Longitudinal Static Stability and Control-1

This set of Aircraft Design Multiple Choice Questions & Answers (MCQs) focuses on "Longitudinal Static Stability and Control-1".

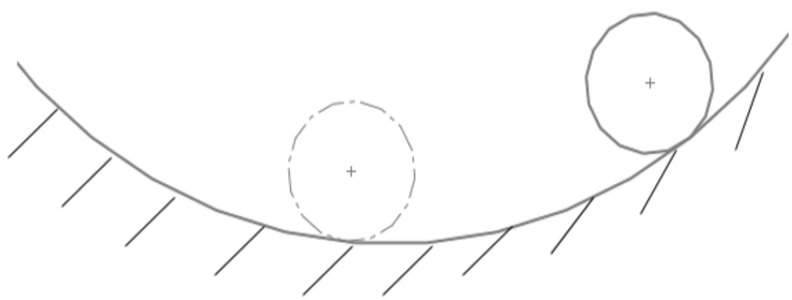
1. Aircraft is said to be statically stable if __________
a) it has initial tendency to come back to its original equilibrium condition after being disturbed
b) it has tendency to return to equilibrium state with the help of pilot's input
c) it has more lift than weight always
d) it has more thrust than drag
Hint: Explanation: An aircraft or an object is said to be statically stable if and only if it has initial tendency to return to its original equilibrium position after being disturbed. Lift is not always greater than the weight. At cruise it will be equal to weight of the aircraft.

2. How can we say that the aircraft has initial tendency to return to its original equilibrium position after being disturbed?
a) If aircraft generates some restoring force or/and moment without any external help
b) If restoring force is not generated to oppose the disturbance
c) If lift is same as weight always
d) If thrust loading is always unity

Hint:: Explanation: If some disturbance is given to the aircraft and aircraft has initial tendency to generate some restoring force or/and moments without any external means then, we say that the aircraft has initial tendency to return to its original equilibrium position after being disturbed. Hence, it has static stability

3. Longitudinal stability means __________
a) stability about pitching axis
b) stability about yawing axis
c) stability about lateral axis
d) stability about negative yawing axis
Hint: Explanation: Longitudinal stability means stability about pitching axis. Pitch up or pitch down moments will be included in this type of stability. Stability about yawing axis is called directional stability and similarly stability about lateral axis is called Lateral stability.

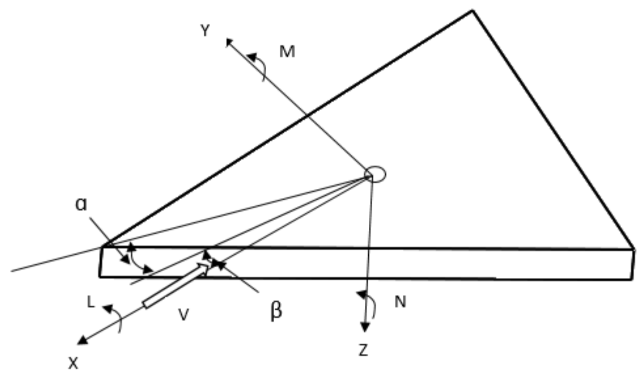
4. Object shown in the following diagram can be considered as __________



a) statically stable
b) statically unstable
c) stability can’t be guessed from diagram
d) neutrally stable

Hint:
Explanation: A typical illustration of stability criteria is shown in the diagram. As shown in the figure, if ball is disturbed from equilibrium position it will return to its original equilibrium position. It has an initial tendency to return to the equilibrium position. Hence, the above diagram is illustrating the concept of statically stable object.

5. If aircraft continues to go farther away from equilibrium position after being disturbed then the aircraft is called _______

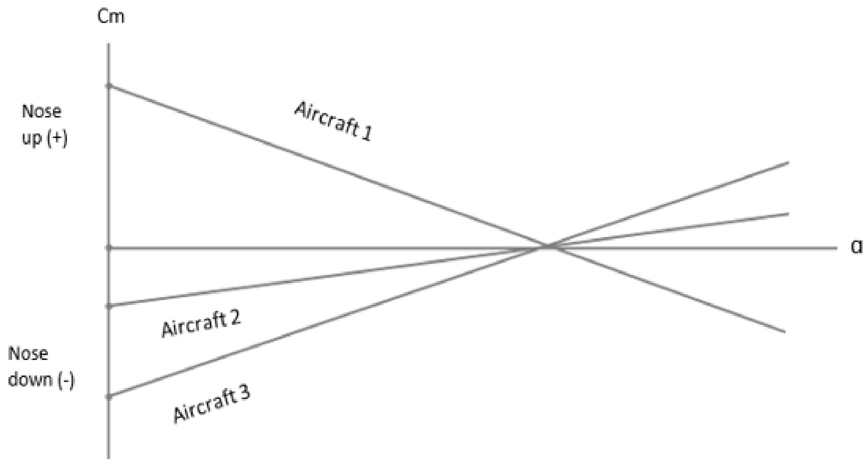


a) unstable
b) stable
c) statically stable
d) neutrally stable

Answer: a
Explanation: If after being disturbed from the equilibrium position, aircraft tends to go further away from the original equilibrium position then it is said that the aircraft is not stable or it is Unstable. It will be called neutrally stable if it attains new equilibrium position however it is not mentioned in the question so the correct answer will be unstable.

6. Following diagram represents ________
a) typical wind axis system
b) drag polar
c) lift curve slope
d) thrust required curve
Explanation: A typical wind axis coordinate system is shown in the diagram. Drag polar is used to provide information about the aircraft drag characteristics. Lift curve is used to provide information about the lift variation of the aircraft wrt angle of attack.

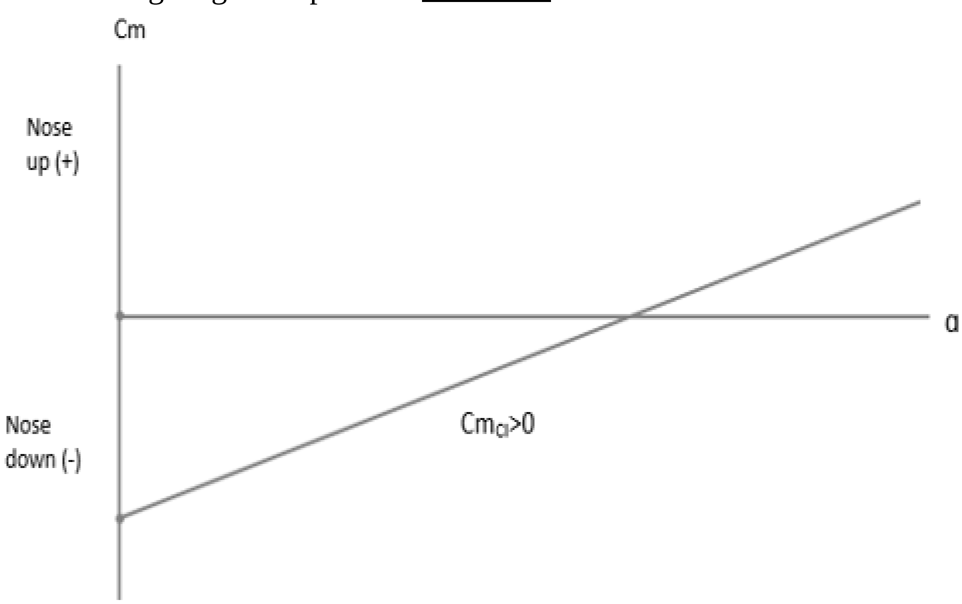
7. Which of the aircraft will be statically stable based on following diagram?



a) aircraft number 1
b) aircraft number 2
c) aircraft number 3
d) same static stability for all 3 aircrafts

Explanation: As shown in the diagram typical pitching moment coefficient curve is represented. Aircraft number 1 will be statically stable. As can be observed in the diagram if aircraft number 1 is disturbed by some forces; let's consider some upward direction gust is encountered. At such conditions it will generate negative pitching moment to oppose the upward deflection and hence, it has initial tendency to return to the original equilibrium position. Therefore it is statically stable.

8. Following diagram represents ________



a) pitching moment coefficient diagram of unstable aircraft
b) pitching moment diagram for stable aircraft

c) lift curve slope
d) drag polar
Explanation: As shown in the diagram typical pitching moment coefficient curve is shown. As shown it is used to provide relationship between pitching moment coefficient and angle of attack. Given diagram is illustrating the concept of statically unstable aircraft. Lift curve is related to lift and AOA.

9. For pitching moment coefficient diagram shown below which one will have positive trim AOA?
a) Aircraft 1
b) Aircraft 2
c) Aircraft 3
d) Aircraft 3 and Curve 2 both
Explanation: Pitching moment coefficient curve is shown for 3 different configurations. To trim at positive AOA, value of zero lift pitching moment coefficient Cm0 should be positive. As can be seen in the diagram aircraft 1 has positive value of Cm0. Hence, aircraft 1 will result in trim at positive AOA.

10. A wing alone arrangement has wing lift curve slope of 2.65 per rad. Find slope of pitching moment coefficient. Given Xcg = 0.3.
a) 0.025 per degree
b) 0.03 per rad
c) 45 per rad
d) 0.0035 per degree
Explanation: Considering ideal location of aerodynamic centre i.e. Xac = 0.25
Slope of pitching moment curve = (wing lift curve slope*[Xcg-Xac])
= (2.56[0.3-0.25])
= 0.1325 per rad = 0.00253 per degree.

11. If moment coefficient about aerodynamic centre of wing is -0.216 and lift coefficient of wing is 1.2. Find moment coefficient about cg. Given cg location as Xcg = 0.3.
a) -0.156
b) 0.123
c) 0.56
d) -1.56
Explanation: Moment coefficient about CG = Moment coefficient about aerodynamic centre of + (wing lift coefficient*[Xcg-Xac])
= -0.216 + (1.2[0.3-0.25]) = -0.156.

12. If CL_{α} wing = 1.2 per rad then, determine CM_{α}. Given Xcg=0.29.
a) 0.076 per rad
b) 45 per rad

c) 0.09 per rad
d) 1.45 per rad
Explanation: $CM_α = CL_α$*[Xcg-Xac] = 1.2*[0.29-0.25] = 0.076 per rad.

13. A wing alone aircraft has aerodynamic centre pitching moment coefficient of -0.126. If lift coefficient at zero AOA is 0.38 then, find Cm0. Consider Xcg=0.3.
a) -0.107
b) -7.89
c) 1.457
d) 0.9845
Explanation: Given, wing alone arrangement, CMac = -0.126, CL0 = 0.38.
Now, Cm0 is given by,
Cm0 = CMac + CL0*[Xcg-Xac] = -0.126 + 0.38*[0.3-0.25] = -1.07.

14. An aircraft with wing aft tail configuration has tail efficiency of 0.95 and tail volume ratio of horizontal tail is 0.7. Determine pitching moment coefficient slope for the tail. Given lift curve slope of tail is 4.2 per rad. Consider downwash derivative as 0.6.
a) -1.1172 per rad
b) 2.45
c) 234.67 per degree
d) 12.788
Explanation: Given, tail efficiency e = 0.95, tail volume ratio of horizontal tail v = 0.7, lift curve slope of tail c = 4.2 per rad, downwash derivative d = 0.6
Pitching moment coefficient slope for the tail = -e*v*c*(1-d)
= -0.95*0.7*4.2*(1-0.6) = -1.1172 per rad.

15. Find tail efficiency if, dynamic pressure at tail and wing is 25Pa and 28Pa respectively.
a) 0.892
b) 67.89%
c) 12.54
d) 0.067
Explanation: Tail efficiency = dynamic pressure at wing / dynamic pressure at tail = 25/28 = 0.892.