FLIGHT SIMULATION

III Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
BAEB23	Elective	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil			Total Classes: 45			

I. COURSE OVERVIEW:

Flight simulation and Control is the science that investigates the stability and control of aircrafts and all other flying vehicles. From the advent of the first flight by the Wright Brothers, it was observed that flight without knowledge of stability and control was not viable. Since then, several different concepts for controlling aircraft flight have been devised including control surfaces, deformable surfaces, morphing of wings etc. This course introduces some of these concepts and describes their operation, as well as the degree of stability that these devices can provide. Modern aircraft control is ensured through automatic control systems known as autopilot. Their role is to increase safety, facilitate the pilot's task and improve flight qualities. The course will introduce modern aircraft stability and control and discuss some of its objectives and applications

II. COURSE OBJECTIVES:

The course should enable the students to:

I. Illustrate the history of flight simulation.
II. Understand the principle of modeling and simulation of flight control systems.
III. Describe the dynamics of aircraft and model validation.

III. COURSE OUTCOMES:

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

CO 1	**Recognize** the aircraft components contributing to the stability of different aircraft models like Military, Civil and transport aircrafts.	**Understand**
CO 2	**Identify** stick fixed and stick free conditions for neutral points with an appropriate static margin, control force and CG limitation.	**Apply**
CO 3	**Interpret** the specific coupling between lateral and directional static stability of the aircraft and its influence on other motion of a typical aircraft.	**Analyze**
CO 4	**Construct** the mathematical model of aircraft motion in longitudinal, lateral and directional cases for establishing the status of the flight vehicles stability.	**Apply**
CO 5	**Explain** qualitatively about motion in three-dimensions, Euler angles and rates, full 6-DOF equations for rigid symmetrical aircraft, state space formulation, and solution in the time domain and flight simulation.	**Analyze**
CO 6	**Apply** the advances of flight dynamics and controls in design of modern airplane control system.	**Apply**

IV. SYLLABUS:

UNIT-I	INTRODUCTION	Classes: 08

Historical Perspective, the first 40 years of flight 1905–1945,analogue computing, 1945–1965, digital computing 1965–1985, the microelectronics revolution, 1985 present, the case for simulation, safety, financial benefits, training transfer, engineering flight simulation, the changing role of simulation, the organization of a flight simulator, equations of motion, aerodynamic model, engine model, data acquisition, gear model, weather model, visual system, sound system, motion system, control loading, instrument displays, navigation systems, maintenance, the concept of real-time simulation, pilot cues, visual cueing, motion cueing, training versus simulation, examples of simulation, commercial flight training, military flight training, Ab initio flight training, land vehicle simulators, engineering flight simulators aptitude testing, computer-based training, maintenance training.

UNIT-II	PRINCIPLES OF MODELLING	Classes: 10

Modelling concepts, Newtonian mechanics, axes systems, differential equations, numerical integration, approximation methods, first order methods, higher order methods, real-time computing, data acquisition, data transmission, data acquisition, flight data, interpolation, distributed systems, a real-time protocol, problems in modelling,

UNIT-III	AIRCRAFT DYNAMICS	Classes: 10

Principles of flight modelling, the atmosphere, forces, aerodynamic lift, aerodynamic side force, aerodynamic drag, propulsive forces, gravitational force, moments, static stability, aerodynamic moments, aerodynamic derivatives, axes systems, the body frame, stability axes, wind axes, inertial axes, transformation between axes.

Earth-centred earth-fixed frame, latitude and longitude, quaternions, equations of motion; Propulsion, piston engines, jet engines, the landing gear, the equations collected; The equations revisited: Long range navigation, coriolis acceleration.

UNIT-IV	SIMULATION OF FLIGHT CONTROL SYSTEMS	Classes: 09

The Laplace transform, simulation of transfer functions; Proportional–integral–derivative control systems, trimming, aircraft flight control systems, the turn coordinator and the yaw damper, the auto- throttle, vertical speed management, altitude hold, heading hold, localizer tracking, auto-land systems, flight management systems.

UNIT-V	MODEL VALIDATION AND VISUAL SYSTEMS	Classes: 08

Simulator qualification and approval, model validation methods, cockpit geometry, open-loop tests, closed-loop tests, latency, performance analysis, longitudinal dynamics, lateral dynamics, model validation in perspective; Visual systems: Background, the visual system pipeline, graphics operations, real-time image generation, a rudimentary real time wire frame image generation system, an open GL real-time image generation system, an open GL real-time textured image generation system, an open scene graph image generation system, visual database management, projection systems, problems in visual systems.

Text Books :

1. David Allerton, “Principles of Flight simulation” John Wiley & Sons, Ltd Publication, 1st Edition 1999.
2. M. J Rycroft, “Flight simulation”, Cambridge university press, 1st Edition, 1999.
3. J. M. Rolfe, K. J. Staples “Flight simulation”, Cambridge University press, 1st Edition, 1987.
4. Jeffrey Strickland, “Missile Flight Simulation”, Lulu press, Inc, 2nd Edition, 2012.
5. Jonathan M. Stern “Microsoft Flight Simulator Handbook” Brady Publishing, 1st Edition, 1995.

Reference Books:

1. RanjanVepa, "Flight Dynamics, Simulation, and Control: For Rigid and Flexible Aircraft", CRC press, 1st Edition, 2014.
2. Duane Mc Ruer, Irving Ashkenas, Dunstan Graham "Aircraft Dynamics and Automatic Control" Princeton University Press, 2nd Edition, 2014.
3. Brian L. Stevens, Frank L. Lewis, "Aircraft Control and Simulation", John Wiley & Sons Ltd Publication, 2nd Edition, 2003.

Web References:

1. https://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol1/kwc2/article1.html
2. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.132.5428&rep=rep1&type=pdf
3. http://research.omicsgroup.org/index.php/Flight_simulator
4. http://as.wiley.com/WileyCDA/WileyTitle/productCd-0471371459.html

E-Text Books:

1. http://www.aeronautics.nasa.gov/pdf/principles_of_flight_in_action_9_12.pdf
2. http://helijah.free.fr/dev/Principles-of-Flight-Simulation.pdf
3. https://leseprobe.buch.de/images-adb/ee/49/ee495ffc-8dc1-4a07-ad7b-b18540b9fb60.pdf
4. http://samples.sainsburysebooks.co.uk/9780470682197_sample_388478.pdf