INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	:	**AIRCRAFT STABILITY AND CONTROL**
Course Code	:	**AAE014**
Regulation	:	IARE - R16
Year	:	2019– 2020
Class	:	B. Tech VI Semester
Branch	:	Aeronautical Engineering
Team of Instructors	:	Dr. Yagya Dutta Dwivedi, Professor, Department of Aeronautical Engineering. Mr. S. Devaraj, Assistant Professor, Department of Aeronautical Engineering.

COURSE OBJECTIVES (COs):

The course should enable the students to:

I	Demonstrate concept of stability and application to dynamic systems like Aircraft, and the role of primary controls and secondary controls in longitudinal stability.
II	Understand the concept of slide slip angle, roll angle and yaw angle their concepts related to lateral-directional stability.
III	Learn about the mathematical modeling of an aircraft in longitudinal, lateral and directional cases.
IV	Estimate the longitudinal and directional parameters with the help of the linearized equations of aircraft motion.
V	Analyze the different type of dynamic modes in longitudinal, lateral and directional motion of aircraft, and recovery from those modes.

COURSE LEARNING OUTCOMES (CLOs)

Students, who complete the course, will be able to demonstrate the ability to do the following:

AAE014.01	Remember concept of stability, controllability and maneuverability in an aircraft.
AAE014.02	Understand the basic mathematics, science and engineering for solving problems of longitudinal, lateral and directional static stability.
AAE014.03	Describe stick fixed and stick free conditions for neutral point.
AAE014.04	Demonstrate different methods for finding static margin, control force and CG limitation.
AAE014.05	Remember total stability parameters in order of merit of flight conditions.
AAE014.06	Understand the cause of instability in an aircraft and solve the issue.
AAE014.07	Identify aircraft different types of stability for different categories of aircraft.
AAE014.08	Demonstrate the aircraft component contribution for lateral and directional stability.
AAE014.09	Understand the axes system and forces and moments.

AAE014.10	Remember the Lateral and directional equations of motion of aircraft.
AAE014.11	Understand the Eulers angles and determination of velocity.
AAE014.12	Apply the Equations of motion for all the six degree of freedom applied to aircraft.
AAE014.13	Understand the linearized equations of motion related to airplane.
AAE014.14	Remember the force contribution in linearization of equations of the motion.
AAE014.15	Understanding the different derivatives used for solving stability and control problems in aircrafts.
AAE014.16	Apply the concept of Linearised longitudinal and lateral-directional equations of perturbed motion.
AAE014.17	Remember the modes of motion characteristics, mode shapes and its significance.
AAE014.18	Understanding one degree of freedom, two degree of freedom approximations.
AAE014.19	Remember short period, constant angle of attack (long period) approximations-solutions.
AAE014.20	Apply equation for longitudinal dynamic stability and lateral dynamic stability considering coefficients of characteristics and stability criteria.

UNIT – I				
INTRODUCTION AND LONGITUDINAL STABILITY - I				
PART - A (SHORT ANSWER QUESTIONS)				
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**Course outcome**	**Course Learning Outcomes (CLOs)**
1	What are the direct propeller contributions to S.L.S arising due to the forces created by propeller and write their simple forms in terms of (h/c) and (lp/c).	Remember	CO1	AAE014.02
2	Summarize the conditions for longitudinal static stability.	Understand	CO1	AAE014.01
3	Discuss the horizontal tail volume ratio and write it's significant.	Remember	CO1	AAE014.01
4	How the forward c.g limit is restricted by the ground effect or for landing maneuvers ?	Understand	CO1	AAE014.02
5	Demonstrate the downwash and write its effects on aircraft stability.	Remember	CO1	AAE014.01
6	Discuss about hinge moment on elevator. How it effect the pilot force?	Understand	CO1	AAE014.01
7	Briefly summarize the need of mass balancing on control surfaces.	Understand	CO1	AAE014.01
8	Identify the center of pressure and aerodynamic center.	Remember	CO1	AAE014.01
9	With the help of Cm vs C_L curve of an airplane, state the stable, neutral and unstable conditions of it.	Understand	CO1	AAE014.01
10	What is the criterion for static longitudinal stability?	Remember	CO1	AAE014.02
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.	Remember	CO1	AAE014.01
2	Demonstrate with diagram of the all three axes used for stability of an aircraft.	Understand	CO1	AAE014.01
3	A pilot wants to pitch up the airplane. Demonstrate the configuration and positions of the control on a neat diagram and explain with force and moments variations.	Remember	CO1	AAE014.01
4	Draw the plot of pitching moment verses angle of attack and explain the all three types of longitudinal static stability.	Remember	CO1	AAE014.01

5	What is the influence of elevator on pitching moment when angle of attack is changed?	Remember	CO1	AAE014.01
6	If the CG is on top of the neutral point. What will be the attitude of the airplane? Explain with diagram.	Remember	CO1	AAE014.01
7	Draw the flow field around an aircraft created by the wing and explain its significance.	Remember	CO1	AAE014.01
8	How stick forces are balanced? Explain need for balancing these forces.	Understand	CO1	AAE014.01
9	Explain the effects of fuselage in longitudinal static stability.	Understand	CO1	AAE014.01
10	Annotate about different trim tabs used in aircraft. What is necessity of these?	Remember	CO1	AAE014.01
11	What is meant by stability of an airplane and what way it is different from Balance?	Remember	CO1	AAE014.01
12	What are the two methods for predicting fuselage contribution to longitudinal stability of airplane? Write down the formulae for simpler method and explain the terms in it.	Understand	CO1	AAE014.01
13	State two contributions for static longitudinal stability and indicate them with a plot.	Remember	CO1	AAE014.02
14	What is Neutral point (NP) of an airplane at stick fixed and power-off condition. Show the new position of 'N0' at power-on condition relative to the earlier N0.	Understand	CO1	AAE014.02
15	What are the two major effects of the running propeller that contribute to the Longitudinal stability and define them.	Understand	CO1	AAE014.01
PART - C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	With neat diagram explain the effect of elevator on longitudinal static stability. Draw the flow pattern with and without elevator deflection on total airplane.	Understand	CO1	AAE014.03
2	If $C_M = +C_{M\alpha}$. ; What will the value of C_{Mo} for cambered and symmetrical airfoil. Also explain the values for positive and negative camber airfoils.	Understand	CO1	AAE014.03
3	Write a short note on the following: a) Trim tabs b) Balance tabs	Understand	CO1	AAE014.03
4	Formulate the mathematical expression for canard contribution on static longitudinal stability. Explain the term obtained. What are the advantages and disadvantaged of this configuration?	Understand	CO1	AAE014.03
5	What are the two methods for predicting fuselage contribution to longitudinal stability of airplane? Write down the formulae for simpler method and explain the terms in it.	Understand	CO1	AAE014.03
6	Find the maximum lift coefficient which can be trimmed by the aircraft with the following characteristics, when the cg is at its forward limit of 0.13 of the amc, assuming the tab angle to be zero: $\bar{V}_T = 0.48$, a = 4.5, $a_1 = 2.8$, $a_2 = 1.2$, $d\varepsilon/d\alpha = 0.4$, aerodynamic centre position h o = 0.18, tailplane setting angle $\eta_T = -1.8°$, $C_{Mo} = -0.018$. The elevator angle travel limits are ±30 °.	Apply	CO1	AAE014.03
7	A jet airplane has the following characteristics $C_{L\alpha w} = 4.87\ rad^{-1}$, $CL_{\alpha t} = 3.32\ rad^{-1}$, $(C_{m\alpha})f,n,p = 0.39\ rad^{-1}$, $S_t/S = 0.25$, $l_t/c = 3.0$, $\eta = 0.9$, $d\varepsilon/d\alpha = 0.4$. 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 is increased to have a static margin of +0.05?	Apply	CO1	AAE014.04
8	An aircraft without tail has the following characteristics: $C_{M0} = -.4$ and $C_{M\alpha} = -.2$/deg. Describe the steady state motion. Find the tendency of aircraft nose. Is it statically stable?	Apply	CO1	AAE014.04
9	An aircraft with wings of rectangular planform and the characteristics given below is in steady level flight at a lift coefficient of 0.3. Find the elevator angle to trim with zero tab angle and the cg margin stick fixed. Wing area = 25 m 2, aspect ratio = 6, c.g at 0.6 m aft of the	Apply	CO1	AAE014.04

	leading edge, tail arm = 6 m, tailplane setting angle = - 1 °, $d\varepsilon/d\alpha$ = 0.46, am = 4.6, a2 = 3.1, a3 = 1.6, C_{Mo} = -0.036, tailplane area = 3.7 m^2, aerodynamic centre at 0.25c.			
10	An aircraft is flying close to the ground at a speed of 50 m s^{-1}. Determine the elevator angle to trim the aircraft, with zero tab angle, if the aerodynamic characteristics in this condition are as follows: Wing loading = 360 kg m^{-2}, a = 4.7, a_1 = 3.4, a_2 = 2.0, $\bar{V}_T$ = 0.48, δC_L due to flap = 0.9, C_{M0} flaps down = -0.162, $d\varepsilon/dC_L$ = 0.11. The cg is 0.03 c aft of the aircraft-less-tail aerodynamic centre. The reduction in downwash due to ground effect is 1.6 ° and the tailplane setting angle is - 3 °. All slopes are expressed per radian.	Apply	CO1	AAE014.04
11	What are the major contributions of the indirect effects of the running propellers on the static longitudinal stability? Draw the diagram and summarize the findings.	Apply	CO1	AAE014.04
12	Briefly recall the c.g limits with the help of a figure and what decides the anticipated c.g travel of the airplane.	Understand	CO1	AAE014.04
13	How the most forward c.g limit of the airplane is fixed? Give the example and demonstrate the limits with neat diagram.	Understand	CO1	AAE014.04
14	Write down the expression for the maximum stability attainable by the elevator using its maximum up-elevation.	Understand	CO1	AAE014.04
15	A pilot wants to roll the airplane to left. Demonstrate with proper diagram about the variation of aerodynamic forces and positions of the control surfaces.	Apply	CO1	AAE014.04
UNIT – II				
LATERAL – DIRECTIONAL STATIC STABILITY				
PART - A (SHORT ANSWER QUESTIONS)				
1	What are the sideslip and side slip angle and its effects?	Remember	CO2	AAE014.05
2	List the reasons for adverse yaw. What is reason for this?	Remember	CO2	AAE014.05
3	What is lateral static stability? In which axis, this occurs?	Remember	CO2	AAE014.05
4	Show the condition for static directional stability.	Understand	CO2	AAE014.05
5	Demonstrate the speed stability and its importance in directional stability.	Understand	CO2	AAE014.06
6	Illustrate different types of ailerons used as flight control devices.	Understand	CO2	AAE014.05
7	How the effect of freeing the elevator changes the tail contribution to the longitudinal stability?	Remember	CO2	AAE014.05
8	How the floating rudder (stick-free) affects the directional stability?	Remember	CO2	AAE014.05
9	Show the power of lateral or aileron control.	Remember	CO2	AAE014.05
10	What are the basic requirements that are to be fulfilled by the lateral control system?	Understand	CO2	AAE014.06
PART - B (LONG ANSWER QUESTIONS)				
1	Demonstrate the contribution of wing and fuselage in airplane directional stability.	Understand	CO2	AAE014.05
2	What are three types of control with reference to C.G of an airplane?	Remember	CO2	AAE014.05
3	Why aerodynamic forces and propulsive forces are of importance to the performance of an aircraft?	Remember	CO2	AAE014.05
4	Compare the Lateral-Directional stability Requirements with longitudinal stability.	Understand	CO2	AAE014.05
5	Find the mathematical expression for yawing moment derivative C_n due to vertical tail.	Understand	CO2	AAE014.05
6	Illustrate with neat diagram about spoilers and its utility. How does this work? Demonstrate and show with required diagram.	Remember	CO2	AAE014.06
7	Recall the effect of the wing sweep to cater directional static stability. Demonstrate the effects of sweepback on yawing and rolling moments.	Remember	CO2	AAE014.06

8	Demonstrate the wing and fuselage contribution to the effect of dihedral in lateral stability.	Understand	CO2	AAE014.05
9	Find the mathematical expression for static margin and how does this affect the directional and lateral stability?	Understand	CO2	AAE014.05
10	What is meant by rudder lock? Demonstrate with suitable diagram and expression.	Remember	CO2	AAE014.05
11	How the total directional stability contribution of airplane is made more stabilizing?	Remember	CO2	AAE014.05
12	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	CO2	AAE014.05
13	Why the rudder is designed to suit one-engine inoperative condition? Demonstrate with suitable sketch mentioning all required forces and moments.	Remember	CO2	AAE014.05
14	What is the criterion to keep the directional stability with stick-free above certain limit or not to lose much?	Understand	CO2	AAE014.05
15	What is the relation for the greatest of pedal force (PF) with respect to sideslip and give its accepted value?	Understand	CO2	AAE014.05
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Show the flow pattern over the vertical tail when the side slip is from left side of the pilot.	Understand	CO2	AAE014.06
2	With neat diagram explain about static roll stability. Show the attitude of airplane in different stability conditions.	Remember	CO2	AAE014.06
3	Find the mathematical expression for vertical tail contribution to directional stability.	Remember	CO2	AAE014.07
4	During flight, it was observed that rudder got fixed 3 degree right. How the pilot will handle this condition? Show with diagram.	Remember	CO2	AAE014.07
5	During flight, the left aileron found stuck to neutral condition. Pilot wanted to roll left. What are the controls needed to do this attitude?	Remember	CO2	AAE014.07
6	Why "T" tail is used in some airplanes? Show the flow pattern and do flow analysis.	Remember	CO2	AAE014.07
7	The wing and fuselage itself give the unstable aircraft. Why? Draw the forces and moments diagram and explain this statement.	Understand	CO2	AAE014.07
8	What are the two methods for predicting fuselage contribution to longitudinal stability of airplane? Write down the formulae for simpler method and explain the terms in it.	Understand	CO2	AAE014.07
9	Determine the aileron and rudder deflections required for an F-15 to maintain a +1 degree ''wings level'' sideslip at 0.9 Mach and 7km. Determine the value of the sideforce coefficient under these conditions. Applicable derivatives are as follow: C_{yo}=0, $C_{y\beta}$= -0.9056/rad, $C_{y\delta a}$ = -0.0047/rad, $C_{y\delta r}$ =0.1492/rad C_{lo}=0, $C_{l\beta}$= -0.0732/rad, $C_{l\delta a}$ = 0.0226/rad, $C_{l\delta r}$ =0.0029/rad C_{no}=0, $C_{n\beta}$= -0.0732/rad, $C_{n\delta a}$ = 0.0226/rad, $C_{n\delta r}$ =-0.0712/rad	Apply	CO2	AAE014.08
10	Draw the plots of C_m vs α and $C_L$vs α showing the effects of elevator deflections in positive and negative direction. Demonstrate the effects of elevator deflection on the angle of attack of the tail plane.	Apply	CO2	AAE014.08
11	How the total directional stability contribution of parts of airplane is made more stabilizing?	Remember	CO2	AAE014.06
12	The static lateral stability should not be too small, Give reason and explain.	Understand	CO2	AAE014.07
13	How the floating rudder (stick-free) affects the directional stability?	Remember	CO2	AAE014.08
14	What are the flight conditions or maneuvers that produce unbalance yawing moments those are to be overcome by rudder?	Remember	CO2	AAE014.07
15	How far aft can we place the cg with retaining stability? Demonstrate this with proper equation and a neat diagram.	Understand	CO2	AAE014.08

UNIT-III				
AIRCRAFT EQUATIONS OF MOTION				
PART - A (SHORT ANSWER QUESTIONS)				
1	Illustrate the slip stream related to aircraft lateral and directional stability.	Remember	CO3	AAE014.09
2	Demonstrate stability axes system and how it differs from body axes system.	Remember	CO3	AAE014.09
3	List the degree of freedom for an airplane and explain its importance.	Understand	CO3	AAE014.09
4	Identify the aircraft response related to aircraft Equations of motions.	Understand	CO3	AAE014.10
5	Draw a diagram of yaw rotation while Earth to Body axis transformation.	Remember	CO3	AAE014.09
6	What are the different ways the moving airplane axis system can be fixed with reference to the airplane?	Remember	CO3	AAE014.09
7	What are linear momentum and angular momentum? Explain with formula.	Remember	CO3	AAE014.09
8	What are the equations of longitudinal motion with free control?	Understand	CO3	AAE014.10
9	Draw a block diagram for transformation of Earth axis system to Body Axis system.	Understand	CO3	AAE014.10
10	How many degrees of freedom does an aircraft have? How many are Translational and how many are rotational?	Remember	CO3	AAE014.09
PART – B (LONG ANSWER QUESTIONS)				
1	Illustrate the six degrees of motion of a dynamic system and how it is formed for the airplane?	Remember	CO3	AAE014.09
2	Outline the different ways the moving airplane axis system can be fixed with reference to the airplane?	Understand	CO3	AAE014.09
3	What is the need for moment equation? Write moment equations in all the three axes and explain each term and give some examples.	Remember	CO3	AAE014.09
4	What is the meaning of aircraft response and applied forces?	Understand	CO3	AAE014.09
5	Interpret about inertia tensor for an aircraft in the body frame of reference.	Understand	CO3	AAE014.09
6	Demonstrate about the $I_{XX,}$ I_{YY} and I_{ZZ}. Draw the diagram and show that in different axes the value will differ.	Understand	CO3	AAE014.10
7	How many degrees of freedom does an aircraft have? How many are translational and how many are rotational?	Remember	CO3	AAE014.10
8	Write three kinematic equations and explain each term in it.	Remember	CO3	AAE014.10
9	Discuss about orientation and position of airplane.	Remember	CO3	AAE014.09
10	Illustrate about the gravitational and thrust force calculation. Give the equation for the thrust force.	Understand	CO3	AAE014.09
11	What are the different ways the moving airplane axis system can be fixed with reference to the airplane?	Remember	CO3	AAE014.09
12	What are the equations of longitudinal motion with free control? Write the equations and explain each term with physical application.	Remember	CO3	AAE014.09
13	"The derivatives due to the tail are appreciable". Give a sketch and explain with necessary tail configurations.	Apply	CO3	AAE014.09
14	How the Euler's angles are useful for getting the relations of Body axes and Earth axes system? Demonstrate with diagram.	Understand	CO3	AAE014.09
15	A rudder deflection of 30 deg produces a stable sideslip angle of 50 deg. Estimate $Cn_{\beta,wf}$. Neglect Downwash, use η_v = 1, $CL\alpha,v$ = .1 deg−1, Sr /St = .6 and V_v = .8.	Apply	CO3	AAE014.09

PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	How Earth Axis to Body Axis transformation takes place? Show Euler's angles and explain.	Understand	CO3	AAE014.09
2	Find the mathematical formulation for aircraft force equations of motion in three directions. Explain all terms clearly.	Understand	CO3	AAE014.09
3	Compare the moments of inertia applicable in equations of motion. Give their mathematical formula.	Understand	CO3	AAE014.10
4	Find the mathematical formulation aircraft moment equations of motion in three directions. Explain all terms clearly.	Understand	CO3	AAE014.10
5	Write the angular acceleration, gyro precession and coupling terms in moment equations and explain about each term.	Understand	CO3	AAE014.11
6	An aircraft has the following Euler angles and Euler rates ψ = 0 deg $\dot{\psi}$ =10 deg/s, θ= 0 deg, $\dot{\theta}$ = 0 deg/s, ϕ = 90 deg, $\dot{\phi}$ 0 deg/s. Find the pitching, rolling and yawing rates. Which motion the pilot will feel?	Apply	CO3	AAE014.11
7	Express all forces (weight, aerodynamic, and thrust) for sea level at military thrust in most convenient axis system. Assume the thrust lines are parallel to the longitudinal axis and in plane of CG. The aircraft weighs 24.5 kN and each engine is delivering 3.11kN thrust.	Apply	CO3	AAE014.11
8	How the stability of dynamic motion can be judged using the coefficients of the 4th order quadratic which govern the motion.	Understand	CO3	AAE014.11
9	Consider a sniper firing a rifle due east at the equator. Ignoring the gravity and drag, what are the equations of motion of the bullet? Use the North-East-Up local coordinate system. Muzzle velocity: 1000m/s. Range: 4km.	Understand	CO3	AAE014.11
10	Consider the T-37 at the following Euler angles: ψ= 90 deg, θ= 10 deg, ϕ=10 deg Describe the aircraft attitude and transform the weight force through these angles to the body axis system. The gross weight is 1000 kg.	Apply	CO3	AAE014.11
11	Demonstrate the relationship with roll angle and sideslip angle. Give the mathematical equations and demonstrate with suitable sketch of flow pattern of the wind.	Apply	CO3	AAE014.09
12	How do determine rotation and velocity in the inertial frame, for intercept, obstacle avoidance etc.	Understand	CO3	AAE014.11
13	Find the mathematical formulation for the force equations in all the three direction i.e Fx, Fy and Fz and demonstrate these forces with aircraft diagram.	Understand	CO3	AAE014.12
14	Relate the applied forces in the equations of motions and write the necessary equation for applied forces in three dimensions.	Remember	CO3	AAE014.12
15	Recall all the six steps for deriving moment equations and explain the terms used in these equations.	Understand	CO3	AAE014.12
UNIT-IV				
LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENT DERIVATIVES				
PART – A (SHORT ANSWER QUESTIONS)				
1	Recall inertial axis system related to aircraft equation of motion.	Remember	CO4	AAE014.12
2	Relate the Roll damping derivative in perturbed EOM.	Remember	CO4	AAE014.12
3	Demonstrate the stability axis system for aircraft system.	Remember	CO4	AAE014.12
4	Show roll helix angle in finding aircraft stability derivatives.	Remember	CO4	AAE014.12
5	List the cross derivative and its significance in finding stability.	Understand	CO4	AAE014.12
6	What are the primary control derivatives for aircraft static stability?	Remember	CO4	AAE014.12
7	Demonstrate and realate the stability derivatives, Clp and Cnr.	Remember	CO4	AAE014.12
8	With a example demonstrate the small perturbation approach so approximate the PDE.	Understand	CO4	AAE014.12
9	What do you understand by first order approximation of applied	Remember	CO4	AAE014.12

	forces and moments?			
10	Briefly demonstrate about Axis systems associated with an angle of attack perturbation.	Understand	CO4	AAE014.12
PART – B (LONG ANSWER QUESTIONS)				
1	Classify the different ways the moving airplane axis system can be fixed with reference to the airplane?	Understand	CO4	AAE014.12
2	Illustrate the change in angle of attack at the horizontal tail because of pitch rate. Explain about positive pitch rate effects on downward velocity.	Understand	CO4	AAE014.12
3	By writing the longitudinal stability derivative $C_{m\alpha}$, explain how this stability is positive, negative or neutral? When it is concluded that the aircraft is statically stable? Draw the plot and show it.	Understand	CO4	AAE014.12
4	Build the equation of speed damping derivatives and explain each term in detail. Draw the plot and contrast with required parameters.	Apply	CO4	AAE014.12
5	Outline about small perturbation approach used to make equations of motions in linear form. How it is useful in linearization of EOM?	Remember	CO4	AAE014.12
6	Relate the linearized equation of motion for wings level, straight flight.	Understand	CO4	AAE014.12
7	What do you understand by first order approximation applied to aerodynamic forces and moments?	Remember	CO4	AAE014.12
8	Briefly demonstrate the method for Non dimensionalzing the First-Order Approximations	Remember	CO4	AAE014.12
9	Demonstrate the derivatives due to change in forward velocity with diagram. Explain the each term with proper applications.	Understand	CO4	AAE014.13
10	Demonstrate the derivatives due to change in downward velocity with diagram. Explain the each terms with proper applications.	Remember	CO4	AAE014.13
11	Simplify the Linearized EOMs for Wings Level, Straight Flight and write the equations and explain.	Understand	CO4	AAE014.12
12	What is Mach tuck derivative? Write its formula and explain each term clearly. Where this term is used?	Remember	CO4	AAE014.13
13	What is downwash lag? Demonstrate with diagram its importance in calculating stability derivatives.	Understand	CO4	AAE014.13
14	Estimate the pitch damping derivative, C_{mq}, for an aircraft with the following characteristics: $C_{L\alpha h}$ = 0.075/deg, η_h = 0.98, V_h = 0.375, $X_h/\bar{c}$ = 3:0.	Apply	CO4	AAE014.13
15	Demonstrate and explain the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why?	Understand	CO4	AAE014.13
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	What do you understand by lateral static stability derivative? Write the formula and explain its importance.	Understand	CO4	AAE014.13
2	Demonstrate the significance of aerodynamic derivatives on airplane stability.	Understand	CO4	AAE014.13
3	Infer about roll helix angle. Show the wing velocity distribution due to roll rate and relate the terms with each other.	Understand	CO4	AAE014.13
4	Find u/U_1 derivative for an aircraft at 1.0668 km and Mach 0.9 ($U_{1=}$ 267 m/s, q= 1383 kg/m^2, S=50m^2) if C_{D1} = 0.03 and C_{Du} = 0.027.If u is perturbed to 268,2 m/s, find the perturbed applied aero force along the x stability axis.	Apply	CO4	AAE014.14
5	Estimate the pitch damping derivative, Cm_q, for an aircraft with following characteristics: $C_{L\alpha h}$ = 0.075/deg, η_h =0.98, V_h = 0.375, (X_h/c) = 3.0. Where c is mean chord length.	Apply	CO4	AAE014.14

6	Find the $C_{L\delta e}$ derivative for an aircraft at 1.0668 km and Mach 0.9 ($U_{1=}$ 267 m/s, q= 1383 kg/m^2, S=50m^2) if C_{D1} = 0.03 and C_{Du} = 0.027.If u is perturbed to 268.2 m/s, $Cm_{\delta e}$ = -0.058/rad. If δe is 1 deg, find the perturbed pitching moment.	Apply	CO4	AAE014.14
7	Find the β derivative for an aircraft at 1km altitude and Mach 0.9 ($U_{1=}$ 267 m/s, q= 1383 kg/m^2, S=50m^2, b = 12m) if $C_{l\beta}$ = -0.08. If β is perturbed to 1 deg, find perturbed rolling moment.	Apply	CO4	AAE014.14
8	Express by mathematical formulation for cross derivative C_{np} and explain each term. Where these terms are used in aircraft?	Understand	CO4	AAE014.15
9	What do you understand by lateral directional perturbed thrust force and moment derivatives? How side force is affecting these parameters?	Remember	CO4	AAE014.15
10	What is downwash lag? Demonstrate with diagram its importance in calculating stability derivatives.	Remember	CO4	AAE014.15
11	Estimate the pitch damping derivative, C_{mq}, for an aircraft with the following characteristics: $C_{L\alpha h}$ = 0.075/deg, η_h = 0.98, V_h = 0.375, X$h/\bar{c}$ = 3:0.	Apply	CO4	AAE014.16
12	Demonstrate and explain the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why?	Understand	CO4	AAE014.16
13	Derive the expression for roll damping derivative and explain its significant on aircraft control design.	Understand	CO4	AAE014.15
14	Illustrate the significance of perturbation of equation of motions. Why this is important in the dynamics analysis of the aircraft?	Understand	CO4	AAE014.16
15	Find the qc/2U_1 derivative for the F-4C aircraft at flight conditions 1.0668 km altitude and Mach 0.9 ($U_{1=}$ 267 m/s, q= 1383 kg/m^2, S=50m^2). C_{Lq}=1.80. If q is 2.5 deg/s, find the perturbed aero force along the z stability axis.	Apply	CO4	AAE014.16
UNIT-V				
AIRCRAFT DYNAMIC STABILITY				
PART - A (SHORT ANSWER QUESTIONS)				
1	What way the dynamic stability analysis of the airplane help the design of control systems and the pilot who operates it ?	Remember	CO5	AAE014.17
2	Is it possible to have dynamic stability without static stability? Give comments and express your thought on this.	Understand	CO5	AAE014.17
3	Illustrate about the phugoid mode in aircraft dynamic mode. Draw a diagram.	Remember	CO5	AAE014.17
4	Recall about short period mode in aircraft dynamic stability.	Remember	CO5	AAE014.18
5	Illustrate Dutch Roll in aircraft dynamic stability. Illustrate with diagram.	Remember	CO5	AAE014.18
6	Interpret the transfer function in aircraft dynamic stability.	Remember	CO5	AAE014.18
7	Expound the damped frequency and its significance on dynamic stability.	Understand	CO5	AAE014.18
8	Elucidate about the dynamic stability. Specify with suitable example.	Understand	CO5	AAE014.16
9	What is meant by weather cocking effect? Define Cooper- Harper rating.	Remember	CO5	AAE014.16
10	Why the study on dynamic characteristics of the airplane is necessary?	Remember	CO5	AAE014.16
PART - B (LONG ANSWER QUESTIONS)				
1	Illustrate the dynamic stability by using spring-mass-damper system. How many degrees of freedom are there for lateral dynamic motion and what are they?	Understand	CO5	AAE014.16

2	What way the dynamic stability analysis of the airplane helps the design of control systems and the pilot who operates it?	Remember	CO5	AAE014.16
5	What is the meaning of first order response? Give example and demonstrate it. Define spiral divergence in dynamic stability?	Remember	CO5	AAE014.16
6	.Write the equation for short period mode and demonstrate all parameters of the equations with their use in an airplane dynamic stability.	Understand	CO5	AAE014.16
7	What are the conditions for overdamped, critically damped and underdamped system? What is its significant in real aircraft dynamic stability?	Understand	CO5	AAE014.16
8	What way the dynamic stability analysis of the airplane help the design of control systems and the pilot who operates it?	Understand	CO5	AAE014.16
9	Write the equation for spiral mode , Dutch roll and roll mode with suitable explanation of each terms in the equations	Remember	CO5	AAE014.16
10	Explain about finding stability by solving and getting roots of the equations. Explain all the conditions.	Remember	CO5	AAE014.16
11	What are the 4- different modes of motion of a dynamic system when responding to a disturbance from an equilibrium position?	Understand	CO5	AAE014.16
12	What are the different modes and stability criterion of dynamic longitudinal motion whose governing equation is a 4th degree quartic?	Remember	CO5	AAE014.16
13	How the stability of dynamic motion can be judged using the coefficients of the 4th order quartic which govern the motion ?	Apply	CO5	AAE014.16
14	What are the characteristic modes of stick-fixed longitudinal motion of airplane?	Understand	CO5	AAE014.16
15	Demonstrate the autorotation and show the cause of autorotation by drawing neat force diagram. What are the occasions when pilot execute the autorotation?	Remember	CO5	AAE014.17
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Illustrate the following term: a) Spiral mode b) Dutch Roll with a neat sketch	Apply	CO5	AAE014.18
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.	Apply	CO5	AAE014.18
3	Interpret with appropriate sketches, the following : a) Phugoid motion b) Spiral instability c) Dutch Roll motion	Understand	CO5	AAE014.17
4	Illustrate about the Aircraft Dynamic Mode shapes and its significance on the dynamic stability of the airplane.	Remember	CO5	AAE014.18
5	The lateral stability quadratic 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.	Apply	CO5	AAE014.18
6	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.	Remember	CO5	AAE014.19
7	Sketch a single parameter stability diagram or a root locus plot when $C_{m\alpha}$ changes from a large negative value to a small positive value	Understand	CO5	AAE014.19
8	Compare about the degrees of freedom (DOF). How many degrees of freedom does a rigid airplane with free aileron, elevator and rudder have? Draw the sketch and show the effect of all The three control surfaces.	Understand	CO5	AAE014.20
9	The roots of a longitudinal stability quartic are: 2.57 ± 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?	Apply	CO5	AAE014.20

10	Demonstrate about the following, a) Aircraft spin entry b) Balance of forces	Understand	CO5	AAE014.20
11	Briefly discuss about the spinning of an aircraft. How to get out of the spin smoothly?	Remember	CO5	AAE014.19
12	What is meant by weather cocking effect? Explain with necessary diagram of this effect and the result of this.	Remember	CO5	AAE014.19
13	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	CO5	AAE014.20
14	"The stability of the aircraft is determined solely by the Eigen values". What are the three cases which explain the three types of dynamic stability and write their equations?	Understand	CO5	AAE014.20
15	Find the time response and stability condition for the following system: $\ddot{x} + 10\dot{x} + 16x = 32; \quad x(0) = 0; \quad \dot{x}(0) = 0$	Apply	CO5	AAE014.20

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