Hall Ticket No | | | | | | | | | | | Question Paper Code: AAEB13

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER-II

B.Tech V Semester End Examinations, November 2020

Regulations: IARE - R18

AIRCRAFT STABILITY AND CONTROL

AERONAUTICAL ENGINEERING

Time: 3 hour | Maximum Marks: 70

Answer ONE Question from each MODULE
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

MODULE-I

1. (a) Discuss about hinge moment on elevator. How it effect the pilot force? [**7m**]

   (b) Find the maximum lift coefficient which can be trimmed by the aircraft with the following characteristics, when the C_g is at its forward limit of 0.13 of the aerodynamic mean chord, assuming the tab angle to be zero: $V_T = 0.48$, $a = 4.5$, $a_I = 2.8$, $a_2 = 1.2$, $\frac{d\epsilon}{d\alpha} = 0.4$, aerodynamic centre position $h_0 = 0.18$, tail plane setting angle $\eta_T = -1.8$, $C_{Mo} = -0.018$. The elevator angle travel limits are $\pm 30°$. [**7m**]

2. (a) A jet airplane has the following characteristics $C_{L\alpha w} = 4.87\,rad^{-1} = 4.87$ rad-1, $C_{L\alpha t} = 3.32\,rad^{-1}$, $C_{M\alpha} = 0.39\,rad^{-1}$ forward neutral point, $\frac{S_t}{s} = 0.25$, $\frac{L_t}{c} = 3.0$, $\eta = 0.9$, $\frac{d\epsilon}{d\alpha} = 0.4$. At the rear most c.g. location the airplane has a static margin stick-fixed of -0.02. By how much the area of horizontal tail is increased to have a static margin of $+0.05$. [**7m**]

   (b) Determine the flow field around an aircraft created by the wing and fuselage and explain its significance on static stability of aircraft. [**7m**]

MODULE-II

3. (a) Identify the aerodynamic forces and propulsive forces are of importance to the performance of an aircraft. [**7m**]

   (b) During flight, the left aileron found stuck to neutral condition. Pilot wanted to roll left. Analyze the types of controls needed to do get this attitude. [**7m**]

4. (a) How the pilots change the airplane altitude? Demonstrate with suitable sketch mentioning all the controls needed with force and moment diagram of each control. [**7m**]

   (b) Examine the aileron and rudder deflections required for an F-15 to maintain a +1 degree "wings level" sideslip at 0.9 Mach and 7 km. Determine the value of the sideforce coefficient under these conditions. Applicable derivatives are as follow:

$C_{y0} = 0$, $C_{y\beta} = -0.9056/rad$, $C_{y\delta a} = -0.0047/rad$ $C_{y\delta r} = 0.1492/rad$ $C_{L0} = 0$, $C_{L\beta} = -0.0732/rad$, $C_{L\delta a} = 0.0226/rad$, $C_{L\delta r} = 0.0029/rad$, $C_{N0} = 0$, $C_{N\beta} = -0.0732/rad$, $C_{N\delta a} = 0.0226/rad$, $C_{N\delta r} = -0.0712/rad$. [**7m**]

MODULE-III

5. (a) Illustrate with a diagram the difference between body axis system and stability axes system. [**7m**]

   (b) Apply the mathematical formulation for the force equations in all the three direction i.e. F_x, F_y and F_z and demonstrate these forces with aircraft diagram. [**7m**]

6. (a) Express about products of Inertia. If an airplane has XZ plane of symmetry, what will be the values for these inertia? [**7m**]

   (b) Express all forces (weight, aerodynamic, and thrust) for sea level at military thrust in An aircraft has the following Euler angles and Euler rates $\psi = 0°$, $\dot{\psi} = 10deg/s$, $\theta = 0°$, $\dot{\theta} = 0deg/s$, $phi = 90°$, $\dot{\phi} = 0deg/s$. Solve and get the pitching, rolling and yawing rates. Which motion the pilot will feel? [**7m**]

MODULE-IV

7. (a) Classify the different ways the moving airplane axis system can be fixed with reference to the airplane?

   (b) Examine the derivative for an aircraft at 1km altitude and Mach 0.9 ($U_1 = 267m/s$, $q = 1383\ kg/m^2$, $S = 50\ m^2$, $b = 12\ m$) if $C_{L\beta} = -0.08$. If β is perturbed to 1°, find perturbed rolling moment. [**7m**]

8. (a) Build the equation of speed damping derivatives and explain each term in detail. Draw the plot and contrast with required parameters. [**7m**]

   (b) Solve the pitch damping derivative, C_{Mq} , for an aircraft with the following characteristics: $C_{L\alpha h} = 0.075/deg$, $\eta_H = 0.98$, $V_H = 0.375$, $X_H/c = 3:0$. [**7m**]

MODULE-V

9. (a) Is it possible to have dynamic stability without static stability? Give comments and express your thought on this. [**7m**]

   (b) Demonstrate the effect of forward speed and cg location on the airplane on dynamic stability. Illustrate the plot of SPPO and velocity and explain its significance on the dynamic stability. [**7m**]

10. (a) Elucidate about the dynamic stability. Specify with suitable example. [**7m**]

    (b) What are the 4- different modes of motion of a dynamic system when responding to a disturbance from an equilibrium position? [**7m**]

****END OF EXAMINATION****

COURSE OBJECTIVES:

The course should enable the students to:

1	The fundamental knowledge on static stability of aircraft in multiple directional motions with their relationship for critical applications in flight vehicles.
2	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
3	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
4	The utilization of advances of flight dynamics and control in design and development of modern airplane control systems.

COURSE OUTCOMES:

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

CO 1	Recall the concept of static stability in longitudinal, lateral and directional modes to be used for different aircrafts stability conditions.
CO 2	Describe the state of an equilibrium, control and trim inputs required for an aircraft in static longitudinal and lateral directional stability.
CO 3	Recognize the aircraft components contributing to the stability of different aircraft models like Military, Civil and transport aircrafts.
CO 4	Identify stick fixed and stick free conditions for neutral points with an appropriate static margin, control force and CG limitation.
CO 5	Interpret the specific coupling between lateral and directional static stability of the aircraft and its influence on other motion of a typical aircraft.
CO 6	Construct the mathematical model of aircraft motion in longitudinal, lateral and directional cases for establishing the status of the flight vehicles stability.
CO 7	Outline the contribution of aircraft components and their influence on lateral and directional static stability on flight vehicles
CO8	Analyze different axis systems used for flight dynamics and their transformations from one system to another system.
CO 9	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.
CO 10	Demonstrate different stability derivatives used in stability and control problems in different degree of freedom of aircrafts using different computational and experimental tools.
CO 11	Categorize different types of dynamic modes in longitudinal, lateral and directional motion of the aircraft and their influence on dynamic stability and safety.
CO 12	Apply the advances of flight dynamics and controls in design of modern airplane control systems.

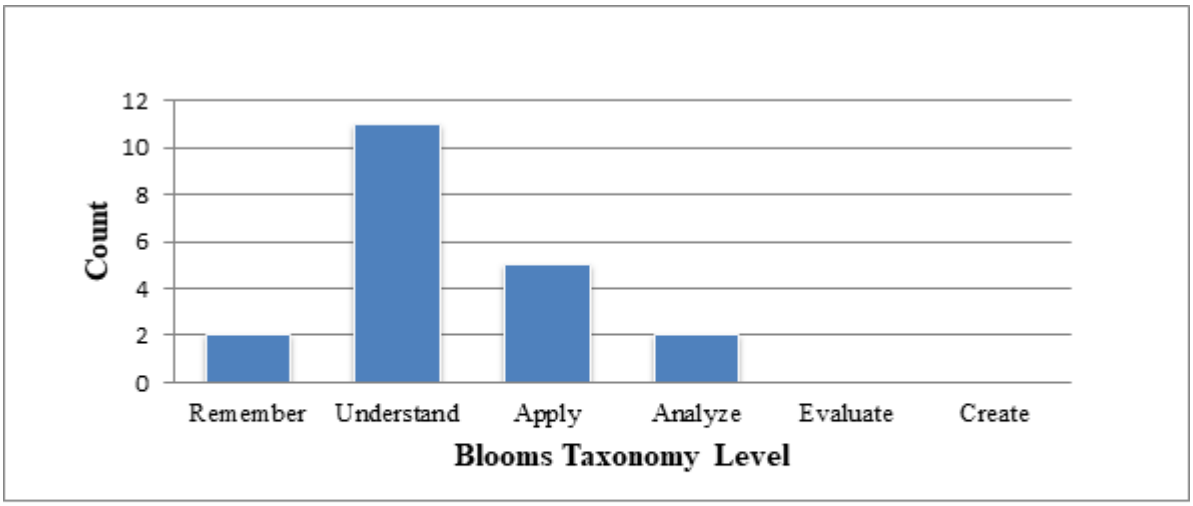
MAPPING OF SEMESTER END EXAMINATION QUESTIONS TO COURSE OUTCOMES

Q.No		All Questions carry equal marks	Taxonomy	CO's	PO's
1	a	Discuss about hinge moment on elevator. How it effect the pilot force?	Remember	CO 1	PO 1
	b	Find the maximum lift coefficient which can be trimmed by the aircraft with the following characteristics, when the C_g is at its forward limit of 0.13 of the aerodynamic mean chord, assuming the tab angle to be zero: $V_T = 0.48$, $a = 4.5$, $a_I = 2.8$, $a_2 = 1.2$, $\frac{d\epsilon}{d\alpha} = 0.4$, aerodynamic centre position $h_0 = 0.18$, tail plane setting angle $\eta_T = -1.8$, $C_{Mo} = -0.018$. The elevator angle travel limits are $\pm 30°$.	Apply	CO 2	PO 2
2	a	A jet airplane has the following characteristics $C_{L\alpha w} = 4.87\,rad^{-1} = 4.87$ rad-1, $C_{L\alpha t} = 3.32\,rad^{-1}$, $C_{M\alpha} = 0.39\,rad^{-1}$ forward neutral point, $\frac{S_t}{s} = 0.25$, $\frac{L_t}{c} = 3.0$, $\eta = 0.9$, $\frac{d\epsilon}{d\alpha} = 0.4$. At the rear most c.g. location the airplane has a static margin stick-fixed of -0.02. By how much the area of horizontal tail is increased to have a static margin of $+0.05$.	Apply	CO 3	PO 1,2
	b	Determine the flow field around an aircraft created by the wing and fuselage and explain its significance on static stability of aircraft.	Understand	CO 2	PO 1
3	a	Identify the aerodynamic forces and propulsive forces are of importance to the performance of an aircraft.	Understand	CO 4	PO 1
	b	During flight, the left aileron found stuck to neutral condition. Pilot wanted to roll left. Analyze the types of controls needed to do get this attitude.	Understand	CO 5	PO 1
4	a	How the pilots change the airplane altitude? Demonstrate with suitable sketch mentioning all the controls needed with force and moment diagram of each control.	Understand	CO 4	PO 1

	b	Examine the aileron and rudder deflections required for an F-15 to maintain a +1 degree "wings level" sideslip at 0.9 Mach and 7 km. Determine the value of the sideforce coefficient under these conditions. Applicable derivatives are as follow: $C_{y0} = 0$, $C_{y\beta} = -0.9056/rad$, $C_{y\delta a} = -0.0047/rad$ $C_{y\delta r} = 0.1492/rad$ $C_{L0} = 0$, $C_{L\beta} = -0.0732/rad$, $C_{L\delta a} = 0.0226/rad$, $C_{L\delta r} = 0.0029/rad$, $C_{N0} = 0$, $C_{N\beta} = -0.0732/rad$, $C_{N\delta a} = 0.0226/rad$, $C_{N\delta r} = -0.0712/rad$.	Analyze	CO 8	PO 2,4
5	a	Illustrate with a diagram the difference between body axis system and stability axes system.	Understand	CO 6	PO 1
	b	Apply the mathematical formulation for the force equations in all the three direction i.e. F_x, F_y and F_z and demonstrate these forces with aircraft diagram.	Apply	CO 6	PO 1
6	a	Express about products of Inertia. If an airplane has XZ plane of symmetry, what will be the values for these inertia?	Understand	CO 7	PO 2
	b	Express all forces (weight, aerodynamic, and thrust) for sea level at military thrust in An aircraft has the following Euler angles and Euler rates $\psi = 0°$, $\dot{\psi} = 10deg/s$, $\theta = 0°$, $\dot{\theta} = 0deg/s$, $phi = 90°$, $\dot{\phi} = 0deg/s$. Solve and get the pitching, rolling and yawing rates. Which motion the pilot will feel?	Apply	CO 8	PO 2,4
7	a	Classify the different ways the moving airplane axis system can be fixed with reference to the airplane?	Understand	CO 6	PO 1
	b	Examine the derivative for an aircraft at 1km altitude and Mach 0.9 ($U_1 = 267m/s$, $q = 1383\ kg/m^2$, $S = 50\ m^2$, $b = 12\ m$) if $C_{L\beta} = -0.08$. If β is perturbed to 1°, find perturbed rolling moment.	Analyze	CO 11	PO 2,4
8	a	Build the equation of speed damping derivatives and explain each term in detail. Draw the plot and contrast with required parameters.	Understand	CO 10	PO 1
	b	Solve the pitch damping derivative, C_{Mq} , for an aircraft with the following characteristics: $C_{L\alpha h} = 0.075/deg$, $\eta_H = 0.98$, $V_H = 0.375$, $X_H/c = 3:0$.	Apply	CO 12	PO 2,4

9	a	Is it possible to have dynamic stability without static stability? Give comments and express your thought on this.	Understand	CO 10	PO 1
	b	Demonstrate the effect of forward speed and cg location on the airplane on dynamic stability. Illustrate the plot of SPPO and velocity and explain its significance on the dynamic stability.	Understand	CO 12	PO 1
10	a	Elucidate about the dynamic stability. Specify with suitable example.	Understand	CO 9	PO 1
	b	What are the 4- different modes of motion of a dynamic system when responding to a disturbance from an equilibrium position?	Remember	CO 1	PO 2

KNOWLEDGE COMPETENCY LEVELS OF MODEL QUESTION PAPER



Signature of Course Coordinator **HOD, AE**
Dr. Yagya Dutta Dwivedi, Professor