INSTITUTE OF AERONAUTICAL ENGINEERING

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AERONAUTICAL ENGINEERING

DEFINITIONS AND TERMINOLOGY QUESTION BANK

Course Name	:	**AIRCRAFT STABILITY AND CONTROL**
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Course Faculty	:	**Dr. Yagya Dutta Dwivedi, Asso. Professor, AE**

OBJECTIVES:

I	To help students to consider in depth the terminology and nomenclature used in the syllabus.
II	To focus on the meaning of new words / terminology/nomenclature

DEFINITIONS AND TERMINOLOGYQUESTION BANK

S.No	QUESTION	ANSWER	Blooms Level	CLO	CO	CLO Code
UNIT-I						
1	Define equilibrium.	If an airplane is to remain in steady uniform flight, the resultant force as well as the resultant moment about the center of gravity must both be equal to zero. An airplane satisfying this condition is said to be in the state of equilibrium or flying at a trim condition.	Understand	1	1	AAE014.01
2	Define downwash and its importance on force and stability	Whenever, flow passes on airfoil, due to its curvature flow direction after some distance from the leading edge, starts coming downwards, called downwash. Downwash, reduces effective relative velocity and hence lift force. This also effects the longitudinal stability	Remember	1	1	AAE014.01
3	Importance of static margin.	Static margin is defined as the distance between the center of gravity (C.G) to the neutral point (NP). This margin gives the state, whether the aircraft will be in state of positive, negative or neutral stable. Airplane designer to ensure that the CG should not go behind NP.	Understand	2	1	AAE014.01
4	What is elevator control power?	Elevator control power is the stability derivative and defined as $C_{m\delta e}$. This derivative defines how effective the elevator is in creating the control moment. The larger the value of $C_{m\delta e}$the more effective the control is in creating the control moment.	Remember	3	1	AAE014.12

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5	What is horizontal tail volume ratio?	Horizontal tail volume ratio is the ratio of product of tail surface area and tail arm to the product of wing surface area and chord length.	Understand	4	1	AAE014.04
6	Define canard.	Canard is a tail surface located ahead of the wing.	Remember	1	1	AAE014.01
7	How airplane tail contributes to static longitudinal stability?	The tail contribution to the static stability of the of the airplane ($C_{m\ alpha}<0$) can be controlled by proper selection of V_H and $C_{L\ alpha.}$ The contribution of $C_{m\ alpha}$ will become more negative by increasing the tail moment arm l_t or tail surface area S_t and by increasing $C_{Lalpha.}$	Understand	1	1	AAE014.01
8	What is stick fixed neutral point?	Stick fixed neutral point is the position of center of gravity where it yields a condition that the slope of pitching moment curve is zero($C_{m\alpha}=0$)	Remember	2	1	AAE014.02
9	What is control effectiveness?	Control effectiveness is a measure of how effective the control deflection is in producing desired control moment.	Understand	3	1	AAE014.03
10	Define longitudinal static stability.	The ability of the airplane to regain its original condition after disturbance in vertical plane (x-z plane). In this the longitudinal axis of the airplane moves up or down with respect to lateral axis.	Remember	4	1	AAE014.04
11	Define center of pressure and aerodynamic center	**Center of Pressure** The center of pressure is the point where the total sum of a pressure field acts on a body. In aerospace, this is the point on the airfoil (or wing) where the resultant vector (of lift and drag) acts. **Aerodynamic Center** The resultant (or the pressure forces) also cause a moment on the airfoil. As the angle of attack increases, the pitching moment at a point (for example, the center of gravity) also changes. However, the pitching moment remains constant at a particular point, which is called the aerodynamic center.	Understand	1	1	AAE014.01
12	What will happen if the CG is at NP?	The airplane will maintain same flight condition. It will behave like the airplane is neutrally longitudinal stable.	Understand	1	1	AAE014.01
13	Define gearing ratio.	Gearing ratio is the measure of mechanical advantage provided by the control system. $G = \delta e/(ls)(\delta s)$	Remember	2	1	AAE014.02
14	Define hinge moments.	Hinge moments are the moments generated due to hinging any movable control surface to a fixed surface.	Understand	3	1	AAE014.03
15	Define Stick free and stick fixed longitudinal stability.	When, the control stick from the cockpit is not disturbed and only controls are disturbed by external forces is called stick fixed. When control sticks are not fixed and pilot apply some force intentionally to disturbed control surfaced called stick free.	Remember	4	1	AAE014.04

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UNIT-II						
1	Define dihedral and its effects.	Dihedral angle is the upward angle from horizontal of the wings or tailplane of a fixed-wing aircraft. Dihedral effect is the amount of roll moment in a direction produced by the amount of side slip in the opposite direction. Dihedral effect is a critical factor in the stability of an aircraft about the roll axis.	Understand	5	2	AAE014.05
2	Define directional static stability.	Directional, or weathercock stability is concerned with the static stability of the airplane about the z axis. It is desirable that the airplane should tend to return to an equilibrium condition when subjected to some form of yawing disturbance.	Remember	5	2	AAE014.05
3	What is sideslip?	A movement of an aircraft in which a relative flow of air moves along the lateral axis, resulting in a sideways movement from a projected flight path, especially a downward slip toward the inside of a banked turn.	Understand	6	2	AAE014.06
4	Define upwash effect.	The slight, upward flow of air just prior to its reaching the leading edge of a rapidly moving airfoil.	Remember	7	2	AAE014.07
5	What is mass balancing?	This ensures that the c.g. of the control surface lies ahead or on the hinge line.	Understand	8	2	AAE014.08
6	What is adverse yaw?	Yaw generated when the ailerons are used. The lifting wing generates more drag, causing an airplane to yaw (turn) toward it.	Remember	5	2	AAE014.05
7	Define anhedral angle.	The downward angle of a wing in relation to a horizontal cross-section line. Opposite of dihedral.	Understand	5	2	AAE014.05
8	Define stick force gradient.	Stick force gradient is a measure of the change in stick force needed to change the speed of the airplane.	Remember	6	2	AAE014.06
9	What is aerodynamic balancing?	The ways and means of reducing the magnitudes of Chαt and Chδe are called aerodynamic balancing.	Understand	7	2	AAE014.07
10	What is lateral static stability?	If the stability of the airplane is concerned to its lateral axis, then the stability associated is called lateral static stability and the moment considered here is the rolling moment.	Remember	8	2	AAE014.08
11	Define SAS.	Stability augmentation system is an electromechanical device that senses the undesirable motion and moves the appropriate controls to damp out the motion.	Understand	5	2	AAE014.05
12	Define condition for static directional stability.	To have static directional stability the slope of yawing moment curve must be positive (C_n >1). If this condition is met the airplane will be directional static stable.	Remember	5	2	AAE014.05
13	Cross wind landings	To maintain alignment with the runway during a cross wind landing requires the pilot to fly the airplane at a side slip angle. The rudder must be powerful enough to permit the pilot to trim the airplane for the specified cross winds.	Understand	6	2	AAE014.06

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14	Define speed stability.	If an aircraft possesses speed stability it automatically recovers its speed when there are any deviations in the speed. If not, the pilot needs to monitor and control the speed of the aircraft continuously which results in fatigue.	Remember	8	2	AAE014.08
15	Define PIO.	If the pilot attempts to correct for a disturbance and that control input is out of the phase with the oscillatory motion of the airplane, the control actions would rather increase the motion rather than correct it. This type of pilot vehicle response is called pilot induced oscillations.	Understand	7	2	AAE014.07
UNIT III						
1	What are aircraft equations of motion?	The equations of motions (EOM) consist of the right hand side of the equations made up of the applied forces and moments, and the left-hand side of the equations providing the aircraft response. The aircraft equations of motion are obtained by applying Newton's 2nd law to a rigid aircraft.	Understand	9	3	AAE014.09
2	Define Euler angles.	The Euler angles are used to rotate the ''vehicle carried'' Earth axis system into coincidence with the body axis system. The Euler angles are expressed as yaw (ψ), pitch (θ), and roll (φ).	Remember	11	3	AAE014.11
3	Define slip stream.	The flow of air driven backward by a propeller or downward by a rotor.	Understand	10	3	AAE014.10
4	Define wash in and wash out.	A method of increasing lift by increasing (wash-in) or decreasing (wash-out) the angle of incidence on the outer part of an airplane wing to counteract the effects of engine torque.	Remember	12	3	AAE014.12
5	Significant of the Reynolds number.	Reynolds number is defined as the ratio of inertial forces to the viscous forces. This gives the idea of flow behaviour and size of the object.	Understand	11	3	AAE014.11
6	Define degree of freedom of airplane.	Six degrees of freedom (6DoF) refers to the freedom of movement of a rigid body in three-dimensional space. It has three translational and three rotational movements. Most airplane performance is considered to move in all 6 DOF.	Remember	9	3	AAE014.09
7	What is frise aileron?	A type of aileron that has a beveled leading edge projecting beyond its inset hinges. When lowered, it forms an extension of the wing surface; when raised, its nose protrudes below the wing, increasing drag and reducing yaw.	Understand	11	3	AAE014.10
8	Define aircraft body axis system.	The body axis system is fixed to the aircraft with its origin at the aircraft's center of gravity. The x axis is defined out the nose of the aircraft along some reference line. The reference line may be chosen to be the chord line of the aircraft or may be along the floor of the aircraft, as is often the case in large transports. The y axis is defined out the right wing of the aircraft, and the z axis is defined as down through the bottom of the aircraft in accordance with the right-hand rule.	Understand	10	3	AAE014.10

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9	Define spoiler.	A long, movable, narrow plate along the upper surface of an airplane wing used to reduce lift and increase drag by breaking or spoiling the smoothness of the airflow.	Understand	9	3	AAE014.09
10	Define aircraft response.	When some force is applied on airplane, this airplane will behave according to the applied force, this is called aircraft response.	Remember	11	3	AAE014.11
11	What is flare?	A simple maneuver performed moments before landing in which the nose of an aircraft is pitched up to minimize the touchdown rate of speed.	Understand	10	3	AAE014.10
12	Define moment of inertia.	Moment of inertia is the indications of the resistance to rotation about that axis.	Remember	12	3	AAE014.12
13	Define flight envelope.	An aircraft's performance limits, specifically the curves of speed plotted against other variables to indicate the limits of speed, altitude, and acceleration that a particular aircraft cannot safely exceed.	Understand	11	3	AAE014.11
14	What are slats?	Slats are the movable vanes or auxiliary airfoils, usually set along the leading edge of a wing but able to be lifted away at certain angles of attack.	Remember	9	3	AAE014.09
15	Define moment of inertia	A rigid body assumes that the different parts of the aircraft are not moving with respect to each other.	Understand	11	3	AAE014.11
UNIT IV						
1	Define perturbed flight	Linearization of the aircraft equations of motion begins with consideration of perturbed motion. Perturbed flight is defined relative to a steady state (trimmed) flight condition using a combination of steady state and perturbed variables for aircraft motion parameters and for force and moments.	Understand	14	4	AAE014.14
2	Define speed damping derivative.	It represents the change in drag coefficient with respect to u/U1 and its value is depend on Mach number.	Remember	13	4	AAE014.13
3	Define elevator.	The movable part of a horizontal airfoil which controls the pitch of an aircraft, the fixed part being the horizontal stabilizer.	Understand	15	4	AAE014.15
4	Define earth axis system.	The Earth axis system is fixed to the Earth with its z axis pointing to the center of the Earth. The x axis and y axis are orthogonal and lie in the local horizontal plane with the origin at the aircraft center of gravity. Often, the x axis is defined as North and the y axis defined as East.	Remember	16	4	AAE014.16
5	Define Mach tuck derivative.	Mach tuck derivative. C_{m_1} is the steady-state aerodynamic pitching moment. It will be nonzero for cases where thrust pitching moment must be counteracted by an aerodynamic pitching moment to trim the aircraft to a total pitch moment of zero. For all other cases such as gliders and power-off flight, C_{m_1} will be equal to zero.	Understand	14	4	AAE014.14

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6	Define inertial axis system.	Inertial axis system is defined as the frame of reference system which is fixed. Earth axis system is generally considered as the inertial axis system.	Understand	14	4	AAE014.14
7	Define Roll damping derivative.	It represents the change in rolling moment coefficient with respect to non dimensional roll rate and is usually negative. It is important factor for lateral- directional dynamic stability characteristics.	Remember	13	4	AAE014.13
8	Define stability axis system.	The stability axis system is rotated relative to the body axis system through the angle of attack. This means that the stability x axis points in the direction of the projection of the relative wind onto the xz plane of the aircraft. The origin of the stability axis system is also at the aircraft center of gravity. The y axis is out the right wing and coincident with the y axis of the body axis system. The z axis is orthogonal and points downward in accordance with the right-hand rule.	Understand	15	4	AAE014.15
9	Define roll helix angle.	The absolute value of change in angle of attack at the wing tips due to roll rate (pb/2U1) is called helix angle. It provides the basis for the form of the non dimensional approach.	Remember	16	4	AAE014.04
10	Define dynamic stability.	Dynamic stability is concerned with the time history of the motion of the vehicle after it is disturbed from its equilibrium point.	Understand	14	4	AAE014.14
11	Define cross derivative	It represents the change in yawing moment coefficient (about z axis) because of a non dimensional roll rate.	Remember	14	4	AAE014.14
12	Define speed damping derivative.	The speed damping derivative represents the change in drag coefficient with respect to u/U_1 and its value is dependent on Mach number.	Understand	13	4	AAE014.13
13	Define mach number.	A number representing the ratio of the speed of an object to the speed of sound in the surrounding air or medium in which it is moving.	Remember	14	4	AAE014.14
14	Define primary control derivative	It is change in coefficient of lift with change in aileron deflection angle. This is also called aileron power.	Understand	13	4	AAE014.13
15	Define perturbed flight.	Linearization of the aircraft equations of motion begins with consideration of perturbed flight. Perturbed flight is defined relative to a steady-state (trimmed) flight condition using a combination of steady-state and perturbed variables for aircraft motion parameters and for forces and moments.	Remember	15	4	AAE014.15
UNIT-V						
1	Define roll mode.	The roll mode has a real root and a first-order (non-oscillatory) response that involves almost a pure rolling motion about the x stability axis. It is usually stable at low and moderate angles of attack but may be unstable at high angles of attack. The roll mode can be excited by a disturbance or an aileron input.	Understand	17	5	AAE014.17

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2	Define damping ratio.	The damping ratio provides an indication of the system damping and will fall between -1 and 1. For stable systems, the damping ratio will be between 0 and 1.	Remember	18	5	AAE014.18
3	Define damped frequency.	The damped frequency represents the frequency that the system actually oscillates at with damping present.	Understand	19	5	AAE014.19
4	What is natural frequency?	The natural frequency is the frequency that the system would oscillate at if there were no damping. It represents the highest frequency that the system is capable of, but it is not the frequency that the system actually oscillates at if damping is present.	Remember	20	5	AAE014.20
5	Define phugoid mode.	The phugoid mode is characterized by complex conjugate roots with a relatively low damping ratio and natural/damped frequency (long period). It is demonstrated by trimming the aircraft in level flight, then inputting aft stick for approximately 2–3 s, bleeding off some airspeed, and then returning the stick to the neutral (trimmed) position. The resulting response is usually oscillatory with significant variations in pitch attitude and airspeed, while angle of attack remains relatively constant.	Understand	17	5	AAE014.17
6	Define Cooper-Harper rating	C-H is a decision tree for pilots to rate a specific mission task. The pilot begins decision process at the lower left corner.	Remember	18	5	AAE014.18
7	Define spiral mode.	The spiral mode is a first-order response (real root) that involves a relatively slow roll and yawing motion of the aircraft. It may be stable or unstable. The spiral is usually initiated by a displacement in roll angle and appears as a descending turn with increasing roll angle if unstable. If the spiral is stable, the aircraft simply returns to wings level after a roll angle displacement.	Understand	19	5	AAE014.19
8	What is steady state solution?	A forcing function is included with a non homogeneous differential equation and the solution is called the non-homogeneous or particular solution. It is also called the steady-state solution when we are dealing with aircraft response.	Remember	20	5	AAE014.20
9	Define time constant.	The lag time associated with this rise to the steady-state value is an important consideration in determining the acceptability of the response from an aircraft handling qualities standpoint. This lag time is typically quantified with the time constant (τ).	Understand	17	5	AAE014.17
10	What is characteristic equation?	The characteristic equation of a transfer function is obtained by setting the polynomial in the denominator of the transfer function equal to zero. The characteristic equation determines the dynamic stability characteristics of the response.	Understand	18	5	AAE014.18
11	Define transfer function	A transfer function is defined as the ratio of Laplace transforms of output to input. It is expressed in Laplace notation.	Remember	17	5	AAE014.17

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12	Define short period mode.	The short period mode is characterized by complex conjugate roots with a moderate to relatively high damping ratio and relatively high natural frequency and damped frequency (short period). It is easily demonstrated by first trimming the aircraft and then disturbing it from trim with a forward-aft neutral pitch stick input (commonly called a doublet). The resulting response back to trim may be either first order (exponential decay) or second order (oscillatory).	Understand	18	5	AAE014.18
13	Define damped frequency.	The damped frequency represents the frequency that the system actually oscillates at with damping present.	Remember	19	5	AAE014.19
14	Define Dutch Roll	Dutch roll is a type of aircraft motion, consisting of an out-of-phase combination of "tail-wagging" and rocking from side to side. This yaw-roll coupling is one of the basic flight dynamic modes.	Understand	20	5	AAE014.20
15	Spiral mode	The spiral mode is a first order response (real root) that involves a relatively slow roll and yawing motion of the aircraft. It may be stable or unstable.	Remember	17	5	AAE014.17

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