



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	:	FLIGHT MECHANICS II
Course Code	:	A52111
Class	:	III B. Tech I Semester
Branch	:	AERO
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OBJECTIVES

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited.

In line with this, Faculty of Institute of Aeronautical Engineering, Hyderabad has taken a lead in incorporating philosophy of outcome based education in the process of problem solving and career development. So, all students of the institute should understand the depth and approach of course to be taught through this question bank, which will enhance learner's learning process.

S No	Question	Blooms taxonomy level	Course Outcomes
UNIT – I			
AIRCRAFT IN EQUILIBRIUM FLIGHT- ELEVATOR ANGLE AND STICK FORCES TO TRIM- LONGITUDINAL STATIC AND MANEUVER STABILITY			
Part - A (Short Answer Questions)			
1	How many degrees of freedom an aircraft has?	Understand	1
2	Write down the rotational and translational motion of an airplane. .	Apply	1
3	Define what is meant by equilibrium condition for an airplane.	Apply	1
4	Define what is meant by static stability.	Apply	1
5	Define dynamic stability.	Knowledge	1
6	Write down the drag polar equation for an airplane.	Knowledge	1
7	Write down the expressions for C_L , C_M , & C_D	Knowledge	1
8	Write down the expressions for α , β in terms of velocity components u , v & w .	Knowledge	1
9	Write down the primary controls and secondary controls of an aircraft.	Knowledge	1
10	Define pressure drag and skin friction drag of an aircraft.	Understand	1

Part - B (Long Answer Questions)			
1	Represent the body axis coordinate system of an airplane and list down the forces, moments and velocity components of an airplane and also show them on the sketch.	Understand	1
2	Explain with relevant figure, the equilibrium conditions of an airplane in a longitudinal symmetric flight.	Understand	1
3	Describe the static stability conditions about the three axis of an airplane.	Understand	1
4	Explain the requirements for static and dynamic stability for an airplane.	Knowledge	1
5	What are the primary and secondary controls and also explain the purpose of each of these controls	Understand	1
6	Explain the difference between inherently stable and marginally stable airplane	Understand	1
7	Write down the six degree of freedom equations of motion of an airplane	Knowledge	1
8	Briefly explain the general aspects of airplane dynamics.	Knowledge	1
9	Explain the aerodynamic controls that are used to maximize the lift	Knowledge	1
10	Explain various methods of reducing the aerodynamics drag of an airplane	Understand	1
Part - C (Problem Solving and Critical Thinking Questions)			
1	Describe with the help of a diagram the mission profile of a civil transport aircraft. What is involved in performance estimation process and where performance estimation can be applied?	Understand	1
2	Aircraft flight controls fall into two broad categories. What are those categories? Explain them in detail with figures	Understand	1
3	A wing section being tested in a wind tunnel is hinged at its leading edge, with freedom to rotate about the hinge axis. Calculate the equilibrium floating angle of the wing at a tunnel speed of 100 kmph, given that: wing weight is 250 N/m ² , c.g. location at 0.4 c.a.c. location at 0.24c, $C_{mac} = -0.04$, $\alpha_{0L} = -3^\circ$, $dC_l/d\alpha = 0.105 \text{ deg}^{-1}$. Assume standard sea level conditions. Is the equilibrium statically stable?	Analyze	1
4	For an airplane the pitching moment co-efficient is given by the following expression when c.g. lies at 0.25c. $C_{m_{cg}} = 0.05 - 0.10CL - 0.01\delta_e$ where δ_e is in degrees. Answer the following: Is the airplane statically stable? Justify. What is the static margin in this case? What is the location of neutral point stick fixed? What is the value of CL for which equilibrium is achieved with zero elevator deflection?	Understand	1
5	Write a short note on the following: i).Trim tabs ii) Balance tabs iii) Balance of forces	Understand	1
6	Explain briefly on Elevators with neat sketch? And discuss about Tailing – edge flaps?	Understand	1
7	A jet airplane has the following characteristics $CL_{\alpha} = 4.87 \text{ rad}^{-1}$, $CL_{at} = 3.32 \text{ rad}^{-1}$, $(C_{m\alpha})_{f,n,p} = 0.39 \text{ rad}^{-1}$, $St/S = 0.25$, $l_t/c = 3.0$, $\eta = 0.9$, $d\epsilon/d\alpha = 0.4$. At the rear most c.g. location the airplane has a static margin stick-fixed of -0.02. By how much the area of the horizontal tail be increased to have a static margin of +0.05?	Analyze	1
8	Explain them with sketches a) Pressure distribution over the body surface & b) Shear stress distribution over the body surface.	Knowledge	1
9	An airplane has the following contributions from various components. $(C_{m_o})_w = -0.096$, $(C_{m_o})_w = 4.3 [X \text{ c.g./c} - 0.25]$ per radian, $(C_{m_o})_{f,n,p} = 0.04$, $(C_{m_o})_{f,n,p} = 0.38$ per radian, $(C_{m_o})_t = +0.17$, $(C_{mat})_{stick-fixed} = -1.04$ per radian . Obtain location of stick-fixed neutral point .	Analyze	1

10	Explain the following terms with examples Stability Equilibrium	Understand	1
UNIT – II			
ESTIMATION OF AERODYNAMIC FORCE AND MOMENT DERIVATIVES OF AIRCRAFT			
Part – A (Short Answer Questions)			
1	Write down the expressions for stability derivatives of an airplane in pitch, yaw and roll.	Knowledge	1
2	Write down the expressions for pitch, yaw and roll control derivatives of an airplane.	Knowledge	1
3	What are three types of control with reference to C.G of an airplane?	Knowledge	1
4	Draw a graph of C_M vs α for statically stable, unstable and neutrally stable aircraft configuration.	Knowledge	2
5	What are the four major effects of propeller slipstreams on the longitudinal stability of an aircraft.	Knowledge	2
6	Define taper ratio and aspect ratio of an airplane.	Knowledge	2
7	Write down the expression for mean aerodynamic chord of an airplane.	Analyze	2
8	Define wing ‘wash out’ and ‘wash in’.	Knowledge	2
9	Define compressibility.	Knowledge	2
10	Define flexibility.	Knowledge	2
Part - B (Long Answer Questions)			
1	What are the assumptions made in the study to stability and control of an airplane.	Understand	1
2	Derive rigid body equations of motion for F_x , F_y , F_z and L , M , N ,	Knowledge	1
3	Describe the components of gravitational forces and thrust forces acting along the body fitted axis system.	Knowledge	1
4	Discuss the variation of aerodynamic $C_m\alpha$ and C_mq with the Mach number graphically.	Understand	2
5	Explain what is meant by pure pitching motion.	Knowledge	2
6	Consider the airplane in yaw orientation, write down the relation between angles and the velocities.	Knowledge	2
7	Show graphically , the Variation of lateral Derivatives $C_l\beta$ and C_{lp}	Knowledge	2
8	Derive the aerodynamic derivatives due to the pitching velocity q .	Knowledge	2
9	List down the Inertia parameters about the three axis their significance in the study of dynamic stability.	Knowledge	2
10	Show the graphical variation of C_{nr} and $C_{n\beta}$ with Mach number and explain	Knowledge	2
Part - C (Problem Solving and Critical Thinking Questions)			
1	Why aerodynamic forces and propulsive forces are of importance to the performance of an aircraft? Explain the Lateral-Directional stability Requirements.	Understand	1
2	What are the purposes for which the performance of an aircraft needs to be measured in flight?	Knowledge	1
3	Explain in detail about the elevator control power with sketches.	Knowledge	2
4	Define floating tendency and restoring tendency in the case of stick-free longitudinal Stability and derive an expression for control surface angle.	Understand	2
5	What is drag? Explain the types of drag and write drag equation?	Understand	2
6	Explain EOM (Equation of Motion)	Understand	2

7	Explain the following term: i). Aerodynamic forces during climbing Flight (with neat diagram)	Understand	2
8	Explain the following terms i).Elevator Hinge moments ii). Pitch rate & Pitch damping	Understand	2
9	Explain the Control Tabs-types, function and construction.	Understand	2
10	Why aerodynamic forces and propulsive forces are of importance to the performance of an aircraft?	Understand	1
UNIT – III			
STICK FREE LONGITUDINAL STABILITY- CONTROL FORCES TO TRIM, LATERAL-DIRECTIONAL STATIC STABILITY AND TRIM			
Part - A (Short Answer Questions)			
1	Define hinge moment and write down the expression for hinge moment coefficient.	Knowledge	3
2	Plot the variation of hinge moment with control deflections	Analyze	3
3	Plot hinge moment variation with angle of attack.	Knowledge	3
4	Write down the equation for elevator floating angle.	Knowledge	3
5	Define neutral point	Knowledge	3
6	What are the functions of trim tab	Knowledge	4
7	Plot the pressure distribution due to control deflection angle.	Analyze	4
8	List the three different types of aerodynamic balancing.	Understand	4
9	List down the different types of manoeuvres and the significance of turn radius and turn rate.	Knowledge	4
10	Define maneuver point.	Knowledge	4
Part - B (Long Answer Questions)			
1	Discuss the effects of allowing the controls free to float.	Knowledge	3
2	Show the variation of hinge moment with angle of attack and sketch the pressure distribution over the airfoil with angle of attack.	Knowledge	3
3	Derive the expression for the total hinge moment coefficient due to the contribution of control deflection and angle of attack.	Knowledge	3
4	Explain the control surface floating characteristics.	Knowledge	3
5	Explain the following type of aerodynamic balancing: a) Horn b) Internal Seal & c) Bevelled Trailing edge	Knowledge	3
6	Briefly explain the functions of control surface tab with relevant sketches and graphs.	Knowledge	4
7	Define the stick free neutral point and write down the expression for the same and explain its significance.	Knowledge	4
8	Explain the aerodynamic forces on a stabilator configuration in stick free condition of an airplane.	Knowledge	4
9	Discuss qualitatively, various ways of improving the lateral and directional stability of an aircraft.	Knowledge	4
10	How are the terms static stability and dynamic stability associated with an airplane?	Knowledge	4
Part - C (Problem Solving and Critical Thinking Questions)			
1	Explain with at least one example for static stability and two examples For dynamic stability. Use sketches.	Knowledge	3
2	Write a short note on Aircraft Axis Systems & Earth to Body Axis System Transformation	Knowledge	3
3	What are the two necessary criteria for longitudinal balance and static stability? Explain with neat sketches.	Knowledge	3

4	Discuss qualitatively, various ways of improving the lateral and directional stability of an aircraft.	Understand	3
5	Derive the expression for the stick fixed neutral point and static margin.	Understand	3
6	Write about the Aircraft component contributions.	Understand	4
7	Derive an expression for stick force gradient (dF/dV) and explain the requirement for proper stick force variation	Analyze	4
8	Define hinge moment coefficient and explain its variation with horizontal tail angle of attack(α_t) and elevator deflection (δ_e).	Analyze	4
9	Show that the stick force is proportional to the difference between the elevator deflection required, $(\delta_e)_{reqd}$, and the floating angle(δ_e free).	Analyze	4
10	Explain the term stick-free neutral point. How can it be determined by flight tests? Explain what are the factors influence the stick-free neutral point.	Analyze	4

UNIT – IV
AIRCRAFT EQUATIONS OF MOTION- PERTURBED MOTION- LINEARISED, DECOUPLED EQUATIONS OF MOTION OF AIRCRAFT

Part – A (Short Answer Questions)

1	Bring out the difference between equilibrium condition and trim condition for an airplane.	Knowledge	5
2	Define longitudinal static stability of an airplane	Knowledge	6
3	List down the various components contribution of pitching moments to the total pitching moment of the airplane about the C.G.	Knowledge	6
4	Show graphically the variation of $C_{Mc.g}$ vs C_L for various vertical position of wing with the fuselage.	Knowledge	6
5	Plot the typical variation $C_{Mc.g}$ vs C_L for stable and unstable airplane.	Knowledge	6
6	Show the typical variation $C_{Mc.g}$ vs C_L for the values of elevator deflections: $\delta_e = 0, -8$ and -10 deg.	Knowledge	6
7	Define trim point at trim angle of attack of an airplane.	Analyze	6
8	Write the expression for elevator control power, $C_m \delta_e$	Analyze	6
9	Define stick fixed neutral point.	Knowledge	6

Part - B (Long Answer Questions)

1	Represent the forces on the airplanes in accelerated and un-accelerated flight and explain.	Knowledge	5
2	Represent the forces on an airplane in an accelerated level turn flight and derive the expressions for angular velocity and radius of turn.	Knowledge	6
3	Draw the schematic diagrams of an airplane in pull-down manoeuvre and obtain the expression for rate of turn and radius of turn.	Apply	6
4	Represent the forces on an airplane in pull-up manoeuvre and derive the expressions for radius of turn and rate of turn.	Knowledge	6
5	An airplane is performing a pull-up manoeuvre at a true airspeed of 350m/sec with a load factor of 4.0 and pull down manoeuvre at a true airspeed of 250m/sec with a load factor of 5.0 calculate the radius of turn and rate of turn in both the manoeuvres.	Apply	6
6	Define load factor. What are its values in (a) level flight (b) free fall (c) in a turnoff radius 200 m at a speed of 100 m/sec (d) at the bottom of a loop of radius 200m at a speed of 100 m/sec.	Knowledge	6
7	Obtain the static stability equation for (dC_m/dc) with the contribution of wing, fuselage, nacelles and horizontal tail.	Analyze	6
8	Derive an expression for (dC_m/dCl) wing	Knowledge	6
9	Obtain an expression for (dC_m/dCl) tail	Analyze	6
10	Define stick-fixed neutral point and derive the expression for the same	Understand	6

Part - C (Problem Solving and Critical Thinking Questions)			
1	With the help of sketches, explain the method of measurement of coupled aerodynamic stability and damping derivatives in a wind tunnel	Understand	5
2	Derive an expression for the elevator angle required to overcome the rotational moment of an aircraft about its pitch axis in terms of the forward velocity and load factor of the airplane 'n' for pull up from level flight, assuming 10% increase in tail damping requirement.	Analyze	6
3	Explain the aerodynamic forces on a stabilator configuration in stick free condition of an airplane	Understand	6
4	Write a short note on Decoupling- conditions for validity, role of symmetry	Understand	6
5	Description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition	Understand	6
6	What are the two necessary criteria for longitudinal balance and stability? Explain with neat sketches.	Knowledge	6
7	Derive an expression for the floating angle of the elevator of an airplane at a given tail angle of attack and air speed V, in terms of the aerodynamic, geometric and Inertial properties of the elevator.	Analyze	6
8	Draw neat sketches about sideslip.	Knowledge	6
9	Bring out the relationship between yaw and roll of an airplane in the following cases. (a) Rolling moment with yaw rate (b) Yawing moment with roll rate.	Knowledge	6
10	Write a typical Transfer Function for an aircraft and explain. How is it useful in explaining the behavior of the aircraft for a disturbance?	Knowledge	6
UNIT – V			
LONGITUDINAL AND LATERAL-DIRECTIONAL DYNAMIC STABILITY			
Part - A (Short Answer Questions)			
1	Define directional static stability of an airplane.	Knowledge	7
2	Write down the expression for yawing moment coefficient.	Knowledge	8
3	Define angle of yaw (ψ) and angle of side slip(β)	Knowledge	8
4	Plot the variation of C_n V_S ψ for directionally stable and unstable airplane.	Knowledge	8
5	Name the control surface applied for directional control.	Knowledge	9
6	Show the typical variation of yawing moment coefficient with rudder deflection with zero degree angle of yaw.	Knowledge	10
7	Define the term 'dihedral effect'.	Understand	10
8	What is the criteria for lateral stability of an airplane.	Understand	10
9	Show graphically 'Phugoid mode' Short period mode' of an airplane	Analyze	10
10	Define directional static stability of an airplane.	Knowledge	10
Part - B (Long Answer Questions)			
1	Draw the airplane with angle side slip (β) and an angle of yaw (ψ) and represent the angles and velocities.	Knowledge	8
2	Define the criteria for directional stability of an airplane and explain with relevant graphs and equations.	Knowledge	8
3	Derive the expression for yawing moment derivative C_n due to vertical tail.	Evaluate	8
4	Briefly explain the following (a) Adverse Yaw (b) Anti-symmetric power (c) Cross- wind during landing and take-off.	Evaluate	9
5	Explain what is meant by 'Rudder Lock'	Knowledge	10

6	What is dorsal fin and explain its significance to directional stability.	Knowledge	10
7	Explain what is meant by dihedral effect and describe the criteria for lateral stability of an airplane.	Understand	10
8	Write about the following terms: (a) Dutch Roll and Spiral Divergence (b) Stability Augmenter.	Understand	10
9	Write a short note on the following: a) Flying Techniques and b) Wind Shear Recovery Techniques	Understand	10
10	Write a short note on Dutch Roll? And differentiate between Directional Divergence and spiral Divergence.	Understand	1
Part - C (Problem Solving and Critical Thinking Questions)			
1	Explain the following term: i). Spiral Flight with a neat sketch ii). Dutch Roll.	Knowledge	8
2	Bring out the relationship between yaw and roll of an airplane in the following cases: a) Rolling moment with yaw rate b) Yawing moment with roll rate.	Understand	8
3	Explain with appropriate sketches, the following :a) Phugoid motion b) Spiral instability c) Dutch Roll motion	Knowledge	8
4	What are the two distinct types of longitudinal modes, required describing the Motion of an aircraft, when the aircraft is not perturbed about the roll or yawing axis? Explain them in detail.	Understand	9
5	Explain Aircraft Dynamic Mode shapes- significance.	Understand	10
6	Explain the term degrees of freedom. How many degrees of freedom does a rigid airplane with free aileron, elevator and rudder have?	Analyze	10
7	The lateral stability quartic for an airplane is : $\lambda^4 + 16\lambda^3 + 13.1\lambda^2 + 9.8\lambda + 0.73 = 0$ Extract the roots of this quartic. Obtain the time to double or halve the amplitude and the period of the oscillatory mode.	Analyze	10
8	Sketch a single parameter stability diagram or a root locus plot when C_{ma} changes from a large negative value to a small positive value	Analyze	10
9	The roots of a longitudinal stability quartic are:- $2.57 \pm i 2.63$; $+0.02$ and- 0.26 . Discuss the types of motions indicated by each mode. What would be the final motion of the airplane?	Analyze	10

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