** Project based skills: Would be able to familiarize themselves with basic experiments and calculations that would inculcate the concept of learning by doing.

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	✓	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications		Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
	5	5	5	5	20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT SYLLABUS:

CO 1	**Identify the type of semiconductor using the principle of Hall effect and also determine the energy gap and resistivity of a semiconductor diode using four probe method.**
	1. Errors and Measurement 2. Hall Effect (Loreentz Force) 3. Energy gap of a Semiconductor diode 4. Resistivity -Four probe Method

CO 2	**Illustrate principle, working and application of wave propagation and compare the results of frequency with theoretical harmonics and overtones.**
	1. Melde's Experiment
CO 3	**Investigate the energy losses, curie temperature and properties associated with a given Ferro magnetic material.**
	1. B-H Curve With CRO 2. Magnetic Materials
CO 4	**Examine launching of light through optical fiber from the concept of light gathering capacity of numerical aperture and determine the divergence of Laser beam**
	1. 1 Optical Fiber 2. 2 Laser Divergence
CO 5	**Graph V-I /L-I characteristics of various optoelectronic devices like Light Emitting diode, Solar cell at different intensities to understand their basic principle of functioning as well as to infer the value of Planck's constant.**
	1. Solar Cell 2. Light Emitting Diode 3. Planck's Constant 4. Biassing Diode
CO 6	**Analyse the variation of magnetic field induction produced at various points along the axis of current carrying coil**
	1. Stewart's and Gee's Appratus

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. C. L. Arora, "Practical Physics", S. Chand Co., New Delhi, 3rd Edition, 2012.
2. Vijay Kumar, Dr. T. Radha krishna, "Practical Physics for Engineering Students", S M Enterprises, 2nd Edition, 2014.
3. Dr. Rizwana, "Engineering Physics Manual", Spectrum Techno Press, 2018

REFERENCE BOOKS:

1. CF Coombs, "Basic Electronic Instrument Handbook", McGraw - HillBookCo.,1972.
2. CH Bernard and CD Epp, John Wiley and Sons, " Laboratory Experiments in College Physics"

20. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	To estimate the error and uncertainty in measurement	CO 1	T1 :10.2
2	Study the phenomenon of Hall effect and determine the charge carrier density and Hall coefficient of a given sample	CO 1	T1:13.5
3	Determination of energy gap of a given semiconductor diode by measuring the variation of current as a function of temperature	CO 1	T1:16.8
4	Determination of the resistivity by forcing current through two outer probes and reading the voltage across the two inner probes of semiconductor by four probe method.	CO 1	T2:5.15 R1:1.16
5	Determination of frequency of a given tuning fork in longitudinal wave propagation and transverse mode of wave propagation	CO 2	T1:15.5 R1:1.13.1
6	Evaluate the energy loss per unit volume of a given magnetic material per cycle by tracing the hysteresis loop (B-H curve)	CO 3	T1:15.7
7	Determine the curie temperature (Tc) and relative permeability of a ferromagnetic materials.	CO 4	T1:15.8
8	Evaluation of numerical aperture and acceptance angle of a given optical fiber.	CO 4	T1:17.9
9	Determination of the beam divergence of the given laser beam	CO 4	T1:17.5
10	Studying the characteristics of solar cell at different intensities and determination of maximum workable power.	CO 5	T1:17.5
11	Studying V-I characteristics of LED in forward bias for different LEDs and measure the threshold voltage and forward resistance	CO 5	T1:19.10
12	Determination of Planck's constant by measuring threshold voltage of given LED.	CO 5	T1:19.10
13	Study the forward bias of LED and reverse bias of Photodiode	CO 5	T1:19.10
14	Study the magnetic field along the axis of current carrying coil – Stewart and Gee's method	CO 6	T1:14.7

21. Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1	To study the bending losses and transmission losses of an optical Fiber
2	To determine the mobility and conductivity of given semiconductor using Hall Effect
3	To Determine the resistivity of given ferromagnetic material using Two Probe method.

22. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Program Outcomes	
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

23. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering Knowledge** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Laboratory experiments, internal and external lab examinations
PO 2	**Problem Analysis** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Laboratory experiments, internal and external lab examinations
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Laboratory experiments, internal and external lab examinations

24. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	1	Laboratory experiments and surveys

3 = High; 2 = Medium; 1 = Low

25. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	✓	-	-		-	-	-	-	-	-	-	-
CO 2	✓	✓		-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

26. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO1	Identify basic principle of Hall effect and make use of mathematical expression for Hall coefficient to deduce the type of semiconductor	3
	PO 2	Understand the given problem statement of variation of resistance with temperature in a semiconductor diode and formulate Resistivity from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 4	Make use of graphical analysis of current versus temperature curve for a given semiconductor, and interpret the data, to provide valid conclusions regarding the energy gap in a given semiconductor	2
CO 2	PO 1	Recall the theory of propagation of longitudinal and transverse waves and make use of number of loops formation in string to determine frequency of an electronically maintained tuning fork.	1
	PO 2	Understand the given problem statement of stationary wave propagation and formulate harmonics and overtones of fundamental frequency from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
CO 3	PO 1	Investigate the energy losses associated with a given ferromagnetic material and make use of graphical representation of hysteresis loop exhibited by magnetic material	2

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
	PO 2	Understand the given problem statement of effect of temperature on a given ferromagnetic material and formulate Curie temperature and relative permittivity from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PSO 3	Apply the CRO for visualizing and analysing the Hysteresis of Ferromagnetic materials.	1
CO 4	PO 1	Interpret launching of light through optical fibre and make use of mathematical expression for analysing light gathering capacity through numerical aperture	2
	PO 2	Understand the given problem statement on directionality of laser light in comparison with ordinary light and formulate the divergence of a given laser source from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	3
CO 5	PO 1	Understand the phenomenon of recombination of electron-hole pair and determine the value of threshold voltage of a given LED	1
	PO 2	Understand the given problem statement of conversion light energy to electrical energy and formulate V-I characteristics of solar cell from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	2
	PO 4	Analyse and interpret the data obtained by using different LED's and synthesise the information to infer the value of Planck's constant	2
CO 6	PO 1	Explain the variation of magnetic field at various points along the axis of current carrying coil and make use of mathematical expression of Tangent's law using Stewart Gee's apparatus.	2
	PO 2	Understand the given problem statement of current loop and formulate magnetic field induction at various points along the axis of current loop from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4

27. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-		-	1
CO 4	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	1	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-

28. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66	40	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 2	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66	40	-	-	-	-	-	-	-	-	-	-	-	-	35
CO 4	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66	40	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 6	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-

29. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	11	6	-	2	-	-	-	-	-	-	-	-	-	-	1
AVERAGE	1.8	1	-	1	-	-	-	-	-	-	-	-	-	-	1

30. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	✓

31. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

32. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		-
2		-
3		-
4		**Quality Education:In order to ensure inclusive and equitable quality education and promote life long learning oppurtunities for all, foundation is very much important. Physics laboratory comes under basic science course falicitating students to gain and ascertain basic knowledge which will help them to envisage to their higher education**

5	GENDER EQUALITY	-
6	CLEAN WATER AND SANITATION	-
7	AFFORDABLE AND CLEAN ENERGY	-
8	DECENT WORK AND ECONOMIC GROWTH	-
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	-.
10	REDUCED INEQUALITIES	-
11	SUSTAINABLE CITIES AND COMMUNITIES	-
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	-
13	CLIMATE ACTION	-
14	LIFE BELOW WATER	-

15		-
16		-
17		-

Approved by: Board of Studies in the meeting conducted on24/08/2023

Signature of Course Coordinator **HOD**
Dr. N V Surya Sharma, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**			
2	Course Title	**OBJECT ORIENTED PROGRAMMING WITH JAVA**			
3	Course Code	ACSD02			
4	Program	B.Tech			
5	Semester	I Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Dr. M V Krishna Rao			
10	Date Approved by BOS	25/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-
		-	-	-	-

13. COURSE OVERVIEW

This course provides a solid foundation in object-oriented programming concepts and hands-on experience in using them. It introduces the concepts of abstraction and reusable code design via the object-oriented paradigm. Through a series of examples and exercises students gain coding skills and develop an understanding of professional programming practices. Mastering Java facilitate the learning of other technologies.

14. COURSE OBJECTIVES

The students will try to learn:

I	The strong foundation with the Java Virtual Machine, its concepts and features.
II	The systematic understanding of key aspects of the Java Class Library
III	The usage of a modern IDE with an object oriented programming language to develop programs.

15. COURSE OUTCOMES

After successful completion of the course, students should be able to:

CO 1	Develop non-trivial programs in an modern programming language.
CO 2	Apply the principles of selection and iteration.
CO 3	Appreciate uses of modular programming concepts for handling complex problems.
CO 4	Recognise and apply principle features of object-oriented design such as abstraction and encapsulation.
CO 5	Design classes with a view of flexibility and reusability.
CO 6	Code, test and evaluate small usecases to conform to a specification.

16. EMPLOYABILITY SKILLS

1. **Problem-Solving and Critical Thinking:** Students learn to analyze complex problems, design solutions using Java's object-oriented principles, and translate real-world scenarios into code.
2. **Debugging and Troubleshooting:** Debugging challenges in the lab help students master error identification, interpretation, and use of debugging tools, essential for real-world software development.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Develop non-trivial programs in an modern programming language.**
	1. Getting Started Exercises 2. Exercises on Number Systems (for Science/Engineering Students)
CO 2	**Apply the principles of selection and iteration.**
	1. Exercises on Decision and Loop 2. Exercises on Input, Decision and Loop 3. Exercises on Nested-Loops (Patterns) 4. Magic(Special) Numbers 5. Exercises on String and char Operations 6. Exercises on Arrays
CO 3	**Appreciate uses of modular programming concepts for handling complex problems.**
	1. Exercises on Methods 2. Exercises on Command-line Arguments and Recursion 3. More (Difficult) Exercises
CO 4	**Recognise and apply principle features of object-oriented design such as abstraction and encapsulation.**
	1. Exercises on Classes and Objects
CO 5	**Design classes with a view of flexibility and reusability.**
	1. Exercises on Inheritance
CO 6	**Code, test and evaluate small usecases to conform to a specification.**
	1. Exercises on Polymorphism, Abstract Classes and Interfaces

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Farrell, Joyce."*Java Programming*", Cengage Learning B S Publishers, 8th Edition, 2020
2. Schildt, Herbert. "*Java: The Complete Reference*" 11th Edition, McGraw-Hill Education, 2018.

Reference Books

1. Deitel, Paul and Deitel, Harvey. "*Java: How to Program*", Pearson, 11th Edition,2018.
2. Evans, Benjamin J. and Flanagan, David. "*Java in a Nutshell*", O'Reilly Media, 7th Edition, 2018.
3. Bloch, Joshua. "*Effective Java*", Addison-Wesley Professional, 3rd Edition, 2017.
4. Sierra, Kathy and Bates, Bert. "*Head First Java*", O'Reilly Media, 2nd Edition, 2005.

Materials Online

1. https://docs.oracle.com/en/java/
2. https://www.geeksforgeeks.org/java
3. https://www.tutorialspoint.com/java/index.htm
4. https://www.coursera.org/courses?query=java

20. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Exercises on Number Systems (for Science/Engineering Students)	CO 1
3	Exercises on Decision and Loop	CO 2
4	Exercises on Input, Decision and Loop	CO 2
5	Exercises on Nested-Loops (Patterns)	CO 2
6	Magic(Special) Numbers	CO 2
7	Exercises on String and char Operations	CO 2
8	Exercises on Arrays	CO 2
9	Exercises on Methods	CO 3
10	Exercises on Command-line Arguments, Recursion	CO 3
11	More (Difficult) Exercises	CO 3
12	Exercises on Classes	CO 4
13	Exercises on Inheritance	CO 5
14	Exercises on Polymorphism, Abstract Classes and Interfaces	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Given an array of integers nums and an integer target, return indices of the two numbers such that they add up to target.
2.	Given a sorted array of distinct integers and a target value, return the index if the target is found. If not, return the index where it would be if it were inserted in order.
3.	Given a roman numeral, convert it to an integer.

4.	Implement the myAtoi(string s) function, which converts a string to a 32-bit signed integer
5.	Given a string s, find the length of the longest substring without repeating characters.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1	LAB PROGRAMS/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	LAB PROGRAMS/CIE/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	LAB PROGRAMS/CIE/SEE
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	LAB PROGRAMS/CIE/SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	LAB PROGRAMS/CIE/SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	LAB PROGRAMS/CIE/SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	2	LAB PROGRAMS/CIE/SEE
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	2	LAB PROGRAMS/CIE/SEE
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	2	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	-	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	-	✓	-	-	-	✓	-	-	-	-	-	-	✓	✓	-
CO 6	-	✓	-	-	-	✓	-	✓	-	-	-	-	✓	✓	-

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PSO 1	Understand, design and analyze computer programs in the areas related to Data exploration, Visualization, Analytics, Big data, Artificial Intelligence, Machine Learning.	4
CO 4	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	6
	PSO 1	Understand, design and analyze computer programs in the areas related to Data exploration, Visualization, Analytics, Big data, Artificial Intelligence, Machine Learning.	3
CO 5	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PO 6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	Understand, design and analyze computer programs in the areas related to Data exploration, Visualization, Analytics, Big data, Artificial Intelligence, Machine Learning.	3
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
CO 6	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PO 6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	4
	PSO 1	Understand, design and analyze computer programs in the areas related to Data exploration, Visualization, Analytics, Big data, Artificial Intelligence, Machine Learning.	3
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	1
CO 2	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	1	7	-	-	-	-	-	-	-	-	-	-	4	-	-
CO 4	-	7	6	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	-	7	-	-	-	1	-	-	-	-	-	-	3	1	-
CO 6	-	7	-	-	-	3	-	2	-	-	-	-	3	1	-

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	-	-	100	-	-	-	-	-	-	-	-	-	50
CO 2	33.3	70	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	33.3	70	-	-	-	-	-	-	-	-	-	-	66.6	-	-
CO 4	-	70	60	-	-	-	-	-	-	-	-	-	50	-	-
CO 5	-	70	-	-	-	20	-	-	-	-	-	-	50	50	-
CO 6	-	70	-	-	-	60	-	66.6	-	-	-	-	50	50	-

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	-	-	3	-	-	-	-	-	-	-	-	-	2
CO 2	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	1	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	-	3	3	-	-	-	-	-	-	-	-	-	2	-	-
CO 5	-	3	-	-	-	1	-	-	-	-	-	-	2	2	-
CO 6	-	3	-	-	-	3	-	3	-	-	-	-	2	2	-
TOTAL	3	15	3	-	3	4	-	3	-	-	-	-	9	4	2
AVERAGE	1	3	3	-	3	2	-	3	-	-	-	-	2	2	2

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

X	NO POVERTY	
X	ZERO HUNGER	
X	GOOD HEALTH AND WELL-BEING	
✓	QUALITY EDUCATION	**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	
X	AFFORDABLE AND CLEAN ENERGY	
X	DECENT WORK AND ECONOMIC GROWTH	

✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Java programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
X	REDUCED INEQUALITIES	
✓	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:** Java programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
X	RESPONSIBLE CONSUMPTION AND PRODUCTION	
✓	CLIMATE ACTION	**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using Java programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
X	LIFE BELOW WATER	
X	LIFE ON LAND	
X	PEACE, JUSTICE AND STRONG INSTITUTIONS	

✓	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,CSE**
Dr. M V Krishna Rao, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (Data Science)**			
2	Course Code	AHSD05			
3	Course Title	**ENGINEERING CHEMISTRY LABORATORY**			
4	Semester	I			
5	Regulations	BT-23			
6	Structure of the course	Practical			
		Lecture Hours			Practical Hours
		-			36
7	Course Offered	Odd Semester ✓		Even Semester ×	
8	Course Coordinator	Dr. B Divya			
9	Date Approved by BOS	24/08/2023			
10	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD05.pdf			
11	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-

12. Course Overview

The course promotes the use of analytical tools from an engineering standpoint. It provides the overview of analytical techniques, and outline the importance of volumetric analysis, comprehensive instrumental analysis for properties of polymers, colorimetric analysis, and spectroscopic analysis. This practical approach gives the awareness to chemical methods and perform testing of materials in various industries.

13. Course Objectives:

The students will try to learn:

I	The quantitative analysis to know the strength of unknown solutions by instrumental methods.
II	The troubles of hard water and its estimation by analytical techniques
III	The applications of appropriate lubricant for finely tuned machinery
IV	The basic knowledge on synthesis of nanomaterials and its properties

14. Course Outcomes:

After successful completion of the course, students should be able to:

CO1	**U**se conductivity meter and potentiometer for measurement of conductance and electromotive force of solutions
CO2	**U**se PH meter for measurement of Strength of Acidic Solutions.
CO3	**M**ake use of the principles of water analysis for domestic and industrial applications.
CO4	**P**redict the Properties of polymeric materials by synthesizing the monomers
CO5	**U**se different types of lubricants to know its properties for the proper lubrication of machinery in industries.
CO6	**I**nterpret the absorption tendency of solids or liquids by using Colorimetry and spectroscopy techniques.

15. Employability Skills

1. **Project based skills:** Awareness on instrumental methods of analysis and real-time applications through properties of materials.

16. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks for internal assessment, continuous lab assessment will be done for 20 marks for the day today's performance including viva voce, 10 marks for the final internal lab assessment, and the remaining 10 marks for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) AppDevelopment (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report/Project and Presentation.

Table 1.0: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 2.0: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Table 3.0: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course Content:

CO 1	**Use conductivity meter and potentiometer for measurement of conductance and electromotive force of solutions**
	1. Determine the Neutralization Point between Strong Acid against Strong Base 2. Estimate the Amount of Iron by Potentiometry 3. Determine the pH of the unknown solution by pH metry
CO 2	**Use PH meter for measurement of strength of acidic solutions.**
	1. Determine the pH of the unknown solution by pH metry
CO 3	**Make use of the principles of water analysis to control the hardness of water used in domestic and industrial purposes**
	1. Determination of chloride content of water by argentometry 2. Measurement of Total Dissolved Solids (TDS) in different water samples 3. Estimate the Total Hardness of water using EDTA
CO 4	**Predict the properties of polymeric materials by synthesizing the monomers.**
	1. Synthesize Thiokol rubber using sodium polysulphide with 1, 2-Dichloroethane.
CO 5	**Use the appropriate lubricant oil for the industrial machinery based on their properties.**
	1. Determine the Viscosity of the Lubricants using Red Wood Viscometer / Ostwald's Viscometer 2. Determine the Flash and Fire Points of Lubricants 3. Determine Cloud and Pour Points of Lubricants
CO 6	**Interpret the absorption tendency of solids or liquids using colorimetry and spectroscopic techniques.**
	1. Estimate the Metal Ion Concentration using Colorimeter 2. Characterization of Nanomaterials by UV-Visible Spectrophotometer

Note: One Course Outcome may be mapped to multiple number of experiments.

19. Course Plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping ; Introduction to chemistry laboratory Safety guidelines to chemistry laboratory	CO 1	T2:10.31
2	Determine the neutralization point by titration of strong acid against strong base by conductometrically.	CO 1	T1:10.12 T2:10.31 R1:1.12.3
3	Studying the electrode potential measurements and estimate the amount of Fe^{2+} by using potentiometer.	CO 1	T2:10.31 R1:1.15
4	Determination of the pH of a given solution by pH metry	CO 1	T1:10.12 R1:1.16
5	Determination of chloride content of water by argentometry.	CO 2	T1:16.8 R1:1.13.1
6	Studying the water hardness and determine the Total Dissolved Solids (TDS) in each test liquid.	CO 3	T5:17.5 R1:1.13.2
7	Studying the specifications of water and estimate the total hardness of water by complexometric method	CO 3	T5:17.5 R1:1.13.3
8	Synthesize Thiokol rubber using sodium polysulphide with 1, 2-Dichloroethane.	CO 4	T3:2.6 R1:1.7.1
9	Studying the viscosity of lubricants and determine the viscosity of lubricants at various temperature using Red wood viscometer	CO 5	T1:19.10 R1:1.17.3
10	Determination of flash and fire points of lubricants by using Pensky Martens apparatus	CO 5	T1:19.10 R1:2.6.1
11	Determination of cloud and pour points of lubricants.	CO 5	T1:19.10 R1:2.6.2
12	Estimation of metals ion concentration by colorimetry	CO 6	T2:16.9 R1:2.10
13	Characterization of nanomaterials by using UV-visible spectrophotometer	CO 6	T2:16.9

20 Experiments for Enhanced Learning (EEL):

S.No	Design Oriented Experiments
1	To study the Beer Lambert's Law and utilize for the determination metal concentration in effluents by colorimetry
2	To study the absorption edges of metal complex using spectrophotometry
3	To study the iron content by potentiometry using different oxidizing agents

21. Program Outcomes & Program Specific Outcomes:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Program Outcomes	
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

22. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Laboratory experiments, internal and external lab examinations.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Laboratory experiments, internal and external lab examinations.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development..	2	Laboratory experiments, internal and external lab examinations.

23. How program specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation	-	
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	-	

3 = High; 2 = Medium; 1 = Low

24. Mapping of each CO with PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

25. Justifications for CO – PO / PSO mapping - direct:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain basic principle of conductance and EMF to make use of titrimetry to obtain graphical plots to determine the strength of acid by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Use basic principles of conductance and EMF to find the neutralization point that helps in interpretation of results..	2
CO 2	PO 1	Interpret the basic principles of pH metry to find the pH of unknown solutions and obtain graphical plots to determine the strength of acid by using principles of science and mathematical expressions or solving engineering problems.	3
	PO 2	Make use of pH metry and find the neutralization point that helps in interpretation of results.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 3	PO 1	Make use of coloured indicators to complex the metal ions, Investigate the concentration of hardness causing salts using Complexometry and argentometry methods by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Identify the problems of hard water and examine the total dissolved salts that provides information and data for its usage in industry.	2
	PO 7	Recognize the problems in industries by using hard water and its impact in socio economic and environmental contexts for sustainable development.	2
CO 4	PO 1	IExplain the polymerization process to synthesize the polymers from monomers by using principles of science and for solving engineering problems	2
CO 5	PO 1	Describe the physical properties of a lubricant and its determination using instrumental methods by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Extend the properties of lubricants with experimental collection of information and data in reaching conclusions by the interpretation of results.	2
CO 6	PO 1	Explain the principle of molecular transitions and make use of mathematical expression of Beer Lambert's Law colorimetry and UV-VIS spectroscopy by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Utilize graphical analysis of concentration versus absorbance for a given solution, and interpret the data, to provide valid conclusions regarding the quantitative analysis.	2

26. Total count of key competencies for CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

27. Percentage of key competencies for CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-

28. Course articulation matrix (PO – PSO mapping):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	17	10	-	-	-		-	-	-	-	-	-	-	-	-
AVERAGE	2.8	2	-	-	-	-	2	-	-	-	-	-	-	-	-

29. Assessment methodology direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology indirect:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:** Enhancement in the additional skills for the students with analytical tools.

5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	**Clean Water and Sanitation:** Ensures the availability to clean water through hard water analysis and its removal with chemical methodology
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14		**Life Below Water:** Knowledge gained on the colorimetry provides awareness to students on the effect of metals from industrial effluents on living organisms in water bodies
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,CSE(DS)**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**			
2	Course Title	**ENGINEERING GRAPHICS**			
3	Course Code	AMED03			
4	Program	B.Tech			
5	Semester	I Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Lecture Hours		Practical Hours	
		15		30	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Faculty	Dr. S Devaraj			
10	Date Approved by BOS	30/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**

13. Course Overview

Introduction to graphical representation using free hand drawing and computer-aided drafting. Engineering graphics covers basic engineering drawing techniques such as lines & lettering, geometrical constructions, principles of tangency, orthographic projections, sectional views, and dimensioning. This course assists to draw 2D drawings for industrial applications.

14. COURSE OBJECTIVES:

The students will try to learn:

I	The basic engineering drawing formats.
II	Projections of points, lines, planes and solids at inclinations of horizontal plane and vertical plane.
III	Use of computer-aided design (CAD) to communicate concepts and ideas in the design of three-dimensional engineering products.

15. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** an ability to dimension and annotate two-dimensional engineering graphics..	Understand
CO 2	**Demonstrate**the freehand sketching to aid in the visualization process and to efficiently communicate ideas graphically.	Understand
CO 3	**Make use of** CAD software for the creation of 3D models and 2D engineering graphics.	Apply
CO 4	**Comprehend** the principles and techniques for creating sectional views of three-dimensional solids in engineering graphics.	Understand
CO 5	**Explain** the application of industry standards and best practices applied in engineering graphics.	Understand
CO 6	**Apply** the general projection theory with emphasis on orthographic projection to represent three-dimensional objects in two-dimensional views.	Apply

16. Employability Skills

1. **Employment advantage:** This can give competitive advantage when seeking employment as Design Engineer.
2. **Problem-Solving and Analytical Thinking:** Engineering Drawing involves CFD analysis and structural analysis of structures before inspection of prototype. This cultivates the ability to think critically and find innovative solutions, which is a fundamental skill sought by employers before finalization of product design in industries.
3. **Safety Awareness:** The analysis, decides the safety factor for the machine member when subjected to static and dynamic forces which enhances safety consciousness. Graduates should consider this awareness in every engineering industry where safety is a priority.

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
	5	5	5	5	20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT SYLLABUS:

CO 1	**Demonstrate an ability to dimension and annotate two-dimensional engineering graphics.**
	1. Introduction to CAD 2. Introduction to Engineering Drawing 3. Exercises on Dimensioning 4. Exercises on Geometrical Constructions
CO 2	**Demonstrate the freehand sketching to aid in the visualization process and to efficiently communicate ideas graphically.**
	1. Exercises on Conic Sections
CO 3	**Make use of CAD software for the creation of 3D models and 2D engineering graphics.**
	1. Exercises on Technical Sketching and Shape Description
CO 4	**Comprehend the principles and techniques for creating sectional views of three-dimensional solids in engineering graphics.**
	1. Exercises on Sectional views
CO 5	**Explain the application of industry standards and best practices applied in engineering graphics.**
	1. Exercise on Development of surfaces-1 (Prisms) 2. Exercise on Development of surfaces-2 (Cylinder, Cone and Pyramid)
CO 6	**Apply the general projection theory with emphasis on orthographic projection to represent three-dimensional objects in two-dimensional views.**
	1. Exercise on orthographic views 2. Exercise on Isometric projection of planes 3. Exercise on isometric projections of solids 4. Demonstration of SOLID WORKS Software 5. Demonstration of CREO Software

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Frederick E Giesecke, Alva Mitchell, Henry C Spencer, Ivan L Hill, John T Dygdon, James E. Novak, R. O. Loving, Shawna Lockhart, Cindy Johnson" *Technical Drawing with Engineering Graphics*", Pearson Education, 16th Edition, 2016.

2. Donald Hearn "*Computer Graphics*", Pearson Education, 12th Edition, 2021.

REFERENCE BOOKS:

1. Basant Agrawal and C M Agrawal "*Engineering Drwing*", 3 rd Edition, Mc GraHill, 2018.
2. James M. Leake, Molly Hathaway Goldstein, Jacob L. Borgerson, "*Engineering Design Graphics, Modelling and Visualization* ", Wiley Publications, 3 rd Edition, 2020.

MATERIALS ONLINE:

1. Lecture notes, ELRV videos and power point presentations
2. Answers / solutions to all questions / problems in the textbook
3. Online exercises
4. Problems and solutions in files

20. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Introduction to AUTOCAD	CO 1	
2	Introduction to Engineering Drawing	CO 1	T1:5.6 R1:1.12.3
3	Exercises on Dimensioning	CO 1	T2:5.10 R1:1.15
4	Exercises on Geometrical Constructions	CO 1	T2:5.15 R1:1.16
5	Exercises on Conic Sections	CO 2	T2:5.17 R1:1.13.1
6	Exercises on Technical Sketching and Shape Description	CO 3	T2:5.18 R1:1.13.2
7	Exercises on Sectional views	CO 4	T2:5.19 R1:1.13.3
8	Exercise on Development of surfaces-1(Prisms)	CO 5	T2:5.20 R1:1.7.1
9	Exercise on Development of surfaces-2 (Cylinder, Cone, Pyramid)	CO 5	T2:5.24 R1:1.17.3
10	Exercise on orthographic views	CO 6	T2:6.3 R1:2.6.1
11	Exercise on Isometric projection of Planes	CO 6	T2:6.5 R1:2.6.2
12	Exercise on Isometric projection of Solids	CO 6	T2:7.7 R1:2.10

S.No	Topics to be covered	CO's	Reference
13	Demonstration of SOLID WORKS Software	CO 6	T2:7.11
14	Demonstration of CREO Software	CO 6	T2:7.11

21. EXPERIMENS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Develop the procedure to draw knuckle joint by using AUTO CAD.
2	Develop the standard procedure to draw 2D drawing of any machine component by using AUTO CAD.

22. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Program Outcomes	
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

23. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	Seminar / Conferences / Research papers
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Seminar / Conferences / Research papers
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	Seminar / Conferences / Research papers

24. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	-	-

3 = High; 2 = Medium; 1 = Low

25. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-	-
CO 2	-	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-	-
CO 3	-	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-	-
CO 4	-	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-	-
CO 5	-	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-	-
CO 6	-	-	-	-	-	-	✓	✓	✓	✓	-	✓	-	-	-

26. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 7	Understand the impact of the engineering graphics in societal and environmental contexts for sustainable development.	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering graphics..	1
	PO 9	Function effectively as an individual, and as a member or leader in a design team.	5
	PO 10	Communicate effectively on complex engineering drawing to write effective reports and design documentation.	2
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of designing.	2
CO 2	PO 7	Understand the impact of the engineering graphics in societal and environmental contexts for sustainable development.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering graphics..	1
	PO 9	Function effectively as an individual, and as a member or leader in a design team.	5
	PO 10	Communicate effectively on complex engineering drawing to write effective reports and design documentation.	2
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of designing.	2
CO 3	PO 7	Understand the impact of the engineering graphics in societal and environmental contexts for sustainable development.	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering graphics..	1
	PO 9	Function effectively as an individual, and as a member or leader in a design team.	5
	PO 10	Communicate effectively on complex engineering drawing to write effective reports and design documentation.	2
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of designing.	2
CO 4	PO 7	Understand the impact of the engineering graphics in societal and environmental contexts for sustainable development.	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering graphics..	1
	PO 9	Function effectively as an individual, and as a member or leader in a design team.	5
	PO 10	Communicate effectively on complex engineering drawing to write effective reports and design documentation.	2
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of designing.	2
CO 5	PO 7	Understand the impact of the engineering graphics in societal and environmental contexts for sustainable development.	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering graphics..	1
	PO 9	Function effectively as an individual, and as a member or leader in a design team.	5
	PO 10	Communicate effectively on complex engineering drawing to write effective reports and design documentation.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of designing.	2
CO 6	PO 7	Understand the impact of the engineering graphics in societal and environmental contexts for sustainable development.	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering graphics..	1
	PO 9	Function effectively as an individual, and as a member or leader in a design team.	5
	PO 10	Communicate effectively on complex engineering drawing to write effective reports and design documentation.	2
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of designing.	2

27. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	1	1	5	2	-	2		-	-
CO 2	-	-	-	-	-	-	1	1	5	2	-	2		-	-
CO 3	-	-	-	-	-	-	1	1	5	2	-	2		-	-
CO 4	-	-	-	-	-	-	1	1	5	2	-	2		-	-
CO 5	-	-	-	-	-	-	1	1	5	2	-	2		-	-
CO 6	-	-	-	-	-	-	1	1	5	2	-	2		-	-

28. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	33.3	33.3	42	40	-	25		-	-
CO 2	-	-	-	-	-	-	33.3	33.3	42	40	-	25		-	-
CO 3	-	-	-	-	-	-	33.3	33.3	42	40	-	25		-	-
CO 4	-	-	-	-	-	-	33.3	33.3	42	40	-	25		-	-
CO 5	-	-	-	-	-	-	33.3	33.3	42	40	-	25		-	-
CO 6	-	-	-	-	-	-	33.3	33.3	42	40	-	25		-	-

29. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
2 - 40 % $< C <$ 60% –Moderate
1-5 $< C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-
CO 2	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-
CO 3	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-
CO 4	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-
CO 5	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-
CO 6	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-
TOTAL	-	-	-	-	-	-	6	12	6	6	-	6	-	-	-
AVERAGE	-	-	-	-	-	-	1	2	1	1	-	1	-	-	-

30. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

31. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

32. Relevance to Sustainability goals

1		
2		
3		

4	QUALITY EDUCATION	**Quality Education:** An engineering drawing course provides students with a strong foundation in design-analysis skills, enhancing their overall educational experience and empowering them to address real-world challenges.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	**Clean Water and Sanitation:** Proper infrastructure design, can contribute to the effective delivery of clean water and sanitation services, benefiting communities' health and well-being.
7	AFFORDABLE AND CLEAN ENERGY	**Affordable and Clean Energy:** Engineering drawing plays a role in the design and analysis of equipments, contributing the sustainable energy solutions. Students learn to optimize energy use, design renewable energy systems, and enhance energy efficiency in various applications.
8	DECENT WORK AND ECONOMIC GROWTH	**Decent Work and Economic Growth:** Engineering drawing equips students with skills that contribute the job creation and economic growth while also promoting ethical and responsible engineering practices.
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Engineering drawing principles is crucial for developing and maintaining sustainable infrastructure and technological innovations. It contribute to designing safer, more durable, and environmentally friendly infrastructure projects.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:**Engineering drawing underpins the construction and maintenance of urban infrastructure, which can withstand environmental challenges and contribute to the safety and sustainability of urban spaces.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on30/08/2023

Signature of Course Faculty **HOD,CSE (DS)**
Dr. S Devaraj, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**	
2	Course Title	**MOBILE APPLICATIONS DEVELOPMENT**	
3	Course Code	ACSD04	
4	Program	B.Tech	
5	Semester	I Semester	
6	Regulation	BT-23	
7	Structure of the course	Practical	
		Lecture Hours	Practical Hours
		0	3
8	Course Offered	Odd Semester ✓	Even Semester ×
9	Course Coordinator	Ms.J Sirisha	
10	Date Approved by BOS	29/08/2023	
11	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse	
12	Course Pre-requistes	Object Oriented Programming	

13. Course Overview

This course focuses on hands-on experience in designing, developing, and testing mobile applications for various platforms helps to gain practical skills in mobile app development, including user interface design, programming, and deployment. The applications of this course can be pre-installed on phones and mobile app development have been required to create various applications.

14. COURSE OBJECTIVES:

The students will try to learn:

I	The mobile application development for different platforms using appropriate tools and frameworks.
II	The user interface design with best practices for usability and user experience.
III	The process of debugging and troubleshooting for common issues in mobile app development.

15. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** layout management and multi layout techniques to create adaptable user interface	Apply
CO 2	**Develop** user interface for mobile application using widgets with event handling.	Develop
CO 3	**Design** push notifications for incoming messages.	Design
CO 4	**Create** mobile application models using appropriate range of methods provided.	Create
CO 5	**Evaluate** applications on mobile platforms with different configurations.	Evaluate
CO 6	**Deploy** applications to the android marketplace for distribution to app store.	Apply

16. Employability Skills

1. **Employment advantage:** This can give competitive advantage when seeking employment as Application Development.
2. **Problem-Solving and Analytical Thinking:** Students are expected to design and develop a high-quality mobile application that addresses a real-world problem in an innovative way. Coursework will include project conception, design, implementation, and pilot testing of mobile phone software applications.

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. SYLLABUS:

CO 1	**Apply layout management and multi layout definition techniques to create adaptable user interface**
	1. Food ordering application 2. Music player application 3. Smart Health Prediction
CO 2	**Develop user interface for mobile Application using widgets with event handling.**
	1. Hostel Management Application 2. Stay safe women security application 3. Controlling Anti Ragging Application
CO 3	**Design push notifications for incoming messages.**
	1. Extracurricular Event Tracking Application 2. Student management system 3. Pharm easy application
CO 4	**Create Mobile application models using appropriate range of methods provided.**
	1. News Application 2. Air Transit Trip Planner App 3. Student-Faculty Document Sharing System
CO 5	**Evaluate applications on mobile platforms with different configurations.**
	1. Online Recruitment System 2. Student Counseling Management System 3. Data Mart Management System
CO 6	**Deploy applications to the android marketplace for distribution to app store.**
	1. Restaurant Reservation And Table Management System 2. Secure Stock Exchange System 3. Country Cargo And Express Couriers System

TEXTBOOKS

1. 1. Reto Meier, Professional Android 4 Application Development, Wile Publication, 1 st Edition, 2012.

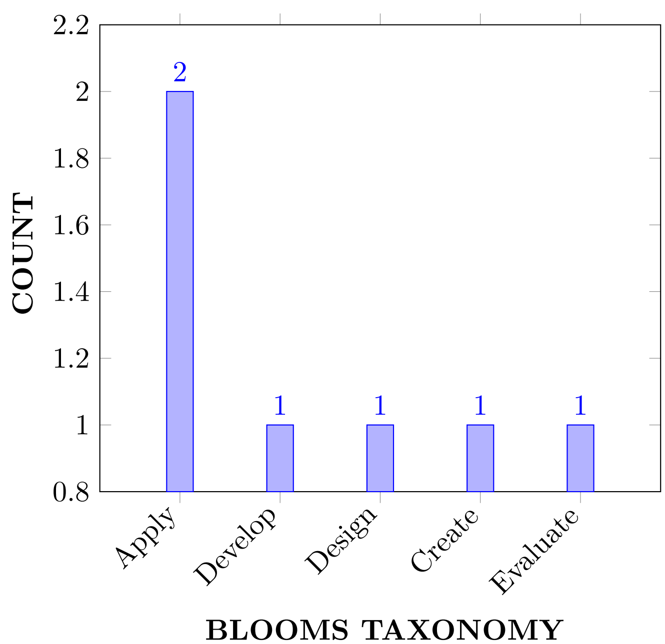
REFERENCE BOOKS:

1. 1. Bill Phillips and Chris Stewart, Kristin Marsicano "*Android Programming*", The Big Nerd Ranch Guide, O'Reilly, 3rd Edition, 2017.
2. 2.Dawn Griffiths, David Griffiths, "*Head First Android Development: A Learner's Guide to Building Android Apps with Kotlin, Third Edition,* ", O'Reilly, 3rd Edition, 2021.
3. 3.Antonio Leiva, "*Kotlin for Android Developers: Learn Kotlin while developing an Android App,*", CreateSpace Independent Publishing, 1st Edition, 2016.

MATERIALS ONLINE:

1. Course Template
2. Lab Manual

20. COURSE KNOWLEDGE COMPETENCY LEVEL



21. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Outcomes	
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation..
PSO 2	Focus on improving software reliability, network security or information retrieval systems
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Experiments /CIE / SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Experiments / CIE / SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal, and Environmental considerations.	3	Lab Experiments / CIE / SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	Lab Experiments / CIE / SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Experiments / CIE / SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Experiments / CIE / SEE

PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1	Lab Experiments / CIE / SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Experiments / CIE / SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation	1	Lab Programs/ CIE /SEE
PSO 2	Focus on improving software reliability, network security or information retrieval systems	1	Lab Programs/ CIE /SEE
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	2	Lab Programs/ CIE /SEE

3 = High; 2 = Medium; 1 = Low

24. MAPPING OF EACH CO WITH PO(s),PSO(s):

	PROGRAM OUTCOMES												PSO'S		
COURSE OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓
CO 4	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓
CO 5	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓
CO 6	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2
	PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	1
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2
	PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	1
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2
	PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	1
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 4	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2
	PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	1
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2
	PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	1
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	3
CO 6	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
	PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2
	PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	1
	PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	3	-	1	-	-	-	2	4	2	1	1	1	2
CO 2	3	2	3	-	1	-	-	-	2	4	2	1	1	1	2
CO 3	3	2	3	-	1	-	-	-	2	4	2	1	1	1	2
CO 4	3	2	3	-	1	-	-	-	2	4	2	1	1	1	2
CO 5	3	2	3	-	1	-	-	-	2	4	2	1	1	1	2
CO 6	3	2	3	-	1	-	-	-	2	4	2	1	1	1	2

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	30	-	100	-	-	-	16.4	40	8.33	25	25	50	50
CO 2	100	20	30	-	100	-	-	-	16.4	40	8.33	25	25	50	50
CO 3	100	20	30	-	100	-	-	-	16.4	40	8.33	25	25	50	50
CO 4	100	20	30	-	100	-	-	-	16.4	40	8.33	25	25	50	50
CO 5	100	20	30	-	100	-	-	-	16.4	40	8.33	25	25	50	50
CO 6	100	20	30	-	100	-	-	-	16.4	40	8.33	25	25	50	50

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1-5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2
CO 2	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2
CO 3	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2
CO 4	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2
CO 5	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2
TOTAL	18	6	6	-	18	-	-	-	6	6	6	6	6	12	12
AVERAGE	3	1	1	-	3	-	-	-	1	1	1	1	1	2	2

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

✓	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
2	Getting Started An Excercises: **Helloworld**	CO 1,CO2	T2:5.6 R1:1.12.3
3	Food Ordering Application	CO 1,CO2,CO3	T2:5.10 R1:1.15
4	Music Player Application:	CO 2,CO3,CO4	T2:5.15 R1:1.16
5	Smart Health Prediction:	CO 2,CO3,CO4	T2:5.17 R1:1.13.1
6	Hostel Management Application:	CO 3,CO4,CO5	T2:5.18 R1:1.13.2
7	Stay Safe Women Security Application:	CO 4,CO5,CO6	T2:5.19 R1:1.13.3
8	Controlling Anti Ragging Application:	CO 3,CO4,CO5	T2:5.20 R1:1.7.1
9	Extracurricular Event Tracking Application	CO 3,CO4,CO6	T2:5.24 R1:1.17.3

S.No	Topics to be covered	CO's	Reference
10	Student Management System	CO 2,CO4,CO5	T2:6.3 R1:2.6.1
11	Pharm Easy Application	CO 2,CO4,CO5	T2:6.5 R1:2.6.2
12	News Application	CO 4,CO5,CO6	T2:7.7 R1:2.10
13	Air Transit Trip Planner App	CO 3,CO4,CO5	T2:7.11
14	Student-Faculty Document Sharing System	CO 2,CO4,CO5	T2:7.11
15	Online Recruitment System	CO 2,CO3,CO4	T2:15.2 R1:8.2
16	Student Counseling Management System	CO 2,CO4,CO5	T2:15.7 R1:8.3.3
17	Data Mart Management System	CO 3,C05,C06	T2:2.1 R1:7.9.2
18	Restaurant Reservation And Table Management System	CO 3,CO5,CO6	T2:2.2 R1:7.9.1
19	Secure Stock Exchange System	CO 4,C05,C06	T2:2.4 R1:7.11
20	Country Cargo And Express Couriers System	CO 3,CO5,C06	T2:16.8 R1:8.12.1

32. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		

4	QUALITY EDUCATION	**Quality Education:** An Mobile Applications Decelopment course provides students with a strong foundation in design-analysis skills, enhancing their overall educational experience and empowering them to address real-world challenges.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Mobile applications development principles is crucial for developing and maintaining sustainable infrastructure and technological innovations. It contribute to designing safer, more durable, and environmentally friendly infrastructure projects.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	

12		
13		
14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,CSE(DS)**
Ms J Sirisha, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**COMPUTER SCIENCE ENGINEERING (DATA SCIENCE)**				
2	Course Title	**PROFESSIONAL COMMUNICATION**				
3	Course Code	AHSD01				
4	Program	B.Tech				
5	Semester	II Semester				
6	Regulation	BT23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
8	Type of course (**Tick type of course**)		Professional Elective	Open Elective	VAC	MOOCs
			-	-	-	-
9	Course Offered	Odd Semester ×		Even Semester ✓		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 64		Tutorials: .... Nil		Practical: .... Nil	
11	Course Coordinator	Dr. Srijani Chowdhury				
12	Date Approved by BOS	24/02/2024				
13	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD01.pdf				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		Intermediate	-	-	English Language and Grammar	

15. Course Overview

The principle aim of the course is that the students will get awareness about the importance of English language in the contemporary times and also, it emphasizes the students to learn this language as a skill (listening skill, speaking skill, reading skill and writing skill). Moreover, the course benefits the students how to solve their day-to-day problems in speaking English language. Besides, it assists the students to reduce the mother tongue influence and acquire the knowledge of neutral accent. The course provides theoretical and practical knowledge of English language and it enables students to participate in debates about informative, persuasive, didactic, and commercial purposes.

16. COURSE OBJECTIVES:

The students will try to learn:

I	Standard pronunciation, appropriate word stress, and necessary intonation patterns for effective communication towards achieving academic and professional targets.
II	Appropriate grammatical structures and also using the nuances of punctuation tools for practical purposes.
III	Critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.
IV	Conceptual awareness on writing in terms of unity, content, coherence, and linguistic accuracy.

17. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** Demonstrate the prime necessities of listening skills and communication skills for academic and non-academic purposes.	Understand
CO 2	**Comunicate** effectively in spoken English on issues and ideas with a reasonable degree of fluency and accuracy in different social settings.	Understand
CO 3	**Strengthen** acceptable language for developing life skills to overcome the challenges at professional platform.	Understand
CO 4	**Interpret** the grammatical and lexical forms of English and use these forms excellently in specific communicative contexts.	Understand
CO 5	**Articulate** main ideas and important details of literary text at advanced reading levels.	Understand
CO 6	**Extend** writing skills for fulfilling academic and work-place requirements of various written communicative functions.	Understand

18. Topic Learning Outcome (TLOs):

S.No	**Topic(s)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
1	Introduction to communication skils	1	**Interpret** fundamental concepts of communication skills through a procedural approach	CO 1	Understand
		2	**Aware** the techniques of perfect communication within and outside the classroom	CO 1	Understand
		3	**Identify** the parameters of the communication within the classroom as well as outside the classroom.	CO 1	Understand

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
		4	**Practice** ethical communication to embrace a diverse range of individuals, communities, and viewpoints	CO 1	Understand
3	Communication Process	5	**Examine** the process of effective communication at different social situations.	CO 1	Understand
		6	**Articulate** the process of effective communication different social situations	CO 1	Understand
4	Listening Skills	7	**Demonstrate** various kinds of listening setbacks within the classroom.	CO 1	Understand
		8	**Understand** in-depth meaning of audio clips	CO 1	Understand
5	Introduction to phonetics	9	**Familiar** with – and be able to Understand – technical terms for describing and analyzing English pronunciation and be able to read and produce phonemic transcriptions and transcription of intonation patterns.	CO 1	Understand
		10	**Articulate** acceptable language at various academical platforms.	CO 2	Understand
6	Significance of speaking skills	11	**Reinforce** effective oral presentation skillas well as acceptable behavioral traits.	CO 2	Understand
		12	**Maintain** global civic attitude at work place and feel as a responsible citizen.	CO 2	Understand
		13	**Plan** as a professional speaker before going to deliver an academic presentation.	CO 2	Understand
7	Generating talks based on visual prompts	14	**Get** consciousness about the importance of using flash cards, handouts and images to have an effective comprehension.	CO 2	Understand
8	Oral presentation using power point slides	15	**Understand** properly making effective PPTs in order to give a successful presentation.	CO 2	Understand
9	Delivering speech effectively	16	**Anticipate** problems with discussion groups	CO 2	Understand
10	Essentials of speaking skills	17	**Show** acceptable attitude at learning place as well as at work place.	CO 3	Understand
11	Exposure to structured talks	18	**Pay** appropriate attention as a learner of English as a second language.	CO 3	Understand
12	The concept of word formation	19	**Enhance** lexical ability to experience of IELTS, TOEFL, GRE tests.	CO 4	Understand

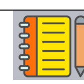
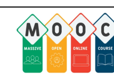
S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
13	Idioms and phrases	20	**Recognize** and understand the meaning of idioms and phrases.	CO 4	Understand
		21	**Able** to create own idiom story using story jumper	CO 4	Understand
14	Sentence structure	22	**Able** to write syntactical organization of given functions in non-periodic interval	CO 4	Understand
15	Usage of punctuation marks	23	**Understand** well using proper punctuation tools to deliver the topic successfully.	CO 4	Understand
16	Advanced level prepositions	24	**Identify** and define prepositions, prepositional phrases and objects of the preposition.	CO 4	Understand
17	Tenses	25	**Use** tenses syetematically to deliver the message without the ambiguity.	CO 4	Understand
18	Subject verb agreement	26	**Learn** the most common rules for subject/verb agreement and also identify proper and improper subject / verb agreement in the peer writing.	CO 4	Understand
19	Degrees of comparison	27	**Able** to use the positive, comparative, and superlative degrees of the regular and irregular adjectives and adverbs.	CO 4	Understand
20	Direct and indirect speech	28	**Define** direct speech and indirect speech and distinguish between direct and indirect speech and classify the rules for converting direct speech to indirect speech and indirect speech to direct speech.	CO 4	Understand
21	Questions tags.	29	**Use** the correct polarity (positive or negative), depending on the polarity of the statement.	CO 4	Understand
22	Significance of reading skills	30	**Accelerate** the ability of reading comprehension in advanced learning	CO 5	Understand
23	Techniques of reading	31	**Know** Vrious parameters of reading skills	CO 5	Understand
		32	**Use** different literary reading tools to establish his/her argument effectively.	CO 5	Understand
		33	**Extends** consolidates and sustains vocabulary growth	CO 5	Understand
24	Significance of writing skills	34	**Aware** the importance of writing skills particuarly at academic domain	CO 6	Understand
25	Effectiveness of writing	35	**Understand** well using proper writing tools to deliver his/her thesis	CO 6	Understand

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
26	The role of a topic sentence and supporting sentences in a paragraph	36	**Write** effective topic sentence as well as supporting sentences to convey a message to his/her readers/audience.	CO 6	Understand
27	Organizing principles of paragraphs in a document	37	**Generate** fa paragraph effectively using prime principles	CO 6	Understand
		38	**Describe** the principles of paragraph writing and properities of paragraphs	CO 6	Understand
29	Report writing	39	**Present** an original thesis on a significant topic within a well defined subject area	CO 6	Understand
30	E-mail writing	40	**Use** effectively technical writing tools at workplace	CO 6	Understand
31	Various formats for letter writing	41	**Knows** how to concise a written text without changing the core idea	CO 6	Understand

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Subject: Employment advantage: Effective English language and communication skills are crucial in many aspects of life, including education, business, workplace and social interactions. Proficient English language skills enable individuals to express themselves clearly, understand others, and engage in meaningful conversations. As the primary language of communication across the globe, proficiency in English is a highly sought-after skill in the international workplace and one of the benefits of learning English is therefore that it significantly boosts our job opportunities.

20. Content Delivery / Instructional Methologies:

✓	 Power Point Pressentation	✓	 Chalk & Talk	✓	 Assignments	x	 MOOC
x	 Open Ended Experiments	x	 Seminars	x	 Mini Project	✓	 Videos

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
35%	Understand
55%	Apply

22. SYLLABUS:

MODULE I	**GENERAL INTRODUCTION AND LISTENING SKILLS | Number of Lectures: 13**
	Introduction to communication skills; communication process; elements of communication; listening skills; significance of listening skills; stages of listening; barriers and effectiveness of listening; Introduction to phonetics; listening comprehension.
MODULE II	**SPEAKING SKILL | Number of Lectures: 13**
	Significance of speaking skills; essentials of speaking skills; verbal and non-verbal communication; generating talks based on visual prompts; public speaking; exposure to structured talks; delivering speech effectively; oral presentation using power point slides; soft skills and hard skills; importance of soft skills for engineers.

MODULE III	**VOCABULARY AND GRAMMAR** **. |Number of Lectures: 13**
	The concept of word formation; idioms and phrases; one-word substitutes, sentence structure (simple, compound and complex); usage of punctuation marks; advanced level prepositions; tenses; subject verb agreement; degrees of comparison; direct and indirect speech; questions tags.
MODULE IV	**READING SKILL | Number of Lectures: 12**
	Significance of reading skills, techniques of reading, skimming-reading for the gist of a text, scanning–reading for specific information, intensive, extensive reading, reading comprehension, metaphor and figurative language.
MODULE V	**WRITING SKILL | Number of Lectures: 13**
	Significance of writing skills; effectiveness of writing; the role of a topic sentence and supporting sentences in a paragraph; organizing principles of paragraphs in a document; writing introduction and conclusion; techniques for writing precis, various formats for letter writing (block format, full block format, and semi bloc format); e-mail writing, report writing.

TEXTBOOKS

1. 1. Anjana Tiwari, "*Communication Skills in English,* ", Khanna Publishing House: New Delhi, 2022.

REFERENCE BOOKS:

1. Norman Whitby, "*Business Benchmark: Pre-Intermediate to Intermediate – BEC Preliminary,* ", Cambridge University Press, 2nd Edition, 2008.
2. Devaki Reddy, Shreesh Chaudhary, "*Technical English,* ", Macmillan, 1st Edition, 2009.
3. Rutherford, Andrea J, "*Basic Communication Skills for Technology,* ", Pearson Education, 2nd Edition, 2010.
4. Raymond Murphy, "*Essential English Grammar with Answers,* ", Cambridge University Press, 2nd Edition, 2010

MATERIALS ONLINE:

1. Lecture notes, ELRV videos and power point presentations
2. Answers / solutions to all questions / problems in the textbook
3. Online exercises
4. Problems and solutions in files

23. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Introduction to communication skills	CO 1	T1; R1
2	Communication process	CO 1	T1; R1
3	Elements of communication	CO 1	T1; R1
4	Significance of listening skills	CO 1	T1; R1
5	Different stages of listening	CO 1	T1, R1
6	Different stages of listening	CO 1	T1, R1
7	Listening comprehension	CO 1	T1, R1
8	Introduction to phonetics	CO 1	T1, R1
9	Significance of speaking skills	CO 2	T1, R1
10	Essentials of speaking skills	CO 2	T1, R1
11	Verbal and non-verbal communication	CO 2	T1; R1, R2
12	Generating talks based on visual prompts	CO 2	T1; R1, R2
13	Public speaking	CO 1	T1; R1, R2
14	Exposure to structured talks	CO 2	T1; R1, R2
15	Oral presentation using power-point slides	CO 2	T1; R1, R2
16	Soft skills and hard skills	CO 3	T1; R1, R2
17	Importance of soft skills for engineers	CO 3	T1; R1, R2
18	Concept of word formation	CO	T1; R1, R2
19	Idioms and phrases	CO 4	T1; R3, R4
20	One-word substitutes	CO 4	T1; R3, R4
21	Sentence structure	CO 4	T1; R3, R4
22	Usage of punctuation marks	CO 4	T1; R3, R4
23	Advanced level prepositions	CO 4	T1; R3, R4
24	Functions of tenses	CO 4	T1; R3, R4
25	Subject verb agreement	CO 4	T1; R3, R4
26	Degrees of comparison	CO 4	T1; R1, R2
27	Direct and indirect speech	CO 4	T1; R1
28	Question tags	CO 4	T1; R1
29	Significance of reading skills	CO 5	T1; R1
30	Techniques of reading	CO 5	T1; R1
31	Skimming and Scanning	CO 5	T1; R1
32	Intensive and extensive reading	CO 5	T1; R1
33	Significance of writing skills	CO 6	T1; R1

S.No	Topics to be covered	CO's	Reference
34	Effectiveness of writing	CO 6	T1; R1
35	The role of a topic sentence	CO 6	T1; R1
36	Supporting sentences to develop a paragraph	CO 6	T1; R1
37	Organizing principles of paragraphs in a document	CO 6	T1; R4
38	Writing introduction and conclusion	CO 6	T1; R4
39	Metaphor and figurative language	CO 6	T1; R4
40	Technicalities of writing precis, Letter, e-mail, report and Various formats for letter writing	CO 6	T1; R4
PROBLEM SOLVING/ CASE STUDIES			
1	The aspects to improve listening comprehension Discuss in detail.	CO 1	TI:10,11
2	Different types of listeners with examples.	CO 1	TI: 19,21
3	The sounds of English language.	CO 1	TI:23,27
4	verbal communication or written communication.	CO 2	TI: 27,30
5	Various difficulties in public speaking.	CO 2	TI: 32,33
6	Different ways of greeting people in formal and informal situation and discuss how do they matter in communication?	CO 2	TI: 35,37
7	'Oral presentation requires a good planning'.	CO 2	TI:36,38
8	Power point presentation and the ways to make Power point presentation.	CO 3	TI: 37,38
9	Methods that are used to establish the process of building vocabulary with examples from the most used words in spoken English.	CO 4	TI:39,41
10	The usage of idioms and phrases in spoken English.	CO 4	TI: 47,50
11	'Structure proposition-evaluation' -Reading technique.	CO 5	TI:56,58
12	Active reading, detailed reading, and speed-reading techniques used in different situations.	CO 5	TI: 79,81
13	The elements of paragraph writing in detail.	CO 6	TI:100,102
14	Logical bridges and Verbal bridges in writing.	CO 6	TI: 102,104
15	The role of topic sentence to develop a paragraph.	CO 6	TI:105, 115
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Soft skills and Interpersonal Communication	CO 3	TI 8,9
2	Language acquisition is a process.	CO 2, CO3	TI: 11,12
3	Communication.	CO 3, CO 4	TI: 20, 25
4	Time management.	CO 5	TI: 36, 42
5	Stress management.	CO 3	T: 55, 68
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Soft Skills for difficult situations in terms of reassurance and reliability.	CO 3	TI
2	Verbal and non-verbal communication.	CO 3	TI
3	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI

S.No	Topics to be covered	CO's	Reference
4	Etiquette and manners. Its importance in social, personal and professional communication.	CO 3	TI
5	Problem solving and decision making.	CO 3	TI

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

Program Outcomes	
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. 1. Clarity (Writing); 2. Grammar/Punctuation (Writing); 3. References (Writing); 4. Speaking Style (Oral); 5. Subject Matter (Oral).	5	CIE/Quiz/AAT

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	
PSO 2	Focus on improving software reliability, network security or information retrieval systems.		
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	-	

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	✓	-		-	-	-

28. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 10	Discuss the heeds of functional grammar and punctuation tools in speaking and writing by generating the clarity of an audio text.	5
CO 2	PO 10	Apply the mathematics, science and Engineering fundamentals to problems involving frictional force additionally in system of forces using the knowledge of mathematics and science fundamentals.	5
CO 3	PO 10	Apply the mathematics, science and Engineering fundamentals for locating centroid and centre of gravity using the knowledge of mathematics and science fundamentals.	5
CO 4	PO 10	Interpret the grammatical knowledge and punctuation marks systematically towards providing clarity in speaking and writing.	5
CO 5	PO 10	Demonstrate the role of grammar and punctuation marks to understand the meaning between the sentences as well as paragraphs in speaking or writing for clarity.	5
CO 6	PO 10	Describe the clarity of grammatical usage and the obligation of punctuation marks in speaking and writing.	5

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % $<C <$ 60% –Moderate

1-5 $<C \leq$ 40% – Low/ Slight

3 - 60% $\leq C <$ 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
TOTAL	-	-	-	-	-		-	-	-	18	-	-	-	-	-
AVERAGE	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	English language has become linguafranca across the globe. For that reason, it is compelsory to learn this language at advanced level. In MNC commpanies, those who have excellent communication skills ,their carrer graph goes to the higher level very quickly. Hence ,the role of English language has become a part of the life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	

7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD**
Dr. Srijani Chowdhury, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**				
2	Course Title	**DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS**				
3	Course Code	AHSD08				
4	Program	B.Tech				
5	Class/Semester	II				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	1	4	-	-
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	×	×	×	×
9	Course Offered	Odd Semester ×		Even Semester ✓		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 16 hours		Practical: 0 hours	
11	Course Coordinator	Mr.P.Shantan Kumar				
12	Date Approved by BOS	23/08/2023				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AHSD02	I	Matrices and Calculus	

15. Course Overview

This course serves as a foundation course on differential equations and vector calculus. It includes techniques for solving ordinary differential equations, partial differential equations, vector differentiation and vector integration. It is designed to extract the mathematical developments, skills, from basic concepts to advance level of engineering problems to meet the technological challenges.

16. COURSE OBJECTIVES:

The students will try to learn:

I	The analytical methods for solving first and higher order differential equations with constant coefficients.
II	The analytical methods for formation and solving partial differential equations.
III	The physical quantities of vector valued functions involved in engineering field. .
IV	The logic of vector theorems for finding line, surface and volume integrals. .

17. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Utilize the methods of differential equations for solving the orthogonal trajectories and Newton's law of cooling
CO 2	Solve the higher order linear differential equations with constant coefficients by using method of variation of parameters.
CO 3	Make use of analytical methods for PDE formation to solve boundary value problems.
CO 4	Identify various techniques of Lagrange's method for solving linear partial differential equations which occur in Science and engineering.
CO 5	Interpret the vector differential operators and their relationships for solving engineering problems.
CO 6	Apply the integral transformations to surface, volume and line of different geometrical models .

18. Topic Learning Outcome (TLOs):

S No	**TOPIC NAME**	**TLO No**	**Topic Learning Outcome's**	**Course Outcome**	Blooms Level
1	Fundamentals of ordinary differential equation	TLO 1	**Summarize** basic fundamentals of ordinary differential equations through a procedural approach.	CO 1	Understand
2	Differential equations of first order	TLO 2	**Identify** the method of variables separable to obtain the solution for ordinary differential equations.	CO 1	Apply
		TLO 3	**Use** the standard methods to solve homogeneous equations.	CO 1	Apply
		TLO 4	**Solve** the ordinary differential equations by converting the non-homogenous equations to homogenous form which is used to get the solution.	CO 1	Apply

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
3	Exact and non-Exact differential equations	TLO 5	**Distinguish** in between non-exact and exact equations with suitable examples	CO 1	Apply
		TLO 6	**Determine** the solution for non-exact equations based on set of ordinary differential equations.	CO 1	Understand
4	Applications of ODE	TLO 7	**Apply** standard methods for finding Orthogonal Trajectories of a family of curves.	CO 1	Apply
		TLO 8	**Determine** temperature of body at any time using Newton's law of cooling.	CO 1	Apply
5	Higher order linear differential equations	TLO 9	**Solve** higher order linear differential equations with constant coefficients to obtain the solution	CO 2	Apply
		TLO 10	**Utilize** the method of variation parameters to obtain the solution of higher order differential equations .	CO 2	Apply
6	Formation of partial differential equation	TLO 11	**Interpret** the partial differential equations by eliminating arbitrary constants.	CO 3	Understand
		TLO 12	**Formulate** the partial differential equations by eliminating arbitrary functions.	CO 3	Understand
7	Method of grouping and multipliers	TLO 13	**Utilize** the method of grouping to solve the Lagrange's linear equations.	CO 4	Apply
		TLO 14	**Use** the method of multipliers to obtain the solution of Lagrange's linear equations.	CO4	Apply
		TLO 15	**Solve** linear partial differential equation by using analytical methods.	CO 4	Apply
8	Fundamentals of vector functions	TLO 16	**Review** the vector properties on vector and scalar point functions which are used to find gradient ,divergence and curl	CO 5	Understand
		TLO 17	**Determine** directional derivative of vector point function to find its rate of change in given direction	CO 5	Understand

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
9	Solenoidal and irrotational vectors	TLO 18	**Interpret** the vector properties to test whether the vector functions are solenoidal or irrotational	CO 5	Understand
10	Line, surface and volume integrals	TLO 19	**Determine** areas and volumes of functions by using line, surface and volume integrals.	CO 6	Understand
11	Integral theorems	TLO 20	**Determine** the areas of functions by using Green's theorem with suitable examples.	CO 6	Apply
		TLO 21	**Identify** the relation between surface integral and volume integral to find the volumes by using Stoke's theorem and Gauss-divergence theorem.	CO 6	Apply

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Differential Equations: Employability/ Skill development: Uses the basic of differential equation calculation concept in the field of engineering.
Vector Calculus: Employability/ Skill development: Uses the concept of definite integral in engineering problems

20. Content Delivery / Instructional Methologies:

✓	Power Point Pressentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	40 Marks
Total	-	-	**100 Marks**	

22. Course content - Number of modules: Five:

MODULE I	**First order and first degree ordinary differential equations | Number of Lectures: 10**
	Exact differential equations, Equations reducible to exact differential equations, linear and Bernoulli's equations,. Applications: Orthogonal Trajectories (Cartesian Coordinates) Newton's law of cooling.
MODULE II	**Ordinary differential equations of higher order | Number of Lectures: 10**
	Second order linear differential equations with constant coefficients: non-homogeneous terms of the type e^{ax},sin ax,cosax, polynomials in x,$e^{ax}V(x)$ and method of variation of parameters.
MODULE III	**Partial differntiatial equations |Number of Lectures: 09**
	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations.
MODULE IV	**Vector differentiation | Number of Lectures: 09**
	Scalar and vector point functions; definitions of gradient, divergent and curl with examples; solenoidal and irrotational vector point functions; scalar potential function.
MODULE V	**Vector integration | Number of Lectures: 10**
	Line integral, surface integral and volume integral, Green's theorem in a plane, Stoke's theorem and Gauss divergence theorem without proofs.

TEXTBOOKS

1. B.S. Grewal "*Higher Engineering Mathematics*", Khanna Publishers, 44th Edition, 2017.
2. Erwin Kreyszig "*Advanced Engineering Mathematics*",10/e, John Wiley& Sons, 2011.

REFERENCE BOOKS:

1. R. K. Jain and S. R. K. Iyengar , "*, Advanced Engineering Mathematics*", 5th Edition, TMH, 2017.
2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas, "*Calculus*", 13/e, Pearson Publishers, 2013.
3. N.P.Bali and Manish Goyal"*A textbook of Engineering Mathematics*",Laxmi Publications, Reprint,2008

4. Dean G. Duffy, "*Advanced Engineering Mathematics with MATLAB*",CRC Press
5. Peter O'Neil, "*Advanced Engineering Mathematics*", Cengage Learning.
6. B.V. Ramana, "*Higher Engineering Mathematics*", McGraw Hill Education.

ELECTRONIC RESOURCES:

1. Engineering Mathematics - I, By Prof. Jitendra Kumar — IIT Kharagpur https://onlinecourses.nptel.ac.in/noc23_ma88/preview
2. Advanced Calculus for Engineers, By Prof. Jitendra Kumar, Prof. Somesh Kumar — IIT Kharagpur https://onlinecourses.nptel.ac.in/noc23_ma86/preview
3. http://www.efunda.com/math/math_home/math.cfm
4. http://www.ocw.mit.edu/resourcs/Mathematics
5. http://www.sosmath.com
6. http://www.mathworld.wolfram.com

23. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
Discussion on OBE			
1	**Discussion on Outcome Based Education, CO, POs and PSOs**		
CONTENT DELIVERY (THEORY)			
1	Introduction to ordinary Differential equations	CO 1	T1:11.1,11.2 R3:11.1,11.2
2	Variable Separable,homogeneous differential equations and non-homogeneous differential equations .	CO 1	T1:11.4,11.5 R3:11.4,11.5
3	Exact differential equations	CO 1	T1:11.7,11.8 R3:11.6,11.7
4	Non-exact differential equations using integrating factors	CO 1	T1:11.9 R3:11.8
5	Linear differential equations of first order	CO 1	T1:11.10 R3:11.9
6	Bernoulli's Equation	CO 1	T1:11.11 R3:11.10
7	Reducible to linear equation by substitution	CO 1	T1:11.12 R3:11.12
8	Applications of ODE, Orthogonal trajectories	CO 1	T1:12.3 R3:12.3,12.4
9	Applications of ODE, Newton's law of cooling	CO 1	T1:12.6 R3:12.9

S.No	Topics to be covered	CO's	Reference
10	Linear Differential Equations of Second and Higher Order with Constant Coefficients	CO 2	T2:2.8 R6:2.5
11	Non-Homogeneous term of the type f (X) = e^{ax}	CO 2	T2:2.8 R6:2.5
12	Non-Homogeneous term of the type f (X) = Sinax	CO 2	T2:7.4 R3:7.1
13	Non-Homogeneous term of the type f (X) = Cosax	CO 2	T2:7.4 R3:7.1
14	Non-Homogeneous term of the type f (X) = X^n.	CO 2	T2:7.4 R3:7.1
15	Determine particular non-homogeneous term of the type f (X) = e^{ax} V(x)	CO 2	T2:7.4 R3:7.1
16	Solving second order linear differential equations using method of variation of parameters.	CO 2	T2:2.1 R6:2.9
17	Introduction to Partial differential equations	CO 3	T1:17.1 R3:16.1
18	Elimination of arbitrary constants (Formation of PDE)	CO 3	T1:17.1,17.2 R3:16.1,16.2
19	Elimination of arbitrary functions (Formation of PDE)	CO 3	T1:17.2 R3:16.2
20	Lagrange's Linear equation- Method of grouping	CO 4	T1:17.5,17.6 R3:16.3.1
21	Lagrange's Linear Equation -Method of Multipliers	CO 4	T1:17.5,17.6 R3:16.4- 16.5
22	Linear Partial differential equation of first order	CO 4	T1:17.5- 17.6 R3:16.5- 16.6
23	Solution of linear partial differential equation	CO 4	T1:17.5- 17.6 R3:16.5- 16.6
24	In Scalar and Vector Point Function(Definitions of Gradient, divergent, curl	CO 5	T1: 8.4 R6:8.1
25	Problems on directional derivative	CO5	T1:8.5 R6:11.3
26	Problems on Gradient of vector point functions	CO 5	T1:8.5 R6:11.3
27	Problems on divergence of vector point functions.	CO 5	T1:8.6 R6:11.4
28	Problems on curl of vector point function	CO 5	T1:8.6 R6:11.4
29	Properties of divergence and curl	CO 5	T1: 8.6 R6:11.7
30	Solenoidal and irrotational vectors	CO 5	T1: 8.6 R6:11.7
31	Introduction to Line integral	CO 6	T1: 8.11 R6:12.2

S.No	Topics to be covered	CO's	Reference
32	Problems on line integral	CO 6	T1: 8.28 R6:12.9
33	Introduction to surface integral	CO 6	T1: 8.12 R6:12.3
34	Problems on surface integral	CO 6	T1: 8.31 R6:12.26
35	Calculating areas by using Green's theorem	CO 6	T1: 8.13.4 R6:12.40
36	Stoke's theorem	CO 6	T1: 8.14 R6:12.6
37	Problems on Stoke's theorem	CO 6	T1: 8.36 R6:12.53
38	Volume integral	CO6	T1:8.15 R6:12.4
39	Gauss divergence theorem	CO 6	T1: 8.16 R6:12.7
40	Calculate the volumes by using Gauss divergence theorem	CO 6	T1: 8.42 R6:12.68
PROBLEM SOLVING/ CASE STUDIES			
1	Solving first order differential equations by using standard methods	CO 1	T1:21.1,21.4 R1:5.1
2	Applications of ODE: Orthogonal trajectories and Newton's law of cooling	CO 1	T1:21.13 R1:5.1,5.3
3	Solving Second order and higher order differential equations with constant coefficients	CO 2	T1:21.14 R1:5.5
4	Solving Second order and higher order differential equations by method of variation of parameters	CO 2	T1:22.3 R1:10.8
5	Solving problems on formation of partial differential equations by elimination of arbitrary constants	CO 3	T1:22.4 R1:10.9
6	Solving problems on formation of partial differential equations by elimination of arbitrary functions	CO 3	T2:10.1 R1:16.1
7	Solving linear Lagrange's equation by using grouping method	CO 4	T2:10.1 R1:16.2
8	Solving linear Lagrange's equation by using multipliers method	CO 4	T2:10.1 R1:16.2
9	Solving problems on Gradient and divergence	CO 5	T2:11.3 R1:16.5
10	Solving problems on Divergence and curl of a vector point functions	CO 5	T2: 11.3 R1:16.11
11	Solving problems on scalar potential function.	CO 5	T2: 11.3 R1:16.11

S.No	Topics to be covered	CO's	Reference
12	Solving problems on vector point functions: Solenoidal and irrotational.	CO 5	T2: 11.3 R1:16.9
13	Solving problems on Green's theorem	CO 6	T2: 11.4 R1:16.18
14	Solving problems on Stokes theorem	CO 6	T1:17.1- 17.2 R1:16.1- 16.2
15	Solving problems on Gauss divergence theorem	CO 6	T1:17.1- 17.2 R1:16.1- 16.2
DEFINITION AND TERMINOLOGY			
1	Definitions and terminology on ordinary differential equations	CO 1	T1:21.1,21.4 R1:5.1
2	Definitions and terminology on higher order differential equations	CO 2	T1:22.1-22.2 R1:10.8
3	Definitions and terminology on partial differential equations	CO 3 CO 4	T2:15.5 R1:7.5
4	Definitions and terminology on vector differentiation	CO 5	T2:10.3 R1:16.4
5	Definitions and terminology on vector integration	CO 6	T1:17.1- 17.2 R1:16.1-16.2
QUESTION BANK			
1	Discussion of first order differential equations	CO 1	T1:21.1,21.4 R1:5.1
2	Discussion of second and higher order differential equations	CO 2	T1:22.1- 22.2 R1:10.8
3	Discussion of partial differential equations	CO 3 CO 4	T2:15.5 R1:7.5
4	Discussion of vector differentiation	CO 5	T2:10.3 R1:16.4
5	Discussion of vector integration	CO 6	T1:17.1- 17.2 R1:16.1- 16.2

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.

PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	-	-

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-

28. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Determine the solution of complex engineering problems modelled by first order linear differential equations by using standard methods of Principles of Mathematics	2
	PO 2	Model the problems with help of ordinary differential equations, formulation of statement Newton's law of cooling apply the basic principle of mathematics and solve complex engineering problems by interpretation of results	6
CO 2	PO 1	Determine the solution of complex engineering problems modelled by Second and higher order linear differential equations with constant coefficients by using Principle of mathematics, substitution method and method of variation of parameter	2
	PO 2	Model the problem with the help of ordinary differential equations, prepare precise statement of the problem and apply method of variation of parameters and other analytical methods to develop the solution and interpret, validate the results through proper documentation	6
CO 3	PO 2	Make use of the different methods in the formulation of Lagrange's linear equation (understand) related to complex engineering problems, solutions are attained based on principles of mathematics to the physical problems of engineering by the interpretation of results.	6
CO 4	PO 1	Solve Lagrange's linear equation related to complex engineering problems such as grouping and multiplier method using principle of mathematics for solving linear partial differential equations which occur in Science and engineering .	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 2	Interpret the statement and formulation by differential calculus of complex engineering problems which transforms vector functions, gradients. Divergence, curl, using principle of mathematics to different bounded regions in calculating areas. by interpretation of results.	6
CO 6	PO 1	Apply the mathematics, science and Engineering fundamentals to dynamic equilibrium the problems for analysis of forces using the knowledge of mathematics and science fundamentals.	2

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	12	12	-	-	-		-	-	-	-	-	-	-	-	-
AVERAGE	3	3	-	-	-		-	-	-	-	-	-	-	-	-

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs. Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it.

x	1		
x	2		

x	3		
✓	4		**Quality Education:**This subject will improve the quality education in engineering and provides the knowledge in mathematical modelling which is used for real time applications
x	5		
x	6		
x	7		
x	8		
x	9		

x	10	REDUCED INEQUALITIES	
x	11	SUSTAINABLE CITIES AND COMMUNITIES	
x	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
x	13	CLIMATE ACTION	
x	14	LIFE BELOW WATER	
x	15	LIFE ON LAND	
x	16	PEACE, JUSTICE AND STRONG INSTITUTIONS	

x	17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 23/08/2023

Signature of Course Coordinator **HOD**
Mr.P.Shantan Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="5">CSE (DATA SCIENCE)</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="5">ESSENTIALS OF PROBLEM SOLVING</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="5">ACSD05</td></tr>
<tr><td>4</td><td>Class / Semester</td><td colspan="5">B.Tech II Semester</td></tr>
<tr><td>5</td><td>Regulation</td><td colspan="5">BT-23</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Structure of the course</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture
3</td><td>Tutorials
0</td><td>Credits
3</td><td>Lab
-</td><td>Credits
-</td></tr>
<tr><td>7</td><td>Type of course
(Tick type of course)</td><td>Core
✓</td><td>Professional Elective
-</td><td>Open Elective
-</td><td>VAC
-</td><td>MOOCs
-</td></tr>
<tr><td>8</td><td>Course Offered</td><td colspan="2">Odd Semester ×</td><td colspan="3">Even Semester ✓</td></tr>
<tr><td rowspan="2">9</td><td colspan="6">Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)</td></tr>
<tr><td colspan="2">Lectures: 48 hours</td><td colspan="2">Tutorials: 0 hours</td><td colspan="2">Practical: – hours</td></tr>
<tr><td>10</td><td>Course Coordinator</td><td colspan="5">Dr. A Naresh Kumar</td></tr>
<tr><td>11</td><td>Date Approved by BOS</td><td colspan="5">22/08/2023</td></tr>
<tr><td>12</td><td>Course Webpage</td><td colspan="5">https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse</td></tr>
<tr><td rowspan="2">13</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td colspan="2">Prerequisites</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td colspan="2">-</td></tr>
</table>

14. Course Overview

This course aims to provide exposure to problem solving through programming. Useful graph theory concepts, numerical techniques, and their applications to real world problems are discussed. Graph theoretical notions and the use of algorithms, both in the mathematical theory of graphs and its applications are discussed. Student will also learn how to implement and interpret numerical solutions by writing a well-designed computer programs in regard to their efficiency and suitability for real-life applications.

15.Course Objectives:

The students will try to learn:

I	The fundamental concepts of graph theory and its properties.
II	The basics related to paths and cycles using Eulerian and Hamiltonian cycles.
III	The applications of graph colouring and traversal algorithms for solving real-time problems.
IV	The numerical methods to solve algebraic equations.
V	The skill to solve numerical integration and ordinary differential equations of first and second order.

16. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	**Outline** the graph terminologies, graph representation techniques, and relate them to practical examples. the static structures dealing with systems of forces using laws of mechanics	Understand
CO 2	**Build** efficient algorithms for various optimization problems on graphs..	Apply
CO 3	**Use** effective techniques from graph theory to solve problems in networking and telecommunication.	Apply
CO 4	**Interpret** the fundamental concepts of polynomials, roots of equations and solve corresponding problems using computer programs.	Apply
CO 5	**Apply** the knowledge of numerical methods to solve algebraic and transcendental equations arising in real-life situations.	Apply
CO 6	**Solve** numerical integrals and ordinary differential equations to simulate discrete time algorithms.	Apply

17. Mapping of topic learning outcomes (TLO) to course outcomes

S. No	Topic(s)	TLC No	Topic Learning Outcome's	Course Outcome	Blooms Level
1	Introduction to graph terminology	1	Understand the graph terminologies to solve real-time problems.	CO 1	Understand
2	Diagraphs, weighted graphs, complete graphs	2	Understand the basics of graph theory and their various properties in various cutting-edge applications such as traffic networks, navigable networks and optimal routing.	CO 1	Understand
3	Graph complements	3	Apply graph complements and graph combinations to solve real world applications like routing, TSP/traffic control.	CO 1	Apply
4	Bipartite graphs				
5	Graph combinations				
6	Isomorphisms				

S. No	Topic(s)	TLC No	Topic Learning Outcome's	Course Outcome	Blooms Level
7	Matrix representations of graphs	4	Show the matrix representations of graphs to know whether pairs of vertices are adjacent or not in the graph.	CO 1	Understand
8	Degree sequence				
9	Eulerian circuits – Konigsberg bridge problem	5	Solve the Konigsberg bridge problem using Eulerian circuits to solve problems for shortening any path.	CO 2	Apply
10	Touring a graph				
11	Eulerian graphs				
12	Hamiltonian cycles	6	Apply Hamiltonian cycles to solve the traveling salesman problem.	CO 2	Apply
13	The traveling salesman problem				
14	Shortest paths – Dijkstra's algorithm	7	Use Dijkstra's algorithm to calculate shortest path from source to destination node.	CO 2	Apply
15	Walks using matrices				
16	Four color theorem	8	Relate the concept of vertex coloring to assign colors to the vertices of a graph using four color theorem.	CO 3	Understand
17	Vertex coloring				
18	Edge coloring	9	Understand proper edge coloring of a graph to apply in scheduling problems.	CO 3	Understand
19	Coloring variations				
20	First-fit coloring algorithm				
21	Depth-first search	10	Apply breadth first or depth first search technique in finding shortest paths and all possible paths.	CO 3	Apply
22	Bread-first search				
23	Minimum spanning trees: Kruskal's algorithms	11	Use minimum spanning tree concept in network design and optimization.	CO 3	Apply
24	Prim's algorithm				
25	Union-find structure				
26	Algebraic equations	12	Solve algebraic and transcendental equations to solve single variable function over the interval.	CO 5	Apply
27	Bisection method				
28	Method of false position				
29	Iteration method				
30	Newton-Raphson method	13	Solve polynomials, logarithmic and exponential functions to solve real time applications.	CO 4	Apply
31	Ramanujan's method				
32	Secant method				
33	Muller's method				

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
34	Numerical integration	14	Solve problems using numerical integration to compute numerical approximations to the integral of the function.	CO 6	Apply
35	Trapezoidal rule				
36	Simpson's 1/3 rule				
37	Simpson's 3/8 rule				
38	Solution by Taylor's series				
39	Euler's method	15	Use Euler's method for approximating solutions to differential equations and curve with line segments.	CO 6	Apply
40	Runge-Kutta's method	16	Apply Runge-Kutta method for solving initial-value problems of differential equations.	CO 6	Apply

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - The tech industry evolves rapidly, and staying up-to-date with the latest programming languages, frameworks, and development practices is crucial. Combining essentials of problem solving skills with a commitment to continuous learning demonstrates a student's dedication to staying relevant in a dynamic field.
2. Project-based skills - Creating projects that utilize graph theory principles to allow a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how problem solving concepts work in practice.

19. Content Delivery / Instructional Methologies:

✓	Power Point Pressentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	**Blooms Taxonomy Level**
17%	Understand
83%	Apply

21. Course content - Number of modules: Five

MODULE I	**GRAPH THEORY** | **Number of Lectures: 8**
	Graph Terminology: Digraphs, weighted graphs, complete graphs, graph complements, bipartite graphs, graph combinations, isomorphisms, matrix representations of graphs – incidence and adjacency matrices, degree sequence.
MODULE II	**GRAPH ROUTES** | **Number of Lectures: 10**
	Eulerian Circuits: Konigsberg bridge problem, touring a graph, Eulerian graphs, Hamiltonian cycles, the traveling salesman problem, shortest paths – Dijkstra's algorithm, walks using matrices.
MODULE III	**GRAPH COLORING AND GRAPH ALGORITHMS** . |**Number of Lectures: 10**
	Graph Colouring: Four color theorem, vertex coloring, edge coloring, coloring variations – first-fit coloring algorithm. **Graph Traversal:** Depth-first search, bread-first search, applications, and minimum spanning trees: Kruskal's and Prim's algorithm, union-find structure.
MODULE IV	**ALGEBRAIC AND TRANSCENDENTAL EQUATIONS** | **Number of Lectures: 10**
	Algebraic Equations: Algebraic equations, method of false position, bisection method, iteration method, Newton-Raphson method, Secant method, Ramanujan's Method, Muller's method (Approximation up to 2 decimals only).
MODULE V	**NUMERICAL INTEGRATION AND ORDINARY DIFFERENTIATIAL EQUATIONS** | **Number of Lectures: 10**

	Numerical Integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Solution by Taylor's series, Euler's method of solving an ordinary differential equation numerically, Runge-Kutta's second order method of solving ordinary differential equations (Approximation up to 2 decimals only).

TEXTBOOKS

1. Karin R Saoub, *Graph Theory: An Introduction to Proofs, Algorithms, and Applications*, Chapman and Hall, 1st Edition, 2021.

2. S S Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Private Ltd., 5th Edition, 2012.

REFERENCE BOOKS:

1. Mahinder Kumar Jain & J. V. Rao, *Numerical Methods: For Scientific and Scientific Computation*, 7th Edition, New Age International Pvt. Ltd., 2019.
2. P Kandasamy, K Thilagavathy, K Gunavathi, *Numerical Methods*, S Chand and Company, 2006.
3. R Balakrishnan, K Ranganathan *A Textbook of Graph Theory*, Springer Exclusive, 2nd Edition, 2019.
4. Jann Kiusalaas, *Numerical Methods in Engineering with Python*,Cambridge University Press, 2nd Edition, 2010.
5. Gary Chartrand, Ping Zhang, *A First Course in Graph Theory*, Dover Publications Inc., 2012.
6. James F. Epperson, *An Introduction to Numerical Methods and Analysis*,Wiley, 2nd Edition, 2021.

Electronic Resources:

1. https://www.geeksforgeeks.org/numerical-methods-and-calculus-gq/
2. https://www.geeksforgeeks.org/program-for-bisection-method/
3. https://ocw.mit.edu/courses/2-993j-introduction-to-numerical-analysis-for-engineering-13-002j-spring-2005/pages/lecture-notes/
4. https://www.tutorialspoint.com/graphs-and-its-traversal-algorithms
5. https://web.mit.edu/urban-or-book/www/book/chapter6/6.4.4.html
6. https://www.hackerearth.com/practice/algorithms/graphs/minimum-spanning-tree/tutorial/
7. https://www.codingninjas.com/studio/library/euler-and-hamilton-paths

Materials Online:

1. Course template

2. Tutorial question bank

3. Tech-talk topics

4. Open-ended experiments
5. Definition and terminology
6. Assignments
7. Model question paper - 1
8. Model question paper - 2
9. Lecture notes
10. Power point presentation
11. E-learning readiness videos (ELRV)

22. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
Discussion on OBE			
1	Discussion on Outcome Based Education, CO, POs and PSOs		
Content Delivery (Theory)			
1	Introduction to graph terminology	CO 1	T1:1.2
2	Diagraphs, weighted graphs, complete graphs	CO 1	T1:1.2.1
3	Graph complements	CO 1	T1:1.2.4
4	Bipartite graphs	CO 1	T1:1.2.5
5	Graph combinations	CO 1	T1:1.2.6
6	Isomorphisms	CO 1	T1:1.2.6
7	Matrix representations of graphs	CO 1	T1:1.4
8	Degree sequence	CO 1	T1:1.6
9	Eulerian circuits – Konigsberg bridge problem	CO 2	T1:2.1.1
10	Touring a graph	CO 2	T1:2.1.2
11	Eulerian graphs	CO 2	T1:2.1.3
12	Hamiltonian cycles	CO 2	T1:2.2
13	The traveling salesman problem	CO 2	T1:2.2.1
14	Shortest paths – Dijkstra's algorithm	CO 2	T1:2.31
15	Walks using matrices	CO 2	T1:2.3.2
16	Four color theorem	CO 3	T1:6.1
17	Vertex coloring	CO 3	T1:6.2
18	Edge coloring	CO 3	T1:6.3
19	Coloring variations	CO 3	T1:6.4
20	First-fit coloring algorithm	CO 3	T1:6.4.1
21	Depth-first search	CO 3	T1:3.3.1
22	Bread-first search	CO 3	T1:3.3.2

S.No	Topics to be covered	CO's	Reference
23	Minimum spanning trees: Kruskal's algorithms	CO 3	T1:3.1.1
24	Prim's algorithm	CO 3	T1:3.1.1
25	Union-find structure	CO 3	T1:3.1.1
26	Algebraic equations	CO 4	T2: 2.1
27	Bisection method	CO 4	T2: 2.2
28	Method of false position	CO 4	T2: 2.3
29	Iteration method	CO 4	T2: 2.4
30	Newton-Raphson method	CO 4	T2: 2.5
31	Ramanujan's method	CO 4	T2: 2.6
32	Secant method	CO 4	T2: 2.7
33	Muller's method	CO 5	T2: 2.8
34	Numerical integration	CO 5	T2: 6.4
35	Trapezoidal rule	CO 5	T2: 6.4.1
36	Simpson's 1/3 rule	CO 5	T2: 6.4.2
37	Simpson's 3/8 rule	CO 5	T2: 6.4.3
38	Solution by Taylor's series	CO 6	T2: 8.2
39	Euler's method	CO 6	T2: 8.4
40	Runge-Kutta's method	CO 6	T2: 8.5
Problem Solving/Case Studies			
1	Matrix representation of graph	CO 1	T1:1.4
2	Euler circuit in a directed graph	CO 2	T1:2.1.1
3	Eulerian path in an undirected graph	CO 2	T1:2.1.1
4	Hamiltonian graph	CO 2	T1:2.2
5	Dijkstra's algorithm	CO 2	T1:2.3.1
6	Breadth first search or traversal for a graph	CO 3	T1:3.3.1
7	Prim's algorithm for minimum spanning tree (MST)	CO 3	T1:3.1.1
8	Bisection method to find a real root of an equation	CO 4	T2:2.2
9	False position method to find a real root of an equation	CO 4	T2:2.3
10	Newton Raphson method to find a real root of an equation	CO 4	T2:2.5
11	Simpsons 1/3 Rule	CO 5	T2:6.4.2
12	Trapezoidal Rule	CO 6	T2:6.4.1
13	Simpsons 3/8 Rule	CO 6	T2:6.4.3
14	Numerical differential equation using Runge-Kutta 2 method (1st order derivative)	CO 6	T2:8.5
15	Numerical differential equation using Taylor Series method (1st order derivative)	CO 6	T2:8.2
Definition and Terminology			
1	Graph basic terminologies, types of graphs and matrix representation	CO 1	T1:1.2-1.4
2	Graph routing algorithms	CO 2	T1:2.1-2.3

S.No	Topics to be covered	CO's	Reference
3	Graph coloring and graph traversal algorithms	CO 3	T1:3.1,3.3, 6.1-6.4
4	Algebraic and transcendental equations	CO 4	T2:2.1-2.8
5	Numerical integration and ordinary differential equations	CO 5, CO 6	T2:6.4.1-6.4.3,8.2, 8.4,8.5
Tutorial Question Bank			
1	Graph basic terminologies, types of graphs and matrix representation	CO 1	T1:1.2-1.4
2	Graph routing algorithms	CO 2	T1:2.1-2.3
3	Graph coloring and graph traversal algorithms	CO 3	T1:3.1,3.3, 6.1-6.4
4	Algebraic and transcendental equations	CO 4	T2:2.1-2.8
5	Numerical integration and ordinary differential equations	CO 5, CO 6	T2:6.4.1-6.4.3,8.2, 8.4,8.5

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Program Outcomes	
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/Quiz/ AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/Quiz/ AAT
PO 3	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	CIE/SEE/Quiz/ AAT

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	CIE/SEE/Quiz/ AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Seminar / Conferences / Research papers

25. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	3	Tech talk
PSO 2	Focus on improving software reliability, network security or information retrieval systems	3	Tech talk

3 = High; 2 = Medium; 1 = Low

26. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	✓	-	-	-	-	-	-	-	✓	-	-
CO 2	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	✓	-
CO 3	✓	-	✓	-	✓	-	-	-	-	-	-	-	✓	✓	-
CO 4	✓	-	✓	-	✓	-	-	-	-	-	-	✓	✓	✓	-
CO 5	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	✓	-	✓	-	-	-	-	-	-	✓	✓	✓	-

27. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the basic graph terminologies, graph complements and representation of graphs.	3
	PO 5	Explain the various types of graphs and formulate problems related to matrix representation of graphs.	1
	PSO 1	Understand the object-oriented programming while writing and analyzing computer programs in the areas related to Machine Learning, Big data, and Artificial Intelligence.	4

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	Apply the knowledge of graph routing algorithms for solving Eulerian circuits, Hamiltonian cycles.	3
	PO 2	Solve the problems related to shortest path algorithms using Dijkstra's algorithm and walks using matrics.	5
	PO 3	Design efficient algorithms for various optimization problems using graph concepts.	8
	PO 5	Demonstrate the solutions of Konigsberg bridge, Chinese postman, traveling salesman problems by touring a graph.	1
	PSO 1	Understand, design and analyse computer programs in the areas related to networking and telecommunication.	5
	PSO 2	Make use of modern computer tools to determine the multiple shortest paths in a graph using various algorithms.	2
CO 3	PO 1	Use the concepts of graph coloring to solve problems in various domains such as register allocation, map colouring, mobile radio frequency assignment etc.	3
	PO 3	Develop solutions in many research areas of computer science such as data mining, image segmentation, image capturing, networking etc.	6
	PO 5	Apply appropriate graph traversal techniques in the field of city planning, traffic control, transport and navigation etc.	1
	PSO 1	Design and analyse computer programs in the areas related to many applications such as social networks, epidemiology, neural networks etc.	6
	PSO 2	Make use of modern computer tools and appropriate programming languages to write programs for various applications of graphs.	2
CO 4	PO 1	Apply the knowledge of numerical methods to solve complex problems handling large systems of equations nonlinearities and complicated grometrics.	3
	PO 3	Design solutions for complex Engineering problems using bisection, Newton-Raphson, Secant method and so on.	8
	PO 5	Apply appropriate algebraic techniques, and transcendental equations in solving complex problems in engineering.	1
	PO 12	Summarize various numerical methods related to numerical integration and differentiation.	7
	PSO 1	Analyse computer programs in optimizing the solutions of various applications.	5
	PSO 2	Illustrate modern computer tools in implementing a wide range of problems in science, engineering, business, finance and operations research.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 1	Apply the knowledge of numerical integration and differentiation to solve many types of real-time problems.	3
	PO 2	Solve various open problems using the concepts of ordinary differential equation (ODE) programming.	8
	PO 3	Develop solutions for complex Engineering problems by solving algebraic equations.	7
	PO 5	Use effective and widely used method for solving differential-equations by using modern tools.	1
	PSO 1	Develop, design and analyse problems for solving initial-value problems of differential equations.	5
CO 6	PO 1	Apply numerical integrals and ordinary differential equations for engineering disciplines.	3
	PO 2	Analyse and solve real life applications such as weather prediction, car safety, machine learning and many other domains.	7
	PO 3	Identify the need for numerical analysis for solving problems throughout the natural sciences, social sciences, engineering, medicine and business.	7
	PO 5	Develop algorithms for obtaining numerical solutions to problems involving continuous variables.	1
	PO 12	Summarize the various numerical methods and apply it in multiple real-time domains for problem solving.	6
	PSO 1	Write programs using appropriate programming languages solving problems in multiple applications such as computational geometry, machine learning, big data, and AI.	6
	PSO 2	Write programs using appropriate programming languages solving problems in multiple applications such as computational geometry, machine learning, big data, and AI.	2

28. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 2	3	5	8	-	1	-	-	-	-	-	-	-	5	2	-
CO 3	3	-	6	-	1	-	-	-	-	-	-	-	6	2	-
CO 4	3	-	8	-	1	-	-	-	-	-	-	7	5	2	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	3	8	7	-	1	-	-	-	-	-	-	-	5	-	-
CO 6	3	7	7	-	1	-	-	-	-	-	-	6	6	2	-

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 2	100	50	80	-	100	-	-	-	-	-	-	-	83.3	100	-
CO 3	100	-	60	-	100	-	-	-	-	-	-	-	100	100	-
CO 4	100	-	80	-	100	-	-	-	-	-	-	88	83.3	100	-
CO 5	100	80	70	-	100	-	-	-	-	-	-	-	100	-	-
CO 6	100	80	70	-	100	-	-	-	-	-	-	75	100	100	-

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	3	-	-	-	-	-	-	-	3	-	-
CO 2	3	2	3	-	3	-	-	-	-	-	-	-	3	3	-
CO 3	3	-	3	-	3	-	-	-	-	-	-	-	3	3	-
CO 4	3	-	3	-	3	-	-	-	-	-	-	3	3	3	-
CO 5	3	2	3	-	3	-	-	-	-	-	-	-	3	-	-
CO 6	3	3	3	-	3	-	-	-	-	-	-	3	3	3	-
TOTAL	**18**	**7**	**15**	**0**	**18**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**18**	**12**	**0**

31. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Viva-voce	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

32. ASSESSMENT METHODOLOGY INDIRECT:

-	Assessment of mini Projects by Experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		**No Poverty:** Python programming aims to end poverty in all its forms everywhere. Its objectives include ensuring that the entire population and especially the poorest and most vulnerable have equal rights to economic resources, access to basic services, property and land control, natural resources and new technologies.
2		
3		
4		**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
5		
6		

7		
8		**Decent work and economic growth:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
9		**Industry, Innovation, and Infrastructure:** Python programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
10		
11		
12		
13		

14		
15		
16		
17		**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on 22-08-2023.

Signature of Course Coordinator **HOD, DS**
Dr. A Naresh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**Computer Science and Engineering (Data Science)**				
2	Course Title	**Elements of Electrical and Electronics Engineering**				
3	Course Code	AEED01				
4	Class/ Semester	I/ II				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	-	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✗		Even Semester ✓		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: *Nil* hours		Practical: *Nil* hours	
10	Course Coordinator	Dr. Damodhar Reddy				
11	Date Approved by BOS	24/08/2023				
12	Course Webpage	www.iare.ac.in/—-/—-				
13	Course Prerequistes	**Level**	**Course Code**	**Course title**	**Semester**	
	-	-	-	-	-	

14. Course Overview

The course provides basic foundation in electrical and electronics. It includes the concepts related to electrical circuits, the fundamental operating principles of electrical machines and the characteristics of semiconductor devices. It also empowers students to understand electronics and electrical systems in their daily lives, from household appliances to personal devices.

15. COURSE OBJECTIVES:

The students will try to learn:

I	The fundamentals of electrical circuits and analysis of circuits with DC and AC excitation using circuit laws.
II	The construction and operation of Electrical machines..
III	The operational characteristics of semiconductor devices with their applications. .

16. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Make use ofbasic electrical laws for solving DC and AC circuits.	Understand
CO 2	Solve the network theorems to calculate the parameters in electrical circuits.	Understand
CO 3	Demonstrate the fundamentals of electromagnetism for the operation of DC and AC machines.	Uderstand
CO 4	Utilize the characteristics of diodes for the construction of rectifiers and regulators circuits.	Understand
CO 5	Interpret the transistor configurations for optimization of the operating point.	Apply
CO 6	Illustrate the amplifier circuits using transistors for computing hybrid parameters.	Apply

18. Topic Learning Outcome (TLOs):

SNo	**TOPIC(S)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come:**	Blooms Level
1	Electrical Circuits	TLO 1	Introduction to electrical circuits	CO1	Understand
		TLO 2	Basic Definitions of Electrical Circuits	CO 1	Understand
		TLO 3	Equivalent resistance of electrical circuits and source transformation of electrical circuits.	CO 1	Understand
2	Electrical laws	TLO 4	Basic Electric laws	CO 1	Understand
		TLO 5	Star to delta and delta bto star transformation	CO 1	Understand
3	Electrical analysis	TLO 6	Calculate voltages and currents with mesh analysis.	CO 1	Apply
		TLO 7	Calculate voltages and currents with nodal analysis	CO 1	Apply
4	AC Circuits	TLO 8	Demonstrate the basics of single-phase AC circuits	CO 1	Understand
5	Electrical Theorem	TLO9	Procedure for Superposition theorem	CO2	Understand
6	Electrical Theorem	TLO10	Procedure for Reciprocity theorem	CO2	Understand
7	Electrical Theorem	TLO11	Procedure for Thevenin's theorem	CO2	Understand
8	Electrical Theorem	TLO12	Procedure for Norton's theorem	CO2	Understand

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
9	Electrical Theorem	TLO13	Procedure for Maximum Power Transfer theorem	CO2	Understand
10	3 phase voltages	TLO14	Voltage and current relationships in star and delta connections	CO2	Understand
11	DC Circuits	TLO 15	Apply the basic theorems to solve the problems on DC circuits.	CO2	Apply
12	3Phase cirrcuits	TLO 16	Basics of three-phase AC circuits	CO2	Understand
‘13	DCmachines and AC machines	TLO 17	Illustrate the construction and operation of DC and AC motors and generators	CO3	Understand
14	DC machines	TLO 18	EMF equation of DC motors and generators	CO3	Understand
15	DC machines	TLO 19	Types of DC motors and generators	CO3	Understand
16	DC machines	TLO 20	Applications and losses of DC motors and generators	CO3	Understand
17	DC machines	TLO 21	Problems based on losses and Efficiency of DC motors and generators	CO3	Apply
18	semiconductor diode	TLO 22	Understand the basics of semiconductor elements	CO4	Understand
19	semiconductor diode characterictics	TLO 23	Illustrate the characteristics of the PN junction diode	CO4	Understand
20	rectifiers	TLO 24	Develop the rectifiers using diodes and their characteristics	CO4	Apply
21	Operation of semiconductor diode	TLO25	Operation of a diode as a switch	CO4	Understand
22	Zener diode	TLO26	Operation of Zener diode as the voltage regulator	CO4	Understand
23	Rectifier parameters	TLO27	Calculation of Rectifier parameters	CO4	Apply
24	Transistors	TLO28	Introduction to bipolar junction transistors	CO5	Understand
25	Transistor configurations	TLO29	Illustrate the characteristics of bipolar junction transistors with various configurations	CO5	Understand
26	Transistor principle	TLO30	Working principle of NPN Transistor	CO5	Understand
27	Transistor principle	TLO31	Working principle of PNP Transistor	CO5	Understand

SNo	**TOPIC(S)**	**TLO No**	**Topic Learning Outcome's**	**Course Outcome:**	Blooms Level
28	Transistor configuration	TLO32	Transistor characteristics under CE configuration	CO5	Understand
29	transistor configuration	TLO33	Transistor characteristics under CB configuration	CO5	Understand
30	transistor configuration	TLO34	Transistor characteristics under CC configuration	CO5	Understand
31	BJT characteristics	TLO35	Input and output characteristics of bipolar junction transistor	CO5	Understand
32	Amplifiers	TLO36	Understand the operation of a transistor as an amplifier	CO6	Understand
33	Amplifier circuits	TLO37	Understand the two port devices and networks of Amplifier circuits	CO6	Understand
34	Models of transistors	TLO38	Small signal operation and models for transistors	CO6	Understand
35	CE Amplifier	TLO39	Method of amplification in CE amplifier	CO6	Understand
36	H parameters	TLO40	Describe the h parameters of bipolar junction transistors with the concept of small signal operation	CO6	Understand

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Project based skills Elements of electrical and electronics engineering for students based on qualitative and quantitative analysis of experimental skills

19. Content Delivery / Instructional Methologies:

✓	Power Point Pressentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

21. Course Content-Number of Modules: Five

MODULE I	**INTRODUCTION TO ELECTRICAL CIRCUITS** . | **Number of Lectures: 09**
	Concept: Ohm's law, Kirchhoff's laws, the equivalent resistance of networks, star to delta transformation, mesh and nodal analysis (with DC source only). Single phase AC circuits: representation of alternating quantities, RMS, average, form and peak factor, RLC series circuit. .
MODULE II	**NETWORK THEOREMS AND THREE PHASE VOLTAGES** . | **Number of Lectures: 10**
	Network Theorems: Superposition, reciprocity, Thevenin's, Norton's, Maximum power transfer theorems for DC excitation circuits. Three phase voltages (Definitions only): voltage and current relationships in star and delta connections. ;

MODULE III	**ELECTRICAL MACHINES AND SEMICONDUCTOR DIODES** . |**Number of Lectures: 10**
	DC and AC machines: Motors and generators, Principle of operation, parts, EMF equation, types, applications, losses and efficiency. **Semiconductor diode:** P-N Junction diode, symbol, V-I characteristics, half wave rectifier, full wave rectifier, bridge rectifier and filters, diode as a switch, zener diode as a voltage regulator..
MODULE IV	**BIPOLAR JUNCTION TRANSISTOR AND APPLICATIONS** . | **Number of Lectures: 10**
	Bipolar junction transistor: characteristics and configurations, working principle NPN and PNP transistor, CE, CB, CC configurations – input and output characteristics, transistor as a switch..
MODULE V	**TRANSISTOR AMPLIFIERS** . | **Number of Lectures: 09**
	Amplifier circuits: Two port devices and network. - Small signal models for transistors – concept of small signal operation - amplification in CE amplifier - h parameter model of a BJT- CE, CB and Emitter follower analysis..

TEXTBOOKS

1. M.S.Sukhija,T K Nagsarkar, " *Basic Electrical and Electronics Engineering* ." Oxford, 1st Edition, 2012.

2. Salivahanan, " *Electronics devices and Circuits* ." TMH, 4th Edition, 2012.

REFERENCE BOOKS:

1. C.L. Wadhwa & "*Electrical Circuit Analysis including Passive Network Synthesis*", International,2nd edition,2009.

2. DavidA Bell, "*Electric circuits*", Oxford University Press,7th edition,2009.

3. P.S Bimbra "*Electrical Machines*", KhannaPublishers,2nd edition,2008.

4. D.P. Kothari and I. J. Nagrath, " *Basic Electrical Engineering*", Tata McGraw Hill, 4th Edition, 2021.

MATERIALS ONLINE:

1. https://www.kuet.ac.bd/webportal/ppmv2/uploads/1364120248DC%20Machines

2. https://www.eleccompengineering.files.wordpress.com/2014/08/a-textbook-of-electrical-technologyvolume-ii-ac-and-dc-machines-b-l-thferaja.pdf

3. https://www.geosci.uchicago.edu/ moyer/GEOS24705/Readings/Klempner_Ch1.pdf

4. https://www.ibiblio.org/kuphaldt/electricCircuits/DC/DC.pdf

5. https://www.users.ece.cmu.edu/ dwg/personal/sample.pdf.

6. https://www.iare.ac.in

22. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	Course Out-come's	Reference
Discussion on OBE			
1	Discussion on Outcome Based Education, CO, POs and PSOs		
CONTENT DELIVERY (THEORY)			
1	Introduction to electrical circuits	CO 1	T1:1.1-1.3
2	Basic definitions of electrical circuits	CO 1	T1:1.4-1.8
3	Equivalent resistance of electrical circuits and Source transformation of electrical circuits	CO 1	T1:2.6
4	Star to delta and delta to star transformation	CO 1	T1:2.7
5	Mesh analysis and problems on mesh analysis	CO 1	T1:2.9
6	Nodal Analysis and problems on nodal analysis	CO 1	T1:2.8
7	Representation of alternating quantities average value, rms value, form factor and peak factor for various waveforms	CO 1	T1:4.1-4.5
8	Concept of impedance, admittance and complex power	CO 1	T1:4.7-4.8
9	Procedure for superposition theorem and problems	CO 2	T1:2.11
10	Procedure for reciprocity theorem and problems	CO 2	T1:2.11.1
11	Procedure for Thevinin's theorem and problems	CO 2	T1:2.11.2
12	Problems on Thevinin's theorem	CO 2	T1:2.11.3
13	Procedure for Norton's theorem and problems	CO 2	T1:2.11.4
14	Problems on Norton's theorem	CO 2	T1:2.11.5
15	Procedure for Maximum power transfer theorem and problems	CO 2	T1:2.11.6
16	Voltage and current relationships in star delta connections	CO 2	T1: 5.2
17	Construction and operation of DC machines	CO 3	T1: 9.2
18	Classification of DC generators and efficiency	CO 3	T1: 9.6
19	Types of DC motors, losses and efficiency	CO 3	T1: 9.7
20	Introduction to semiconductor devices	CO 4	T2: 1.1
21	PN junction diode, symbol and its voltage current characteristics	CO 4	T2: 1.2
22	Operation of half wave rectifier with and without filters	CO 4	T2: 1.9
23	Operation of full wave rectifier with and without filters	CO 4	T2: 1.10
24	Operation of diode as switch	CO 4	T2: 1.11
25	Operation of zener diode as voltage regulator	CO 4	T2: 1.12
26	Calculation of Rectifier parameters	CO 4	T2: 1.10
27	Introduction to bipolar junction transistors	CO 5	T2: 3.1
28	Working principle of NPN transistor	CO 5	T2: 3.1.2
29	Operation of PNP transistor	CO 5	T2: 3.1.3

S.No	Topics to be covered	Course Out-come's	Reference
30	Transistor characteristics under CB configuration	CO 5	T2: 3.6
31	Transistor characteristics under CE configuration	CO 5	T2: 3.7
32	Transistor characteristics under CC configuration	CO 5	T2: 3.8
33	Biasing and load line of transistors	CO 5	T2: 4.1
34	Operation of transistor as an amplifier	CO 6	T2: 3.9
35	Introduction to port devices and network	CO 6	T2: 5.2
36	Concept of small signal operation for transistors	CO 6	T2: 5.2.7
37	Amplification in common emitter amplifier	CO 6	T2: 5.3.1
38	Calculation of h parameter model of a BJT CE configuration	CO 6	T2: 5.3.2
39	Calculation of h parameter model of a BJT CB configuration	CO 6	T2: 5.3.3
40	Calculation of h parameter model of a BJT CC configuration.	CO 6	T2: 5.5
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on equivalent resistance	CO 1	T1: 2.6
2	Problems on star to delta and delta to star transformation	CO 1	T1: 2.7
3	Problems on mesh and nodal analysis	CO 1	T1: 2.8-2.9
4	Problems on superposition theorem	CO 2	T1: 2.11
5	Problems on reciprocity theorem	CO 2	T1: 2.11.1
6	Problems on Maximum power transfer theorem	CO 2	T1: 2.11.2
7	Problems on emf equation of DC generators	CO 3	T1: 9.2
8	Problems on efficiency of DC generators	CO 3	T1: 9.3
9	Problems on DC motors	CO 3	T1: 9.4
10	Problems on efficiency of DC motors	CO 3	T1: 9.5
11	Problems on alternator emf equation	CO 4	T1: 7.4
12	Problems on alternators	CO 4	T1: 7.5
13	Problems on rectifiers using diodes	CO 4	T2: 1.10
14	Problems on transistors CB configuration	CO 5	T2: 3.6
15	Problems on transistors CE and CC configuration	CO 6	T2: 3.7-3.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to Engineering Mechanics	CO 1	T1: 1.1-1.12
2	Definition and terminology from network theorems and three phase AC circuits	CO 2	T1: 2.1-2.12
3	Definition and terminology from electrical machines and diodes	CO 3, CO 4	T1: 7,8,9 T2: 1.1-1.12
4	Definition and terminology from transistors	CO 5	T2: 3.1-3.10
5	Definition and terminology from transistor amplifier circuits	CO 6	T2: 9.1-9.6
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Question bank from electrical circuits	CO 1	T1: 1.1-1.12
2	Question bank from network theorems and three phase AC circuits	CO 2	T1: 1.1-1.12

S.No	Topics to be covered	Course Out- come's	Reference
3	Question bank from electrical machines and diodes	CO 3,CO 4	T1: 7,8,9 T2: 1.1-1.12
4	Question bank from electrical machines and diodes	CO 5	T2: 3.1-3.10
5	Question bank from transistor amplifier circuits	CO 6	T2:9.1-9.6

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

Program Outcomes	
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems..
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/AAT

25. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	-	-

3 = High; 2 = Medium; 1 = Low

26. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

27. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recollect the concept of electricity is described through scientific principles, importance Kirchhoff laws in relation with law of conservation of energy and charge circuits are explained using mathematics, engineering fundamentals and various source transformation techniques are adopted for solving complex circuits.	3
CO 2	PO 1	Demonstrate various network theorems in order to determine the same using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Verify various network theorems for their validation using mathematical calculations.	4
CO 3	PO 1	The principle of operation and characteristics of DC and AC machines are explained by applying engineering fundamentals including device physics.	3
	PO 2	Calculate the voltage generated and torque developed in DC and AC generators and motors by using first principles of mathematics .	4
CO 4	PO1	Illustrate the volt-ampere characteristics of semiconductor devices to derive mathematical model for diode current, static and dynamic resistance by applying the principles of mathematics and scientific principles for solving complex engineering problems.	2
	PO 2	Understand the given problem statement and formulate the static and dynamic resistance from the volt-ampere characteristics of the semiconductor devices using experimental design.	3
CO 5	PO 1	Understand the characteristics and operation of transistors with the knowledge of engineering fundamentals	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 1	Understand the mathematical principles for design the biasing techniques for BJT amplifier circuits for stable operation by applying the methodology	2
	PO 2	Demonstrate the calculation of h parameters with small signal operation using the principles of mathematics and natural sciences.	4

28. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	6	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-

31. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certificates	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

32. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		

3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	This subject improves the quality of education in engineers and gives the awareness of electrical usage in day to day life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	

10		
11		
12		Responsible Consumption and Production: This subject gives the importance of electricity, by learning how to optimize electrical energy for different applications, students can contribute to reducing energy consumption and minimizing electronic waste and the need for saving energy.
13		
14		
15		
16		

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on - 24/08/2023

Signature of Course Coordinator **HOD**

Dr. Damodhar Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="4">COMPUTER SCIENCE ENGINEERING (DS)</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="4">PROFESSIONAL COMMUNICATION LABORATORY</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="4">AHSD04</td></tr>
<tr><td>4</td><td>Program</td><td colspan="4">B.Tech</td></tr>
<tr><td>5</td><td>Semester</td><td colspan="4">II Semester</td></tr>
<tr><td>6</td><td>Regulation</td><td colspan="4">BT23</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Lecture Hours</td><td>Practical Hours</td></tr>
<tr><td colspan="3">3</td><td>3</td></tr>
<tr><td>8</td><td>Course Offered</td><td colspan="2">Odd Semester ×</td><td colspan="2">Even Semester ✓</td></tr>
<tr><td>9</td><td>Course Coordinator</td><td colspan="4">Dr.K.Bhaskar</td></tr>
<tr><td>10</td><td>Date Approved by BOS</td><td colspan="4">24/08/2023</td></tr>
<tr><td>11</td><td>Course Webpage</td><td colspan="4">https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-ae</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td>Prerequisites</td></tr>
<tr><td>B.Tech</td><td>AHSD04</td><td>II</td><td>-</td></tr>
</table>

13. Course Overview

This laboratory course is designed to introduce students to create a wide exposure on language learning techniques of the basic elements of listening skills, speaking skills, reading skills and writing skills. In this laboratory, students are trained in communicative English language skills, phonetics, word accent, word stress, rhythm, intonation, oral presentations and extempore speeches. Students are also taught in terms of seminars, group-discussions, presenting techniques of writing, participating in role plays, telephonic etiquettes, asking and giving directions, information transfer, debates, description of persons, places and objects etc. The laboratory encourages students to work in a group, engage in peer-reviews and inculcate team spirit through various exercises on grammar, vocabulary, and pronunciation games etc. Students will make use of all these language skills in academic, professional and real time situations.

14 COURSE OBJECTIVES:

The students will try to learn:

I	English speech sounds, word accent, intonation and stress patterns for effective pronunciation.
II	Critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.
III	Language techniques for social interactions such as public speaking, group discussions and interviews.
IV	Computer-assisted multi-media instructions and independent language learning.

15 COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Articulate** the use of draw, modify and dimension commands of AutoCAD for development of 2D and 3D drawings.	Understand
CO 2	**Differentiate**stress shifts, syllabification and make use of past tense and plural markers effectively in connected speech; besides participate in role plays with confidence.	Understnad
CO 3	**Apply** weak forms and strong forms in spoken language and maintain intonation patterns as a native speaker to avoid mother tongue influence; moreover, practice various etiquettes at professional platform.	Understand
CO 4	**Demonstrate** Errors in pronunciation and the decorum of oral presentations; for that reason, take part joining in group discussions and debates with much critical observations	Understand
CO 5	**Strengthen** writing effective messages, notices, summaries and also able to write reviews very critically of art and academical videos.	Understnad
CO 6	**Argue** scholarly, giving the counters to open ended experiments, and also writing slogans for the products talentedly.	Understand

16. Employability Skills

1. **Employment advantage:**Effective English language and communication skills are crucial in many aspects of life, including education, business, workplace and social interactions. Proficient English language skills enable individuals to express themselves clearly, understand others, and engage in meaningful conversations. As the primary language of communication across the globe, proficiency in English is a highly sought-after skill in the international workplace and one of the benefits of learning English is therefore that it significantly boosts our job opportunities

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	x	Probing Further Questions

6. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	3	5	20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
-	-	-	-	-	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. SYLLABUS:

CO 1	**Recognise English speech sounds in order to execute formal and informal communication**
	1. Introduction to pronunciation 2. Introducing self and introducing others and feedback 3. Introduction to phonetics, listening to English sounds, Vowel and Consonant sounds 4. Describing a person or place or a thing using relevant adjectives – feedback 5. Pronunciation practice
CO 2	**Construct required dialogues in role plays in verbal communication**
	1. Role plays on fixed expressions in various situations 2. Structure of syllables 3. Asking for directions and giving directions 4. Weak forms and strong forms 5. Intonation
CO 3	**ADifferentiate mother tongue influence while speaking English in JAM sessions, debates, group discussions and telephonic conversations.**

	1. Word accent and stress shifts 2. JAM Sessions using public address system 3. Extempore-Picture 4. Etiquette 5. Debates 6. Listening comprehension 7. Group discussion
CO 4	**Pronounce past tense and plural markers and weak forms and strong forms as a native speaker.**
	1. Past tense and plural markers 2. Neutralization of Mother Tongue Influence (MTI) 3. Weak forms and strong forms 4. Common errors in pronunciation practice through tongue twisters 5. Minimal pairs
hline CO 5	**Demonstrate the techniques of writing leaflets, messages and notices..**
	1. Writing slogan related to the image 2. Providing reviews and remarks 3. Writing slogan related to the image 4. Demonstration on how to write leaflets, messages and notices
CO 6	**Use language appropriately during interviews and oral presentations.**
	1. Oral presentations 2. Techniques and methods to write summaries and reviews of videos 3. Information transfer 4. Open ended experiments-phonetics practice 5. Open ended experiments-text to speech

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Professional Communication laboratory manual.

REFERENCE BOOKS:

1. Meenakshi Raman, Sangeetha Sharma, Technical Communication Principles and Practices, Oxford University Press, New Delhi, 3rd Edition, 2015..
2. Rhirdion, Daniel, Technical Communication, Cengage Learning, New Delhi, 1st Edition, 2009..

MATERIALS ONLINE:

1. Cambridge online pronunciation dictionary https://dictionary.cambridge.org/
2. Cambridge online pronunciation dictionary https://dictionary.cambridge.org/
3. Repeat after us https://brycs.org/clearinghouse/3018/
4. Language lab https://brycs.org/clearinghouse/3018/
5. Oxford online videos

19. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	CALL LAB: Introduction to pronunciation ICS LAB: Introducing self and introducing others and feedback:	CO 1	Understnad
2	CALL LAB: Introduction to phonetics, listening to English sounds, Vowel and Consonant sounds. ICS LAB: Describing a person or place or a thing using relevant adjectives – feedback	CO 1	Understnad
3	CALL LAB: Structure of syllables. ICS LAB: JAM Sessions using public address system	CO 2	Understnad
4	CALL LAB: Word accent and stress shifts. ICS LAB: Asking for directions and giving directions	CO 2	Understand
5	CALL LAB: Past tense and plural markers ICS LAB: Role plays on fixed expressions in various situations	CO 2	Understand
6	CALL LAB: Weak forms and strong forms ICS LAB: Extempore-Picture	CO 3	Understand
7	CALL LAB: Intonation ICS LAB: Interpretation of Proverbs and Idioms	CO 3	Understand
8	CALL LAB: Neutralization of Mother Tongue Influence (MTI) ICS LAB: Etiquette	CO 3	Understand
9	CALL LAB: Common errors in pronunciation practice through tongue twisters ICS LAB: Oral Presentations	CO 4	Understand
10	CALL LAB: Minimal pairs ICS LAB: Debates	CO 4	Understand

S.No	Topics to be covered	CO's	Reference
11	CALL LAB: Listening comprehension ICS LAB: Group discussion	CO 4	Understand
12	CALL LAB: Demonstration on how to write leaflets, messages and notices. ICS LAB: Techniques and methods to write summaries and reviews of videos	CO 5	Understand
13	CALL LAB: Pronunciation practice ICS LAB: Information transfer	CO 5	Understand
14	CALL LAB; Open Ended Experiments-Phonetics Practice ICS LAB: Providing reviews and remarks	CO 6	Understand
15	CALL LAB: Open Ended experiments-Text to Speech. ICS LAB: Writing slogan related to the image	CO 6	Understand

20. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Specific Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Program Specific Outcomes	
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

21. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	5	CIE/Quiz/AAT

22. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	-	-

3 = High; 2 = Medium; 1 = Low

23. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-

24. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 10	Discuss the significance of individual learning and the advantages of being a team member and also develop leadership qualities.	5
CO 2	PO 9, PO 10	Demonstrate about roleplays and its impact to enhance fluency levels. Strengthen word accent and stress shifts while doing group discussions.	3, 5
CO 3	PO 9, PO 10	Use intonation in connected speech while participating debates. Identify the number syllables in words and pronounce them as a native speaker.	3, 5
CO 4	PO 10	Pronouns the sentences within the tone boundaries maintaining the melody of the language	3
CO 5	PO 10	Interpret writing leaflets, messages and notices like a professional.	5

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 9, PO 10	Explain the procedure of preparing for interviews and academical oral presentations. Besides, recognising English speech sounds in order to maintain speaking efficiency	3, 5

25. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-

26. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	100	100	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	100	100	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	100	100	-	-	-	-	-

27. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	9	18	-	-	-	-	-
AVERAGE	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

28. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

29. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments

30 Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		

4		**E**nglish language has become linguafranca across the globe. For that reason, it is compulsory to learn this language at advanced level. In MNC commpanies, those who have excellent communication skills ,their carrer graph is going to high very quickly. Hence ,the role of English language has become a part of the life.
5		
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17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD, CSE (DS)**
Dr.K.Bhaskar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="4">CSE (DATA SCIENCE)</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="4">PROGRAMMING FOR PROBLEM SOLVING LABORATORY</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="4">ACSD06</td></tr>
<tr><td>4</td><td>Program</td><td colspan="4">B.Tech</td></tr>
<tr><td>5</td><td>Semester</td><td colspan="4">II Semester</td></tr>
<tr><td>6</td><td>Regulation</td><td colspan="4">BT-23</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Tutorial Hours</td><td>Practical Hours</td></tr>
<tr><td colspan="3">1</td><td>2</td></tr>
<tr><td>8</td><td>Course Offered</td><td colspan="2">Odd Semester ×</td><td colspan="2">Even Semester ✓</td></tr>
<tr><td>9</td><td>Course Coordinator</td><td colspan="4">Dr. M Laxmidevi Ramanaiah</td></tr>
<tr><td>10</td><td>Date Approved by BOS</td><td colspan="4">25/09/2023</td></tr>
<tr><td>11</td><td>Course Webpage</td><td colspan="4">www.iare.ac.in</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td>Prerequisites</td></tr>
<tr><td>UG</td><td>ACSD01</td><td>I</td><td>Object Oriented Programming</td></tr>
</table>

13. COURSE OVERVIEW

The course is designed with the fundamental programming skills and problem-solving strategies necessary to tackle a wide range of computational challenges. Through hands-on programming exercises, students will learn how to write code, analyze problems and develop solutions using various tools. This course empowers individuals to automate tasks and create innovative solutions to complex challenges.

14. COURSE OBJECTIVES

The students will try to learn:

I	The fundamental programming constructs and use of collection data types in python.
II	Comprehensive understanding of data structures and algorithms in software development and effective problem solving.
III	Principles of graph theory and be able to apply their knowledge to a wide range of practical problems across various disciplines.
IV	Skills necessary to apply numerical methods effectively in solving a wide range of mathematical and scientific problems.

15. COURSE OUTCOMES

After successful completion of the course, students should be able to:

CO1	Adapt programming concepts and skills using python programming.
CO2	Encourage critical thinking and problem-solving skills by tackling complex problems.
CO3	Gain a solid understanding of fundamental data structures like stacks,queues,trees for effective problem-solving skills.
CO4	Apply graph routing and shotest path algorithms to solve real world problems.
CO5	Develop problem-solving skills and the ability to solve graph-related challenges like graph coloring,traversals.
CO6	Exposed to various numerical integration techniques to tackle a wide range of computational problems.

16. EMPLOYABILITY SKILLS

1. **Problem-Solving and Critical Thinking:** Students learn to analyze complex problems, design solutions using object-oriented principles, and translate real-world scenarios into code.
2. **Debugging and Troubleshooting:** Debugging challenges in the lab help students master error identification, interpretation, and use of debugging tools, essential for real-world software development.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Summarize programming concepts and skills needed for a solid foundation in python programming through hands on coding exercises.**
	1. Getting Started Exercises
CO 2	**Develop the ability to solve a variety of programming problems and algorithms using python.**
	1. Exercises on simple problems using lists, tuples, sets and dictionaries.
CO 3	**Understand complex and custom data structures to solve real-world problems.**
	1. Exercises on implementation of stacks 2. Exercises on implementation of queues
CO 4	**Demostrate proficiency implementing graph algorithms to solve variety of problems and scenarios.**
	1. Exercises on graph representaion 2. Exercises on implementation of graph routing algorithms 3. Exercises on shortest path algorithms
CO 5	**Build critical thinking skills to solve the various real-world applications to using graph theory**
	1. Exercises on graph colouring 2. Exercises on graph traversals 3. Exercises on minimum spanning trees
CO 6	**Learn the importance of numerical methods and apply those thinking skills to tackle a wide range of computational problems..**
	1. Exercises on roots of quadratic equations 2. Exercises on numerical integration 3. Exercises on ordinary differential equations

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Eric Matthes."*Python Crash Course: A Hands-On, Project-based Introduction to Programming*", No Starch Press, 3rd Edition, 2023.

2. John M Zelle "*Python Programming: An Introduction to Computer Science*" Ingram short title, 3rd Edition, 2016.

Reference Books

1. Martin C. Brown. "*Python: The Complete Referencel*", Mc. Graw Hill, Indian Edition, 2018.
2. Paul Barry "*Head First Python: A Brain-Friendly Guide*", O'Reilly, 2nd Edition, 2016
3. Taneja Sheetal, Kumar Naveen "*Python Programming – A Modular Approach*", Pearson, 1st Edition, 2017.
4. R Nageswar Rao "*Core Python Programming*", Dreamtech Press, 2018.

Materials Online

1. https://realPython.com/python3-object-oriented-programming/
2. https://python.swaroopch.com/oop.html
3. https://python-textbok.readthedocs.io/en/1.0/object oriented programming.html
4. https://www.programiz.com/python-programming/
5. https://www.geeksforgeeks.org/python-programming-language/

20. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Matrix Operations	CO 2
3	Stack	CO 3
4	Queue	CO 3
5	Graph Representation	CO 4
6	Graph Routing Algorithms	CO 4
7	Shortest Path Algorithms	CO 4
8	Graph Coloring	CO 5
9	Graph Traversal	CO 5
10	Minimum Spanning Tree (MST)	CO 5
11	Roots of Equations	CO 6
12	Numerical Integration	CO 6
13	Ordinary Differential Equations	CO 6
14	Final Notes	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Implement error handling to catch file-related exceptions.
2.	Call a custom function that takes parameters and returns a value.
3.	Read data from a text file, perform some operation, and write the result back to a new file.
4.	Implement a program to add, remove, and manipulate elements in a list.
5.	Use list comprehensions to generate new lists.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	LAB PROGRAMS/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	LAB PROGRAMS/CIE/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2.6	LAB PROGRAMS/CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	LAB PROGRAMS/CIE/SEE

PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	LAB PROGRAMS/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	LAB PROGRAMS/CIE/SEE
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	LAB PROGRAMS/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2.5	LAB PROGRAMS/CIE/SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		**Strength**	**Proficiency Assessed by**
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation..	1.6	LAB PROGRAMS/CIE/SEE
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	1.6	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	✓
CO 2	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	✓
CO 3	✓	✓	✓	✓	✓	-	-	-	✓	-	-	-	✓	-	✓
CO 4	✓	✓	✓	✓	✓	-	-	-	✓	-	-	-	✓	-	✓
CO 5	✓	✓	✓	✓	✓	-	-	-	✓	-	✓	✓	✓	-	✓
CO 6	✓	✓	✓	✓	✓	-	-	-	✓	-	✓	✓	✓	-	✓

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Summarize programming concepts and skills needed for a solid foundation in python programming using principles of mathematics, and engineering fundamentals.	1
	PO 2	Identify, formulate the programming concepts and skills required for python programming using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PSO 1	Understand, design and analyze computer programs in the areas related to analyse large data sets.	2
	PSO 3	Make use of modern computer tools for solving programming problems and algorithms for providing optimized solutions.	1
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2
	PSO 1	Understand, design and analyze computer programs in the areas related to analyse large data sets.	1
	PSO 3	Make use of modern computer tools for solving programming problems and algorithms for providing optimized solutions.	1
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3
	PSO 1	Understand, design and analyze computer programs in the areas related to UAV and experimental studies.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 4	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	Understand the graph algorithms to to visualize and analyse large data sets.	2
	PSO 3	Accumulate the sufficient knowledge of graph and apply it in real-time for providing optimized solutions to data analysis.	1
CO 5	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2
	PSO 1	Understand, design and analyze graph theory to utilize the concepts in data analysis.	1
	PSO 3	Infer sufficient knowledge of graph theory and apply it in real-time for providing optimized solutions.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3
	PSO 1	Understand the numerical methods to apply the skills to tackle data analysis problems.	1
	PSO 3	Acquire the knowledge on numerical methods for providing optimized solutions.	1

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
Key Competencies	3	10	10	11	1	5	3	3	12	5	12	12	3	2	3
CO 1	1	2	-	-	1	-	-	-	-	-	-	-	2	-	1
CO 2	1	3	2	-	-	-	-	-	-	-	-	-	1	-	1
CO 3	2	2	3	2	1	-	-	-	3	-	-	-	1	-	2
CO 4	2	2	3	2	1	-	-	-	3	-	-	-	2	-	1
CO 5	2	2	3	2	1	-	-	-	2	-	2	2	1	-	2
CO 6	2	2	3	2	1	-	-	-	3	-	2	3	1	-	1

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	20	-	-	100	-	-	-	-	-	-	-	66.7	-	33.7
CO 2	33.3	30	20	-	-	-	-	-	-	-	-	-	33.7	-	33.7
CO 3	33.3	20	30	18	100	-	-	-	25	-	-	-	33.7	-	66.7
CO 4	66.7	20	30	18	100	-	-	-	25	-	-	-	66.7	-	33.7
CO 5	66.7	20	30	18	100	-	-	-	16	-	16	16	33.7	-	66.7
CO 6	66.7	20	30	18	100	-	-	-	25	-	16	25	33.7	-	66.7

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	-	-	3	-	-	-	-	-	-	-	3	-	1
CO 2	1	1	1	-	-	-	-	-	-	-	-	-	1	-	1
CO 3	1	1	3	2	3	-	-	-	1	-	-	-	1	-	3
CO 4	3	1	3	2	3	-	-	-	1	-	-	-	3	-	1
CO 5	3	1	3	2	3	-	-	-	1	-	2	2	1	-	3

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	3	1	3	2	3	-	-	-	1	-	2	3	1	-	1
TOTAL	12	6	13	8	15	-	-	-	4	-	4	5	10	-	10
AVERAGE	2	1	2.6	2	3	-	-	-	1	-	2	2.5	1.6	-	1.6

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.

5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Python programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:** Python programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	

13		**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using python programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
14		
15		
16		**Peace, Justice, and Strong Institutions:** Python programming skills can be applied to create tools for transparency, accountability, and data security. By focusing on ethical coding practices, the lab can contribute to strong and just institutions.
17		**Partnerships for the Goals:**Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,CSE(DS)**
Dr. M Laxmidevi Ramanaiah, Associate Professor CSE(DS)

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	CSE (DATA SCIENCE)			
2	Course Code	AMED02			
3	Course Title	MANUFACTURING PRACTICE			
4	Semester	II Semester			
5	Regulation	BT-23			
6	Structure of the course	Practical			
		Lecture Hours		Practical Hours	
		–		2	
7	Course Offered	Odd Semester ✗		Even Semester ✓	
8	Course Coordinator	Ms. Sravanthi Gudikandula			
9	Date Approved by BOS	28/02/2024			
10	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cseaiml			
11	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		–	–	–	No prerequisites

12. Course Overview:

This course provides the opportunity to become confident with new tools, equipment, and techniques for creating physical objects and mechanisms with a variety of materials. The students will learn the concepts of 3D printing, laser cutting, circuit board soldering, wood carving and CNC machining. Skills learned in the course enable the students about the design process in digital manufacturing used in various industrial applications.

13. Course objectives:

The students will try to learn:

I	The digital and additive manufacturing techniques used in various industrial applications in the current era to develop prototype models.
II	The unconventional machining processes and their selective applications as an alternative to traditional manufacturing methods.
III	The standard electrical wiring practices for domestic and industrial appliances.
IV	The soldering and de-soldering components on a circuit board safely and correctly.

14. Course outcomes:

After successful completion of the course, students should be able to:

CO 1	Practice the various types of manufacturing methods for preparing the given material to desired shape by using traditional and unconventional manufacturing practices.
CO 2	Execute the additive manufacturing technology for learning about the 3D printing processes and techniques.
CO 3	Select computer numerical control laser techniques for preparing the required geometrical profiles
CO 4	Demonstrate with the moulding techniques for producing cast components in complex shapes using different patterns
CO 5	Make use of computer numerical technologies to create products using wood carving techniques.
CO 6	Apply the plumbing skills to work with fittings and pipes made of PVC and galvanized steel.

15. Employability Skills:

1. **Employment advantage:** This can give competitive advantage when seeking employment to apply knowledge about engineering tools used in manufacturing of products.
2. **Programming skills:**Understanding basics of CNC programming for application in laying, shaping and cutting process for product development.
3. **Project based skills:** This can give hands on experience for design, analysis and fabrication of prototype model for real time applications.
4. **Safety Awareness:** Understanding the different machines, instruments and tools to handle in real-time environment and can apply this awareness to workplaces where safety is a priority.

16. Content delivery / Instructional methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	✓	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
–	–	–	–	–	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course content:

CO 1	**Practice the various types of manufacturing methods for preparing the given material to desired shape by using traditional and unconventional manufacturing practices.**
	1. Preparation of mild steel (MS) material for step turning with grooving operation. **Try** 1.1 Preparation of Mild Steel (MS) material for step turning with tapper operation. 2. Preparation of mild steel (MS) material for thread cutting and knurling operation. **Try** 2.1 Preparation of aluminium material for step turning with tapper operation. 3. Preparation of slotting operation. **Try** 3.1 Perform the boring and reaming operation on a rectangular work piece to obtain the required dimensions using vertical milling machine. 4. Preparation of V-groove operation. **Try** 4.1 Perform the key ways on a cylindrical work piece to obtain the required dimensions using shaping machine. 5. Demonstration on industry standard grinding. **Try** 5.1 Demonstration grinding methods and machines.
CO 2	**Execute the additive manufacturing technology for learning about the 3D printing processes and techniques.**
	1. Preparation of stepped pulley with PLA material. **Try** 1.1 Preparation of spur gear with ABS material.
CO 3	**Select computer numerical control laser techniques for preparing the required geometrical profiles on non-metallic materials.**

	1. Preparation of acrylic gears using CNC laser engraving / cutting machine. **Try** 1.1 Preparation of artistic components IARE logo using CNC laser engraving. 2. Demonstration of articulated robot for lifting load. **Try** 2.1 Demonstration the pick and place operation for the articulated robot 3. Demonstration of milling and lathe system switchable on one simulator. **Try** 3.1 Demonstration the combination of CNC Simulator with CNC machining simulation.
CO 4	**Demonstrate the assembly and disassembly of electrical equipment's and controls for safe domestic applications.**
	1. Preparation of wiring for a stair case arrangement using a two-way switch. **Try** 1.1 Prepare wiring for a tube light with switch control. 2. Preparation of soldering from a circuit board. **Try** 2.1 Perform desoldering operation from a circuit board. 3. Perform the maintenance of ceiling fan and ending the trouble shoot. problems. **Try** 3.1 Perform the maintenance for mixer grinder from a circuit board.
CO 5	**Make use of computer numerical technologies to create products using wood carving techniques.**
	1. Preparation of wooden wheel using computerized wood carving machine. **Try** 1.1 Preparation of IARE lettering using CNC wood carving.
CO 6	**Apply the plumbing skills to work with fittings and pipes made of PVC and galvanized steel.**

	1. Preparation of PVC material for pipe threading and fitting. **Try** 1.1 Preparation of galvanized steel I joint.

TEXTBOOKS

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Media promoters and publishers private limited, Mumbai, 2020.
2. Kalpakjian S, Steven S. Schmid, "Manufacturing Engineering and Technology", Pearson Education India Edition, 7 th Edition, 2019.

REFERENCE BOOKS:

1. Rupinder Singh, J. Paulo Davim, "Additive Manufacturing: Applications and Innovations", CRC Press, 2 nd Edition, August, 2021.
2. Jeyaprakash Natarajan , Muralimohan Cheepu , Che-Hua Yang , "Advances in Additive Manufacturing Processes", Bentham Books, 4 th Edition, September, 2021.

MATERIALS ONLINE:

1. Lab manual
2. Question bank

19. Course plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's
1	Preparation of stepped pulley with PLA material using the principles of 3D printing and additive manufacturing techniques.	CO 1
2	Preparation of acrylic gears using CNC laser engraving / cutting machine.	CO 1
3	Preparation of wooden wheel using computerized wood carving machine.	CO 1
4	Preparation of PVC material for pipe threading and fitting using die sets.	CO 2
5	Preparation of mild steel (MS) material for step turning with grooving operation using computer numerical control (CNC) lathe machines.	CO 2
6	Preparation of mild steel (MS) material for thread cutting and knurling operation using conventional lathe machines.	CO 3
7	Preparation of slotting operation using milling machine.	CO 4

S.No	Topics to be covered	CO's
8	Preparation of V-groove operation using shaping machine.	CO 4
9	Preparation of wiring for a stair case arrangement using a two-way switch.	CO 5
10	Preparation of soldering and desoldering from a circuit board.	CO 6
11	Perform the maintenance of ceiling fan and ending the trouble shoot problems.	CO 6
12	Demonstration of articulated robot for lifting load.	CO 6
13	Demonstration of milling and lathe system switchable on one FANUC simulator.	CO 6
14	Demonstration on industry standard grinding.	CO 6

20. Experiments for enhanced learning (EEL):

S.No	Product Oriented Experiments
1	**Divided Tenon Joint:** It is the simplest form of Mortise and tenon joint and this joint is made by fitting a short tenon into a continuous groove. This joint has the advantage of being easy to cut and is often used to make cabinet doors and other light duty frame and panel assemblies.
2	**Cross Fitting:** It is the fundamental of type of fitting which are used fitting trade and it is formed by joining the two inclined shaped cut specimens together and is often used to join the universal bearings.
3	**hard soldering:** Metals and alloys of dissimilar compositions can be hard-soldered (brazed or silver-soldered) together, for example: copper to brass; copper to steel; brass to steel; cast iron to mild steel; and mild steel to stainless steel.
4	**T-Pipe Joint:** T-pipe is a type of fitting which is T-shaped having two outlets at 90 degrees to the main line. It is short piece of pipe with a lateral outlet. It is widely used as pipe fittings.
5	**Concrete cube:** Plastic or Steel Concrete Cube Moulds are used to form specimens for concrete compressive strength testing. They can also be used as sample containers in the determination of mortar set times as indicated in ASTM C403 and AASHTO T 197.

21. Program Outcomes and Program Specific Outcomes:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

22. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1	Lab Exercises

PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1	CIA
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	Lab Exercises
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1	SEE

23. How program specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

24. Mapping of each CO with PO(s), PSO(s):

COURSE OUTCOME	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	-	✓	-	-	-	-	-	✓	-	-	-	✓
CO 2	✓	-	✓	-	-	-	-	-	-	-	✓	-	-	-	✓
CO 3	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓
CO 4	✓	-	✓	-	-	-	-	-	-	-	✓	-		-	-
CO 5	-	-	-	-	✓	-	-	-	-	-	✓	-		-	-
CO 6	✓	-	-	-	✓	-	-	-	-	-	✓	-	-	-	✓

25. Justifications for CO – PO/ PSO mapping -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of engineering fundamentals to join given wooden pieces according to given sketch to develop required joint.	1
	PO 3	Conversion of given design into a practical output using designsolution for complex engineering problems and design system components.	2
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	1
	PO 11	Demonstrate knowledge and understanding of the engineeringand management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Apply the computing theory, mathematics, statistical methods in data analytics for providing solutions.	2
CO 2	PO 1	Apply the knowledge of engineering fundamentals to join given metal pieces according to given sketch to develop required joint.	1
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	1
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Apply the computing theory, mathematics, statistical methods in data analytics for providing solutions.	2
CO 3	PO 1	Apply the knowledge of engineering fundamentals to make metal rod into given required shape according to given sketch to develop required joint.	1
	PO 5	Develop the given resources and engineering tools into required shape as given in the diagrammatical representation.	1
	PSO 3	Apply the computing theory, mathematics, statistical methods in data analytics for providing solutions.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 4	PO 1	Apply the knowledge of engineering fundamentals to make the casting product from given materials according to given sketch to develop required shape.	1
	PO 3	Conversion of given design into a practical output using design solution for complex engineering problems and design system components	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
CO 5	PO 5	Develop the given resources and engineering tools into required shape as given in the diagrammatical representation	1
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1
CO 6	PO 1	Apply the knowledge of engineering fundamentals to make the required electrical connection according to given circuit diagram to develop connection.	1
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	1
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Apply the computing theory, mathematics, statistical methods in data analytics for providing solutions.	2

26. Total count of key competencies for CO – PO/ PSO mapping

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	2	-	1	-	-	-	-	-	2	-	-	-	2
CO 2	1	-	-	-	1	-	-	-	-	-	2	-	-	-	2
CO 3	1	-	-	-	1	-	-	-	-	-	-	-	-	-	2
CO 4	1	-	2	-	-	-	-	-	-	-	2	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-
CO 6	1	-	-	-	1	-	-	-	-	-	2	-	-	-	2

27. Percentage of key competencies CO – PO/ PSO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	20	-	100	-	-	-	-	-	16.6	-	-	-	100
CO 2	33.3	-	-	-	-	-	-	-	-	-	16.6	-	-	-	100
CO 3	33.3	-	-	-	100	-	-	-	-	-	-	-	-	-	100
CO 4	33.3	-	20	-	-	-	-	-	-	-	16.6	-	-	-	-
CO 5	-	-	-	-	100	-	-	-	-	-	16.6	-	-	-	-
CO 6	33.3	-	-	-	100	-	-	-	-	-	16.6	-	-	-	100

28. Course articulation matrix PO / PSO mapping:

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	1	-	3	-	-	-	-	-	1	-	-	-	3
CO 2	1	-	-	-	-	-	-	-	-	-	1	-	-	-	3
CO 3	1	-	-	-	3	-	-	-	-	-	-	-	-	-	3
CO 4	1	-	1	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-
CO 6	1	-	-	-	3	-	3	-	-	-	1	-	-	-	3
Total	5	-	2	-	12	-	-	-	-	-	4	-		-	12
Average	3	-	1	-	3	-	-	-	-	-	1	-	-	-	3

29. Assessment methodology -Direct:

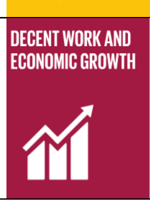
CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	✓

30. Assessment methodology -Indirect:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31. Relevance to Sustainability goals (SDGs):

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:** Manufacturing Practice course provides students with a strong foundation in CNC programming for application in laying, shaping and cutting process for product development, enhancing their learning experience and empowering them to address real- world challenges.
5		
6		
7		
8		

9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production:** By focusing on efficient material use, waste reduction, and product durability, manufacturing practice can aid in designing products and systems that align with responsible consumption and production practices.
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 28.02.2024.

Signature of Course Coordinator **HOD,DS**
Ms. Sravanthi Gudikandula, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**COMPUTER SCIENCE ENGINEERING (DATA SCIENCE)**			
2	Course Code	AEED01			
3	Course Title	**ELECTRICAL AND ELECTRONICS ENGINEERING LAB**			
4	Semester	II			
5	Regulations	BT-23			
6	Structure of the course	Practical			
		Lecture Hours		Practical Hours	
		-		36	
7	Course Offered	Odd Semester ✓		Even Semester ×	
8	Course Coordinator	Mr. G.Viswanath			
9	Date Approved by BOS	24/08/2023			
10	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AEED03.pdf			
11	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-

12. Course Overview

This course serves as a foundation course on electrical engineering. It covers a broad range of fundamental electrical circuits and devices. The concepts of current, voltage, power, basic circuit elements, electrical and electronic devices and their application in more complex electrical systems are to be imparted to the students

13. Course Objectives:

The students will try to learn:

I	The basic laws for different circuits.
II	The elementary experimental and modeling skills for handling problems with electrical machines in the industries and domestic applications to excel in professional career.
III	The intuitive knowledge needed to test and analyze the performance leading to design of electric machines by conducting various tests and calculate the performance parameters.
IV	Gain knowledge on semiconductor devices like diode and transistor

14. Course Outcomes:

After successful completion of the course, students should be able to:

CO1	**D**emonstrate an electric circuit by proving laws and solving theorems	Understand
CO2	**I**dentify the performance characteristics of DC shunt motor by suitable test.	Apply
CO3	**D**iscuss the performance of induction generator to study magnetizing characteristics.	Apply
CO4	**A**cquire basic knowledge on the working of diodes and rectifiers to study their characteristics.	Understand
CO5	**I**dentify transistor configuration to deduce its working characteristics.	Apply
CO6	**U**se of half wave and full wave rectifiers to study the characteristics.	Understand

15. Employability Skills

1. **Innovative Thinking:** This course helps the students to think innovative through different experiments and tests.
2. **Technological Knowledge:** Here they gain technical knowledge on electrical equipment.
3. **Safety awareness:** Students get holistic safety awareness about electricity which is very important for anyone.

16. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks for internal assessment, continuous lab assessment will be done for 20 marks for the day today's performance including viva voce, 10 marks for the final internal lab assessment, and the remaining 10 marks for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) AppDevelopment (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessmentduring day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report/Project and Presentation.

Table 1.0: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 2.0: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Table 3.0: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course Content:

CO 1	**Solve the source resistance, cu‘rrents, voltage and power using various laws associated with electrical circuits.**
	1. Introduction to electrical circuits 2. Exercises on Basic Electrical Circuit Law’s 3. Exercises on Mesh Analysis 4. Exercises on Nodal Analysis
CO 2	**Analyze open circuit characteristics of DC Shunt Generator**
	1. Observe the voltage build up, critical field resistance, critical speed
CO 3	**Perform Open circuit and Short Circuit tests on single phase transformer to observe efficiency**
	1. Conduct Open circuit and Short circuit tests on Transformer
CO 4	**Demonstrate Thevenin’s and Norton’s theorems to reduce complex networks into simple equivalent networks with DC excitation**
	1. Exercises on Thevenin’s Theorem 2. Exercises on Norton’s Theorem
CO 5	**Apply Faraday’s laws of electromagnetic induction for calculating the various performance parameters in magnetic circuits.**
	1. Exercises on Determination of Circuit Impedance 2. Exercise on Series and Parallel Resonance
CO 6	**Use the connecting wires of good continuity, short circuit of connecting wire leads damage of circuit parameters.**
	1. Exercise on Z and Y Parameters 2. Exercise on H and ABCD Parameters

19. Course Plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
2	Introduction to electrical circuits	CO 1	T1:2.1 R1:1.12.3
3	Exercises on Basic Electrical Circuit Law's	CO 1	T1:1.12-1.18 R1:1.15
4	Exercises on Mesh Analysis	CO 1	T1:5.1-5.2 R1:1.16
5	Exercises on Nodal Analysis	CO 2	T1:5.3 R1:1.13.1
6	Exercises on Characteristics of Periodic Waveforms	CO 3	T1:2.4 R1:1.13.2
7	Exercises on Determination of Circuit Impedance	CO 5	T1:2.4 R1:1.13.3
8	Exercises on Thevenin's Theorem.	CO 4	T1:5.1-5.2 R1:1.7.1
9	Exercises on Norton's Theorem	CO 4	T1:5.3 R1:1.17.3
10	Exercises on Superposition Theorem	CO 3	T1:5.3 R1:2.6.1
11	Exercises on Reciprocity Theorem	CO 3	T1:5.7 R1:2.6.2
12	Exercise on Series and Parallel Resonance	CO 5	T1:1.3-1.8 R1:2.10
13	Exercise on Maximum Power Transfer Theorem	CO 3	T1:8.12-8.14
14	Exercise on Half Wave Rectifier	CO 6	T1:8.12-8.14
15	Exercise on Full Wave Rectifier	CO 6	T1:8.12-8.14

20 Experiments for Enhanced Learning (EEL):

S.No	Design Oriented Experiments
1	To study the Speed Control methods of D.C. motor
2	To study the Rectifier working and it's characteristics

21. Program Outcomes & Program Specific Outcomes:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Outcomes	
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

22. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations,and give and receive clear instructions.	2	CIE/Quiz/AAT

23. How program specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

24. Mapping of each CO with PO(s),PSO(s):

COURSE OUTCOME	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	✓	-	-	-	-	✓	-	-	✓	-	-
CO 2	✓	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	✓	-	-	✓	-	-	-	-	✓	-	-	✓	-	-
CO 4	✓	✓	-	-	✓	-	-	-	-	✓	-		✓	-	-
CO 5	✓	✓	-	-	✓	-	-	-	-	✓	-	-	-	-	-
CO 6	✓	✓	-	-	✓	-	-	-	-	✓	-	-	-	-	-

25. Justifications for CO – PO / PSO mapping - direct:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the basics of mathematics, engineering sciences and other sciences to understand the concept of DC and AC Circuits.	3
	PO 2	Validate the principles of different laws associated with electrical circuits from obtained principles using basics fundamentals of mathematics and engineering sciences.	3
	P0 5	Validate the principles of different laws associated with electrical circuits using digital simulation	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
	PS0 1	Verify the various electrical circuit laws using computing tools like Simulink	1
CO 2	PO 1	Recall the basics of mathematics, engineering sciences and other sciences to understand the concept of Kirch- hom's laws	3
	PO 2	Analyze mesh analysis and nodal analysis technique using principles of mathematics, science and engineering fundamentals	5

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 5	Analyze mesh analysis and nodal analysis technique using digital simulation	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
	PS0 1	Verify mesh and nodal analysis using computing tools like Simulink	1
CO 3	PO 1	Apply the basics of mathematics, engineering sciences and other sciences to understand the network theorems	3
	PO 2	Describes the different Theorems with AC andDC excitation from obtained principles using basics fundamentals of mathematics and engineering sciences.	5
	PO 5	Construct various electrical circuits to validate Theorems with DC excitation using digital simulation	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
	PS0 1	Verify the superposition principle, reciprocity and maximum power transfer condition for the electrical network with DC excitation using computing tools like Simulink	1
CO 4	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals to the solution of magnetic circuits	3
	PO 2	Describes the fundamental characteristics of electromagnetic induction, self and mutual inductance in the single coil and coupled coils magnetic circuits using basics fundamentals of mathematics and engineering sciences.	5
	PO 5	Construct various electrical circuits to validate Thevenin's and Norton's theorems using digital simulation	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
	PS0 1	Verify Thevenin's and Norton's theorems for the electrical network with DC excitation using computing tools like Simulink	1
CO 5	PO 1	Recall the basics of mathematics, engineering sciences and other sciences to understand the concept of two port network and graph theory.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Validate the principles of different parameters and network topology from obtained principles using basics fundamentals of mathematics and engineering sciences.	5
	PO 5	Validate the principles of different parameters and network topology using digital simulation.	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
CO 6	PO 1	Identify complex engineering problems on two port network and graph theory using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 2	Recall the basics of mathematics, engineering sciences and other sciences to understand the concept of duality.	5
	PO 5	Determine the H and ABCD parameters for Circuit using digital simulation.	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1

26. Total count of key competencies for CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	-	-	1	-	-	-	-	3	-	-	1	-	-
CO 2	3	5	-	-	1	-	-	-	-	3	-	-	1	-	-
CO 3	3	5	-	-	1	-	-	-	-	3	-	-	1	-	-
CO 4	3	5	-	-	1	-	-	-	-	3	-	-	1	-	-
CO 5	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-
CO 6	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-

27. Percentage of key competencies for CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	-	-	100	-	-	-	-	60	-	-	34	-	-
CO 2	100	50	-	-	100	-	-	-	-	60	-	-	34	-	-
CO 3	100	50	-	-	100	-	-	-	-	60	-	-	34	-	-
CO 4	100	50	-	-	100	-	-	-	-	60	-	-	34	-	-
CO 5	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO'S PSO 1	PSO 2	PSO 3
CO 6	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-

28. Course articulation matrix (PO – PSO mapping):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO'S PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	3	-	-	-	-	3	-	-	1	-	-
CO 2	3	2	-	-	3	-	-	-	-	3	-	-	1	-	
CO 3	3	2	-	-	3	-	-	-	-	3	-	-	1	-	-
CO 4	3	2	-	-	3	-	-	-	-	3	-	-	1	-	
CO 5	3	2	-	-	3	-	-	-	-	3	-	-	-	-	-
CO 6	3	2	-	-	3	-	-	-	-	3	-	-	-	-	-
TOTAL	18	12	-	-	18		-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	-	3	-	2	-	-	-	-	-	-	-	-

29. Assessment methodology direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology indirect:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		

2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** This subject will improve the quality education in engineers and gives the awareness in electrical usage in day-to-day life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	

11		
12		**Responsible Consumption and Production** This subject impacts the demand of electricity and need for saving energy
13		
14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,DS**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE(DATA SCIENCE)**				
2	Course Title	**PROBABILITY AND STATISTICS**				
3	Course Code	AHSD11				
4	Program	B.Tech				
5	Semester	III				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	1	4	-	-
8	Type of course (**Tick type of course**)	Core ✓	Professional Elective ×	Open Elective ×	VAC ×	MOOCs ×
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 16 hours		Practical: 0 hours	
11	Course Co ordinator	Dr. G SRINIVASU				
	Course Instructor	Mr.SATYANARAYANA G				
12	Date Approved by BOS	23/08/2023				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AHSD02	I	Matrices and Calculus	
		B.Tech	AHSD08	II	Differential Equations Vector Calculus	

15. Course Overview

Probability theory is the branch of mathematics that deals with modelling uncertainty. The course includes: random variables, probability distributions, hypothesis testing, confidence interval and linear regression. The use of probability models and statistical methods is for analyzing data, designing, manufacturing a product and the observed class frequencies for engineering and sciences.

16. COURSE OBJECTIVES:

The students will try to learn:

I	The theory of probability, conditional probability, Bayes theorem and their applications.
II	The theory of random variables, basic random variate distributions and their applications.
III	The role of Binomial, Poisson and Normal distributions in solving the real-life problems.
IV	The methods and techniques for quantifying the degree of closeness among two or more variables by using coefficient of correlation and the concept of linear regression analysis.
V	The Estimation theory and hypothesis testing in statistics play a vital role in the assessment of the quality of the materials, products and ensuring the standards of the engineering process.

17. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the axioms of the probability, conditional probability and by using these concepts, establish the elementary theorems on probability. Explain the role of Bayes theorem in solving the typical uncertain problems in probability.	Understand
CO 2	**Explain** the role of random variables and types of random variables, expected values of the discrete and continuous random variables under randomized probabilistic conditions.	Understand
CO 3	**Interpret** the parameters of random variate Probability distributions such as Binomial, Poisson and Normal distribution by using their probability functions, expectation and variance.	Understand
CO 4	**Apply** Bivariate Regression as well as Correlation Analysis for statistical forecasting.	Apply
CO 5	**Identify** the role of statistical hypotheses, types of errors, confidence intervals, the tests of hypotheses for large samples in making decisions over statistical claims in hypothesis testing	Apply
CO 6	**Identify** the tests of hypothesis for small samples in making decisions over statistical claims in hypothesis testing	Apply

18. Topic Learning Outcome (TLOs):

S No	**TOPIC NAME**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
1	Classical definition of probability	TLO 1	**Summarize** basic fundamentals of probability through a procedural approach.	CO 1	Understand
2	Axiomatic Approach of probability	TLO 2	**Define** axioms of probability to obtain the solution of problems in probability.	CO 1	Apply
		TLO 3	**Use** the axioms of probability to solve the problems.	CO 1	Apply

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
3	Elementary theorems on probability	TLO 4	**Utilize** axioms of probability to prove the elementary theorems on probability	CO 1	Apply
		TLO 5	**Determine** the solution for problems related to probability	CO 1	Understand
4	Bayes Theorem	TLO 6	**Apply** Bayes Theorem for finding the solution of problems related to probability.	CO 1	Apply
5	Random Variables	TLO 7	**Distinguish** Discrete and Continuous Random Variables	CO 2	Understand
6	Probability mass function and Probability density function	TLO 8	**Define** the probability mass function and Probability density function.	CO 2	Understand
		TLO 9	**Utilize** the concept of random variables to obtain the solution of related problems.	CO 2	Apply
7	Binomial Distribution	TLO 10	**Define** the probability distribution of Binomial distribution.	CO 3	Understand
		TLO 11	**Interpret** Mean and Variance of binomial distribution.	CO3	Understand
		TLO 12	**Solve** the problems by using Binomial Distribution.	CO 3	Apply
8	Poisson Distribution	TLO 13	**Interpret** Poisson distribution as a limiting case of Binomial distribution.	CO 3	Understand
		TLO 14	**Interpret** Mean and Variance of poisson distribution.	CO3	Understand
		TLO 15	**Solve** the problems by using Poisson Distribution.	CO 3	Apply
9	Normal Distribution	TLO 16	**Define** the probability density function of Normal distribution.	CO 3	Understand
		TLO 17	**Interpret** Mean, Variance and Mode of normal distribution.	CO3	Understand
		TLO 18	**Solve** the problems by using Normal Distribution.	CO 3	Apply
9	Correlation	TLO 19	**Define** the correlation coefficient and Formulate the Karl-Pearson's Coefficient of correlation to solve some problems for the given data	CO 4	Understand

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
		TLO 20	**formulate** Rank correlation coefficient to solve the problems for the given data.	CO 4	Apply
10	Regression Lines	TLO 21	**Formulate** the regression lines of y on x and x on y to solve some problems.	CO 4	Understand
		TLO 22	**Find** the angle between two regression lines and using this formulae determine the solution of some problems.	CO 4	Apply
11	Test of Hypothesis	TLO 23	**Test** of significance for single mean and difference of means for large samples with suitable examples.	CO 5	Apply
		TLO 24	**Test** of significance for single proportion and difference of proportions for large samples with suitable examples.	CO 5	Apply
		TLO 25	**Explain** t-distribution, F-distribution and Chi-square distribution with suitable examples.	CO 6	Apply

19. Employability Skills

Probability: Employability/ Skill development: Uses the basics of theory of probability in the field of engineering.
Statistics: Employability/ Skill development: Uses the concept of the testing of hypothesis in engineering problems

20. Content Delivery / Instructional Methologies:

✓	Power Point Pressentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	40 Marks
Total	-	-	**100 Marks**	

22. Course content - Number of modules: Five:

MODULE I	**PROBABILITY** | **Number of Lectures: 10**
	Probability, axiomatic approach, elementary theorems on probability, conditional probability, multiplication theorem, Bayes theorem (without proof).
MODULE II	**RANDOM VARIABLES** | **Number of Lectures: 09**
	Random variables: Discrete and continuous random variables, probability distribution, probability mass function and probability density function.
MODULE III	**PROBABILITY DISTRIBUTIONS** | **Number of Lectures: 10**
	Binomial distribution: Mean and variance of Binomial distribution, Poisson distribution: Poisson distribution as a limiting case of Binomial distribution, Mean and variance of Poisson distribution, Normal distribution: mean, variance, mode, median of normal distribution.
MODULE IV	**CORRELATION AND REGRESSION** | **Number of Lectures: 09**
	Correlation- Karl Pearson's coefficient of correlation, rank correlation, repeated ranks, Regression: Lines of reghression, regression coefficient, angle between two regression lines.
MODULE V	**TEST OF HYPOTHESIS** | **Number of Lectures: 10**
	Population, sample, standard error; test of significance: Null hypothesis, alternate hypothesis. Types of errors, level of significance. Large sample tests: Test of hypothesis for single mean, difference between means, single proportion and difference between proportions. Small sample tests: Student's t- distribution, F-distribution and chi-square distribution. .

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons Publishers, 9th Edition, 2014.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2012.

REFERENCE BOOKS:

1. N. P. Bali, "Engineering Mathematics", Laxmi Publications, 9th Edition, 2016.

2. S. C. Gupta, V. K. Kapoor, “Fundamentals of Mathematical Statistics”, S. Chand and Co., 10th Edition, 2000.

3. Richard Arnold Johnson, Irwin Miller and John E. Freund, “Probability and Statistics for Engineers”, Prentice Hall, 8th Edition, 2013.

MATERIALS ONLINE:

1. Course template
2. Tutorial question bank
3. Definition and terminology
4. Tech-talk topics
5. Assignments
6. Model question paper-I
7. Model question paper-II
8. Lecture notes
9. Early learning readiness videos (ELRV)
10. Power point presentations

ELECTRONIC RESOURCES:

1. http://e4uhu.com/down/Applied/9th
2. https://toaz.info/32fa2f50-8490-42cf-9e6a-f50cb7ea9a5b
3. http://www.mathworld.wolfram.com

23. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
Discussion on OBE			
1	**Discussion on Outcome Based Education, CO, POs and PSOs**		
CONTENT DELIVERY (THEORY)			
1	Probability Basic definitions	CO 1	T2:26.3
2	Probability	CO 1	R2:21.48
3	Axioms of Probability	CO 1	T2:26.6 R2:21.50
4	Elementary theorems on Probability	CO 1	T2:26.6 R2:21.50

S.No	Topics to be covered	CO's	Reference
5	Conditional Probability	CO 1	T2:26.7 R2:21.51
6	Multiplication theorem	CO 1	T2:26.7 R2:21.51
7	Bayes theorem	CO 1	T2:26.7 R2:21.51
8	Discrete random variables	CO 2	T2:26.10
9	Continuous random variables	CO 2	T2:26.10
10	Probability distribution	CO 2	T2:26.14 R2:21.55
11	Probability mass function	CO 2	T2:26.15 R2:21.58
12	Probability Density Function	CO 2	T2:26.16 R2:21.61
13	Mathematical Expectation	CO 2	T2:25.12 R2:21.24
14	Binomial Distribution	CO 3	T2:25.16 R2:21.29
15	Mean and Variance of Binomial Distribution	CO 3	T2:25.14 R2:21.31
16	Expected Frequency of Binomial Distribution	CO 3	T2:25.14 R2:21.33
17	Poisson Distribution as a limiting case of binomial distribution	CO 3	R2:21.33
18	Mean and Variance of Poisson distribution	CO 3	T2:27.2 R2:21.64
19	Expected Frequency of Poisson Distribution	CO 3	T2:27.2
20	Normal distribution – I	CO 3	T2:27.2 R2:21.67
21	Mean and Variance of Normal Distribution	CO 3	T2:27.2
22	Mode and Median of Normal distribution	CO 3	T2:27.3 R2:21.71
23	Normal distribution – II	CO 3	T2:27.4 R2:21.68
24	Correlation	CO 4	T2:27.7 R2:21.74
25	Karl-Pearson's coefficient of Correlation	CO 4	T2:27.7 R2:21.74
26	Rank Correlation	CO 4	T2:27.12 R2:21.75

S.No	Topics to be covered	CO's	Reference
27	Rank Correlation for Repeated Ranks	CO 4	T2:27.8 R2:21.72
28	Regression Lines	CO 4	T2:27.8 R2:21.73
29	Regression coefficients	CO 4	T2:27.14 R2:21.78
30	Angle between two regression Lines	CO 4	T2:27.19 R2:21.814
31	Sampling distribution - Population, sample, standard error	CO 5	T2:27.12 R2:21.82
32	Test of significance: Null hypothesis, Alternate hypothesis, types of errors, level of significance	CO 5	T2:26.15 R2:21.58
33	Testing of hypothesis for Large Samples	CO 5	T2:26.15 R2:21.58
34	Test of hypothesis for single mean	CO 5	T2:26.16 R2:21.61
35	Test of hypothesis for difference of means	CO 5	T2:25.14 R2:21.33
36	Test of hypothesis for single proportion	CO 5	R2:21.33
37	Test of hypothesis for difference of proportions	CO 5	T2:27.2 R2:21.64
38	Testing of hypothesis for small samples	CO 6	T2:27.2
39	Student's t-distribution for single mean	CO 6	T2:26.16 R2:21.61
40	Student's t-distribution for difference of means	CO 6	T2:25.12 R2:21.24
41	F-distribution	CO 6	T2:25.16 R2:21.29
42	Chi-Square distribution – I	CO 6	T2:27.14 R2:21.78
43	Chi-Square distribution – II	CO 6	T2:27.12 R2:21.82
PROBLEM SOLVING/ CASE STUDIES			
44	Problems on Probability	CO 1	T2:26.3
45	Problems on Discrete and Continuous random variables	CO 1	R2:21.48
46	Problems on Probability mass function	CO 1	T2:26.6 R2:21.50
47	Problems on Probability density function	CO 1	T2:26.7 R2:21.51
48	Problems on Binomial Distribution	CO 2	T2:26.8
49	Problems on Poisson Distribution	CO 2	T2:26.10

S.No	Topics to be covered	CO's	Reference
50	Problems on Normal Distribution	CO 2	T2:26.14 R2:21.55
51	Problems on Correlation	CO 3	T2:26.15 R2:21.58
52	Problems on Regression	CO 4	T2:26.16 R2:21.61
53	Problems on Sampling distribution	CO 5	T2:25.12 R2:21.24
54	Problems on Test of hypothesis for single mean and difference of means	CO 5	T2:25.16 R2:21.29
55	Problems on Test of hypothesis for single proportion and difference of proportions	CO 6	T2:25.14 R2:21.31
56	Problems on t-distribution	CO 6	T2:25.14 R2:21.33
57	Problems on F-distribution	CO 6	R2:21.33
58	Problems on Chi-Square distribution	CO 6	T2:27.2 R2:21.64
DISCUSSION OF DEFINITION AND TERMINOLOGY			
59	Definitions terminology discussion on probability and random variables	CO 1	T2:26.6 R2:21.50
60	Probability and Random variables	CO 2	T2:26.7 R2:21.51
61	Definitions& terminology discussion on correlation and regression.	CO 3, CO 4	T2:25.14 R2:21.33
62	Definitions & terminology discussion on Tests of Hypothesis.	CO 5	R2:21.33
63	Definitions & terminology discussion on Tests of significance.	CO 6	R2:21.33
DISCUSSION OF QUESTION BANK			
64	Question bank discussion on Probability, Random variables and Probability Distributions	CO 1	T2:26.6 R2:21.50
65	Question bank discussion on probability distributions.	CO 2	T2:26.7 R2:21.51
66	Question bank discussion on correlation and regression.	CO 3,CO 4	T2:25.14 R2:21.33
67	Question bank discussion on Tests of Hypothesis.	CO 5	R2:21.33
68	Question bank discussion on Tests of significance.	CO 6	R2:21.33

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.

PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

25. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.		
PSO 2	Focus on improving software reliability, network security or information retrieval systems.		
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.		

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

28. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Determine the solution of complex engineering problems by using Axiomatic approach and elementary theorems of Probability	2
	PO 2	Interpret the statement of Bayes Theorem and determine the solution of complex engineering problems related to probability	6
CO 2	PO 1	Explain (understanding) the concept of random variables and their role in solving complex engineering problems involving random events and uncertainty by using Mathematical functions (principles of mathematics).	2
CO 3	PO 1	Interpret the Probability distributions such as Binomial, Poisson and Normal distribution (Understanding) and appreciate their importance and applicability (Apply) in solving complex engineering problems involving uncertainty.	2
	PO 2	Apply the suitable formulae to find mean, variance, mode and median for the given distributions. Use area property to solve the problems in normal distribution.	6
CO 4	PO 1	Interpret Karl-Pearson's coefficient of correlation, rank correlation and rank correlation for repeated ranks for solving some real-time complex engineering problems governed by correlation with the knowledge of fundamental principles of mathematics.	2
	PO 2	Apply the standard Regression line equations for solving some complex engineering problems. Understand the angle between two regression lines and apply the formulae to solve some related problems.	6

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 1	Interpret population, sample, standard error, null hypothesis and alternate hypothesis.	2
	PO 2	Explain the types of errors and level of significance in hypothesis testing of complex engineering problems.	6
CO 6	PO 1	Explain the working principle to test the given hypothesis. Interpret the test of hypothesis for single mean, difference of means, single proportion and difference of proportions for large samples.	2
	PO 2	Apply t-distribution, F-distribution, Chi-square distribution to test the hypothesis for small samples.	6

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % $<C < 60\%$ –Moderate

1-5 $<C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	15	-	-	-		-	-	-	-	-	-	-	-	-
AVERAGE	3	3	-	-	-		-	-	-	-	-	-	-	-	-

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech-talk / 5 Minutes Video	✓	Open Ended Experiments	-
Definitions and Terminology	✓	Quiz	✓	Assignments	✓

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

34. Relevance to Sustainability goals

Brief description about the course and how its relevance to SDGs.

Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it.

x	1		
x	2		

x	3	GOOD HEALTH AND WELL-BEING	
✓	4	QUALITY EDUCATION	**Quality Education:**This subject will improve the quality education in engineering and provides the knowledge in mathematical modelling which is used for real time applications
x	5	GENDER EQUALITY	
x	6	CLEAN WATER AND SANITATION	
x	7	AFFORDABLE AND CLEAN ENERGY	
x	8	DECENT WORK AND ECONOMIC GROWTH	
x	9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
x	10	REDUCED INEQUALITIES	
x	11	SUSTAINABLE CITIES AND COMMUNITIES	
x	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	

x	13	CLIMATE ACTION	
x	14	LIFE BELOW WATER	
x	15	LIFE ON LAND	
x	16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
x	17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 23/08/2023

Signature of Course Coordinator **HOD**
Dr. G. Srinivasu, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**				
2	Course code	**AECD04**				
3	Course Title	**COMPUTER SYSTEM ARCHITECTURE**				
4	Class / Semester	II/ I				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 0 hours		Practical: – hours	
10	Course Coordinator	Dr Ganapathi Rao Gajula, Assistant Professor				
11	Date Approved by BOS	22/08/2023				
12	Course Webpage	https://lms.iare.ac.in/index?route=course/details /course id=528				
13	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		-	-	-	-	

14. Course Overview

This course introduces the principles of basic computer organization, CPU organization, and the basic architecture concepts. The course emphasizes performance and cost analysis, instruction set design, register transfer languages, arithmetic, logic and shift micro-operations, pipelining, memory technology, memory hierarchy, virtual memory management, and I/O organization of computer, parallelprocessing and inter process communication and synchronization.

15. Course Objectives:

The students will try to learn:

I	The concepts of register transfer logic and arithmetic operations, instruction format, and instruction cycle.
II	The basic components of computer sysytems, functionality, and interactions with the components.
III	Memory hierarchy, memory management and I/O management.
IV	Pipelining and Multiprocessor techniques for the improvement of efficiency

16. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** a thorough understanding of the basic concepts and principles of computer sytem architecture.	Understand
CO 2	**Analyze** different types of instruction sets and addressing modes.	Analyze
CO 3	**Evaluate** memeory management techniques such as paging, segmentation and virtual memory.	Evaluate
CO 4	**Compare** different I/O techniques, including programmed I/O, interrupt driven I/O,and direct memory access (DMA) .	Understand
CO 5	**Explore** the implications of parallel processing and apply concepts of pipelining and parallelism to enhance sytem performance.	Analyze
CO 6	**Summarize** the concepts of pipelining and interprocess communication for advanced processor design.	Understand

17. Topic Learning Outcome (TLOs):

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
1	Register Transfer	1	**Identify** the purpose and function . of registers in a computer system.	CO 1	Understand
		2	**Evaluate** the efficiency of different bus architectures in terms of data transfer speed and reliability.	CO 1	Evaluation
2	Microoperations	3	**Define arithmetic microoperations** and their role in performing basic arithmetic tasks within a CPU.	CO 1	Understand
		4	**Utilize** a decimal arithmetic unit to perform operations such as addition and subtraction on decimal numbers.	CO 1	Apply

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
3	Arithmetic Logic Shift Unit: Levels of abstraction	5	**Describe** the functions and components of an Arithmetic Logic Shift Unit (ALU) and its role in performing arithmetic and logic operations.	CO 1	Understand
		6	**Demonstrate** how an ALU performs different operations (arithmetic, logic, shift) by simulating ALU operations.	CO 1	Apply
		7	**Analyze** the steps involved in binary addition and subtraction to troubleshoot common errors in these operations.	CO 1	Analyze
4	Instruction Codes:	8	**Analyze** the impact of different instruction codes on processor performance and instruction execution.	CO 2	Analyze
		9	**Define** what instruction codes are and their role in computer architecture.	CO 2	Understand
5	Timing and Control:	10	**Analyze** how timing and control mechanisms affect the synchronization and execution of instructions in a CPU.	CO 2	Analyze
6	Addressing Modes	11	**Analyze** the impact of different addressing modes on instruction execution and memory access.	CO 2	Analyze
7	Data Transfer and Manipulation	12	**Describe** the mechanisms and operations involved in data transfer and manipulation within a computer system.	CO 2	Understand
		13	Micro programmed control **Explain** the process of address sequencing) in the design of control units.	CO 3	Understand
		14	**Analyze** the differences between hardwired control and micro programmed control.	CO 3	Analyze
8	Input-Output Organization:	15	**Identify** various peripheral devices and their functions in a computer system.	CO 3	Remember
		16	**Assess** the PCI Express architecture and identify its physical and logical components.	CO 3	Evaluate

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		17	**Illustrate** the communication protocol between CPU and Input-Output Processors (IOPs).	CO 4	Apply
9	Memory Organization	18	**List** the different types of semiconductor RAMs and their characteristics.	CO 4	Remember
		19	**Explain** the concept of memory hierarchy and its significance in computer architecture.	CO 4	Understand
10	Semiconductor RAMs	20	**Describe** the internal organization of Static RAM (SRAM) and Dynamic RAM (DRAM)	CO 4	Understand
		21	**Assess** the impact of memory hierarchy on system performance and provide recommendations for optimal memory configurations in specific computing environments.	CO 5	Evaluate
11	Nonvolatile Solid-State Memory Technologies	22	**Critique** current nonvolatile memory technologies (such as SSDs) and predict future trends in memory technology. predict future trends in memory technology.	CO 5	Evaluate
12	Memory Hierarchy	23	**Assess** the impact of memory hierarchy on system performance and provide recommendations for optimal memory configurations in specific computing environments.	CO 5	Evaluate
		24	**Differentiate between synchronous and asynchronous DRAMs** in terms of operation and application.	CO 5	Understand
13	Pipelining	25	**Define** key terms such as pipelining, vector processing, and multiprocessors.	CO 6	Remember
		26	**Describe** the advantages and disadvantages of using instruction pipelining in CPU design.	CO 6	Understand
		27	**Apply** knowledge of interconnection structures to design a simple multiprocessor network.	CO 6	Apply

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		28	**Analyze** the performance trade-offs between using vector processors and traditional scalar processors in different computational scenarios.	CO 6	Analyze
14	Multicore Computers	29	**Assess** the software performance issues that can arise in multicore systems and propose strategies to mitigate them.	CO 6	Evaluate

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - The tech industry evolves rapidly, and staying up-to-date with the latest programming languages, frameworks, and development practices is crucial. Combining CSA skills with a commitment to continuous learning demonstrates a student's dedication to staying relevant in a dynamic field.
2. Project-based skills - Creating projects that utilize CSA methodologies allows a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how CSA concepts work in practice.

19. Content Delivery / Instructional Methologies:

✓	Power Point Presentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definitions and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given in the first two modules. Each question carries 12 marks. There could be a maximum of two sub-divisions in a question.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE:

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

21. Course content - Number of modules: Five

MODULE I	**REGISTER TRANSFER AND MICROOPERATIONS | Number of Lectures: 10**
	Register transfer, Bus, and memory transfers, Arithmetic microoperations, Logic microoperations, Shift microoperations, and Arithmetic logic shift unit. Computer arithmetic: Addition and subtraction, floating point arithmetic operations, decimal arithmetic unit.
MODULE II	**ORGANIZATION OF A COMPUTER | Number of Lectures: 09**
	Instruction codes, Computer registers, Computer instructions, Timing and control, Instruction cycle, Program Input-Output and Interrupt. Instruction formats, Addressing modes, Data Transfer and Manipulation, Program Control, RISC.
MODULE III	**MICROPROGRAMMED CONTROL AND INPUT-OUTPUT ORGANIZATION | Number of Lectures: 10**
	Micro Programmed Control: Control memory, Address sequencing, Design of control unit, Hardwired control, Micro programmed control. **Input-Output Organization:** Peripheral devices, Input-Output interface, Modes of transfer, Priority interrupt –Daisy chaining priority, Parallel priority interrupt, Priority encoder; Direct Memory Access, Input-Output Processor – CPU-IOP communication; PCI Express - PCI physical and logical architecture.
MODULE IV	**MEMORY ORGANIZATION | Number of Lectures: 09**
	Memory organization: Memory hierarchy, main memory, auxiliary memory, associative memory, cache memory, virtual memory; Semiconductor RAMs – Internal organization, Static memories, Dynamic RAMs, Synchronous and Asynchronous DRAMs, Structure of larger memories; Read-only memories, Cache memories – Mapping functions; Nonvolatile Solid-State Memory Technologies, Solid state drives.

MODULE V	MULTIPROCESSORS | Number of Lectures: 09
	Pipeline and Vector Processing: Parallel processing, Pipelining, Instruction pipeline, Vector processing, Array processors. **Multiprocessors:** Characteristics of multiprocessors, Interconnection structures, Inter-processor arbitration. **Multicore Computers:** Hardware performance issues, Software performance issues, Multicore organization, Intel Core i7-990X.

TEXTBOOKS

1. *M. Morris Mano, "Computer Systems Architecture", Pearson, 3 rd Edition, 2015.*
2. Patterson, Hennessy, "Computer Organization and Design: The Hardware/Software Interface", Morgan Kaufmann, 5 th Edition, 2013.

REFERENCE BOOKS:

1. John. P. Hayes, "Computer System Architecture", McGraw-Hill, 3 rd Edition, 1998.
2. Carl Hamacher, Zvonko G Vranesic, Safwat G Zaky, "Computer Organization", McGraw-Hill, 5 th Edition, 2002.
3. William Stallings, "Computer Organization and Architecture", Pearson Edition, 8 th Edition, 2010

22. Course plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
Discussion on Outcome Based Education, CO, POs, and PSOs			
CONTENT DELIVERY (THEORY)			
1	Register transfer: Register transfer language, register transfer	CO 1	T1: 4.1, 4.2
2	Bus and memory transfers	CO 1	T1: 4.3
3	Arithmetic micro operations	CO 1	T1: 4.4
4	Logic micro operations	CO 1	T1: 4.5
5	Shift micro operations	CO 1	T1: 4.6
6	Computer arithmetic: Addition and subtraction	CO 1	T1: 10.2
7	Floating point arithmetic operations	CO 1	T1: 10.5
8	Decimal arithmetic unit	CO 1	T1: 10.6
9	Organization of a computer: Instruction codes	CO 2	T1: 5.1
10	Computer registers	CO 2	T1: 5.2
11	Computer Instructions	CO 2	T1: 5.3

S.No	Topics to be covered	CO's	Reference
12	Timing and control	CO 2	T1: 5.4
13	CPU design: Instruction cycle	CO 2	T1: 5.5
14	Program Input-output and interrupt	CO 2	T1: 5.7
15	Instruction formats	CO 2	T1: 5.6
16	Addressing modes	CO 2	T1: 8.5
17	Data transfer and manipulation, program control.	CO 2	T1: 8.6, 8.7
18	RISC	CO 3	T1: 8.5
19	Micro Programmed Control: Control memory	CO 3	T1: 7.1
20	Address sequencing	CO 3	T1: 7.2
21	Design of control unit	CO 3	T1: 7.4
22	Hardwired control	CO 3	T1: 7.4
23	Micro Programmed Control	CO 3	T1: 7.1
24	Input or output organization: Peripheral devices	CO 3	T1: 11.1, 11.2
25	Input or output Interface	CO 3	T1: 11.1, 11.2
26	Modes of transfer, Priority interrupt	CO 4	T1: 11.4
27	Daisy Chaining Priority , Parallel Priority interrupt	CO 4	T1: 11.5
28	Priority Encoder, Direct memory access	CO 4	T1: 11.5
29	Input-Output Processor – CPU-IOP communication	CO 4	T1: 11.7
30	PCI Express, PCI physical and logical architecture	CO 4	T1: 11.8
31	Memory organization: Memory hierarchy and Main memory	CO 4	T1: 12.1, 12.2
32	Auxiliary memory, associative memory, Cache memory, virtual memory	CO 5	T1: 12.3, 12.4
33	Semiconductor RAMs – Internal organization	CO 5	T1: 13.5, 13.6
34	Static Memories, Dynamic RAMs	CO 5	T1: 13.5, 13.6
35	Synchronous and Asynchronous DRAMs	CO 5	T1: 13.5
36	Structure of larger memories	CO 5	T1: 13.7
37	Read-only memories, Cache memories – Mapping functions	CO 5	T1: 13.8
38	Nonvolatile Solid-State Memory Technologies , Solid state drives	CO 5	T1: 13.9
39	Pipeline and Vector Processing: Parallel processing, Pipelining-arithmetic pipeline	CO 6	T1: 9.1
40	Instruction pipeline	CO 6	T1: 9.4
41	Multiprocessors: Characteristics of multiprocessors	CO 6	T1: 13.1

S.No	Topics to be covered	CO's	Reference
42	Inter connection structures and Inter processor arbitration	CO 6	T1: 13.2, 13.3
43	Multicore Computers: Hardware performance issues, Software performance issues	CO 6	T1: 17.2, 17.3
44	Multicore organization, Intel Core i7-990X	CO 6	T1: 17.4
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on bus and address lines.	CO 1	
2	Problems on instruction sets.	CO 1	
3	Problems on computer arithmetic addition and subtraction.	CO 1	
4	Problems on multiplication and division.	CO 1	
5	Problems on addressing modes.	CO 2	
6	Problems on Timing and control.	CO 2	
7	Problems on Data Transfer and Manipulation.	CO 2	
8	Problems related to input-output operations and interrupts.	CO 3	
9	Problems related to interrupts.	CO 3	
10	Problems on direct memory access.	CO 4	
11	Nonvolatile Solid-State Memory Technologies..	CO 5	
12	Solid state drives.	CO 5	
13	Problems on arithmetic pipelining.	CO 6	
14	Problems on multiprocessors.	CO 6	
15	Problems on Vector Processing.	CO 6	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Register Transfer and Microoperations.	CO 1	
2	Organization of a Computer.	CO 2	
3	Microprogrammed control and Input-Output Organization.	CO 3, CO 4	
4	Memory Organization.	CO 5	
5	Multiprocessors.	CO 5 , CO 6	
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Register Transfer and Microoperations.	CO 1	
2	Organization of a Computer.	CO 2	
3	Microprogrammed control and Input-Output Organization.	CO 3, CO 4	
4	Memory Organization.	CO 5	
5	Multiprocessors.	CO 5 , CO 6	

23. Program outcomes and Program specific outcomes:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.

PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

24. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE
PO 2	**Problem analysis:** Identity, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and Environmental considerations.	3	CIE/SEE
PO 4	**Conduct investigations of complex problems:**Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Tech talk/Definitions and terminology
PO 12	**Life-Long Learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/SEE

25. How program-specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	3	Tech talk /Definitions and terminology/ Assignments
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	2	Tech talk /Definitions and terminology/ Assignments
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	3	Tech talk /Definitions and terminology/ Assignments

3 = High; 2 = Medium; 1 = Low

26. Mapping of each CO with PO(s), PSO(s):

COURSE OUTCOME	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	-	-		✓	✓	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-
CO 3	✓	✓	✓	✓	-	-	-	-	-	✓	-	-	✓	-	-
CO 4	✓	✓	-	✓	-	-	-	-	-	✓	-	-	✓	-	-
CO 5	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 6	✓	-	-	-	-	-	-	-	-	✓	-	✓	✓	-	✓

27. Justifications for CO – PO / PSO mapping - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain the various functional units of Computer with computer science principles.	1
	PO 2	Explore the types of programming languages for problem identification and to formulate computer science and Engineering Problems.	2
	PO 3	Evaluate the instruction set architecture based on the cost drivers, integration, manage design process and understand customer needs..	4

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	Demonstrate a thorough understanding of the basic concepts and principles of computer sytem architecture justify it with Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	1
	PSO 2	Parallel processing and optimized memory caching accelerate search algorithms, improving the speed and accuracy of large-scale information retrieval systems like search engines.	1
CO 2	PO1	Focus on improving software reliability, network security or information retrieval systems.	2
	PSO 1	Leveraging parallelism and efficient memory management enhances the performance of statistical models and tools, enabling faster analysis and visualization of large data sets.	2
	PSO 2	Optimizing CPU, memory hierarchy, and data buses, ensuring efficient data processing and communication elements enhances software reliability by improving fault tolerance, strengthens network security with faster encryption processes, and accelerates information retrieval through parallel data access.	3
CO 3	PO 1	Select appropriate addressing mode for finding effective address of operand using mathematical and computer science principles	2
	PO 2	Choose appropriate addressing mode for information and data collected from various sources memory locations or registers and perform microoperations and validation the results for interpretation	1
	PO 3	Classify the addressing modes in terms of defining various problems and understanding appropriate codes of practice.	3
	PO 4	Utilize Instruction set architecture of processors for designing assembly language programs through laboratory skills and technical literature.	2
	PO 10	Make use of variety of addressing modes to fetch operands for the development of assembly language program with clarity and semantics or grammar of the assembly language.	2
	PSO 1	Efficient memory handling allows statistical models to process large datasets effectively, enabling smooth analysis and visualization by maximizing memory use and minimizing delays.	1
CO 4	PO 1	Explain the concept of data representation by applying mathematical and computer science principles.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Understand the data representation and computer arithmetic for understanding of appropriate codes to formulate, solve problem, document and interpretation of results.	6
	PO 3	Identify the appropriate representation of data suitable for customer needs, investigation of a problem, identify and manage architecture design process.	4
	PO 4	Communicate effectively in orally and written by comprehend and write effective reports and design documentation with the engineering community by having major focus on clarity on content, Grammar/Punctuation, appropriate References, good Speaking style and depth in subject matter.	2
	PO 10	Recognize the need for advanced concepts in binary arithmetic and algorithms for developing applications through continuing education efforts with ongoing learning – stays up with industry trends/ new technology and continued personal development in the broadest context of technological change	3
	PSO 1	DMA's efficiency in handling large data transfers is ideal for building statistical models, enabling faster analysis and real-time visualization of large data sets.	1
CO 5	PO 1	Design control unit by considering various issues and types risk assessment and analysis activity to identify and analyze root causes using computer science principles.	1
	PO 2	Design and develop hardwired and micro programmed control units with knowledge and uncertainty of commercial engineering process and management.	2
	PO 3	Design a control memory of system by investigating and defining various problems, understanding user needs.	3
	PO 4	Utilize micro instructions for designing assembly language programs through laboratory skills, technical literature, technical uncertainty and quality issues.	3
	PO 10	Recognize the need for advanced concepts of control memory design and micro instructions based on micro architecture for developing applications through continuing education efforts with ongoing learning – stays up with industry trends/ new technology and continued personal development in the broadest context of technological change.	4
	PSO 1	The techniques are crucial for building statistical models and analyzing large datasets efficiently, enabling faster computations and real-time data visualization.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 3	Applying these principles, along with computing theory, mathematical models, and optimization techniques, enhances data analytics, enabling more accurate and faster solutions for complex problems.	1
CO 6	PO 1	Understand the concept of pipelining to improve performance of the system by applying mathematical principles and computer science methodologies.	2
	PO 10	Communicate in written form by comprehending and writing effective reports and design documentation advanced micro architectures with the engineering community by having major focus on clarity on content, Grammar/Punctuation, good Speaking style	2
	PO 12	Recognize the need for advanced concepts for developing applications through continuing education efforts with ongoing learning – stays up with industry trends/ new technology and continued personal development in the broadest context of technological change.	4
	PSO 1	The techniques are essential for building statistical models and analyzing large datasets, enabling faster computations and seamless visualization of complex data patterns.	1
	PSO 3	Leveraging the concepts, along with computing theory, mathematical models, and optimization techniques, enhances data analytics systems, providing faster and more efficient solutions.	1

28. Total count of key competencies for CO – PO / PSO mapping:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	2	4	-	-	-	-	-	-	-	-	-	1	1	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	2	3	-
CO 3	2	2	1	3	-	-	-	-	-	2	-	2	1	-	-
CO 4	3	6	-	4	-	-	-	-	-	2	-	3	1	-	-
CO 5	1	2	3	3	-	-	-	-	-	2	-	4	1	-	2
CO 6	2	-	-	-	-	-	-	-	-	2	-	4	1	-	1

29. Percentage of key competencies CO – PO / PSO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.4	20	40	-	-	-	-	-	-	-	-	-	20	9	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-	-	40	27.2	-
CO 3	66.6	20	10	27.3	-	-	-	-	-	20	-	16.6	20	-	-
CO 4	100.0	60	-	36.4	-	-	-	-	-	20	-	25	20	-	-
CO 5	33.4	20	30	27.3	-	-	-	-	-	20	-	33.4	20	-	28.5
CO 6	66.6	-	-	-	-	-	-	-	-	20	-	33.4	20	-	14.2

30. Course articulation matrix PO / PSO mapping:

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0$\leq$ C$\leq$ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	2	-	-	-	-	-	-	-	-		1	1	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	1	1	-
CO 3	3	1	1	1	-	-	-	-	-	1	-	1	1	-	-
CO 4	3	3	-	1	-	-	-	-	-	1	-	1	1	-	-
CO 5	1	1	1	1	-	-	-	-	-	1	-	1	1	-	1
CO 6	3	-	-	-	-	-	-	-	-	1	-	1	1	-	1
TOTAL	14	6	4	3	-	-	-	-	-	4	-	4	6	2	2
AVERAGE	2.3	1.5	2.6	1	-	-	-	-	-	1	-	1	1	1	1

31. Assessment methodology - Direct:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Definitions and Terminology	✓	Tech talk / 5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓	Tech Talk	✓

32. Assessment methodology - Indirect:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write a brief description of the course and its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality education:** Guarantee an education system that is both inclusive and fair, offering high-quality learning experiences and lifelong opportunities accessible to all.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	

7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, innovation, and infrastructure:** Strong skills in CSA enable to design and development of services like memory technology, data processing in a modular and maintainable way, contributing to a more flexible and scalable infrastructure.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable cities and communities:** CSA skills can develop software solutions that contribute to urban sustainability, improve quality of life, and address challenges like smart city solutions, energy efficiency and monitoring, waste management systems, public transportation optimization, environmental sensor networks, education, and awareness faced by modern cities.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on 22-08-2023.

Signature of Course Coordinator **HOD DS**
Dr Ganapathi Rao Gajula, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**COMPUTER SCIENCE AND ENGINEERING(DS)**				
2	Course code	**ACSD09**				
3	Course Title	**OPERATING SYSTEMS**				
4	Class / Semester	II /III				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 0 hours		Practical: – hours	
10	Course Coordinator	Ms. B.Indu				
11	Date Approved by BOS	28/08/2023				
12	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse				
13	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		-	-	-	-	

14. Course Overview

The Operating Systems course provides a comprehensive understanding of how software manages hardware resources and provides essential services for applications. It covers key concepts such as process management, memory management, file systems, and system calls. Students will explore the design and implementation of modern operating systems, including concepts like concurrency, synchronization, and virtual memory. Practical experience is gained through hands-on projects and exercises that simulate real-world system management challenges

15. Course Objectives:

The students will try to learn:

I	The principles of operating systems, services and functionalities with its evolution.
II	The structures, functions and components of modern operating systems.
III	The conventional hardware at different OS abstraction levels.
IV	The essential skills to examine issues and methods employed in design of operating systems with identification of various functionalities.

16. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** different architectures used in the design of modern operating systems.	Understand
CO 2	**Solve** problems related to process scheduling, synchronization, and deadlock handling in uniprocessor and multi-processing systems.	Apply
CO 3	**Implement** memory allocation algorithms for effective utilization of resources.	Apply
CO 4	**Select** various page replacement algorithms applied for the allocation of frames.	Analyze
CO 5	**Analyze** different file allocation methods and disk scheduling algorithms applied for efficient utilization of storage.	Analyze
CO 6	**Outline** mechanisms used in the protection of resources in real-time environment.	Understand

17. Topic Learning Outcome (TLOs):

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
1	Operating systems objectives and functions	1	**Summarize** the objectives and core functions of operating systems ,providing foundational knowledge.	CO 1	Understand
		2	**Discuss** the importance of operating systems in coordinating system activities, ensuring seamless operation.	CO 1	Understand
		3	**Explain** how operating systems manage hardware and software resources leading to system efficiency.	CO 1	Understand
2	Evolution of operating systems	4	**Summarize** the historical development of operating systems from batch to real-time systems.	CO 1	Understand

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		5	**Evaluate** the impact of technological advancements on the evolution of operating systems.	CO 1	Analyze
		6	**Compare** different types of operating systems, highlighting their evolution and modern applications.	CO 1	Analyze
3	System calls and user interface	7	**Summarize** the purpose and types of system calls, explaining their role in OS operations.	CO 1	Remember
		8	**Explain** how user interfaces interact with system calls, leading to improved user experience.	CO 1	Understand
		9	**Analyze** how system programs utilize system calls for executing complex tasks efficiently.	CO 1	Analyze
4	Process concepts and states	10	**Explain** the concept of a process and its various states, leading to effective process management.	CO 2	Understand
		11	**Analyze** the role of the Process Control Block (PCB) in managing process information.	CO 2	Analyze
		12	**Compare** the transitions between different process states, understanding the process lifecycle.	CO 2	Remember
5	Process scheduling algorithms	13	**Describe** various process scheduling algorithms, focusing on optimizing CPU utilization.) within different parts of a program.	CO 2	Understand
		14	**Evaluate** scheduling algorithms based on efficiency criteria to optimize process scheduling.	CO 2	Evaluate
		15	**Compare** preemptive and non-preemptive scheduling approaches to identify their advantages and disadvantages.	CO 2	Analyze
6	Process synchronization	16	**Explain** the critical section problem and its relevance in ensuring process synchronization.	CO 2	Understand
		17	**Apply** synchronization techniques such as semaphores and monitors to solve synchronization challenges.	CO 2	Apply

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		18	**Analyze** deadlock situations and apply methods to prevent and resolve deadlocks.	CO 2	Apply
7	Memory management techniques	19	**Summarize** memory management techniques such as paging and segmentation for effective resource allocation.	CO 3	Understand
		20	**Analyze** the role of virtual memory in modern operating systems and its impact on performance.	CO 3	Analyze
		21	**Evaluate** different page replacement algorithms to improve system performance.	CO 3	Evaluate
8	Page replacement algorithms	22	**Explain** the concept of page replacement in memory management, ensuring optimal memory usage.	CO 4	Understand
		23	**Compare** common page replacement algorithms, such as FIFO and LRU, to select the best fit for different scenarios.	CO 4	Analyze
		24	**Use** Analyze to minimize its impact on system performance.	CO 4	Analyze
9	File system structure	25	**Summarize** the structure and organization of file systems, enabling efficient data storage and access.	CO 5	Understand
		26	**Analyze** different file allocation methods to optimize file storage and retrieval.	CO 5	Analyze
		27	**Analyze** swap space management techniques for efficient resource utilization in operating systems.	CO 5	Analyze
10	Deadlocks	28	**Explain** the characteristics of deadlocks and their impact on system performance.	CO 6	Understand
		29	**Apply** methods to prevent, avoid, and recover from deadlocks in system operations.	CO 6	Apply
		30	**Analyze** deadlock detection techniques to ensure system reliability.	CO 6	Remember

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Outcome	Blooms Level
11	Protection mechanisms	31	**Summarize** the principles of protection in operating systems to safeguard resources.	CO 6	Understand
		32	**Explain** various access control mechanisms to secure system resources from unauthorized access.	CO 6	Understand
		33	**Evaluate** capability-based systems and language-based protection mechanisms to implement robust security strategies.	CO 6	Evaluate

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - Problem-Solving Develop the ability to analyze, design, and implement solutions to complex programming challenges using various algorithms and data structures.Code Efficiency Enhance programming skills by writing optimized, clean, and maintainable code that effectively utilizes system resources.
2. Project-based skills - Project Planning and Management Develop the ability to plan, organize, and manage projects from inception to completion, including setting milestones, allocating resources, and meeting deadlines.Collaboration and Teamwork Enhance skills in working effectively within a team, communicating clearly, and integrating diverse ideas to achieve project goals collaboratively.

19. Content Delivery / Instructional Methologies:

✓	Power Point Presentation	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definitions and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.
Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given in the first two modules. Each question carries 12 marks. There could be a maximum of two sub-divisions in a question.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE:

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

21. Course content - Number of modules: Five

‘

MODULE I	**Introduction** | **Number of Lectures: 09**
	Operating systems objectives and functions: Computer system architecture,operating systems structure, operating systems operations; Evolution of operating systems: Simple batch, multi programmed, time shared, personal computer, parallel distributed systems, real time systems, special purpose systems, operating system services, user operating systems interface; Systems calls: Types of systems calls, system programs, protection and security, operating system design and implementation, operating systems structure,virtual machines.
MODULE II	**Process and CPU Scheduling Process Co-ordination** | **Number of Lectures: 09**
	Process concepts: The process, process state, process control block, threads;Process scheduling: Scheduling queues, schedulers, context switch, preemptive scheduling, dispatcher, scheduling criteria, scheduling algorithms, multiple processor scheduling; Real time scheduling; Thread scheduling; Case studies Linux windows; Process synchronization, the critical section problem;Peterson‘s solution, synchronization hardware, semaphores and classic problems of synchronization, monitors
MODULE III	**Memory Mansgement and Virtual Memory**| **Number of Lectures: 09**
	Logical and physical address space: Swapping, contiguous memory allocation,paging, structure of page table. Segmentation: Segmentation with paging,virtual memory, demand paging; Performance of demand paging: Page replacement, page replacement algorithms, allocation of frames, thrashing
MODULE IV	**File System Interface, Mass-Storage Structure**| **Number of Lectures: 09**
	The concept of a file, access methods, directory structure, file system mounting, file sharing, protection, file system structure, file system implementation, allocation methods, free space management, directory implementation, efficiency and performance; Overview of mass storage structure: Disk structure, disk attachment, disk scheduling, disk management, swap space management; Dynamic memory allocation: Basic concepts; Library functions.

MODULE V	**Deadlocks, Protection** | **Number of Lectures: 09**
	System model: Deadlock characterization, methods of handling deadlocks,deadlock prevention, dead lock avoidance, dead lock detection and recovery form deadlock system protection, goals of protection, principles of protection, domain of protection, access matrix, implementation of access matrix, access control, revocation of access rights, capability based systems, language based protection

TEXTBOOKS

1. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, —Operating System Principles‖,Wiley Student Edition, 8th Edition, 2010.
2. William Stallings, —Operating System- Internals and Design Principles‖, Pearson Education, 6th Edition, 2002.

REFERENCE BOOKS:

1. Andrew S Tanenbaum,—Modern Operating Systems‖, PHI, 3rd Edition, 2007.
2. D. M. Dhamdhere,—Operating Systems a Concept based Approach, Tata McGraw-Hill, 2nd Edition, 200

MATERIALS ONLINE:

1. www.smartzworld.com/notes/operatingsystems
2. www.scoopworld.in
3. www.sxecw.edu.in
4. www.technofest2u.blogspot.com

22. Course plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
Discussion on Outcome Based Education, CO, POs, and PSOs			
CONTENT DELIVERY (THEORY)			
1	Computer system architecture, operating systems structure	CO 1	T1:1.1-1.4
2	operating systems operations	CO 1	T1:1.5
3	Evolution of operating systems: Simple batch, multi programmed, time shared, personal computer	CO 1	T2:2.2
4	parallel distributed systems, real time systems, special purpose systems,	CO 1	T2:2.2
5	operating system services, user operating systems interface	CO 1	T2:2.1-2.2

S.No	Topics to be covered	CO's	Reference
6	Systems calls: Types of systems calls, system programs	CO 1	T2:2.3-2.5
7	protection and security, operating system design and implementation	CO 1	T1:2.6
8	operating systems structure, virtual machines.	CO 1	T1:2.7-2.8
9	Process concepts: The process, process state	CO 2	T1:3.1-3.2
10	process control block, threads;	CO 2	T1:3.2-3.4
11	Process scheduling: Scheduling queues, schedulers, context switch	CO 2	T1:5.2
12	preemptive scheduling, dispatcher, scheduling criteria	CO 2	T1:5.3
13	scheduling algorithms	CO 2	T1:5.3
14	multiple processor scheduling	CO 2	T1:5.3
15	Real time scheduling; Thread scheduling;	CO 2	T1:5.4-5.5
16	Case studies Linux windows	CO 2	T1:5.6, 21.4
17	Process synchronization, the critical section problem	CO 2	T1:6.1
18	Peterson's solution	CO 2	T1:6.2-6.3
19	synchronization hardware	CO 2	T1:6.4
20	semaphores, classic problems of synchronization, monitors	CO 2	T1:6.7
21	Logical and physical address space: Swapping, contiguous memory allocation	CO 3	T1:8.1
22	paging, structure of page table	CO 3	T1:8.2
23	Segmentation: Segmentation with paging	CO 3	T1:8.3
24	virtual memory, demand paging,Performance of demand paging	CO 3	T1:8.4-8.6
25	Page replacement, page replacement algorithms,	CO 4	T1:8.6
26	allocation of frames,Thrashing	CO 4	T1:9.6
27	The concept of a file, access methods,directory structure	CO 4	T1:10.1-10.3
28	file system mounting,file sharing, protection	CO 4	T1:10.6
29	file system structure	CO 4	T1:10.6
30	file system implementation	CO 4	T1:11.3
31	allocation methods	CO 4	T1:11.4
32	free space management,directory implementation, efficiency and performance	CO 4	T1:11.6
33	Overview of mass storage structure: Disk structure, disk attachment	CO 5	T1:12.1-12.3
34	disk scheduling, disk management, swap space management	CO 5	T1:12.4-12.6
35	Dynamic memory allocation: Basic concepts; Library functions.	CO 5	T1:12.7-12.8
36	System model: Deadlock characterization, methods of handling deadlocks	CO 6	T1:7.1-7.2

S.No	Topics to be covered	CO's	Reference
37	deadlock prevention,deadlock avoidance,dead lock detection and recovery form deadlock system protection	CO6	T1:8.3
38	goals of protection, principles of protection, domain of protection	CO 6	T2:27.8
39	access matrix, implementation of access matrix, access control, revocation of access rights	CO 6	T2:27.9
40	capability based systems, language based protection	CO 6	T1:8.2-8.3
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on CPU scheduling algorithms	CO 2	T1:5.3-5.3
2	Problems on contiguous memory allocation	CO 3	T1:8.1-8.3
3	Problems on paging and segmentation	CO 3	T1:8.4-8.6 T1:9.1-9.2
4	Problems on segmentation	CO 3	T1:8.4-8.6 T1:9.1-9.2
5	Problems on page replacement algorithms	CO 4	T1:9.4-9.6
6	Problems on file allocation methods	CO 5	T1:11.3-11.6
7	Problems on disk scheduling	CO 5	T1:12.1-12.6
8	Problems on deadlock avoidance	CO 2	T1:8.1-8.3
9	Problems on recovery from deadlocks	CO 2	T1:8.1-8.3
10	Problems on deadlock prevention	CO 2	T1:8.1-8.3
11	Problems on Protection	CO 6	T1:8.2-8.3
12	Problems on Synchronization	CO 2	T1:8.2-8.3
13	Problems on thrashing	CO 4	T1:9.6
14	Problems on deadlock prevention	CO 2	T1:8.3
15	Problems on dynamic memory allocation	CO 5	T1:12.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions on operating systems fundamentals	CO 1	T1:1.2
2	Definitions on process, CPU scheduling and process coordination	CO 2	T1:1.5
3	Definitions on memory management and virtual memory	CO 3, CO 4	T1:8,9
4	Definitions on file system interface and mass storage structure	CO 5	T1:10,11
5	Definitions on deadlocks and protection	CO 2, CO 6	T1:9.1
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Introduction	CO 1	T1:1.2
2	Process and CPU Scheduling, Process Coordination	CO 2	T1:1.5
3	Memory Management and Virtual Memory	CO 3,4	T1:8,9
4	File System and Mass Storage Structure	CO 5	T1:10,11
5	Deadlocks, Protection	CO 2,6	T1: 9.1

23. Program outcomes and Program specific outcomes:

PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.

PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

24. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2.7	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.5	SEE / CIE / AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE / CIE / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	SEE / CIE / AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1.7	SEE / CIE / AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	SEE / CIE / AAT

25. How program-specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation..	2.5	SEE/AAT
PSO 2	Focus on improving software reliability, network security or information retrieval systems..	3	SEE/AAT
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	2	SEE/AAT

3 = High; 2 = Medium; 1 = Low

26. Mapping of each CO with PO(s), PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 2	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	✓	-
CO 3	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 4	✓	✓	✓	✓	-	-	-	-	-	✓	-	-	✓	✓	-
CO 5	✓	✓	✓	-	-	-	-	-	-	✓	-	✓	✓	-	-
CO 6	✓	-	-	-	-	-	-	-	-	✓	-	✓	✓	✓	✓

27. Justifications for CO – PO / PSO mapping - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the structure and evolution of operating system by understanding fundamentals of Computer engineering specialization and mathematical and scientific principles.	3
	PO 10	Communicate effectively on evolution of operating systems including deep subject knowledge.	1
	PO 12	By understanding different operating system architectures, one can personally continue understanding of different operating systems developed by the companies to stay up with new technology and for personal development.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	Statistical models like regression and clustering, along with tools like Python and R, enable effective analysis and visualization of large OS data sets for performance optimization.	2
	PSO 3	By applying computing theory, mathematical models, statistical methods, and optimization techniques, data analytics can drive efficient solutions for system resource management and performance tuning.	2
CO 2	PO 1	Understand the concept of Process, process scheduling, issues and their solutions related to process synchronization by using mathematical principles, fundamental of Computer engineering specialization and scientific principles.	3
	PO 2	Identify synchronization problem and understand the problem statement of classical synchronization problems collect the data needed for solving the problem then analyze different models of solutions for classical synchronization problems by semaphores and monitors and interpret the solutions	6
	PO 3	Define the process synchronization problem, understand the user needs then identify the resources required next manage the design process using banker's algorithm and evaluate outcomes.	4
	PO 4	By having the knowledge of characteristics of process and understanding the context in classical synchronization problems and the solutions provided using the technical constructs like semaphores and monitors with their working strategies, these can be applied for understanding of other synchronization problems.	5
	PO 10	Communicate effectively on process communication using process communication techniques and explaining each technique.	2
	PO 12	By understanding process management, one can personally continue understanding internal functioning of operating systems developed by the companies to stay up with new technology and for personal development.	2
	PSO 1	Statistical models, such as queueing theory and time series analysis, alongside tools like Python and R, enable the analysis and visualization of large data sets for performance optimization.	4

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 2	To solve process scheduling, synchronization, and deadlock handling in uniprocessor and multi-processing systems, algorithms like priority scheduling and semaphores are applied to optimize resource management.	2
CO 3	PO 1	Describe the need and various techniques for memory management by understanding the limits of contiguous memory allocation through applying mathematical principles, fundamental of Computer engineering specialization and scientific principles	3
	PO 2	Identify problem of memory management and understand the problem statement of contiguous memory management then analyze different models of non-contiguous memory management.	3
	PO 3	Define the problem related to contiguous memory management, understand the user needs then identify the memory requirements of each process next manage the design process by using non-contiguous memory management techniques and evaluate outcomes.	4
	PO 10	Communicate effectively on memory management techniques with clarity on contiguous and varied strategies and explaining each technique with appropriate terminology.	2
‘	PSO 1	By using statistical models such as regression and clustering, along with tools like Python and R, large data sets can be analyzed and visualized to enhance memory management and system performance.	4
CO 4	PO 1	Understand the concept of virtual memory and various algorithms for effective usage of memory by applying the knowledge of computer engineering fundamentals, mathematical and scientific principles.	3
	PO 2	Identify the need for page replacement, understand the problem statement of allocation of pages to frames, then collect the data related to available pages and frames then analyze various models for solving problem based on the given sequence of pages and interpret their results accordingly.	6
	PO 3	Define the problem of mapping of large virtual memory to the existing physical memory, understand the user needs then manage the design process using page replacement algorithms and evaluate outcomes by identifying the number of page faults incurred.	4

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	By understanding characteristics of process, understanding the context in virtual memory management using demand paging and segmentation, this knowledge can be applied for virtualizing engineering process.	4
	PO 10	Communicate on utilization of main memory using pictorial representation of demand paging and segmentation and explaining them in detail.	2
	PSO 1	Statistical models such as time series analysis, coupled with tools like Python and R, can analyze memory access patterns and visualize data for optimizing algorithm performance and minimizing page faults.	2
	PSO 2	The page replacement algorithms like LRU, FIFO, and Optimal techniques enhance software reliability, strengthen network security by preventing resource exhaustion, and optimize information retrieval systems for faster, more reliable data access.	2
CO 5	PO 1	Understand the concept of file system and analyze various file allocation methods by using the knowledge of computer engineering fundamentals, mathematical and scientific principles.	3
	PO 2	Identify the need for disk scheduling, understand the problem statement of disk scheduling, then collect the data related to location of data to be accessed in the disk structure then analyze different scheduling algorithm models used for solving problems related to finding total head movements and interpret their results.	6
	PO 3	Define the problem of file allocation to disk block, understand the user needs then identify the free disk space available next manage the design process by using appropriate file allocation methods.	4
	PO 10	Communicate on effective utilization of mass storage structures clearly using pictorial representation of disk structure.	2
	PO 12	By understanding mass storage structure, one can personally continue understanding of different storage devices developed by the companies to stay up with new technology.	2
	PSO 1	The regression and clustering, and tools like Python and R can be used to analyze disk access patterns and visualize data for optimizing storage performance and resource management..	4

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 1	Explain the importance of protection of objects and the protection provided for them by using domain concept in terms of access matrix implementation by applying knowledge of computer science fundamentals.	1
	PO 10	Communicate on protection of computer system components using protection strategies in detail.	1
	PO 12	By understanding the concept of protection, one can study and analyze various protection mechanisms developed recently for personal development.	2
	PSO 1	The access control lists (ACLs), encryption, and priority-based scheduling to protect resources in real-time environments.	2
	PSO 2	Enhance software reliability, fortify network security, and optimize information retrieval systems by ensuring secure, efficient, and timely access to critical resources.	2
	PSO 3	By applying computing theory, mathematical models, and statistical methods, along with optimization techniques, data analytics can enhance resource protection and ensure efficient, secure system operations.	2

28. Total count of key competencies for CO – PO / PSO mapping:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	1	-	2	2	-	2
CO 2	3	6	4	5	-	-	-	-	-	2	-	2	4	2	-
CO 3	3	3	4	-	-	-	-	-	-	2	-	-	4		-
CO 4	3	6	4	4	-	-	-	-	-	2	-	-	2	2	-
CO 5	3	6	4	-	-	-	-	-	-	2	-	2	4	-	-
CO 6	1	-	-	-	-	-	-	-	-	1	-	2	2	2	2

29. Percentage of key competencies CO – PO / PSO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	20	-	25	50		50
CO 2	100	60	40	45	-	-	-	-	-	40	-	25	100	100	-
CO 3	100	30	40	-	-	-	-	-	-	40	-	-	100	-	-
CO 4	100	60	40	36	-	-	-	-	-	40	-	-	50	100	-
CO 5	100	60	40	-	-	-	-	-	-	40	-	25	100	-	-
CO 6	33	-	-	-	-	-	-	-	-	20	-	25	50	100	50

30. Course articulation matrix PO / PSO mapping:

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	1	-	1	2	-	2
CO 2	3	3	2	2	-	-	-	-	-	2	-	1	3	3	-
CO 3	3	1	2	-	-	-	-	-	-	2	-	-	3	-	-
CO 4	3	3	2	2	-	-	-	-	-	2	-	-	2	3	-
CO 5	3	3	2	-	-	-	-	-	-	2	-	1	3	-	-
CO 6	1	-	-	-	-	-	-	-	-	1	-	1	2	3	2
TOTAL	16	10	8	4	-	-	-	-	-	10	-	4	15	9	4
AVERAGE	2.7	2.5	2	2	-	-	-	-	-	1.7	-	1	2.5	3	2

31. Assessment methodology - Direct:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Definitions and Terminology	✓	Tech talk / 5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓	Tech Talk	✓

32. Assessment methodology - Indirect:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write a brief description of the course and its relevance to SDGs.

1		
2		
3		
4		**Quality education:** The Operating Systems equips students with essential skills to manage and optimize digital systems, fostering analytical thinking and problem-solving, which supports by promoting inclusive and equitable quality education.
5		
6		

7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, innovation, and infrastructure:** The Operating Systems is crucial for developing the technical expertise needed to innovate and maintain robust digital infrastructures, directly contributing by supporting industry growth and technological advancement.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable cities and communities:** The Operating Systems empowers students to create efficient, secure, and resilient digital systems, supporting by enabling the development of sustainable and smart city infrastructures.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on 28-08-2023.

Signature of Course Coordinator
Ms. B.Indu, Assistant Professor

HOD CSE(DS)

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	CSE(DATA SCIENCE)				
2	Course code	ACDD01				
3	Course Title	DISCRETE MATHEMATICAL STRUCTURES				
4	Semester	III				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	-	3	-	-
7	Type of course (Tick type of course)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)					
	Lectures: 48 hours		Tutorials: 0 hours		Practical: – hours	
10	Course Coordinator	Dr. S.Sreekanth				
11	Date Approved by BOS	28/08/2023				
12	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/ACDD01.pdf				
13	Course Prerequistes	Level	Course Code	Semester	Prerequisites	
		-	-	-	-	

14. Course Overview

The purpose of this course is to provide a clear understanding of the concepts that underlying fundementias with emphasis on their applications to computer science. It highlights mathematical definitions and proofs as well as applicable methods. The contents include formal logic notation, proof methods; induction, well- ordering; sets, relations; growth of functions; permutations and combinations, counting principles, recurrence equations, trees and more general graphs.

15. Course Objectives:

The students will try to learn:

I	The fundamental knowledge of statement notations and logical connectives which are used to convert English sentences into logical expressions..
II	Properties of binary relations, equivalence, compatibility and partial ordering relations, lattices, Hasse diagram; Functions: Inverse function, composition of functions, recursive functions; Lattices: Lattices as partially ordered sets; Definition and examples, properties of lattices, sub lattices, some special lattices
III	The effective use of combinatory principles for calculating probabilities and solving counting problems.
IV	Finding the solution of linear homogeneous and non homogeneius recurrence relations by substitution and generating function method
V	The effective use of graph theory in subsequent fields of study such as computer networks, and algorithms for solving real world engineering problems.

16. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	**Compute** mathematical definitions and its notations to convert statements from common language to formal logic and reduce its equivalent forms	Understand
CO 2	**Apply** the rules of inference and explore the conclusion of the implication and implement the knowledge of rules of inference for predicate logic of single and two variables .	Apply
CO 3	**Calculate** from Properties of binary relations interpret equivalence, compatibility, partial ordering relations,Lattice theory and Using the concept of function find Inverse, composition and recursive functions.	Apply
CO 4	**Demonstrate** the theoretical concepts of algebraic structures to find semi groups, monoids , groups, sub groups ,homomorphism, isomorphism, rings and Permutations and combinatorics concepts to solve practical and abstract mathematical problems.	Apply
CO 5	**Compute** generating function for different sequence of functions and Solve the homogeneous and nonhomogeneous recurrence relations by Using substitution method and generating function.	Apply
CO 6	**Understand** the fundamental concepts of graphs, properties of graph isomorphism, Eulerian, Hamiltonian graphs, planar graphs,coloring techniques to determine the chromatic number of a graph,spanning trees and Demonstrate the ability to find minimal spanning trees in weighted graphs using algorithms like Prim's and Kruskal's	Understand

17. Topic Learning Outcome (TLOs):

— S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
1	Mathematical Logic	1	**Understand** the use of logical statements and notations to represent mathematical propositions.	CO 1	Understand
		2	**Identify** and apply logical connectives (e.g., AND, OR, NOT, CONDITIONAL and BICONDITIONAL) to construct and interpret complex logical statements.	CO 1	Understand
		3	**Construct** well-formed formulas (WFFs) in propositional logic, ensuring they adhere to the syntactic rules of logic.	CO 1	Understand
		4	**Identify** the cocepts of tautologies, logical equivalence, and implications, and apply these concepts to simplify and solve logical expressions. ensuring they adhere to the syntactic rules of logic.	CO 1	Understand
		5	**Develope** truth tables for logical statements to determine their truth values under various interpretations.	CO 1	Understand
2	Normal Forms	6	**Convert** logical expressions into disjunctive normal forms (DNF) and understand their significance in simplifying logical problems.	CO 1	understand
		7	**Express** the logical statements in conjunctive normal forms (CNF) and apply these forms in the context of problem-solving and logical analysis.	CO 1	Understand
		8	**Differentiate** between principal disjunctive and conjunctive normal forms and apply them to represent logical expressions in their most simplified forms.	CO 1	Apply
3	Predicate Calculus	9	**Understand** the foundations of predicate logic and distinguish between propositional logic and predicate logic in terms of scope and application.	CO2	Understand

— S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		10	**Define** and work with statement functions, variables, and quantifiers (universal and existential) to express logical statements involving predicates.	CO2	Remember
		11	**Identify** free and bound variables within logical expressions and understand their role in the interpretation and manipulation of predicates.	CO 2	Remember
		12	**Apply** the rules of inference to derive conclusions from given premises, ensuring logical consistency and validity in argumentation.	CO 2	Remember
		13	**Demonstrate** the ability to prove consistency within a logical system and use proof by contradiction to validate or refute logical propositions.	CO 2	Understand
4	Relations	14	**Apply** the properties of binary relations, including reflexivity, symmetry, antisymmetry, and transitivity, and apply these properties to identify specific types of relations.	CO 3	Apply
		15	**Demonstrate** the equivalence relations and their application in partitioning sets into equivalence classes.	CO 3	Understand
		16	**Apply** the concepts of compatibility and partial ordering relations to organize elements within a set according to a specific hierarchy.	CO 2	Apply
		17	**Use** Hasse diagrams to visually represent partial orders and lattices, and analyze their structure to understand relationships between elements in a set.	CO 3	Apply

— S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
5	Functions	18	**Apply** the concept of a function,inverse of a function, and Perform the composition of functions and interpret the results in the context of combining multiple operations or transformations.	CO 3	Apply
		19	**Apply** the concept of recursive functions, recognizing their role in defining sequences, processes, and mathematical functions.	CO 3	Apply
6	Lattices	20	**Apply** the properties of lattices, including the concepts of meet and join, to solve problems involving order and structure.	CO 3	Apply
		21	**Explore** the special types of lattices, such as distributive and modular lattices, their unique properties and applications.	CO 3	Apply
7	Algebraic Systems	22	**Understand** the fundamental concepts of algebraic systems for semigroups and monoids, focusing on the associative property and the existence of an identity element in monoids.	CO 4	Understand
		23	**Acquire** the basic concepts of a group, and explore its properties, including closure, associativity, identity, and inverses, with examples from various mathematical contexts.	CO 4	Apply
		24	**Apply** the concepts of homomorphism and isomorphism to demonstrate the relationships and structural similarities between different algebraic systems.	CO 4	Apply
		25	**Explore** the basic concept of rings, and their properties, including the distributive property, and understand their role as algebraic systems combining both addition and multiplication operations.	CO 4	Understand

— S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
8	Combinatory	26	**Apply** the fundamental counting principles to solve problems involving the enumeration of possible outcomes in various scenarios.	CO 4	Apply
		27	**Differentiate** between permutations and combinations, and compute combinations to solve problems involving selection of objects from a set.	CO 4	Understand
		28	**Compute** permutations and combinations with repetitions, and their application in more complex counting problems.	CO 4	Apply
		29	**Apply** binomial and Multinomial theorems to related combinatorial problems, involving multiple variables in their expansions.	CO 4	Apply
		30	**Use** the generalized inclusion-exclusion principle to calculate the cardinality of unions of multiple sets, accounting for overlaps, and apply it in complex counting problems.	CO 4	Understand
9	Recurrence Relations	31	**Understand** how generating functions can represent and manipulate sequences in various mathematical contexts.	CO 5	Understand
		32	**Formulate** recurrence relations, recognizing their role in describing sequences and iterative processes in mathematics and computer science.	CO 5	Understand
		33	**Solve** recurrence relations, transforming them into simpler forms or explicit formulas using the method of substitution	CO 5	Apply
		34	**Solve** recurrence relations, converting them into algebraic equations that can be solved systematically.using the method of generating function	CO 5	Apply

— S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		35	**Solve** homogeneous recurrence relations using the method of characteristic roots, for traceing general solutions and particular solutions based on initial conditions.	CO 5	Apply
10	Graphs	36	**Understand** the fundamental concepts and terminologies of graph theory, including vertices, edges, degree, and types of graphs.	CO 6	Understand
		37	**Demonstrate** the concept of graph isomorphism, recognizing when two graphs are structurally identical despite differing in representation.	CO 6	Understand
		38	**Apply** Euler's theorem to determine the existence of an Eulerian path or circuit in a given graph. and whether a graph contains a Hamiltonian cycle or path.	CO 6	Apply
		39	**Apply** Kuratowski's theorem to determine if a graph is planar, including the use of graph drawing techniques.	CO 6	Apply
		40	**Determine** the chromatic number of a graph by considering graph coloring techniques , and solve problems related to scheduling, map coloring, and other real-world applications.	CO 6	Understand
		41	**Solve** weighted digraphs related to shortest paths, network flows, and optimization in weighted networks.	CO 6	Apply
		41	**Explain** the concept of region graphs and graph coloring principles to determine the chromatic number,	CO 6	Apply
11	Trees	42	**Understand** the properties and structure of trees, including rooted trees, to reprasent hierarchical modeling and various algorithmic problems.	CO 6	Understand

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		43	**Apply** the concept of spanning trees and use the corresponding algorithms such as Prim's and Kruskal's to find minimal spanning trees in weighted graphs, optimizing for the minimum total weight or cost in network connections.	CO 6	Apply

18. Content Delivery / Instructional Methologies:

✓	Power Point Presentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Project-based skills - Creating projects that utilize Graph theory principles allows a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how graph concepts will work in practice.

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definitions and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.
Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. No choice is given in the first two modules. Each question carries 12 marks. There could be a maximum of two sub-divisions in a question.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE:

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

21. Course content - Number of modules: Five

MODULE I	**MATHEMATICAL LOGIC AND PREDICATES | Number of Lectures: 10**
	Mathematical logic: Statements and notations, connectives, well-formed formulas, truth tables,tautology, equivalence implication; Normal forms: Disjunctive normal forms, conjunctive normal forms, principle disjunctive normal forms, principle conjunctive normal forms; Predicatecalculus: Predicative logic, statement functions, variables and quantifiers, free and bound variables, rules of inference, consistency, proof of contradiction. **Abstraction:** Layers of abstraction, forms of abstraction, abstraction mechanisms.
MODULE II	**RELATIONS, FUNCTIONS AND LATTICES | Number of Lectures: 09**
	Relations: Properties of binary relations, equivalence, compatibility and partial ordering relations, lattices, Hasse diagram; Functions: Inverse function, composition of functions,recursive functions; Lattices: Lattices as partially ordered sets; Definition and examples, properties of lattices, sub lattices, some special lattices
MODULE III	**ALGEBRAIC STRUCTURES AND COMBINATORICS | Number of Lectures: 10**
	Algebraic structures: Algebraic systems, examples and general properties, semi groups and monoids, groups, sub groups, homomorphism, isomorphism, rings. **Combinatory: The fundamental counting principles, permutations, disarrangements, combinations, permutations and combinations with repetitions, the binomial theorem, multinomial theorem, generalized inclusion exclusion principle**
MODULE IV	**RECURRENCE RELATION | Number of Lectures: 10**
	Recurrence relation: Generating functions, function of sequences calculating coefficient of generating function, recurrence relations, solving recurrence relation by substitution and generating functions, Characteristics roots solution of homogeneous recurrence relation.

MODULE V	GRAPHS AND TREES | Number of Lectures: 09
	Graphs: Basic concepts of graphs, isomorphic graphs, Euler graphs, Hamiltonian graphs, planar graphs, graph coloring, digraphs, directed acyclic graphs, weighted digraphs, region graph, chromatic numbers **Trees:** Trees,spanning trees, minimal spanning trees.

TEXTBOOKS

1. J. P. Tremblay, R. Manohar *"Discrete Mathematical Structures with Applications to Computer Science"*, TataMcGraw Hill, India, 1st edition, 1997.
2. JoeL. Mott, Abraham Kandel, Theodore P. Baker,*"Discrete Mathematics for Computer Scientists and Mathematicians"*, Prentice Hall of India Learning Private Limited, New Delhi, India, 2nd edition, 2010.

REFERENCE BOOKS:

1. Kenneth H. Rosen, *"Discrete Mathematics and Its Applications"*, Tata Mcgraw-Hill, New Delhi, India, 6th edition, 2012.
2. C. L. Liu, D. P. Mohapatra, *"Elements of Discrete Mathematics"*, Tata Mcgraw-Hill, India, 3rd edition,2008.
3. Ralph P. Grimaldi, B. V. Ramana, *"Discrete and Combinatorial Mathematics - An Applied Introduction"*,, PearsonEducation, India, 5th edition, 2011.
4. D. S. Malik, M. K. Sen, *"Discrete Mathematical Structures: Theory and Applications"*, Thomson CourseTechnology, India, 1st edition, 2004.

MATERIALS ONLINE:

1. http://www.web.stanford.edu/class/cs103x
2. http://www.cse.iitd.ernet.in/ bagchi/courses/discrete-book
3. http://www.saylor.org/course/cs202/
4. http://www.nptel.ac.in/courses/106106094/
5. http://www.dmtcs.org/dmtcs-ojs/index.php/dmtcs

22. Course plan:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
Discussion on Outcome Based Education, CO, POs, and PSOs			
CONTENT DELIVERY (THEORY)			
1	Describe the statements and notations, connectives	CO 1	T1:1.1,1.2

S.No	Topics to be covered	CO's	Reference
2	Explain well-formed formulas	CO 1	T1:1.2.7
3	Explain truth tables tautology, contradiction and contingency and related problems	CO 1	T1, T1:1.2.8
4	Explain equivalence implications, DNF, CNF	CO 1	T1:1.2.9
5	Explain equivalence implications, PDNF, PCNF	CO 1	T1:1.2.9, 1.2.11,1.32
6	Illustrate predicative statement functions, variables and quantifiers	CO 2	T1:1.5,1.4.2, 1.4.3
7	Illustrate predicative free and bound variables	CO 2	T1:1.5,1.4.2,1.4.3
8	Illustrate predicative rules of inference	CO 2	T1:1.5,1.4.2,1.4.3
9	Consistency	CO 2	T1:1.5,1.4.2,1.4.3
10	Demonstrate proof of contradiction	CO 2	TI:1.4.3, 1.4.4,2.3.1
11	Demonstrate automatic theorem proving and related problems	CO 3	TI:1.4.3,1.4.4,2.3.1,
12	Define relation and properties of binary relations	CO 3	TI:2.3.6
13	Explain equivalence relation and solve the related problems,	CO 3	TI: 2.3.7,2.3.8
14	Explain closures and solve the related problems	CO 3	TI: 2.3.7
15	Explain compatibility , partial order relation and solve the related problems	CO 3	TI: 2.3.8
16	Solve partial order relation problems	CO 3	TI: 2.3.8
17	Explain Hasse diagram and construct Hasse diagram for different problems	CO 3	R2:4.3,T1:2.4.1
18	Definition and examples, properties of lattices	CO 3	R2:4.3,T1:2.4.1
19	Definition lattices as algebraic systems, sub lattices, direct product and homomorphism, some special lattices.	CO 3	R2:4.3,T1:2.4.1
20	Define function,invertible function and related problems	CO 3	T1:2.4.2,2.4.3,4.1
21	Define composition of functions, recursive functions,	CO 3	T1:2.4.2,2.4.3,4.1
22	Demonstrate Algebraic systems, examples and general properties semi groups and monoids	CO 4	TI:3.1, R1:6.2
23	Explain Groups and related problems	CO 4	TI:3.2, R1:6.3
24	Define subgroups, homomorphism and solving related problems	CO 4	TI:3.2, R1:6.3
25	Define isomorphism, rings and related problems	CO 45	TI:3.3, R1:6.4
26	Explain the fundamental counting principles, permutations, disarrangements	CO 4	RI:7.1-7.2
27	Explain combinations, permutations and combinations with repetitions	CO 4	RI:7.2-7.3
28	Solve the related problems on binomial theorem, multinomial theorem	CO 4	RI:7.4-7.5

S.No	Topics to be covered	CO's	Reference
29	Generalized inclusion exclusion principle	CO 4	RI:7.5-7.6
30	Describe generating functions, function of sequences	CO 5	R2:8.1
31	calculating coefficient of generating function	CO 5	R2:8.2
32	solving recurrence relation by generating function	CO 5	R2:8.4
33	Find Characteristics roots solution of homogeneous recurrence relation	CO 5	R2:8.5
34	Solution of non homogeneous recurrence relation	CO 5	R2:8.6
35	Explain basic concepts of graphs, isomorphic graphs and related problems .	CO 6	R2:9.1
35	Explain basic concepts of isomorphic graphs and related problems .	CO 6	R2:9.1
37	Describe Euler graphs, Hamiltonian graphs, Planar graphs and solve the corresponding problems.	CO 6	R2:9.8,9.9
38	Describe digraphs, directed acyclic graphs, weighted digraphs, region graph, and chromatic numbers.	CO 6	T2:5.5, 5.9,5.10
39	Explain trees, spanning trees, minimal spanning trees.	CO 6	R2:10.4 10.6,10.7
40	Question Bank discussion	CO 6	R2:10.4 10.6,10.7
PROBLEM SOLVING/ CASE STUDIES			
1	4. Show that the following premises are inconsistent. (a) If jack misses many classes through illness, then he fails high school (b) If jack fails high school, then he is uneducated. (c) If jack reads lot of books, then he is not uneducated. Jack misses many classes through illness and lot of books	CO 1	
2	Translate the following proposition in symbolic form, and find its negation: "If all triangles are right angled, then no triangle is equiangular	CO 1	
3	Define conditional proposition and logical equivalence with suitable examples.	CO 1	
4	Let X = 1, 2, 3 and f, g, h and s be functions from X to X as given below. f = (1, 2), (2, 3), (3, 1) g = (1, 2), (2, 1), (3, 3) h = (1, 1), (2, 2), (3, 1) s = (1, 1), (2, 2), (3, 3) Then find f o g, g o f, (f o g)oh, fo (g o h)	CO 2	
5	Consider the set A=ball,bed,dog,let,egg and define the relation R on A by R=(x,y) —x,y A and x R y if x and y contain some letter. Show R is a compatibility relation which is not transitive..	CO 2	
6	Find the inverse of the function of the following: i)f(x) = 10/57 3x ii)4.e(6x+2)	CO 3	
7	Let W = 1, -1, i, -i , the set of all fourth roots of unity. Verify W4 is a group under multiplication	CO 3	

S.No	Topics to be covered	CO's	Reference
8	If o is an operation on Z defined by xoy=x+y+1, Prove that ¡Z,o¿ is an abelian group.	CO 4	
9	Out of 12 employees, group of four trainees is to be sent for "Software testing and QA" training of one month. (a) In how many ways can the four employees be selected? (b) What if there are two employees who refuse to go together? (c)What if there are two employees who want to go together? (d) What if there are two employees who want to go together and there are two employees who refuse to go together?	CO 4	
10	From the words. (a)TALLAHASSEE (b)MISSISSIPPI How many arrangements can be made such that, (a) No two letters A of TALLAHASSEE appear together Number of 4 letter words for both the given words	CO 4	
11	A bit is either 0 or 1. A byte is a sequence of 8 bits. Find (i) the number of bytes, (ii) the number of bytes that begin with 11 and end with 11. (iii) the number of bytes that begin with 11 and do not end with 11, and (iv) the number of bytes that begin with 11 or end with 1	CO 4	
12	Solve the recurrence relation using the method of undetermined coefficients.an = 2an1an2, a1 = 1.5, a2 =3	CO 5	
13	Using Generating function solve the recurrence relation an an1 6an2=0 and given a0 = 2, a1=1	CO 5	
14	Show that a simple graph is bipartite if and only if it is possible to assign one of two different colors to each vertex of the graph so that no two adjacent vertices are assign the same color.	CO 6	
15	What is prims algorithm? Explain the procedure of this algorithm with suitable examples.	CO 6	
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
1	Consider the statements P Mark is rich. and Q Mark is happy. Write the following statements into symbolic form. a) Mark is poor but happy. b) Mark is rich or unhappy. c) Mark is neither rich nor happy. d) Mark is poor or he is both rich and unhappy.	CO 1	
2	If a finite set A has n elements, then how many reflexive relations on A.	CO 2	
3	Demonstrate about distributive lattice. CO 3		
4	Define Automorphism .	CO 4	
5	Find the generating function for the sequence 1,1,....1	CO 5	
6	Explain the matrix representation of graph.	CO 6	

S.No	Topics to be covered	CO's	Reference
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Define statement and atomic statement.	CO 1	
2	Define free and bound variables.	CO 2	
3	Define totally ordered set	CO 3	
4	Explain the number of ways of selecting 9 committees with 7 persons.	CO 4	
5	Write the generating function for the following sequence 0 ,1,2,3, -4…	CO 5	
6	What is the order and size of a graph?	co6	

23. Program outcomes and Program specific outcomes:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Program Outcomes	
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

24. How program outcomes are assessed:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE
PO 2	**Problem analysis:** Identity, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and Environmental considerations.	3	CIE/SEE

25. How program-specific outcomes are assessed:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	3	Tech talk /Definitions and terminology/ Assignments

3 = High; 2 = Medium; 1 = Low

26. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-

27. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain mathematical definitions and its notations to convert statements from common language to formal logic. Define the concepts of various normal forms of the compound propositions ,various normal forms	2
	PSO 1	Remember the basic of properties of logic for designing algorithms, system software and knowledge discovery tools.	3
CO 2	PO 1	Applythe rules of inference, principle of inclusion and exclusion and automatic theorem for finding the proof of arguments by understanding mathematical principles and scientific principles.	2
CO 3	PO 1	Understand the basics of relations, functions, its properties, compatibility and partial ordering relations and Make use of lattices, its properties and types for representing the finite sets in multidimensional applications by applying mathematical principles and scientific principles.	3

	PO 2	Understand the given problem and develop the solution using recursive and functions from the provided information and interpret of results. Identify concepts of Lattice and analyze different types of Lattices	4
	PSO 1	Make use of the concept of relations for developing algorithms of machine learning and networking concepts.	2
CO 4	PO 1	Analyze proof of propositions in algebraic structures using homomorphism and isomorphism, Understanding the concepts of permutations, combinations, binomial and multinomial theorems by mathematical principles, engineering methodologies and scientific principles..	2
	PO 2	Understand the given problem and analyze (problem formulation) the properties of algebraic structures from the provided information and data in reaching substantiated conclusions by the interpretation of results.	4
	PSO 1	Make use of computational and experimental tools for creating system software, in data science and desire for higher studies in field of machine Learning and data science	3
CO 5	PO 1	Analyze Fibonacci numbers, Ackermann and Towers of Hanoi algorithms using recurrence relations by mathematical principles, engineering methodologies and scientific principles	3
	PO 2	Understand the given problem and the problem on probability using counting methods from the provided information and data, and the interpretation of results	3
	PO 3	Make Use of recurrence relations to develop programs (define problem) for finding the solution (innovative) of complex engineering problems by using different methods which satisfy the user constraints and cost limitations	5
	PSO 1	Analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking	6
CO 6	PO 1	Understand the basics of graphs, its types and applications for visualizing the given data by applying computer science fundamentals, mathematical principles, and scientific methodologies	3
	PO 2	Understand the given problem and choose appropriate graph theory model for solving given problem from the provided information and data, and interpretation of results	3
	PO 3	Applying the Knowledge of Graph Theory to solve real life problems like Traveling Salesperson problem, construction of telephone network, Railway track	3

	PSO 1	Understand the given problem and develop algorithm using recursion and recurrence relations for designing intelligent systems and knowledge discovery tools	3

28 TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	3	10	10	11	1	5	3	3	12	10	11	12	1	2	3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	2	4	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	3	6	-	-	-	-	-	-	-	-	-	6	-	-
CO 6	3	3	3	-	-	-	-	-	-	-	-	-	3	-	-

29 PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	66.7	0	0	0	0	0	0	0	0	0	0	0	5 0	0	0
CO 2	66.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 3	100	40	0	0	0	0	0	0	0	0	0	0	33.3	0	0
CO 4	66.7	40	0	0	0	0	0	0	0	0	0	0	50	0	0
CO 5	100	30	60	0	0	0	0	0	0	0	0	0	60	0	0
CO 6	100	30	30	0	0	0	0	0	0	0	0	0	50	0	0

30 COURSE ARTICULATION MATRIX (PO – PSO MAPPING): CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - 5 % $<C < 40\%$ –Low/Slight
2 -40% $<C \leq 60\%$ –Moderatet
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 5	3	1	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	1	1	-	-	-	-	-	-	-	-	-	2	-	-
TOTAL	18	4	4	-	-	-	-	-	-	-	-	-	10	-	
AVERAGE	3	1	2	-	-	-	-	-	-	-	-	-	2	-	

31 ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1,PO2,PO3	SEE Exams	PO1,PO2,PO3	Seminars	PO1
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	-	-	-	-
Assignments	PO 1				

32 ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

-

33. Relevance to Sustainability goals

Write a brief description of the course and its relevance to SDGs.

1		
2		

3		
4		**Quality education:** Guarantee an education system that is both inclusive and fair, offering high-quality learning experiences and lifelong opportunities accessible to all.
5		
6		
7		
8		
9		**Industry, innovation, and infrastructure:** Strong knowledge on graphs and mathematical skills enable to design and development of services like Computer Networks and Communication, Social Networks,Transportation Networks, Biology and Medicine and Electrical Engineering. it a powerful tool in both theoretical research and practical problem-solving across many domains.

10		
11		**Sustainable cities and communities:** Graph theory and Mathematical skills plays a significant role in the design, analysis, and optimization of sustainable cities and communities. It helps in addressing challenges related to urban planning, resource management, transportation, and more.
12		
13		
14		
15		
16		

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 28-08-2023.

Signature of Course Coordinator **HOD CSE(DS)**
Dr. S.Sreekanth, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**COMPUTER SCIENCE AND ENGINEERING(DS)**				
2	Course Title	**DATA STRUCTURES**				
3	Course Code	ACSD08				
4	Class / Semester	B.Tech III Semester				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 0 hours		Practical: – hours	
10	Course Coordinator	N.Lakshmi Deepthi				
11	Date Approved by BOS	22/08/2023				
12	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse				
13	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	ACSD05	II	Essentials of Problem Solving	

14. Course Overview

The course covers some of the general-purpose data structures and algorithms, and software development. Topics covered include managing complexity, analysis, static data structures, dynamic data structures and hashing mechanisms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter in real life. This course reaches to student by power point presentations, lecture notes, and lab which involve the problem solving in mathematical and engineering areas.

15. Course Objectives:

The students will try to learn:

I	The skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.
II	The basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching
III	The fundamentals of how to store, retrieve, and process data efficiently.
IV	The implementing these data structures and algorithms in Python.
V	The essential for future programming and software engineering courses.

16. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	**Interpret** the complexity of algorithm using the asymptotic notations.	Understand
CO 2	**Select** appropriate searching and sorting technique for a given problem.	Apply
CO 3	**Construct** programs on performing operations on linear and nonlinear data structures for organization of a data.	Apply
CO 4	**Make use of** linear data structures and nonlinear data structures solving real time applications.	Apply
CO 5	**Describe** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	Understand
CO 6	**Compare** various types of data structures in terms of implementation, operations and performance.	Analyze

17. Mapping of topic learning outcomes (TLO) to course outcomes

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
1	Introduction to data structures	1	Understand various data structures to solve real-time problems.	CO 1	Understand
2	Classification of data structures, Operations on data structures	2	Understand the classification and operations of various data structures.	CO 1	Understand
3	Recursive algorithms and performance analysis	3	Understand the specifications of writing algorithms, developing recursive procedures.	CO 1	Understand
4	Searching Techniques: Linear Search, Binary Search	4	Apply knowledge of searching techniques to solve real word applications.	CO 2	Apply
5	Uniform Binary Search, Interpolation Search				
6	Fibonacci Search and comparison				

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
7	Sorting techniques: Bubble, Selection sort	5	Apply knowledge of sorting techniques to solve real word applications.	CO 2	Apply
8	Insertion, Quick sort				
9	Merge, Radix sort, Shell sort and comparison				
10	Stack ADT, definition and operations, Implementations of stacks using array	6	Understand stack data structure and apply the knowledge to perform infix to postfix conversion and postfix evaluation.	CO 3,CO 4, CO 6	Apply
11	Applications of stacks, Arithmetic expression conversion and evaluation				
12	Queues: Primitive operations; Implementation of queues using Arrays	7	Understand stack data structure and apply the knowledge to solve real world applications.	CO 3,CO 4, CO 6	Apply
13	Applications of linear queue, circular queue				
14	double ended queue (deque)				
15	Linked lists: Introduction, singly linked list, representation of a linked list in memory	8	Apply linked list data structure to perform polynomial representation and sparse matrix manipulation	CO 3,CO 4, CO 6	Apply
16	operations on a single linked list, Applications of linked lists Polynomial representation				
17	Sparse matrix manipulation				
18	Types of linked lists: Circular linked lists	9	Understand types of linked lists and implement stack and queue mechanisms using linked list.	CO 3,CO 4, CO 6	Apply
19	doubly linked lists				
20	Linked list representation and operations of Stack				
21	Linked list representation and operations of queue				

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
22	Trees: Basic concept, binary tree	10	Understand the concept of trees and various methods of its representation.	CO 3	Apply
23	binary tree array representation				
24	binary tree linked list representation				
25	binary tree traversal	11	Understand inorder, preorder and post order traversals of trees.	CO 3	Apply
26	Binary tree variants	12	Understand various variants of binary trees in real world applications.	CO 3	Apply
27	Threaded binary tree				
28	Application of trees	13	Apply the knowledge of variants of binary trees and its operations to solve real world problems.	CO 4	Apply
29	Graphs: Basic concept, graph terminology	14	Understand the basics of graphs, its representation and implementation.	CO 3	Apply
30	Graph Representations-Adjacency matrix, Adjacency lists				
31	Graph implementation				
32	Graph traversals – BFS	15	Apply the basics of graphs, its representation to implement graph traversals.	CO 3,CO 4, CO 6	Apply
33	Graph traversals – DFS				
34	Application of graphs				
35	Minimum spanning trees – Prims and Kruskal algorithms	16	Understand the concept of spanning tress and two algorithms for finding minimum spanning trees	CO 3,CO 4, CO 6	Apply
36	Binary search trees: Binary search trees, properties and operations	17	Understand the concept of binary search tree with its variants.	CO 3	Understand
37	Balanced search trees: AVL trees				
38	Introduction to M-Way search trees	18	Understand various generalized versions of binary tress.	CO 3,CO 4, CO 6	Understand
39	B trees				
40	Hashing and collision	19	Apply the concept of hashing in real world applications for data fast retreival.	CO 5	Apply

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - The tech industry evolves rapidly, and staying up-to-date with the latest programming languages, frameworks, and development practices is crucial. Combining essentials of problem solving skills with a commitment to continuous learning demonstrates a student's dedication to staying relevant in a dynamic field.
2. Project-based skills - Creating projects that utilize graph theory principles to allow a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how problem solving concepts work in practice.

19. Content Delivery / Instructional Methologies:

✓	Power Point Presentation	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definition and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	40 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

21. Course content - Number of modules: Five

MODULE I	**INTRODUCTION TO DATA STRUCTURES, SEARCHING AND SORTING** | **Number of Lectures: 9**
	Basic concepts: Introduction to data structures, classification of data structures, operations on data structures, Algorithm Specification, Recursive algorithms, Data Abstraction, Performance analysis- time complexity and space complexity, Introduction to Linear and Non Linear data structures **Searching techniques:** Linear and Binary search, Uniform Binary Search, Interpolation Search, Fibonacci Search; **Sorting techniques:** Bubble, Selection, Insertion, and Quick, Merge, Radix and Shell Sort and comparison of sorting algorithms.
MODULE II	**LINEAR DATA STRUCTURES** | **Number of Lectures: 9**
	Stacks: Stack ADT, definition and operations, Implementations of stacks using array, applications of stacks, Arithmetic expression conversion and evaluation; **Queues:** Primitive operations; Implementation of queues using Arrays, applications of linear queue, circular queue and double ended queue (deque).
MODULE III	**LINKED LISTS** |**Number of Lectures: 9**
	Linked lists: Introduction, singly linked list, representation of a linked list in memory, operations on a single linked list; Applications of linked lists: Polynomial representation and sparse matrix manipulation. **Types of linked lists:** Circular linked lists, doubly linked lists; Linked list representation and operations of Stack, linked list representation and operations of queue.
MODULE IV	**NON LINEAR DATA STRUCTURES** | **Number of Lectures: 9**
	Trees: Basic concept, binary tree, binary tree representation, array and linked representations, binary tree traversal, binary tree variants, threaded binary trees, application of trees **Graphs:** Basic concept, graph terminology, Graph Representations -Adjacency matrix, Adjacency lists, graph implementation, Graph traversals – BFS, DFS, Application of graphs, Minimum spanning trees – Prims and Kruskal algorithms.
MODULE V	**BINARY TREES AND HASHING** | **Number of Lectures: 9**
	Binary search trees: Binary search trees, properties and operations; **Balanced search trees:**AVL trees; Introduction to M- Way search trees, B trees; **Hashing and collision:** ntroduction, hash tables, hash functions, collisions, applications of hashing.

TEXTBOOKS

1. Rance D. Necaise, —Data Structures and Algorithms using Python, Wiley Student Edition.
2. Benjamin Baka, David Julian, —Python Data Structures and Algorithms, Packt Publishers, 2017.

REFERENCE BOOKS:

1. S. Lipschutz, —Data Structures , Tata McGraw Hill Education, 1st Edition, 2008.
2. D. Samanta, —Classic Data Structures, PHI Learning, 2nd Edition, 2004.

Electronic Resources:

1. https://www.tutorialspoint.com/data_structures_algorithms/algorithms_basics.htm
2. https://www.codechef.com/certification/data-structures-and-algorithms/prepare
3. https://www.cs.auckland.ac.nz/software/AlgAnim/dsToC.html
4. https://online-learning.harvard.edu/course/data-structures-and-algorithms

22. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
Discussion on OBE			
1	Discussion on Outcome Based Education, CO, POs and PSOs		
Content Delivery (Theory)			
1	Introduction to data structures	CO 1	T1:1.1.3 R2 : 1.4
2	Classification of data structures, Operations on data Structures	CO 1	T1:1.1.3 R2 : 1.4
3	Recursive algorithm, Performance Analysis	CO 1	T1:1.2 T1:5.1
4	Searching techniques: Linear search, binary search	CO 2	T1:5.1
5	Searching techniques: Uniform binary search and interpolation search	CO 2	T1:5.1
6	Searching techniques: Fibonacci search and comparison	CO 2	T1:5.1
7	Sorting techniques: Bubble sort, selection sort	CO 2	R1:14.5
8	Sorting techniques: Insertion sort, Quick sort	CO 2	T1:5.2 R2: 10.2
9	Sorting techniques: Merge sort and Radix sort, Shell sort and comparison of sorting algorithms	CO 2	T1:5.2 R2 : 10.2
10	Stacks ADT, definition and operations, implementation of stacks using Arrays	CO 3, CO 6	T1:7.1
11	Applications of stacks, arithmetic expression conversion and evaluation	CO 4, CO 6	T1:7.2
12	Queues: Primitive operations; Implementation of queues using Array	CO 3	T1:8.1
13	Applications of linear queue, circular queue	CO 4	T1:8.4
14	Double ended queue (deque)l	CO 3	R2 : 5.4
15	Linked lists: Introduction, singly linked list, representation of a linked list in memory	CO 3	T1:9.1
16	Operations on a single linked list, Applications of linked lists - Polyomial representation	CO 3	T1:9.2
17	Sparse matrix manipulation	CO 4, CO 6	T1:9.3

S.No	Topics to be covered	CO's	Reference
18	Types of linked lists:Circular linked lists	CO 3	T1:9.3
19	double linked lists	CO 3	T1:9.4
20	Linked list representation and operations of Stack	CO 3	T1:9.4
21	Linked list representation and operations of queue	CO 3	T1:9.4
22	Trees: Basic concept, Binary Tree	CO 3	T1:13.1
23	Binary tree representation using array	CO 3	T1:13.2
24	Binary tree representation using linked list	CO 3	T1:13.2
25	Binary tree traversal	CO 3	T1:13.2
26	Binary tree variants	CO 3	T1:13.2
27	Threaded binary tree	CO 3	T1:13.2
28	Application of trees	CO 4	T1:13.2.3
29	Graphs: Basic concept, graph terminology	CO 3	R2 : 8.2
30	Graph representation- Adjacency matrix, adjacency list	CO 3	R2 : 8.2
31	Graph implementation	CO 3	R2 : 8.2
32	Graph traversals BFS	CO 3, CO 4, CO 6	T2:6.2
33	Graph traversals :DFS	CO 3, CO 4, CO 6	T2:6.2
34	Application of graphs	CO 3, CO 4, CO 6	T2:6.2
35	Minimum Spanning Trees-Prims and Kruskal algorithms	CO 3, CO 4, CO 6	T1:6.1 T2:5.6
36	Binary search trees, properties and operations	CO 3	T1:13.2.3
37	AVL trees	CO 3	T1:13.2.3
38	M- Way search trees, B trees	CO 3, CO 4, CO 6	T1:14.3
39	B trees	CO 3	T1:14.3
40	Hashing, Collision	CO 5	R2 : 6.4
	Problem Solving/Case Studies		
1	Problems on linear search, binary search and Fibonacci search.	CO 2	T1:5.1
2	Problems on bubble sort, selection and insertion sort	CO 2	T1:5.2 R2 : 10.2
3	Problems on quick and merge sort	CO 2	T1:5.2 R2 : 10.2
4	Problems on Arithmetic expression conversion and evaluation	CO 4 CO 4	T1:7.2
5	Problems on single linked list to add, delete element	CO 3, CO 4	T1:9.8
6	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.8
7	Problems on circular linked list to add, delete element	CO 3, CO 4	T1:9.4
8	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.3
9	Problems on stack using linked list	CO 3, CO 4	T1:9.7

S.No	Topics to be covered	CO's	Reference
10	Problems on queue using linked list	CO 3, CO 4	T1:9.8
11	Problems on Binary tree :creation ,insertion and deletion of a node	CO 3	T1:13.2
12	Problems on Graph Traversal: DFS and BFS	CO 3, CO 4	T2:6.2
13	Problems on MST: Prim's and Kruskal's	CO 3, CO 4	T1:6.1 14:5.6
14	Problems on Binary search tree	CO 4	T1:14.3
15	Problems oh hashing	CO 5	R2 : 6.4
Definition and Terminology			
1	Data Structures, Searching and Sorting	CO 1,CO2,CO 3	T1:1 R1:14
2	Linear Data Structures - Stack, Queue	CO 3	T1:7,.T1:8
3	Linked Lists - Single Linked List, Double Linked List, Circular Linked Lists	CO 3	T1:9
4	Non Linear data Structures - Trees, Graphs	CO 3	T1:7.5
5	Binary Trees, Binary Search Tree, Hashing and Collision	CO 3 CO 5	T1:14
Tutorial Question Bank			
1	Introduction to Data Structures, Searching and Sorting	CO 1, CO2,CO6	T1:1 R1:14
2	Linear Data Structures	CO 3,CO 4,CO 6	T1:9
3	Linked Lists	CO 3,CO 4,CO 6	T1:2.5
4	Non Linear Data Structures	CO 3,CO 4,CO 6	T1: 4.1
5	Binary Trees and Hashing	CO 3,CO 5,CO 6	T1: 5.1

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation..
PSO 2	Focus on improving software reliability, network security or information retrieval systems. .
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/SEE/Open ended Experiments
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Tech Talk/Open ended Experiments
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	Tech Talk/Open ended Experiments

25. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	**Build** suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	3	CIE/ SEE/ Tech Talk/ Open ended experiments
PSO 2	**Focus on** improving software reliability, network security or information retrieval systems.	2.4	CIE/ SEE/ Tech Talk/ Open ended experiments
PSO 3	**Make use of** computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions	1	CIE/ SEE/ Tech Talk/ Open ended experiments

3 = High; 2 = Medium; 1 = Low

26. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	✓
CO 2	✓	✓	✓	-	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 3	✓	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 4	✓	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 5	✓	-	✓	-	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	✓	✓	✓

27. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO1	PO 1	**Understand** (knowledge) the concept of conventional digital communication system and (understand) various types of pulse analog modulation techniques for signals analysis by applying the principles of **mathematics, science,** and **engineering fundamentals**.	3
	PO 2	**Problem Analysis** on different types of algorithms to analyze space and time complexities.	4
	PO 3	**Design the Solutions** for finding space and time complexities of a complex algorithm and representing it by asymptotic notations	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 10	**Subject matter and speaking style** assessed in explanation of various algorithms, algorithm complexity.	2
	PSO1	**Build and Design** complex algorithms and specify its space and time complexities and representing it by asymptotic notations for faster processing of data.	3
	PSO3	**Make use of modern** computer tools for finding space and time complexities of a complex algorithm	1
CO 2	PO 1	**Make use** of broad knowledge of searching and sorting techniques for an efficient search from a data structure and optimize the efficiency of other algorithms by applying the knowledge of mathematics, science, Engineering fundamentals.	1
	PO 2	**Problem Analysis** on different types of search sort algorithms to analyze space and time complexities.	5
	PO 3	**Design/Development of Solutions** using appropriate searching and sorting techniques for designing a solution for complex Engineering problems.	2
	PO 5	**Implementation of**different sorting and searching techniques for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of searching and sorting along with efficiency of searching and sorting techniques in terms of space and time complexity	2
	PSO1	**Build the** complex problems and analyzing it and apply appropriate sorting and searching techniques for data processing.	4
	PSO2	**Focus on**various selecting and sorting techniques while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various selecting and sorting techniques and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 3	PO 1	**Make use of** linear and nonlinear data structures to organize the data in a particular way so to use them in the most effective way by applying the basic knowledge of mathematics, science, engineering fundamentals	2
	PO 2	**Problem analysis:** Organizing the given data in particular way by performing the operations on linear and nonlinear data structures to use the data in the most effective way.	7

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue by Designing solutions for complex Engineering.	5
	PO 4	**Conduct Investigations** Conduct Investigations of Complex Problems: Ability to apply operations on linear and nonlinear data structures in order to organize the given data in a particular way	4
	PO 5	**Implementation of** Implementation of different operations on linear and nonlinear data structures for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks and queues	2
	PSO1	**Build the** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for Developing the solution.	4
	PSO2	**Focou** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 4	PO 1	**Make use of** linear and nonlinear data structures for solving real time applications by applying the basic knowledge of mathematics, science, engineering fundamentals	3
	PO 2	**Problem analysis:**Solving real time applications by performing the operations on linear or nonlinear data structures.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue for Designing real time applications.	2
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Implementation of** different operations on linear and nonlinear data structures for solving real time applications with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO1	**Build the** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for solving real time applications.	4
	PSO2	**Focous** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	1
	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 5	PO 1	**Understand** the knowledge of hashing techniques and collision resolution methods and implementing for specified problem domain using knowledge of mathematics, science and engineering fundamentals	1
	PO 3	**Design the Solution** for efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	2
	PO 5	**Implementation of** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of Hashing, Collision techniques	2
	PSO1	**Build the** complex problems and analyzing it and apply appropriate hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	4
	PSO2	**Focus on** various hashing techniques and collision resolution methods while designing and developing information retrieval systems and its applications	1
	PSO3	**Make Use of** sufficient knowledge hashing techniques and collision resolution methods so that new product can be developed, which leads to become successful entrepreneur in the present market.	1
CO 6	PO 1	**Understand** various types of data structures in terms of implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals	3
	PO 2	**Problem Analysis:** Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	7

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 3	**Design the Solution** complex problems or efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	5
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Understand** the Implementation of various types of data structures with the help of computer software	1
	PO 10	**Subject matter and speaking** style assessed in explanation of Implementation of various types of data structures.	2
	PO 12	**Keeping current in CSE** and advanced engineering concepts of Implementation of various types of data structures by tech talk, concept videos and open ended experiments	3
	PSO 1	**Build** suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	4
	PSO 2	**Focous** improving software reliability, network security or information retrieval systems of data structures while designing and developing information retrieval systems and its applications	1
	PSO 3	**Make use of** sufficient knowledge Implementation of various types of data structures so that new product can be developed, which leads to become successful entrepreneur in the present market.	1

28. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	4	2	-	-	-	-	-	-	2	-	-	3	-	1
CO 2	1	5	2	-	1	-	-	-	-	2	-	-	4	2	1
CO 3	2	7	5	4	1	-	-	-	-	2	-	-	4	2	1
CO 4	3	7	2	4	1	-	-	-	-	2	-	-	4	1	1
CO 5	1	-	2	-	1	-	-	-	-	2	-	-	4	1	1
CO 6	3	7	5	4	1	-	-	-	-	2	-	3	4	1	1

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	40	20	-	-	-	-	-	-	40	-	-	75	-	25
CO 2	33.3	50	20	-	100	-	-	-	-	40	-	-	100	100	25
CO 3	66.6	70	50	36.3	100	-	-	-	-	40	-	-	100	100	25
CO 4	100	70	20	36.3	100	-	-	-	-	40	-	-	100	50	25
CO 5	33.3	-	20	-	100	-	-	-	-	40	-	-	100	50	25
CO 6	100	70	50	36.3	100	-	-	-	-	40	-	25	100	50	25

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	1	-	-	-	-	-	-	1	-	-	3	-	1
CO 2	1	2	1	-	3	-	-	-	-	1	-	-	3	3	1
CO 3	3	3	2	1	3	-	-	-	-	1	-	-	3	3	1
CO 4	3	3	1	1	3	-	-	-	-	1	-	-	3	2	1
CO 5	1	-	1	-	3	-	-	-	-	1	-	-	3	2	1
CO 6	3	3	2	1	3	-	-	-	-	1	-	1	3	2	1
TOTAL	12	12	8	3	15	-	-	-	-	6	-	1	18	12	6
AVERAGE	2.0	2.4	1.3	1.0	3.0	-	-	-	-	1	-	1	3	2.4	1

31. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Viva-voce	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	✓
Assignments	✓				

32. ASSESSMENT METHODOLOGY INDIRECT:

-	Assessment of mini Projects by Experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	Quality education: Guarantee an education system that is both inclusive and fair, offering high-quality learning experiences and lifelong opportunities accessible to all.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	

7		
8		
9		Industry, innovation, and infrastructure: Strong problem solving skills with appropriate data structures enable to design and development of services like microservice architecture, cloud computing, machine learning, and AI integration in a modular and maintainable way, contributing to a more flexible and scalable infrastructure.
10		
11		Sustainable cities and communities: Programming skills with appropriate use of data structures can develop software solutions that contribute to urban sustainability, improve quality of life, and address challenges like smart city solutions, energy efficiency and monitoring, waste management systems, public transportation optimization, environmental sensor networks, education, and awareness faced by modern cities.
12		

13		
14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on 13-08-2024.

Signature of Course Coordinator **HOD, CSE(DS)**
N.Lakshmi Deepthi, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**CSE (DATA SCIENCE)**	
2	Course Title	**OPERATING SYSTEMS LABORATORY**	
3	Course Code	ACSD10	
4	Program	B.Tech	
5	Semester	III Semester	
6	Regulation	BT-23	
7	Structure of the course	Practical	
		Lecture Hours	Practical Hours
		3	3
8	Course Offered	Odd Semester ✓	Even Semester ☐
9	Course Coordinator	Ms. G. INDU	
10	Date Approved by BOS	24/08/2023	
11	Course Webpage	www.iare.ac.in/—-/—-	
12	Course Prerequistes	**Level**	**Prerequisites**
		UG	Programming For Problem Solving

13. Course Overview

The course covers some of the design aspects of operating system concepts. Topics covered include process scheduling, memory management, deadlocks, disk scheduling strategies, and file allocation methods. The main objective of the course is to teach the students how to select and design algorithms that are appropriate for problems that they might encounter in real life.

14. COURSE OBJECTIVES:

The students will try to learn:

I	The functionalities of main components in operating systems and analyze the algorithms used in process management.
II	Algorithms used in memory management and I/O management
III	Different methods for preventing or avoiding deadlocks and File systems.

15. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Acquire** knowledge of the operating system structure and process	Understand
CO 2	**Analyze** the performance of process scheduling algorithms .	Analyze
CO 3	**Evaluate** the process memory requirement and its fragmentation.	Evaluate

CO 4	**Analyze** the safe state and deadlock mechanism	Analyze
CO 5	**Analyze** the performance of the disk scheduling algorithms	Analyze
CO 6	**Apply** to simulate file structures and allocation methods.	Apply

16. Employability Skills

1. **Employment advantage:** This can give competitive advantage when seeking employment as Software Engineer.
2. **Problem-Solving and Analytical Thinking:** Operating System Laboratory Experiments involves Memory management, File Organization algorithms and Implementation ,Paging Activities and Process Scheduling Etc..Analytical thinking problem solving which are useful for developing new operating System

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT:

CO 1	**Acquire knowledge of the operating system structure and process .**
	1. The Busy Printer 2. The Software Developer's Tasks 3. Managing a Restaurant's Orders 4. Emergency Room Prioritization
CO 2	**Analyze the performance of process scheduling algorithms .**
	1. Managing System and User Processes 2. Managing Job Scheduling in a Computing Center 3. Managing Print Jobs in a Shared Printing Environment 4. Task Scheduling in a Multi-User System 5. Job Scheduling in a Computing Cluster

CO 3	**Evaluate the process memory requirement and its fragmentation.**
	1. Memory Variable Technique (MVT) 2. Best Fit Memory Allocation 3. Worst Fit Memory ALlocation 4. Multiprogramming with a Fixed Number of Tasks (MFT) 5. Simulating Paging Memory management 6. Futuristic Space Station 7. CentralAI 8. MetroCentral 9. AI Lab 10. MedTech Hospital
CO 4	**Analyze the safe state and deadlock mechanism**
	1. The Tale of the Printing Press and Its Inks 2. The Tale of the Library and Its Book Reservations 3. The Tale of the Automated Warehouse and Its Robots 4. The Tale of the Coffee Shop and Its Baristas 5. The Tale of the Theater Production and Its Props
CO 5	**Analyze the performance of the disk scheduling algorithms**
	1. The Disk Access Dilemma 2. The SSTF Disk Scheduling Challenge 3. FutureTech Corporation 4. The C-Scan Disk Scheduling Odyssey 5. The C-SCAN Disk Scheduling Quest at TechFusion Labs
CO 6	**Ability to simulate file structures and allocation methods**
	1. Managing Student Records in a School Database 2. Managing Medical Records in a Hospital Information System 3. Managing Digital Media Files in a Multimedia Application 4. DigitalArchive 5. EnterpriseX

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Operating System Principle- Abraham Siberchatz, Peter B. Galvin, Greg Gagne 7th Edition, John Wiley
2. Advanced programming in the Unix environment, W.R.Stevens, Pearson education.

REFERENCE BOOKS:

1. Operating Systems – Internals and Design Principles, William Stallings, Fifth Edition–2005, Pearson Education/PHI
2. Operating System - A Design Approach-Crowley, TMH.
3. Modern Operating Systems, Andrew S Tanenbaum, 2nd edition, Pearson/PHI

MATERIALS ONLINE:

1. Lecture notes, ELRV videos and power point presentations
2. Answers / solutions to all questions / problems in the textbook
3. Online exercises
4. Problems and solutions in files

20. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	CO 1	
2	a. The Busy Printer b. The Software Developer's Tasks c. Managing a Restaurant's Orders d. Emergency Room Prioritization	CO 1	T2:5.6 R1:1.12.3
3	Managing System and User Processes b. Managing Job Scheduling in a Computing Center c. Managing Print Jobs in a Shared Printing Environment d. Task Scheduling in a Multi-User System e. Job Scheduling in a Computing Cluster	CO 2	T2:5.10 R1:1.15
4	File Allocation Strategies a. Managing Student Records in a School Database b. Managing Medical Records in a Hospital Information System c. Managing Digital Media Files in a Multimedia Application d. DigitalArchive e. EnterpriseX	CO 6	T2:5.15 R1:1.16
5	Memory Management a. Memory Variable Technique (MVT) b. Best Fit Memory Allocation c. Worst Fit Memory ALlocation d. Multiprogramming with a Fixed Number of Tasks (MFT) e. Simulating Paging Memory management	CO 3	T2:5.17 R1:1.13.1

S.No	Topics to be covered	CO's	Reference
6	Contiguous Memory Allocation a. Futuristic Space Station b. CentralAI c. MetroCentral d. AI Lab e. MedTech Hospital	CO 3	T2:5.18 R1:1.13.2
7	Paging Memory Management a. CloudTech b. EduTech University c. GameTech Studios d. MedCare Hospital e. ShopMart	CO 3	T2:5.19 R1:1.13.3
8	Resource Allocation a. UrbanOS – Resource Allocation Graph b. UrbanOS – Wait for Graph c. The Library Conference d. The Dining Philosophers e. Banker's Algorithm	CO 4	T2:5.20 R1:1.7.1
9	Disk Scheduling The Disk Access Dilemma b. The SSTF Disk Scheduling Challenge c. FutureTech Corporation d. The C-Scan Disk Scheduling Odyssey e. The C-SCAN Disk Scheduling Quest at TechFusion Labs	CO 5	T2:5.24 R1:1.17.3
10	Concurrency Control a. The Tale of the Library Management System b. The Tale of the Restaurant Reservation System c. The Tale of the Online Shopping Cart System d. The Tale of the Collaborative Document Editing System e. The Tale of the Bank Account Management System	CO 2	T2:6.3 R1:2.6.1
11	Page Replacement Algorithms a. The Story of a Busy Café and Its Orders b. The Tale of the Library and Its Book Shelves c. The Story of the Busy Café and Its Special Recipe Book d. The Tale of the Art Gallery and Its Exhibition e. The Tale of the Library and Its Popular Books	CO 3	T2:6.5 R1:2.6.2
12	Process Synchronization a. The Tale of the Bakery and Its Busy Kitchen b. The Tale of the Busy Coffee Shop and Its Coffee Machines c. The Tale of the Conference Room and Its Reservations d. The Tale of the Restaurant Kitchen and Its Limited Resources e. The Tale of the Garden and Its Watering Schedule	CO 2	T2:7.7 R1:2.10
13	Deadlock and Prevention a. The Tale of the Printing Press and Its Inks b. The Tale of the Library and Its Book Reservations c. The Tale of the Automated Warehouse and Its Robots d. The Tale of the Coffee Shop and Its Baristas e. The Tale of the Theater Production and Its Props	CO 4	T2:7.11
14	Customer Service - M/M/1 Queue Analysis b. Telecommunication Company - M/M/c Queue Analysis	CO 6	T2:7.11
15	The Tale of the Busy Call Center and Its Call Routing System d. The Tale of the Hospital Emergency Room (ER) e. The Tale of the Online Gaming Server	CO 5	T2:15.2 R1:8.2
16	UrbanOS – Resource Allocation Graph b. UrbanOS – Wait for Graph c. The Library Conference d. The Dining Philosophers e. Banker's Algorithm	CO 5	T2:15.7 R1:8.3.3

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1	Customer Service - M/M/1 Queue Analysis
2	Telecommunication Company - M/M/c Queue Analysis
3	The Tale of the Busy Call Center and Its Call Routing System
4	The Tale of the Hospital Emergency Room (ER)
5	The Tale of the Online Gaming Server

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1	LAB PROGRAMS/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	LAB PROGRAMS/CIE/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	LAB PROGRAMS/CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	LAB PROGRAMS/CIE/SEE

PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	LAB PROGRAMS/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	LAB PROGRAMS/CIE/SEE
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	LAB PROGRAMS/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	LAB PROGRAMS/CIE/SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	2	LAB PROGRAMS/CIE/SEE
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions.	2	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	✓
CO 2	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	✓	✓	✓	✓	-	-	-	✓	-	-	-	✓	-	✓
CO 4	✓	✓	✓	✓	✓	-	-	-	✓	-	-	-	✓	-	✓
CO 5	✓	✓	✓	✓	✓	-	-	-	✓	-	✓	✓	✓	-	✓

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	✓	✓	✓	✓	✓	-	-	-	✓	-	✓	✓	✓	-	✓

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PSO 1	Apply knowledge of operating systems with skills in statistical modeling and data analysis, you can build efficient, scalable solutions that leverage both system-level efficiency and data-driven insights. This integrated approach is vital for modern computing challenges, where both system performance and data analysis are key.	2
	PSO 3	Apply computing theory, mathematics, statistical methods, and optimization techniques in data analytics, you can provide data-driven solutions. These principles help in making informed decisions, improving the efficiency of algorithms, and optimizing system resources. This integration ensures that your solutions are both theoretically sound and practically efficient.	1
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	By using suitable statistical models, tools, and techniques, we can rigorously analyze the performance of process scheduling algorithms and provide data-driven justifications for your conclusions.	1
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3
	PSO 1	Building suitable statistical models and using the right tools and techniques, you can effectively evaluate process memory requirements and fragmentation. This data-driven approach will allow you to justify your conclusions with solid evidence, helping to optimize memory allocation strategies and reduce fragmentation.	1
	PSO 3	By effectively using modern tools to evaluate and address memory requirements and fragmentation, you not only enhance your technical skills but also position yourself for career advancement, entrepreneurial ventures, and advanced academic pursuits.	2
CO 4	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3
	PSO 1	By analyzing safe states and deadlock mechanisms, you can design and manage computer programs across various domains more effectively. Implementing strategies to ensure safe states and handling deadlock situations can improve the reliability and efficiency of algorithms, system software, web applications, big data processing, AI/ML systems, and networking protocols	2
	PSO 3	By leveraging modern tools and techniques to analyze safe states and deadlocks, you can enhance your technical skills, drive innovation, and position yourself for success in both entrepreneurial ventures and academic pursuits.	1
CO 5	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2
	PSO 1	By applying graph theory to the analysis of disk scheduling algorithms, you can enhance your understanding of how these algorithms manage disk I/O and identify opportunities for optimization. This approach not only improves performance but also leverages mathematical concepts to provide a deeper analysis and justification of the effectiveness of different scheduling strategies.	1
	PSO 3	By leveraging computing theory, mathematical analysis, statistical methods, and optimization techniques, you can rigorously evaluate the performance of disk scheduling algorithms and provide data-driven recommendations for improving system performance	1
CO 6	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3
	PSO 1	Apply simulations to algorithms, system software, web design, big data, AI, ML, and networking, you can design more efficient systems, optimize performance, and solve complex problems related to data management and resource allocation. This holistic approach enhances your ability to create innovative solutions and advance in your career or academic pursuits..	1
	PSO 3	By simulating file structures and allocation methods and applying computing theory, mathematical analysis, statistical methods, and optimization techniques, you can gain valuable insights into how different strategies affect file system performance. This approach helps in providing data-driven solutions to optimize file allocation and improve overall system efficiency.	1

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
Key Competencies	3	10	10	11	1	5	3	3	12	5	12	12	3	-	3
CO 1	1	5	-	-	1	-	-	-	-	-	-	-	2	-	1
CO 2	1	3	2	-	-	-	-	-	-	-	-	-	1	-	1

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	2	2	3	2	1	-	-	-	3	-	-	-	1	-	2
CO 4	2	2	3	2	1	-	-	-	3	-	-	-	2	-	1
CO 5	2	2	3	2	1	-	-	-	2	-	2	2	1	-	2
CO 6	2	2	3	2	1	-	-	-	3	-	2	3	1	-	1

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	50	-	-	100	-	-	-	-	-	-	-	66.7	-	33.7
CO 2	33.3	30	20	-	-	-	-	-	-	-	-	-	33.7	-	33.7
CO 3	66.7	20	30	18	100	-	-	-	25	-	-	-	33.7	-	66.7
CO 4	66.7	20	30	18	100	-	-	-	25	-	-	-	66.7	-	33.7
CO 5	66.7	20	30	18	100	-	-	-	16	-	16	16	33.7	-	66.7
CO 6	66.7	20	30	18	100	-	-	-	25	-	16	25	33.7	-	33.7

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0$\leq$ C$\leq$ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	2	-	-	1	-	-	-	-	-	-	-	2	-	1
CO 2	1	3	2	-	-	-	-	-	-	-	-	-	1	-	1
CO 3	2	2	3	2	1	-	-	-	3	-	-	-	1	-	2
CO 4	2	2	3	2	1	-	-	-	3	-	-	-	2	-	1
CO 5	2	2	3	2	1	-	-	-	2	-	2	2	1	-	2
CO 6	2	2	3	2	1	-	-	-	3	-	2	3	1	-	1
TOTAL	10	13	14	8	5	-	-	-	11	-	4	5	9	-	8
AVERAGE	1.66	2.16	2.33	1.33	0.83	-	-	-	1.83	-	0.66	0.83	1.5	-	1.33

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

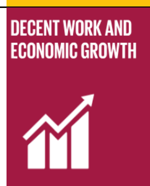
30. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	

7		
8		
9		**Industry, Innovation, and Infrastructure:**Operating Systems Lab implement with Python programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
10		
11		**Sustainable Cities and Communities:**Operating Systems Lab implement with Python programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
12		
13		**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using python programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
14		

15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:**Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Signature of Course Coordinator **HOD,CSE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**COMPUTER SCIENCE ENGINEERING (DATA SCIENCE)**			
2	Course Title	**DATA STRUCTURES LABORATORY**			
3	Course Code	ACSD11			
4	Program	B.Tech			
5	Semester	III Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Dr. D.Sreenivasulu			
10	Date Approved by BOS	25/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		UG	ACSD02	I	OOPS with JAVA
		-	-	-	-

13. Course Overview

The course covers some of the general-purpose data structures and algorithms, and software development. Topics covered include managing complexity, analysis, static data structures, dynamic data structures and hashing mechanisms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter in real life. This course reaches to student by power point presentations, lecture notes, and lab which involve the problem solving in mathematical and engineering areas.

14. Course Objectives:

The students will try to learn:

I	To provide students with skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.
II	To provide knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching.
III	The fundamentals of how to store, retrieve, and process data efficiently.

15. Course Outcomes:

After successful completion of the course, students should be able to:

CO 1	Interpret the complexity of algorithm using the asymptotic notations.	Understand
CO 2	Select appropriate searching and sorting technique for finding effective solution of given problem.	Apply
CO 3	Construct programs to perform operations on linear data structures for memory organization of data.	Apply
CO 4	Make use of nonlinear data structures for solving real time applications.	Apply
CO 5	Demonstrate operations on Balanced Data Structures for efficient storage and retrieval of data.	Understand
CO 6	Choose suitable data structures based on implementation, operations and performance while solving real world problems.	Apply

16. Employability Skills

1. **Problem-Solving and Critical Thinking:** Students learn to analyze complex problems, design solutions using Java's object-oriented principles, and translate real-world scenarios into code.
2. **Debugging and Troubleshooting:** Debugging challenges in the lab help students master error identification, interpretation, and use of debugging tools, essential for real-world software development.

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19 COURSE CONTENT

CO 1	**Interpret the complexity of algorithm using the asymptotic notations.**
	1. Getting Started Exercises
CO 2	**Select appropriate searching and sorting technique for finding effective solution of given problem.**
	1. Exercises on Searching 2. Exercises on Sorting 3. Exercises on Divide and Conquer
CO 3	**Construct programs to perform operations on linear data structures for memory organization of data.**
	1. Exercises Stack Data Structures 2. Exercises on Queue Data Structures 3. Exercises on Linked Lists 4. Exercises on Circular and Doubly Linked Lists
CO 4	**Make use of nonlinear data structures for solving real time applications.**
	1. Exercises on Trees 2. Exercises on BST
CO 5	**Demonstrate operations on Balanced Data Structures for efficient storage and retrieval of data.**
	1. Exercises on AVL Trees 2. Exercises on Graph Traversal
CO 6	**Choose suitable data structures based on implementation, operations and performance while solving real world problems.**
	1. Exercises on Data Structures based Applications 2. Exercises on Minimum Cost Spanning Tree

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Mark Allen Weiss,"*Data Structures and Problem Solving using Java*", Pearson Fourth Edition.
2. Michael T. Goodrich and Roberto Tamassia "*Data Structures and Algorithms in Java*" , John Wiley Sons, Inc., Fourth Edition

REFERENCE BOOKS:

1. Deitel, Paul and Deitel, Harvey. "*Java: How to Program*", Pearson, 11th Edition,2018.
2. Evans, Benjamin J. and Flanagan, David. "*Java in a Nutshell*", O'Reilly Media, 7th Edition, 2018.

MATERIALS ONLINE:

1. https://www.codechef.com/certification/data-structures-and-algorithms/prepare
2. https://www.geeksforgeeks.org/java
3. https://www.tutorialspoint.com/java/index.htm
4. https://online-learning.harvard.edu/course/data-structures-and-algorithms

20.COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Exercises on Searching	CO 2
3	Exercises on Sorting	CO 2
4	Exercises onDivide and Conquer	CO 2
5	Exercises on Stacks	CO 3
6	Exercises on Queues	CO 3
7	Exercises on Linked Lists	CO 3
8	Exercises on Circular and Doubly Linkde Lists	CO 3
9	Exercises on Trees	CO 4
10	Exercise on BST	CO 4
11	Exercises on AVL trees	CO 5
12	Exercises on Graph Traversal Techniques	CO 4
13	Exercises on Spanning Trees	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Write a function to determine if two trees are identical or not: (Two trees are identical when they have the same data and the arrangement of data is also the same)
2.	Given a binary search tree, task is to find Kth largest element in the binary search tree.
3.	Ind Strongly Connected Components (SCCs) of Given Graph G. .
4.	Given an array of pairs, find all symmetric pairs in it. (wo pairs (a, b) and (c, d) are said to be symmetric if c is equal to b and a is equal to d. For example, (10, 20) and (20, 10) are symmetric. Given an array of pairs find all symmetric pairs in it)
5.	Find distance between two nodes of a Binary Tree.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build Suitable Statistical models, tools and techniques to analyze large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, Network Security or Information Retrieval Systems.

Program Outcomes	
PSO 3	Make use of computing theory, mathematics, statistical method and the principles of optimization techniques in data analysis for providing solutions.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	LAB PROGRAMS/ CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	LAB PROGRAMS/ CIE/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	LAB PROGRAMS/ CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	LAB PROGRAMS/ CIE/SEE
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	LAB PROGRAMS/ CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Viva voce /CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	Viva Voce/ CIE/SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Build Suitable Statistical models, tools and techniques to analyze large data sets for visualization and interpretation.	3	LAB PROGRAMS/CIE/SEE
PSO 2	Focus on improving software reliability, Network Security or Information Retrieval Systems.	2	LAB PROGRAMS/CIE/SEE
PSO 3	Make use of computing theory, mathematics, statistical method and the principles of optimization techniques in data analysis for providing solutions.	2.8	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	✓
CO 2	✓	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	-	✓
CO 3	✓	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 4	✓	✓	✓	✓	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 5	✓	-	✓	-	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	✓	✓	✓

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO1	PO 1	**Understand** (knowledge) the concept of Algorithm Analysis and Types of Notations used to represent Time and Space Complexities (Understand) by applying principles of **mathematics** and **engineering fundamentals**.	3
	PO 2	**Problem Analysis** on different types of algorithms to analyze space and time complexities.	4
	PO 3	**Design the Solutions** for finding space and time complexities of a complex algorithm and representing it by asymptotic notations	2
	PO 10	**Subject matter and speaking style** assessed in explanation of various algorithms, algorithm complexity.	2
	PSO1	**Design and analyze** by combining asymptotic analysis and suitable statistical tools, so we can effectively analyze and interpret large data sets, enabling more informed decisions and better algorithm performance understanding.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO3	**Make use of modern** Asymptotic notations provide a framework for evaluating and optimizing algorithms in terms of time and space complexity. Understanding these concepts, supported by mathematical models and statistical analysis, allows for the design of algorithms that can efficiently handle large data sets, ensuring scalable, optimized solutions	3
CO 2	PO 1	**Make use** of broad knowledge of searching and sorting techniques for an efficient search from a data structure and optimize the efficiency of other algorithms by applying the knowledge of mathematics, science, Engineering fundamentals.	1
	PO 2	**Problem Analysis** on different types of search sort algorithms to analyze space and time complexities.	5
	PO 3	**Design/Development of Solutions** using appropriate searching and sorting techniques for designing a solution for complex Engineering problems.	2
	PO 5	**Implementation of**different sorting and searching techniques for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of searching and sorting along with efficiency of searching and sorting techniques in terms of space and time complexity	2
	PSO1	**Choose** the right searching and sorting technique is essential for building efficient algorithms to handle large datasets. Sorting algorithms like Merge Sort or Quick Sort are highly effective for large data, while Binary Search is optimal for fast lookups in sorted data	3
	PSO3	**Make use of** right searching and sorting technique involves evaluating the problem based on dataset size, whether the data is sorted, and the time/space trade-offs. Binary search is optimal for large, sorted datasets, while Quick Sort and Merge Sort provide efficient sorting mechanisms, especially for large dataset.	2
CO 3	PO 1	**Make use of** linear and nonlinear data structures to organize the data in a particular way so to use them in the most effective way by applying the basic knowledge of mathematics, science, engineering fundamentals	2
	PO 2	**Problem analysis:** Organizing the given data in particular way by performing the operations on linear and nonlinear data structures to use the data in the most effective way.	7

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue by Designing solutions for complex Engineering.	5
	PO 4	**Conduct Investigations** Conduct Investigations of Complex Problems: Ability to apply operations on linear and nonlinear data structures in order to organize the given data in a particular way	4
	PO 5	**Implementation of** Implementation of different operations on linear and nonlinear data structures for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks and queues	2
	PSO1	**construct** programs for operations on linear data structures like arrays, linked lists, stacks, and queues, use efficient memory management techniques such as dynamic memory allocation for optimal data organization	3
	PSO2	**Implementing** efficient linear data structures like arrays or linked lists optimizes memory usage, enhancing software reliability by minimizing memory leaks and improving data access speed for Information Retrieval Systems	1
	PSO3	**Make use of** Computing theory, mathematics, and statistical methods guide the development of algorithms, while optimization techniques enhance performance and resource utilization.	3
CO 4	PO 1	**Make use of** linear and nonlinear data structures for solving real time applications by applying the basic knowledge of mathematics, science, engineering fundamentals	3
	PO 2	**Problem analysis:**Solving real time applications by performing the operations on linear or nonlinear data structures.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue for Designing real time applications.	2
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Implementation of** different operations on linear and nonlinear data structures for solving real time applications with the help of computer software	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs	2
	PSO1	**Understand** Programs utilizing linear data structures efficiently manage memory and process large datasets, while statistical models and visualization tools, such as regression analysis and data plotting, facilitate interpretation and insights	3
	PSO2	**Applying** linear data structures enhance software reliability and security by optimizing data access and integrity, and by improving information retrieval efficiency through structured memory organization.	1
	PSO3	**Make use of** computing theory, mathematics, and optimization principles, programs for linear data structures like arrays and linked lists can efficiently manage memory and optimize operations through precise algorithmic design and statistical analysis	3
CO 5	PO 1	**Understand** the knowledge of hashing techniques and collision resolution methods and implementing for specified problem domain using knowledge of mathematics, science and engineering fundamentals	1
	PO 3	**Design the Solution** for efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	2
	PO 5	**Implementation of** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of Hashing, Collision techniques	2
	PSO1	**Employing** statistical models and tools to analyze large datasets facilitates effective visualization and interpretation, while balanced data structures ensure efficient storage and retrieval by maintaining optimal organization and access times	3
	PSO2	**Applying** software reliability and network security through balanced data structures ensures efficient data storage and retrieval, reducing vulnerabilities and improving system robustness	1
	PSO3	**Building** computing theory, mathematics, and optimization principles, balanced data structures like AVL trees ensure efficient storage and retrieval of data through algorithmic balancing and statistical performance analysis	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 1	**Understand** various types of data structures in terms of implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals	3
	PO 2	**Problem Analysis:** Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	7
	PO 3	**Design the Solution** complex problems or efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	5
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Understand** the Implementation of various types of data structures with the help of computer software	1
	PO 10	**Subject matter and speaking** style assessed in explanation of Implementation of various types of data structures.	2
	PO 12	**Keeping current in CSE** and advanced engineering concepts of Implementation of various types of data structures by tech talk, concept videos and open ended experiments	3
	PSO 1	**Understand** appropriate statistical models and tools to analyze large datasets allows for effective visualization and interpretation, while choosing suitable data structures ensures efficient implementation, operation, and performance in solving real-world problems.	3
	PSO 2	**Applying** appropriate data structures—such as hash tables for network security or trees for information retrieval—enhances software reliability and system performance by optimizing access, storage, and manipulation operations to address real-world challenges effectively	1
	PSO 3	**Applying** computing theory, mathematics, and optimization principles enables the selection of appropriate data structures, like arrays or linked lists, to efficiently implement and perform operations based on real-world problem requirements and performance considerations.	3

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	4	2	-	-	-	-	-	-	2	-	-	3	-	3
CO 2	1	5	2	-	1	-	-	-	-	2	-	-	3	-	2
CO 3	2	7	5	4	1	-	-	-	-	2	-	-	3	1	3
CO 4	3	7	2	4	1	-	-	-	-	2	-	-	3	1	3
CO 5	1	-	2	-	1	-	-	-	-	2	-	-	3	1	3
CO 6	3	7	5	4	1	-	-	-	-	2	-	3	3	1	3

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	40	20	-	-	-	-	-	-	40	-	-	75	-	75
CO 2	33.3	50	20	-	100	-	-	-	-	40	-	-	75	-	50
CO 3	66.6	70	50	36.3	100	-	-	-	-	40	-	-	75	50	75
CO 4	100	70	20	36.3	100	-	-	-	-	40	-	-	75	50	75
CO 5	33.3	-	20	-	100	-	-	-	-	40	-	-	75	50	75
CO 6	100	70	50	36.3	100	-	-	-	-	40	-	25	75	50	75

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
2 - 40 % $< C < 60\%$ –Moderate
1-5 $< C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	1	-	-	-	-	-	-	1	-	-	3	-	3
CO 2	1	2	1	-	3	-	-	-	-	1	-	-	3	-	2
CO 3	3	3	2	1	3	-	-	-	-	1	-	-	3	2	3
CO 4	3	3	1	1	3	-	-	-	-	1	-	-	3	2	3

COURSE OUTCOMES	PROGRAM OUTCOMES PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO'S PSO 1	PSO 2	PSO 3
CO 5	1	-	1	-	3	-	-	-	-	1	-	-	3	2	3
CO 6	3	3	2	1	3	-	-	-	-	1	-	1	3	2	3
TOTAL	12	12	8	3	15	-	-	-	-	6	-	1	18	8	17
AVERAGE	2.0	2.4	1.3	1.0	3.0	-	-	-	-	1	-	1	3.0	2.0	2.8

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

X	NO POVERTY	
X	ZERO HUNGER	
X	GOOD HEALTH AND WELL-BEING	
✓	QUALITY EDUCATION	**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.

X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	
X	AFFORDABLE AND CLEAN ENERGY	
X	DECENT WORK AND ECONOMIC GROWTH	
✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Java programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
X	REDUCED INEQUALITIES	
✓	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:** Java programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
X	RESPONSIBLE CONSUMPTION AND PRODUCTION	

✓	CLIMATE ACTION	**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using Java programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
X	LIFE BELOW WATER	
X	LIFE ON LAND	
✓	PEACE, JUSTICE AND STRONG INSTITUTIONS	**Peace, Justice, and Strong Institutions:** Java programming skills can be applied to create tools for transparency, accountability, and data security. By focusing on ethical coding practices, the lab can contribute to strong and just institutions.
✓	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ________________.

Signature of Course Coordinator **HOD,CSE(DS)**
Dr. D.Sreenivasulu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**COMPUTER SCIENCE & ENGINEERING (DS)**			
2	Course Title	**PROGRAMMING WITH OBJECTS LABORATORY**			
3	Course Code	AITD02			
4	Program	B.Tech			
5	Semester	III Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Y Sujana			
10	Date Approved by BOS	05/08/2024			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-
		-	-	-	-

13. COURSE OVERVIEW

This course explores the essentials of C# and .NET, highlighting foundational programming techniques, object-oriented design, and advanced features like exception handling, concurrency, data manipulation, and file management. Developers use C#, a versatile .NET language, to efficiently build applications for desktops, servers, web, mobile, and IoT, streamlining the entire software development process. This lab course equips students with core C# skills and practical experience in real-world scenarios, preparing them for success in software development.

14. COURSE OBJECTIVES

The students will try to learn:

I	Introduce students to C# syntax and object-oriented programming to enable them to design robust and reusable code.
II	Enable students to effectively manage and manipulate data using collections, generics, and LINQ.
III	Prepare students to enhance application performance and responsiveness using multithreading and asynchronous programming techniques.

15. COURSE OUTCOMES

After successful completion of the course, students should be able to:

CO 1	Develop core programming skills in C# for basic application development.	Develop
CO 2	Design and implement functions to enhance code modularity and reusability.	Design
CO 3	Utilize advanced techniques for pattern matching and integrating external services.	Utilize
CO 4	Apply principles of object-oriented design to create structured and scalable applications.	Apply
CO 5	Implement robust error handling and manage file operations effectively.	Implement
CO 6	Create and manage concurrent processes to improve application performance.	Build

16. EMPLOYABILITY SKILLS

1. **Technical Proficiency:** Develop strong coding skills in C#, enabling students to write clean, efficient, and maintainable code that meets industry standards.
2. **Problem-Solving Abilities:** Enhance analytical and logical thinking skills to effectively tackle complex programming challenges and develop innovative solutions.
3. **Collaboration and Teamwork:** Work collaboratively on projects and assignments, fostering communication and teamwork skills essential for software development teams.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Develop core programming skills in C# for basic application development.**
	1. Getting Started Exercises 2. Arrays
CO 2	**Design and implement functions to enhance code modularity and reusability.**
	1. Functions and Function Overlaoding
CO 3	**Utilize advanced techniques for pattern matching and integrating external services.**
	1. String Manipulations 2. Motley Coding Tasks 3. Foundations of LINQ and Generic Types 4. Advanced Methods and Collections
CO 4	**Apply principles of object-oriented design to create structured and scalable applications.**
	1. Classes & Objects 2. Inheritance 3. Polymorphism, Abstract Classes and Interfaces
CO 5	**Implement robust error handling and manage file operations effectively.**
	1. Exception Handling 2. File Handling
CO 6	**Create and manage concurrent processes to improve application performance.**
	1. Explore Threads

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Troelsen, A., & Japikse."*Pro C# 10 with .NET 6: Foundational Principles and Practices in Programming Eleventh Edition*", Apress, Eleventh edition,2022.

2. Jon Skeet "*C# in Depth*" Fourth Edition, Manning, 2019.

Reference Books

1. Andrew Stellman,Jennifer Greene. "*Head First C#: A Learner's Guide to Real-World Programming with C# and .NET* ", O'Reilly Media, 5th Edition,2024.
2. Ian Griffiths. "*Programming C# 10: Build Cloud, Web, and Desktop Applications*", O'Reilly Media, First Edition, 2022.
3. Mark J Price. "*C# 12 and .NET 8 – Modern Cross-Platform Development Fundamentals*", Packt Publishing, 8th edition,2023.

Materials Online

1. https://learn.microsoft.com/en-us/dotnet/csharp
2. https://www.codecademy.com/learn/learn-c-sharp
3. https://www.pluralsight.com/paths/c-10
4. https://www.c-sharpcorner.com/
5. https://www.dotnetperls.com/category_c

20. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Arrays	CO 1
3	String Manipulations	CO 3
4	Functions and Function Overlaoding	CO 2
5	Motley Coding Tasks	CO 3
6	Classes & Objects	CO 4
7	Inheritance	CO 4
8	Polymorphism, Abstract Classes and Interfaces	CO 4
9	Exception Handling	CO 5
10	File Handling	CO 5
11	Foundations of LINQ and Generic Types	CO 3
12	Advanced Methods and Collections	CO 3
13	Explore Threads	CO 6
14	Mini Projects	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Given a series of strings, restructure them so that they are listed as one would find them in a library catalog. Display the strings in this orderly fashion, treating letters with no distinction between cases.
2.	You are given a collection of product reviews with ratings. Filter out and display only those reviews that have a rating of 4 stars or higher. Present these reviews in a manner that highlights their rating.
3.	You have a list of customer orders with various amounts. Extract and show the orders that exceed $100. Present these orders in a manner that highlights their total value.
4.	Implement a banking application that performs transactions such as deposits and withdrawals. Handle exceptions related to insufficient funds or invalid transaction amounts, and ensure the application provides clear feedback to the user.
5.	Build a real-time chat application where multiple users can send and receive messages simultaneously. Implement a system that handles concurrent message exchanges and ensures that all messages are delivered and displayed correctly.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change
Program Specific Outcomes	
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.
PSO 2	Focus on improving software reliability, network security or information retrieval systems.
PSO 3	Make use of computing theory, mathematics, statistical methods and the principles of optimization techniques in data analytics for providing solutions

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1	LAB PROGRAMS/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	LAB PROGRAMS/CIE/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1	LAB PROGRAMS/CIE/SEE

PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	LAB PROGRAMS/CIE/SEE
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	LAB PROGRAMS/CIE/SEE
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	LAB PROGRAMS/CIE/SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	LAB PROGRAMS/CIE/SEE
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	LAB PROGRAMS/CIE/SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		**Strength**	**Proficiency Assessed by**
PSO 1	Build suitable statistical models, tools and techniques to analyse large data sets for visualization and interpretation.	3	LAB PROGRAMS/CIE/SEE
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	3	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	✓	-	-	-	-	-	-	✓	✓	-	-
CO 2	✓	-	✓	-	✓	-	-	-	-	-	-	-	✓	✓	-
CO 3	✓	-	-	✓	✓	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	-	✓	-	-	-	✓	-	-	-	-	-	✓	✓	-
CO 5	-	✓	-	✓	-	-	-	✓	-	-	-	-	✓	✓	-
CO 6	✓	-	✓	-	-	-	✓	-	-	-	-	-	✓	✓	-

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Engineering Knowledge:** Core programming skills involve applying fundamental programming principles and knowledge, which supports solving complex engineering problems.	3
	PO 5	**Modern Tool Usage:** Developing core programming skills includes using modern programming tools and techniques.	1
	PO 12	**Life-long Learning:** Mastery of core programming skills supports continuous learning and adaptation to technological advancements.	8
	PSO 1	**Build suitable statistical models, tools and techniques:** Core programming skills provide the foundational knowledge required to understand and analyze various types of computer programs, including those related to algorithms, system software, and other areas listed in PSO1.	4
CO 2	PO 1	**Engineering Knowledge:** Designing and implementing functions require applying knowledge of engineering fundamentals to solve complex problems.	3
	PO 3	**Design/Development of Solutions:** This CO involves creating solutions (functions) that address specific needs, considering various factors such as safety and effectiveness.	10
	PO 5	**Modern Tool Usage:** Implementation of functions often involves using modern programming tools and techniques.	1
	PSO 1	**Build suitable statistical models, tools and techniques:** Designing and implementing functions is crucial for creating efficient algorithms and system software. This CO supports the understanding and development of computer programs, aligning with the objectives of PSO1.	4
	PSO 2	**Focus on improving software reliability:** Proper function design and implementation enhance software reliability by ensuring that functions perform as expected and integrate seamlessly with other components. Understand, design and analyze computer programs:	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 3	PO 1	**Engineering Knowledge:** Integrating advanced text and services involves applying specialized knowledge in programming to address complex problems.	3
	PO 4	**Conduct Investigations of Complex Problems:** Integration tasks may involve researching and analyzing different services and technologies to ensure effective integration.	11
	PO 5	**Modern Tool Usage:** Utilizing tools and resources for advanced integration tasks aligns with modern tool usage.	1
	PSO 1	**Build suitable statistical models, tools and techniques:** Integrating advanced text and services involves designing and analyzing complex interactions between different software components, supporting the goals of PSO1.	4
CO 4	PO 1	**Engineering Knowledge:** Object-oriented design involves applying principles of programming and software engineering to create well-structured solutions.	3
	PO 3	**Design/Development of Solutions:** This CO focuses on designing systems or components using object-oriented principles to meet specified needs.	10
	PO 7	**Environment and Sustainability:** Good object-oriented design practices contribute to sustainable software development by creating reusable and maintainable code.	3
	PSO 1	**Build suitable statistical models, tools and techniquess:** Object-oriented design is fundamental to understanding and creating complex systems in various domains such as web design, AI, and networking, aligning with PSO1.	4
	PSO 2	**Focus on improving software reliability:** Object-oriented principles contribute to building reliable and maintainable software systems, supporting the goals of improving software reliability.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 2	**Problem Analysis:** Effective error handling and file management require analyzing problems and applying solutions based on established principles.	3
	PO 4	Conduct Investigations of Complex Problems: This involves understanding and solving issues related to file management and error handling through research-based methods.	11
	PO 8	**Ethics:** Proper error handling ensures reliable and ethical software behavior, aligning with professional ethics and responsibilities.	3
	PSO 1	**Build suitable statistical models, tools and techniques:** Effective error handling and file management are essential aspects of designing robust and efficient software systems, relevant to PSO1.	4
	PSO 2	**Focus on improving software reliability:** This CO directly addresses improving software reliability by ensuring that errors are properly managed and files are efficiently handled.	2
CO 6	PO 1	**Engineering Knowledge:** Managing concurrency involves applying advanced programming knowledge to address complex issues related to simultaneous operations.	3
	PO 3	**Design/Development of Solutions:** This CO involves designing and implementing solutions that handle multiple processes or tasks concurrently.	10
	PO 7	**Environment and Sustainability:** Efficient concurrency management helps optimize resource usage, contributing to sustainable software practices.	3
	PSO 1	**Build suitable statistical models, tools and techniques:** Managing concurrency is crucial for developing advanced software systems that perform efficiently under simultaneous operations, aligning with PSO1.	4
	PSO 2	**Focus on improving software reliability:** Proper concurrency management improves software reliability by ensuring that multiple tasks can be executed without conflicts or errors.	2

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	1	-	-	-	-	-	-	8	4	-	-
CO 2	3	-	10	-	1	-	-	-	-	-	-	-	4	2	-
CO 3	3	-	-	11	1	-	-	-	-	-	-	-	4	-	-
CO 4	3	-	10	-	-	-	3	-	-	-	-	-	4	2	-
CO 5	-	3	-	11	-	-	-	3	-	-	-	-	4	2	-
CO 6	3	-	10	-	-	-	3	-	-	-	-	-	4	2	-

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	20	-	-	-	33.3	-	-	-	-	-	-	100	100	-	-
CO 2	20	-	33.3	-	33.3	-	-	-	-	-	-	-	100	100	-
CO 3	20	-	-	50	33.3	-	-	-	-	-	-	-	100	-	-
CO 4	20	-	33.3	-	-	-	50	-	-	-	-	-	100	100	-
CO 5	-	100	-	50	-	-	-	100	-	-	-	-	100	100	-
CO 6	20	-	33.3	-	-	-	50	-	-	-	-	-	100	100	-

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1-5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	-	-	1	-	-	-	-	-	-	3	3	-	-
CO 2	1	-	1	-	1	-	-	-	-	-	-	-	3	3	-
CO 3	1	-	-	2	1	-	-	-	-	-	-	-	3	-	-
CO 4	1	-	1	-	-	-	2	-	-	-	-	-	3	3	-
CO 5	-	3	-	2	-	-	-	3	-	-	-	-	3	3	-
CO 6	1	-	1	-	-	-	2	-	-	-	-	-	3	3	-
TOTAL	5	3	3	4	3	-	4	3	-	-	-	3	18	12	-
AVERAGE	1	3	1	2	1	-	2	3	-	-	-	3	3	3	-

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

X	NO POVERTY	
X	ZERO HUNGER	
X	GOOD HEALTH AND WELL-BEING	
✓	QUALITY EDUCATION	**Quality Education:** Students can gain a deeper understanding of how technology addresses global challenges, promoting quality education by enhancing their critical thinking and problem-solving skills in the context of sustainable development.
X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	

X	AFFORDABLE AND CLEAN ENERGY	
✓	DECENT WORK AND ECONOMIC GROWTH	**Skill Development for Employment:** Learning C# equips students with in-demand programming skills, enhancing their employability and contributing to economic growth by preparing them for careers in the tech industry.
✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Fostering Innovation:** Proficiency in C# enables students to develop innovative software solutions, supporting the growth of technology-driven industries and contributing to the advancement of infrastructure.
X	REDUCED INEQUALITIES	
✓	SUSTAINABLE CITIES AND COMMUNITIES	**Building Smart Solutions:** C# programming skills can be used to develop applications that support smart city initiatives, such as efficient public transportation systems and smart energy management, promoting more sustainable urban living.
X	RESPONSIBLE CONSUMPTION AND PRODUCTION	
X	CLIMATE ACTION	
X	LIFE BELOW WATER	
X	LIFE ON LAND	

✓	PEACE, JUSTICE AND STRONG INSTITUTIONS	**Promoting Ethical Technology Use:** Learning to develop secure and reliable software helps create trustworthy digital systems, which can contribute to stronger institutions and promote justice through technology.
✓	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,CSE(DS)**
Y Sujana, Assistant Professor