INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

DEPARTMENT OF AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**AIRCRAFT STABILITY AND CONTROL**					
Course Code	AAEB13					
Program	B.Tech					
Semester	Five					
Course Type	Core					
Regulations	**IARE - R18**					
Course Structure	**Theory**			**Practical**		
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**	
	3	1	3	-	-	
Chief Coordinator	Dr. Yagya Dutta Dwivedi, Professor					

COURSE OBJECTIVES (COs):

The students will try to learn:	
I	The fundamental knowledge on basic static stability of aircraft in multiple directional motions with their relationship for critical applications in flight vehicles.
II	The aircraft stability and control equations of motion to correlate qualitatively with potential applications in aircraft stability in different axes.
III	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
IV	The utilization of advances of flight dynamic and control in design and development of modern airplane control systems.

COURSE OUTCOMES:

At the end of the course the students should be able to:

Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 1	**Recall** the concept of static stability in longitudinal, lateral and directional modes to be used for different aircrafts stability conditions.	Remember

CO 2	**Describe** the state of an equilibrium, control and trim inputs required for an aircraft in static longitudinal and lateral directional stability.	Understand
CO 3	**Recognize** the aircraft components contributing to the stability of different aircraft models like Military, Civil and transport aircrafts.	Understand
CO 4	**Identify** stick fixed and stick free conditions for neutral points with an appropriate static margin, control force and CG limitation.	Apply
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.	Understand
CO 6	**Construct** the mathematical model of aircraft motion in longitudinal, lateral and directional cases for establishing the status of the flight vehicles stability.	Apply
CO 7	**Outline** the contribution of aircraft components and their influence on lateral and directional static stability on flight vehicles.	Understand
CO 8	**Analyze** different axis systems used for flight dynamics and their transformations from one system to another system.	Analyze
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.	Understand
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.	Understand
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.	Analyze
CO 12	**Apply** the advances of flight dynamics and controls in design of modern airplane control systems.	Apply

QUESTION BANK:

MODULE – I				
INTRODUCTION AND LONGITUDINAL STABILITY - I				
PART - A (SHORT ANSWER QUESTIONS)				
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**How does this Subsume the level**	**Course Outcome**
1	Recall the term static stability and its need in airplane.	Remember	----	CO 1
2	State the conditions for longitudinal static stability.	Remember	----	CO 1
3	Describe the horizontal tail volume ratio and write it's significant.	Understand	Learner to recall the concept of lift and moment. Then explain what happens when the horizontal tail is used to make the aircraft statically stable in longitudinal direction.	CO2
4	Explain the forward center of gravity (CG) limit restrictions by the ground effect or for landing maneuvers?	Understand	Learner to define the CG and ground effect. Then explain the restrictions posed by these to maneuvers performance.	CO1
5	Demonstrate the downwash and write its effects on aircraft stability.	Understand	Learner to define downwash and then go for further to know the effects of downwash in aircraft stability.	CO2

6	Discuss about hinge moment on elevator. How it effect the pilot force?	Understand	Learner first to know the hinge and then hinge moment. Then explain about its effects on pilot force.	CO2
7	Express the need of mass balancing on control surfaces.	Understand	Learner to know about the mass and its concentration and then to express about mass balancing in control surfaces.	CO2
8	Define the center of pressure and aerodynamic center.	Remember	----	CO1
9	With the help of Cm vs C_L curve of an airplane, state the stable, neutral and unstable conditions of it.	Understand	Learner to define static stability and then plot Cm vs Cl and then assess the stability type.	CO2
10	What is the criterion for static longitudinal stability?	Remember	----	CO1
11	Explain by the example of pendulum, the force which makes system stable or unstable.	Understand	Learner to know about pendulum and force diagram then see which direction forces are acting to make stable or unstable.	CO1
12	Name the four motions which make the system statically stable.	Remember	----	CO1
13	Explain the motions which are neither statically stable nor dynamically stable.	Understand	Learner to recall different types of motion and then describe about statically or dynamically stable system.	CO2
14	Recall the body axes system and draw positive directions in neat diagram.	Remember	----	CO1
15	Explain C_{mo} by giving equation. What are the other parameters which decide its value?	Understand	Learner to relate coefficient of moment with Cm0 and then describe other parameters which affects these.	CO2
16	Define derivative of coefficient of moments and its importance in finding static longitudinal stability.	Remember	----	CO1
17	Differentiate between positive, neutral and negative static longitudinal stability with moment diagram.	Understand	Learner to define all the three static stability and then draw the moment diagram and assess its stability.	CO1 CO2
18	Enumerate the equations of pitching moments, rolling moment and yawing moment.	Understand	Learner to define the pitching, Rolling and Yawing moment and then write the equations and describe each term.	CO1 CO2
19	Show with diagram about positive elevator deflection, and rudder deflection and in this condition what will be the attitude of the airplane?	Understand	Learner to define elevator and elevator deflection then describe the effects of elevator deflection.	CO2
20	"The coefficient of rolling and yawing moment at zero angle of attack is zero for symmetrical airplane". Discuss with neat sketch.	Understand	Learner to relate Cl and Cn at zero AOA and then discuss with necessary diagram.	CO2
PART - B (LONG ANSWER QUESTIONS)				
1	Illustrate 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	Learner to **name** all the axes system and then **describe** the Body Axis system and then illustrate with forces and moments on the airplane.	CO2
2	Demonstrate with diagram of the all three axes used for stability of an aircraft.	Understand	Learner to **define** all the three axes and then **explain** about stability in different axes system.	CO2
3	Demonstrate the configuration and positions of the control on a neat diagram and explain with force and moments variations when a pilot wants to pitch up the airplane.	Understand	Learner to **select** configuration and position and then **recall** different forces acting on it at last **demonstrate** all forces and moments.	CO2
4	Explain all the three types of longitudinal static stability and draw the plot of pitching moment verses angle of attack.	Understand	Learner to **define** all the three types of static stability and then **draw** the plots of moment diagram and assess	CO1 CO2

			its stability.	
5	Demonstrate the influence of elevator on pitching moment when angle of attack is changed.	Understand	Learner to **define** the pitching, Rolling and Yawing moment and then **write** the equations and describe each term	CO2 CO3
6	If the center of gravity (CG) is coinciding with the neutral point (NP). What will be the attitude of the airplane? Explain with suitable diagram.	Apply	Learner to **recall** CG, and NP, then **describe** these and use necessary formula to get the attitude of the airplane.	CO3
7	Determine the flow field around an aircraft created by the wing and fuselage and explain its significance on static stability of aircraft.	Understand	Learner to **know** the flow parameters and then **how** the flow will change its path with interaction of the aircraft components.	CO2 CO3
8	Summarize the stick forces are balanced. Explain need for balancing these forces.	Understand	Learner to **define** forces on stick and then **describe** far balancing of these forces.	CO2
9	Explain the effects of fuselage in longitudinal static stability of the aircraft.	Understand	Learner to **recall** fuselage and longitudinal stability and then **explain** it's significant on airplane.	CO2
10	Annotate about different trim tabs used in aircraft. What is necessity of these?	Understand	Lerner to **define** the trim and also trim tab and then **explain** its use on the aircraft static stability.	CO3
11	What is meant by stability of an airplane and what way it is different from Balance?	Understand	Learner to **correlate** with stability and balancing and then **enumerate** different balancing techniques.	CO2
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	Learner to **recall** fuselage and then **describe** its effects on stability at last give a suitable **formulations**.	CO3
13	State two contributions for static longitudinal stability and indicate them with a plot.	Remember	---	CO1
14	Describe the 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	Lerner to **find** NP and **define** power off condition. Then **extend** this to new position of the NP for NO condition	CO3
15	Illustrate the two major effects of the running propeller that contribute to the Longitudinal stability and define them?	Understand	Learner to **define** longitudinal stability and then **discuss** major effects which takes place in propeller.	CO3
16	Outline the major contributions of the indirect effects of the running propellers on the static longitudinal stability? Draw the diagram and summarize the findings.	Apply	Learner to **define** indirect effects of propeller stability and then **describe** the moment diagram and then **Apply** the results by necessary plots..	CO3
17	Develop the concept of c.g limits on static stability with the help of a suitable figure and what interprets the anticipated c.g travel of the airplane.	Understand	The learner to **define** C.G and static stability and then **interpret** the C.G variation.	CO2
18	Identify the effects of the most forward c.g limit of the airplane. Extend the discussion to demonstrate the limits with neat diagram.	Understand	The learner to **define** C.G limits and then **interprets** the C.G variation with diagram.	CO3
19	Write down the expression for the maximum stability attainable by the elevator using its maximum up-elevation.	Apply	The learner to **recall** the stability and then **describe** about maximum attainable stability and its **application** to get this	CO2
20	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	The learner to **recall** the roll then **describe** about forces and moments and then **assign** proper control position so that pilot gets required roll.	CO2 CO3

PART - C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	Explain the effect of elevator on longitudinal static stability with neat diagram. Draw the flow pattern with and without elevator deflection on total airplane.	Understand	The learner to **define** longitudinal stability and then **show** the flow behavior with elevator deflection.	CO3
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.	Analyze	The learner to **define** the Cm then **explains** the effects of camber **use** the formula and then do **analysis** of result.	CO3
3	Write a short note on the following: a) Trim tabs b) Balance tabs	Understand	The learner to **recall** trim tab and balance tab and then **describe** these terms in detail,	CO2 CO3
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?	Apply	The learner to **define** canard, then **describe** its effects. **Assign** mathematical formulations to get the model.	CO2 CO3
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	The learner to **relate** the fuselage contribution in stability and **outline** the formulae for this contribution.	CO2 CO3
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, dε/dα = 0.4, aerodynamic centre position h o = 0.18, tailplane setting angle η_T= - 1.8 °, C_{Mo} = -0.018. The elevator angle travel limits are ±30 °.	Analyze	The learner to **find** lift coefficient, **describe** about trim and **identify** formulae to be used and get the results and then **analyze** the answer for aircraft stability.	CO2 CO3
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, η= 0.9, dε/dα= 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	The learner to **define** CG then **describe** its effects on stability. **Assign** mathematical formulations to get the result.	CO2 CO3
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?	Analyze	The learner to **find** condition for stability then **describe** about steady state motion and **identify** formulae to be used and get the results and then **analyze** the answer for aircraft stability.	CO2 CO3
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 leading edge, tail arm = 6 m, tail plane setting angle = - 1 °, dε/dα = 0.46, am = 4.6, a2 = 3.1, a3 = 1.6, C_{Mo} = -0.036, tail plane area = 3.7 m^2, aerodynamic center at 0.25c.	Apply	The learner to **find** condition for steady and level flight then **describe** about elevator angle to trim and **identify** formulae to be used and get the results and then **analyze** the answer for aircraft stability.	CO2 CO3
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	Analyze	The learner to **find** condition for stability at near the ground then **describe** elevator angle and **identify** formulae to be used and get the results and then **analyze** the answer for aircraft stability in ground effect..	CO2 CO3

	expressed per radian.			

MODULE – II

LATERAL – DIRECTIONAL STATIC STABILITY

PART – A (SHORT ANSWER QUESTIONS)

1	Describe the sideslip and side slip angle and its effects.	Remember	----	CO1
2	Identify the reasons for adverse yaw. What is the primary reason for this?	Understand	The learner to **recall** adverse yaw then **enumerate** the reasons for this phenomenon	CO2
3	Define is lateral static stability. In which axis, this occurs?	Remember	----	CO1
4	Illustrate the condition for static directional stability by stating mathematical equation applicable.	Understand	The learner to **define** static directional stability then **describes** the mathematical equations.	CO2
5	Demonstrate the speed stability and its importance in directional stability.	Understand	The learner to **find** speed stability then **discusses** the reasons for this phenomenon.	CO2 CO3
6	Illustrate different types of ailerons used as flight control devices.	Understand	The learner to **recall** types of ailerons then **enumerate** the effects of this in flight controls.	CO2 CO3
7	Recall the effect of freeing the elevator changes the tail contribution to the longitudinal stability?	Remember	----	CO1
8	Identify the floating rudder (stick-free) affects the directional stability?	Understand	The learner to **define** floating rudder and then **enumerate** how this affect the directional stability.	CO2
9	Summarize the power of lateral or aileron control of an airplane.	Understand	The learner to **recall** adverse yaw then **enumerate** the reasons for this phenomenon	CO2
10	Recall the basic requirements that are to be fulfilled by the lateral control system?	Remember	----	CO1
11	Explain the side force generated by differential stabilator.	Understand	The learner to **relate** force and describe its effects on differential stabilator.	CO2
12	Describe aircraft rolling moment and write the equation of this.	Understand	The learner to **recall** moment and describe the equations related to this.	CO3
13	Define lateral static stability derivative. Which condition aircraft will have positive lateral stability	Understand	The learner to **relate** static stability and **describe** its derivatives and conditions.	CO3
14	Identify four aspects of aircraft design which influence lateral static stability derivative.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO3
15	Illustrate with neat diagram about effect of wing geometrical dihedral in static stability.	Understand	The learner to **relate** force and **describe** its effects on wing configuration.	CO4
16	Describe effect wing position on static lateral and directional stability on aircraft.	Remember	----	CO2
17	Differentiate the effects of wing sweep and dihedral of static stability in lateral direction.	Understand	The learner to **define wing sweep** and **explain** its effects on dihedral wing system.	CO4
18	What is meant by rudder lock? Show with suitable diagram and expression.	Remember	----	CO1
19	Recall the three types of controls with reference to C.G of an airplane	Remember	----	Co1
20	Find the mathematical expression for yawing moment derivative C_n due to vertical tail.	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO3

PART - B (LONG ANSWER QUESTIONS)

1	Demonstrate the contribution of wing and fuselage in airplane directional stability.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
2	Enumerate the effects of vertical tail on directional stability. Some aircrafts having two or more vertical tail. Give the advantages and disadvantages of single and multi-vertical tail	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO4
3	Identify the aerodynamic forces and propulsive forces are of importance to the performance of an aircraft?	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
4	Compare the Lateral-Directional stability Requirements with longitudinal stability.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
5	Illustrate with Cl versus Beta plot, about lateral stability in roll and show the position of different forces and velocity components.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
6	Illustrate with neat diagram about spoilers and its utility. How does this work? Demonstrate and show with required diagram.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
7	Recall the effect of the wing sweep to cater directional static stability. Demonstrate the effects of sweepback on yawing and rolling moments.	Remember	----	CO5
8	Demonstrate the wing and fuselage contribution to the effect of dihedral in lateral stability.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
9	Find the mathematical expression for static margin and how does this affect the directional and lateral stability?	Remember	----	CO5
10	Explain Proverse Yaw with three examples. When this yaw shall happen?	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
11	How the total directional stability contribution of airplane is made more stabilizing?	Remember		CO4
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	The learner to **name** the design aspects and describe its influence on static stability.	CO4
13	Why the rudder is designed to suit one-engine inoperative condition? Demonstrate with suitable sketch mentioning all required forces and moments.	Remember		CO5
14	What is the criterion to keep the directional stability with stick-free above certain limit or not to lose much?	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
15	Identify the relation for the greatest of pedal force (PF) with respect to sideslip and give its accepted value?	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO5
16	Explain the contribution of different aircraft parts like wing, fuselage and horizontal tail on lateral and directional static stability of aircraft.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
17	"The static lateral stability should not be too small". Give the reason and develop the suitable formulations and plots.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
18	Illustrate the affects of floating rudder (stick-free) on the directional stability of the aircraft.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
19	Enumerate the flight conditions or maneuvers that produce unbalance yawing moments those are to be overcome by rudder.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5

20	Demonstrate how far aft we can place the cg with retaining stability of an airplane using proper equation and a neat diagram.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Show the flow pattern over the vertical tail when the sideslip is from left side of the pilot.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
2	With neat diagram explain about static roll stability. Show the attitude of airplane in different stability conditions.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO4
3	Develop the mathematical expression for vertical tail contribution to directional stability.	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO4
4	During flight, it was observed that rudder got fixed 3 degree right. Explain, how the pilot will handle this condition? Show with diagram.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO5
5	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.	Analyze	The learner to **relate** aileron with neutral condition and **identify** the effects after stuck then apply the moment of the controls.	CO4
6	Identify the need of the ‘T’ tail in some airplanes. Show the air flow pattern over the wing and ‘T’ tail and do flow analysis.	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO4
7	“The wing and fuselage itself give the unstable aircraft”. Explain this concept by drawing the forces and moments diagram.	Understand	The learner to **name** the design aspects and **describe** its influence on static stability.	CO5
8	Identify 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.	Apply	The learner to **find** two methods to **predict** effect of fuselage then **describe** mathematical concept.	CO5
9	Examine 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	Analyze	The learner to **relate** aileron and rudder **identify** its mathematical formulae and then **apply** to get the result and then do **analysis**.	CO4
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.	Understand	The learner to **recall** about Cm, Cl and **discuss** about plot verses AOA.	CO4
MODULE-III				
AIRCRAFT EQUATIONS OF MOTION				
PART - A (SHORT ANSWER QUESTIONS)				
1	Illustrate the slip stream related to aircraft lateral and directional stability.	Understand	The learner to **define** the slip angle and **enumerate** directional static stability.	CO5
2	Demonstrate stability axes system and how it differs from body axes system.	Understand	The learner to **recall** the stability axes then **differentiate** with other axes system.	CO5
3	List the degree of freedom for an airplane and explain its importance.	Remember	----	CO1
4	Find the aircraft response related to aircraft Equations of motions.	Remember	----	CO1

5	Demonstrate with a suitable diagram of yaw rotation while Earth to Body axis transformation.	Understand	The learner to **name** the Euler's angle and then demonstrate the rotation.	CO5
6	Show the different ways for moving airplane axis system can be fixed with reference to the airplane?	Remember	----	CO1
7	Explain about linear momentum and angular momentum with formula.	Understand	The learner to **define** linear moment and **explain** its use in stability.	CO5
8	What are the equations of longitudinal motion with free control?	Remember	----	CO1
9	Outline with the block diagram for transformation of Earth axis system to Body Axis system.	Understand	The learner to **relate** the transformation of axis system and **discuss** its principle.	CO5
10	How many degrees of freedom does an aircraft have? How many are Translational and how many are rotational?	Remember	----	CO1
11	Identify the system of reference frames with a simple example.	Understand	The learner to **name** the reference frames and then **enumerates** its influence on static stability.	CO5
12	Demonstrate inertial frame of reference with suitable sketch. In which frame of reference Newton's laws of motion are valid?	Understand	The learner to **define** the inertial frame of reference and its **application** of Newton's law of motion.	CO5
13	Illustrate with a diagram the difference between body axis system and stability axes system.	Understand	The learner to **name** the different axes system and **describe** its influence on static stability.	CO6
14	Describe the axes system in which the weight vector and Thrust vectors are expressed easily.	Understand	The learner to **restate** the weight vector and **Identify** thrust vector.	CO6
15	Show the vectors of thrust in body axis system and in which direction the value of this force will be zero.	Understand	The learner to **Show** the different vectors and illustrate its influence on static stability.	CO7
16	Describe the full range of yaw angle, pitch angle and roll angle for an aircraft at 6 DOF.	Understand	The learner to **recall** yaw angle and **discuss** about 6 DOF.	CO7
17	Convert body axis system to stability axis system and write the forces in all the three directions.	Understand	The learner to **name** all the axes and then **how** to convert from one system to another.	CO6
18	Identify the Applied forces used in Equations of Motion and name them.	Understand	The learner to **define** applied forces and then Identify equations of motion.	CO7
19	Establish about moment of inertia. Write the formulae for Ixx and Iyy.	Understand	The learner to **Define** moment of inertia and then **write** the formula of inertia in different axes.	CO7
20	Express about products of Inertia. If an airplane has XZ plane of symmetry, what will be the values for these inertia?	Understand	The learner to **name** different product of inertia and then **assess** its effect if aircraft is symmetrical or asymmetrical.	CO6
PART – B (LONG ANSWER QUESTIONS)				
1	Illustrate the six degrees of motion of a dynamic system and how it is formed for the airplane?	Understand	The learner to **name** all the 6 DOF and then **describe** in airplane system.	CO6
2	Outline the different ways the moving airplane axis system can be fixed with reference to the airplane?	Understand	The learner to **recall** ways of moving airplane axis system then illustrate with diagram.	CO6
3	Explain about moment equation in an airplane. Write moment equations in all the three axes and explain each term and give some examples.	Understand	The learner to **Restate** different moment equation and then **write** each term and **explain**.	CO7
4	Describe about aircraft response and applied forces used in the derivation of equations of motion.	Understand	The learner to **define** aircraft response and the **derive** the equations	CO7
5	Interpret about inertia tensor for an aircraft in the body frame of reference.	Understand	The learner to **recall** inertia tensor and **demonstrate** these with	CO6

			examples.	
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	The learner to **Define** moment of inertia and then **write** the formula of inertia in different axes.	CO6
7	How many degrees of freedom does an aircraft have? How many are translational and how many are rotational?	Understand	The learner to **recall** yaw angle and **discuss** about 6 DOF.	CO7
8	Express the three kinematic equations of motion and explain each term used in it.	Understand	The learner to **recall** the three kinematic equations and then **describe** each term clearly.	CO7
9	Outline different types of orientation and position of the airplane giving suitable sketch with all necessary parameters.	Understand	The learner to **name** the different types of orientation and **illustrate** parameters.	CO6
10	Illustrate about the gravitational and thrust force calculation. Give the equation for the thrust force.	Understand	The learner to **define** force of gravitational then explains how the thrust force is calculated.	CO6
11	Explain the different ways the moving airplane axis system can be fixed with reference to the airplane?	Understand	The learner to **define** aircraft axis system with reference system and explain with stepwise.	CO7
12	Describe equations of longitudinal motion with free control. Write the equations and explain each term with physical application.	Understand	The learner to **recall** aircraft longitudinal motion and **explain** with physical application giving examples.	CO7
13	"The derivatives due to the tail are appreciable". Give a sketch and explain with necessary tail configurations.	Understand	The learner to **restate** derivatives of aircraft and then **explain** with tail effect.	CO6
14	How the Euler's angles are useful for getting the relations of Body axes and Earth axes system? Demonstrate with diagram.	Understand	The learner to **name** the Euler's angles and **describe** method of transformation	CO6
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, CLα,v = .1 deg−1, Sr /St = .6 and V_v = .8.	Analyze	The learner to **define** rudder and then **describe** about side slip angle then use formulae to **apply** and after getting answer do the **analysis**.	CO7
16	Demonstrate the relationship with roll angle and sideslip angle. Give the mathematical equations and demonstrate with suitable sketch of flow pattern of the wind.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO7
17	How do determine rotation and velocity in the inertial frame, for intercept, obstacle avoidance etc.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO6
18	Apply 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.	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO6
19	Relate the applied forces in the equations of motions and write the necessary equation for applied forces in three dimensions.	Understand	The learner to **recall** applied forces and **describe** EOMs.	CO7
20	Demonstrate all the six steps for deriving moment equations and explain the terms used in these equations.	Understand	The learner to **name** the six steps for moment equations and **write** the meaning of each term.	CO7
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Demonstrate the Earth Axis to Body Axis transformation. Show Euler's angles and explain.	Understand	The learner to **recall** applied forces then **describe** EOMs.	CO6
2	Find the mathematical formulation for aircraft force equations of motion in three directions. Explain all terms clearly.	Understand	The learner to **name** all forces and **describe** its application.	CO6
3	Compare the moments of inertia applicable in equations of motion. Give their mathematical formula.	Apply	The learner to **relate** moment of inertia and **identify** its mathematical equations by **describing** moment derivatives.	CO7

4	Find the mathematical formulation aircraft moment equations of motion in three directions. Explain all terms clearly.	Understand	The learner to **name** all forces and **describe** its application.	CO7
5	Develop the angular acceleration, gyro precession and coupling terms in moment equations and discuss about each term.	Apply	The learner to **define** angular acceleration, gyro procession and coupling term, **identify** its mathematical systems by **describing** each derivatives.	CO6
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. Solve and get the pitching, rolling and yawing rates. Which motion the pilot will feel?	Apply	The learner to **relate** Euler's angles **identify** its mathematical systems by **describing** moment rates.	CO6
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.	Analyze	The learner to **relate** all forces **identify** the best axis system systems. **Apply** the mathematical formulations and then **analyze** the result.	CO8
8	Identify the assessing parameters for stability of dynamic motion using the coefficients of the 4^{th} order quadratic which govern the motion?	Apply	The learner to **find** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO8
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.	Apply	The learner to **recall** gravity and drag forces, **describe** its mathematical systems and **apply** the equations of motion.	CO7
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.	Analyze	The learner to **relate** Euler's angle, **identify** its mathematical systems then **describe** attitude so get it's motion.	CO8

MODULE-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 equations of motion.	Remember	----	CO1
2	Relate the Roll damping derivative in perturbed equations of motion.	Remember	----	CO1
3	Demonstrate the stability axis system for aircraft system.	Understand	The learner to **name** the stability axes system and describe its influence on static stability.	CO9
4	Show roll helix angle in finding aircraft stability derivatives.	Understand	The learner to **recall roll helix angle** and describe its influence on stability derivatives.	CO8
5	List the cross derivative and its significance in finding stability.	Understand	The learner to **define** cross derivative then discuss about it.	CO8
6	What are the primary control derivatives for aircraft static stability?	Understand	The learner to **restate** the primary control derivative and **describe** its influence on static stability.	CO8
7	Illustrate the stability derivatives, Clp and Cnr.	Understand	The learner to **name** some derivatives and **describe** its influence on static stability.	CO9
8	Demonstrate the small perturbation approach so approximate the PDE with an example.	Understand	The learner to **name** the design aspects and **discuss** its influence on PDE.	CO9
9	What do you understand by first order	Understand	The learner to **know** the first order	CO8

	approximation of applied forces and moments?		mathematical solution then **describe** forces and moments.	
10	Demonstrate about Axis systems associated with an angle of attack perturbation.	Understand	The learner to **find** axis system associated with AOA and **identify** about perturbation.	CO9
11	Describe all the six steps for linearization of Equations of motion.	Understand	The learner to **name** all six steps and illustrate its procedure.	CO8
12	Represent the Body Fixed Stability axis system with suitable examples.	Remember	----	CO1
13	Express the need of using Kinematic equations to solve equations of motion.	Understand	The learner to **recall** all kinematic equations and then **solve** the equation by using mathematics.	CO8
14	Develop the first order approximation of applied Aero Forces and Moments.	Apply	The learner to **relate** aerodynamic forces and to **identify** its mathematical systems by **describing** moments.	CO9
15	Establish the relation between non dimensional variables in rolling moment (l_A).	Understand	The learner to **name** the non-dimensional variables and its **influence** on static stability.	CO9
16	Describe speed damping derivatives (C_{Du}) and write its equation.	Understand	The learner to **recall** speed damping derivative and **describe** all the equations	CO8
17	Relate the speed damping derivative with Mach Number.	Understand	The learner to **define** the speed damping derivative and **how** it affects the stability of the system.	CO8
18	Explain Mach Tuck derivative (C_{mu}) and how this derivative used to establish stability criterion.	Apply	The learner to **relate** Mach Tuck and **identify** its mathematical systems by **describing** stability derivatives.	CO9
19	Distinguish between Downwash and vortex. Illustrate difference with sketch.	Understand	The learner to **recall** downwash and then distinguish this with vortex with diagram.	CO9
20	Express roll damping derivatives and write its equation.	Understand	The learner to **define** damping derivatives and **write** all terms of equation.	CO8
PART – B (LONG ANSWER QUESTIONS)				
1	Classify the different ways the moving airplane axis system can be fixed with reference to the airplane?	Understand	The learner to **find** axis system associated with AOA and **identify** about perturbation	CO9
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	The learner to **define** pitch rate and describe the influence downward velocity.	CO8
3	Apply the longitudinal stability derivative Cmα, and 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.	Apply	The learner to **relate** Cmα **identifies** its mathematical systems by **describing** variation of pitching with AOA.	CO8
4	Build the equation of speed damping derivatives and explain each term in detail. Draw the plot and contrast with required parameters.	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO8
5	Outline about small perturbation approach used to make equations of motions in linear form. How it is useful in linearization of EOM?	Understand	The learner to **know** the perturbation approach and **how** to make linearize.	CO9
6	Relate the linearized equation of motion for wings level, straight flight.	Understand	The learner to **recall** EOMs and **describe** its influence during wing level flight.	CO9
7	What do you understand by first order approximation applied to aerodynamic forces and moments?	Understand	The learner to **recall** the first order approximation and discuss about aerodynamic forces and moments.	CO8
8	Briefly demonstrate the method for Non dimensional the First-Order Approximations	Understand	The learner to **recall** the first order approximation and discuss on static	CO8

			stability.	
9	Demonstrate the derivatives due to change in forward velocity with diagram. Explain the each term with proper applications.	Understand	The learner to **define** the derivative due to change of velocity and **describe** each term.	CO8
10	Demonstrate the derivatives due to change in downward velocity with diagram. Explain the each term with proper applications.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO9
11	Analyze the Linearized EOMs for Wings Level, Straight Flight and write the equations and explain.	Analyze	The learner to **relate** yawing and **identify** its mathematical systems **describing** moment derivatives.	CO9
12	Define the Mach tuck derivative? Write its formula and explain each term clearly. Where this term is used?	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO8
13	Demonstrate with diagram about downwash lag and its importance in calculating stability derivatives.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO8
14	Examine the pitch damping derivative, Cmq , for an aircraft with the following characteristics: $C_{L\alpha h}$ = 0.075/deg, η_h = 0.98, V_h = 0.375, $Xh/\bar{c}$ = 3:0.	Analyze	The learner to **relate** pitch damping and **identify** its mathematical systems by **describing** damping derivatives.	CO8
15	Demonstrate the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why?	Understand	The learner to **define**the primary control and **describe** its influence using mathematical formula.	CO9
16	What do you understand by lateral directional perturbed thrust force and moment derivatives? How side force is affecting these parameters?	Understand	The learner to **recall** lateral perturbation and discuss side force during perturbation.	CO9
17	What is downwash lag? Demonstrate with diagram its importance in calculating stability derivatives.	Understand	The learner to **define** the downwash lag and **describe** its influence on static stability.	CO8
18	Demonstrate the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why?	Understand	The learner to **name** the primary control and **show** its influence on elevator power.	CO8
19	Derive the expression for roll damping derivative and explain it's significant on aircraft control design.	Apply	The learner to **relate** roll damping and **identify** its mathematical systems so as to **explain** aircraft control.	CO8
20	Illustrate the significance of perturbation of equation of motions. Why this is important in the dynamics analysis of the aircraft?	Understand	The learner to **know** perturbation approach and **how** to make linearize equation.	CO9
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Compare the lateral static stability derivative with longitudinal static stability derivatives. Write the formula and explain its importance.	Understand	The learner to **define** derivative and **write** the formula on static derivative.	CO9
2	Demonstrate the significance of aerodynamic derivatives on airplane stability.	Understand	The learner to **name** the different derivatives and **describe** its aerodynamic influence.	CO8
3	Infer about roll helix angle. Show the wing velocity distribution due to roll rate and relate the terms with each other.	Understand	The learner to **define** roll helix angle and describe its influence on wing velocity distribution.	CO8
4	Solve 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	The learner to **relate** velocity ratio and **illustrate** its formula by **describing** perturbed derivatives.	CO8
5	Examine 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.	Analyze	The learner to **define** pitch damping derivative and **assess** its mathematical expressions and to **calculate** moment derivatives.	CO9

6	Solve 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_{δ_e} = -0.058/rad. If δ_e is 1 deg, find the perturbed pitching moment.	Apply	The learner to **relate** elevator deflection derivative and **identify** required formula then **calculate** moment derivatives.	CO8
7	Examine 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.	Analyze	The learner to **relate** elevator deflection derivative and **identify** required formula then **calculate** moment derivatives.	CO8
8	Explain by mathematical formulation for cross derivative C_{np} and explain each term. Where these terms are used in aircraft?	Understand	The learner to **define** cross derivative and **identify** its mathematical systems by **describing** moment derivatives.	CO8
9	Solve the pitch damping derivative, Cmq , for an aircraft with the following characteristics: $C_{L\alpha h}$ = 0.075/deg, η_h = 0.98, V_h = 0.375, $Xh/\overline{c}$ = 3:0.	Apply	The learner to **recall** elevator deflection derivative and **identify** required formula then **calculate** Pitch damping derivatives.	CO9
10	Solve 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.	Analyze	The learner to **relate** elevator deflection derivative and **identify** required formula then **calculate** derivatives and then analyze the result.	CO9
MODULE-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	----	CO10
2	Is it possible to have dynamic stability without static stability? Give comments and express your thought on this.	Understand	The learner to **name** the stability and **describe** its different static stability.	CO10
3	Illustrate about the phugoid mode in aircraft dynamic mode. Draw a diagram.	Understand	The learner to **define** the phugoid and **discuss** its influence on static stability.	CO11
4	Recall about short period mode in aircraft dynamic stability.	Remember	----	CO11
5	Illustrate Dutch Roll in aircraft dynamic stability. Illustrate with diagram.	Understand	The learner to **recall** the Dutch roll and **identify** its influence on dynamic stability.	CO11
6	Interpret the transfer function in aircraft dynamic stability.	Understand	The learner to **restate** transfer function and **describe** its influence on dynamic stability.	CO10
7	Explain the damped frequency and its significance on dynamic stability.	Understand	The learner to **recall** damped frequency and **describe** its influence on dynamic stability.	CO10
8	Elucidate about the dynamic stability. Specify with suitable example.	Understand	The learner to **define** dynamic stability and **illustrate** its influence on stability.	CO11
9	Describe weather cocking effect also discuss about Cooper- Harper rating.	Understand	The learner to **define** weather cocking and **describe** its influence on dynamic stability.	CO11
10	Demonstrate the possibilities for system poles and its associated behavior in dynamic stability with suitable examples and diagram.	Understand	The learner to **restate** system poles and **discuss** its influence on dynamic stability.	CO11
11	Enumerate the equation of mass- spring- damper	Understand	The learner to **relate** mass- spring -	CO10

	system at zero displacement.		balance and **describe** its influence zero shift.	
	Interpret the over damped system by giving relation of real root of the quadratic equation.	Understand	The learner to find damped system and **describe** its influence quadratic equation.	CO10
12	Explain with suitable equation about damping ratio and natural frequency. How these two parameters used to stablish the dynamic stability of an aircraft.	Apply	The learner to **relate** damping equations to **identify** its mathematical formula by **describing** dynamic derivatives.	CO11
13	Illustrate the influence of complex plane root location on the transient response of the system.	Understand	The learner to **find** complex roots and to **discuss** about transient response.	CO11
14	Discuss the aircraft longitudinal dynamic modes with suitable diagram. Name two important longitudinal modes and explain with example from airplane.	Apply	The learner to **relate** dynamic modes and **identify** required formula then **describe** longitudinal modes.	CO11
15	Illustrate the short period mode and its relations with flying qualities of the aircraft.	Understand	The learner to **recall** the short period modes and to **describe** its influence on dynamic modes.	CO10
16	Express the mathematical concept of dynamic stability criteria used to assess the flight behavior.	Apply	The learner to **define** dynamic stability then **identifies** formulae and then **assesses** its behavior.	CO10
17	Outline the different types of inputs for forcing functions by plotting a suitable diagram.	Understand	The learner to **know** the inputs and types then **define** forcing function and then plot it.	CO11
18	Relate the transfer function and the characteristic equation in dynamic stability mode.	Understand	The learner to **relate** the transfer function and **describe** its influence on dynamic stability.	CO10
19	Enumerate the Longitudinal linearized equations of motion in Laplace form and describe each term	Understand	The learner to **name** all equations and **describe** Laplace form.	CO10
20	Discuss the factors affecting Natural frequency in short period mode of dynamic stability.	Understand	The learner to **define** natural frequency then **describes** its influence on short period mode.	Co11
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	The learner to **relate** mass- spring - balance and **describe** its influence zero shift.	CO10
2	What way the dynamic stability analysis of the airplane helps the design of control systems and the pilot who operates it?	Understand	The learner to **define** dynamic stability and **discuss** its influence on control system.	CO10
5	Explain the first order response. Give example and demonstrate it. Define spiral divergence in dynamic stability?	Understand	The learner to **find** the first order response and interpret its influence on spiral divergence.	CO11
6	Construct the equation for short period mode and demonstrate all parameters of the equations with their use in an airplane dynamic stability.	Apply	The learner to **relate** short period mode and **identify** its formula to get dynamic stability.	CO11
7	Demonstrate the conditions for over damped, critically damped and underdamped system? What is its significant in real aircraft dynamic stability?	Understand	The learner to find damped system and **describe** its influence quadratic equation.	CO11
8	Interpret the way dynamic stability analysis of the airplane help the design of control systems and the pilot who operates it?	Understand	The learner to **find** way of dynamic modes and **explain** its principle.	CO10
9	Summarize the equation for spiral mode , Dutch roll and roll mode with suitable explanation of each terms in the equations	Understand	The learner to **recall** spiral modes and **describe** Dutch and roll mode	CO10
10	Find stability by solving and getting roots of the equations. Explain all the conditions.	Understand	The learner to **name** the design aspects and describe its influence on static stability.	CO11

11	What are the 4- different modes of motion of a dynamic system when responding to a disturbance from an equilibrium position?	Understand	The learner to **name** different modes and **describe** disturbance from equilibrium.	CO11
12	Develop the different modes and stability criterion of dynamic longitudinal motion whose governing equation is a 4th degree quartic?	Apply	The learner to **relate** yawing and **identify** its mathematical systems by **describing** moment derivatives.	CO11
13	How the stability of dynamic motion can be judged using the coefficients of the 4th order quartic which govern the motion?	Apply	The learner to **relate** short period mode and **identify** its formula to get dynamic stability and to **assess** the motion of airplane.	CO10
14	What are the characteristic modes of stick-fixed longitudinal motion of airplane?	Understand	The learner to **define** stick fixed **describes** its influence on longitudinal motion.	CO10
15	Demonstrate the autorotation and show the cause of autorotation by drawing neat force diagram. What are the occasions when pilot execute the autorotation?	Understand	The learner to **recall** the autorotation to describe flying quality of airplane.	CO11
16	Demonstrate about the following, a) Aircraft spin entry b) Balance of forces	Understand	The learner to **define** aircraft spin and balance of forces.	CO11
17	Briefly discuss about the spinning of an aircraft. How to get out of the spin smoothly?	Understand	The learner to **recall** spinning of airplane and to **execute** methods of recovery.	CO11
18	What is meant by weather cocking effect? Explain with necessary diagram of this effect and the result of this.	Understand	The learner to **define** weather cocks and **assess** its influence on dynamic stability.	CO11
19	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	The learner to **know** effect of speed and c.g location on dynamic stability and to **express** its significant	CO12
20	"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?	Apply	The learner to **define** Eigen values and **identify** three cases by **describing** equations of dynamic stability.	CO12
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Illustrate the following term: a) Spiral mode b) Dutch Roll with a neat sketch	Understand	The learner to **define** the spiral mode and Dutch roll and **describe** its motion.	CO10
2	Show 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	The learner to **recall** the roll and yaw coupling and **relate** its influence on dynamic stability.	CO9
3	Interpret with appropriate sketches, the following : a) Phugoid motion b) Spiral instability c) Dutch Roll motion	Understand	The learner to **find** the short period modes and **describe** its influence on dynamic stability.	CO9
4	Illustrate about the Aircraft Dynamic Mode shapes and its significance on the dynamic stability of the airplane.	Understand	The learner to **define** dynamic mode and **summarize** the significance on dynamic stability.	CO10
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.	Analyze	The learner to **find** lateral stability to **identify** its mathematical expression by **describing** oscillatory mode.	CO11
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.	Understand	The learner to **recall** the longitudinal mode and to describe its motion in dynamic conditions.	CO10
7	Illustrate a single parameter stability diagram or a	Understand	The learner to **name** different	CO10

	root locus plot when Cmα changes from a large negative value to a small positive value		parameters to **identify** its dynamic stability.	
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	The learner to **define** DOF and **describe** its control surfaces to be used.	CO12
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	The learner to **find** longitudinal stability and **identify** its quadratic form to **describe** motion of airplane.	CO10
10	Solve the time response and stability condition for the following system: $\ddot{x} + 10\dot{x} + 16x = 32; \quad x(0) = 0; \quad \dot{x}(0) = 0$	Analyze	The learner to **relate** time response and to **identify** stability condition by using characteristics equations then **apply** these mathematical formula to **solve** the problem and do **analysis** of the result.	CO11

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