School of Aeronautics (Neemrana)

Question Paper For Internal Assessment Examination (Theory) - Old Scheme i.e 2012 Syllabus

[Approved By AICTE / Director General of Civil Aviation, Affiliated to RTU & BTU]

Instructions For Students / Faculty

Mid Term I (Total 40 Marks, 1 Hr. & 30 Min, Syllabus From Beginning of The Session)

Total number of questions to be given are 8, each carrying 10 marks and it is compulsory to attend 2 questions from each part i.e. Part A and B. There is a choice of two questions out of four in each part. Part A will be theoretical or derivation type **(Not More Than 70 Words For Question).** Part B will be fully numerically oriented questions **(Not More Than 70 Words For Question)**, except for the list of subjects given below. No objective type or fill in the blanks shall be given, but subpart of question can be given for both Part A & B.

Mid Term II (Total 50 Marks, 1 Hr. & 45 Min, Syllabus From Beginning of The Session)

Total number of questions to be given are 8, each carrying 10 marks and it is compulsory to attend 2 questions from Part A and three questions from Part B. There is a choice of two questions out of four in part A and 3 questions out of 4 in Part B. Part A will be theoretical or derivation type **(Not More Than 70 Words For Question).** Part B will be fully numerically oriented questions **(Not More Than 70 Words For Question)**, except for the list of subjects given below. No objective type or fill in the blanks shall be given, but subpart of question can be given for both Part A & B.

Mid Term III (Total 60 Marks, 2 Hrs, Syllabus From Beginning of The Session)

Total number of questions to be given are 10, each carrying 10 marks and it is compulsory to attend 2 questions from Part A and 4 questions from Part B. There is a choice of two questions out of four in part A and 4 questions out of 6 in Part B. Part A will be theoretical or derivation type **(Not More Than 70 Words For Question).** Part B will be fully numerically oriented questions **(Not More Than 70 Words For Question)**, except for the list of subjects given below. No objective type or fill in the blanks shall be given, but subpart of question can be given for both Part A & B.

*** LIST OF ELABORATIVE THEORY QUESTION SUBJECTS**: Aircraft Materials, Aircraft System, Aircraft Rules & Regulation-I, Mechanics of Composite Materials, Aircraft Design, Aircraft Rules & Regulation-II, Avionics-I, Helicopter Theory, Maintenance of Airframe and System Design, Avionics-II, Airlines and Airport Management, Maintenance of Power Plant & Systems

FACULTY MEMBERS, PLEASE ENSURE EXCEPT ABOVE LISTED SUBJECTS, NO THEORITICAL ELABORATIVE QUESTION SHOULD BE GIVEN IN PART 'B' OF QUESTION PAPER

STUDENT IS ALLOWED TO ENTER LATE NOT MORE THAN 15 MIN AFTER STARTING OF

STUDENT IS ALLOWED TO ENTER LATE NOT MORE THAN 15 MIN AFTER STARTING OF EXAM, AND MAY LEAVE THE EXAM HALL ON EXPIRY OF ATLEAST OF 1 Hr FROM THE STARTING TIME OF EXAMINATION

Question Paper & Student Details

Mid Term*	Mid Term 1	Date of Submission of QP	02/09/2019
Name of Faculty*	Mr Ranjay Kr. Singh	Date of Examination*	10/09/2019
Subject*	7AN5 – Aircraft Stability and Control (Old)	Course*	B.Tech (Aeronautical Enginee...
Batch	Combined Batches 10,11	Semest...	Semester : 7
Email Id of Faculty:*	ranjaykrsingh88@gmail.com	Phone Number of Faculty*	955 556 1562

Student Name

Student Reg No.

Part A

Question : 1*

What do you understand by equilibrium condition of object? Deduce the equilibrium equations of unaccelerated flights.

Lesson Plan* 1 | Topic* Equilibrium | Source* J.D.Anderson, Prin

Question : 2*

Illustrate and describe the stability criteria of longitudinal, lateral and directional flight. Explain each term clearly by example.

Lesson Plan* 2 | Topic* Criterioa of stbility | Source* J.D.Anderson, Prin

Question : 3*

Write the assumptions used while deriving stability equations of aircraft and define the terms static stability and dynamic stability with the help of figures and graphs.

Lesson Plan* 3 **Topic*** Types of stbility **Source*** J.D.Anderson, Prin

Question : 4*

Draw a neat sketch of airplane and shows the body axis system also labelled and explain in briefs the symbols and notation, which is used to completely define the motion of airplane.

Lesson Plan* 4 **Topic*** Types of stability **Source*** J.D.Anderson, Prin

Part B

Question : 1*

Find the expression for the co-efficient of moment about C.G. of aircraft due to the wing and states effect of C.G. location and Cm,0 on the longitudinal static stability of aircraft.

Lesson Plan* 9 **Topic*** Contribution of wing **Source*** J.D.Anderson, Prin

Question : 2*

A wing-body is tested in a subsonic wind tunnel. The lift is found to be zero at a geometric angle of attack $\alpha = -1.5^{\circ}$. At $\alpha = 5^{\circ}$, lift coefficient is measured as 0.52. Also at $\alpha = 1.0^{\circ}$ and 7.88°, moment coefficient about C.G. are measured as -0.01 and 0.05, respectively. C.G. is located at 0.35c. Calculate the location and moment coefficient about the aerodynamic center of wing.

Lesson Plan* 10 **Topic*** Contribution of wing **Source*** J.D.Anderson, Prin

Question : 3*	The wing area and chord of test model are 1.5 m*2 and 0.45 respectively is placed in stream of air at 100 m/s. The moment about C.G. when the lift is zero is found to be -12.4 N-m. When the model is pitched to another angle of attack, the lift and moment about the C.G. are 3675 N and 20.67 N.m, respectively. Calculate value of moment-coefficient about the aerodynamic-center. (Take density = 1.2256 Kg/m*3)

Lesson Plan*	10	**Topic***	Contribution of wing	**Source***	J.D.Anderson, Prin

Question : 4*	If the slope of the Cm versus CL curve is -0.15 and the pitching moment coefficient at zero lift is equal to 0.08, determine the trim lift coefficient. If the center of gravity of the airplane is located at 30% of chord length, determine neutral point.

Lesson Plan*	10	**Topic***	Contribution of wing	**Source***	R.C.Nelson, Fligt st

Question : 5	

Lesson Plan		**Topic**		**Source**	

Question : 6	

Lesson Plan		**Topic**		**Source**	

Upload Scanned Document In Case of Numerical or Diagram for any of the above question

Mention question number with relevant fig / numerical / equations. Max 150 KB

Choose files or drag here

I have scrutinized the question paper. There is no spelling mistake or any type of irrelevant question.

Part A

(1) Ans.

If the resultant of forces and moments about C.G. of any mechanical system is zero then the system is said to be in equilibrium condition.

$\sum F_{CG} = 0$

$\sum M_{CG} = 0$

Equilibrium equation of unaccelerated flight:

(A) Steady state and level flight

$\sum F_{flight\ path} = 0$; T = D ------ (1)

$\sum F_{Perpendicular\ to\ flight\ path} = 0$; L= W ---------(2)

$\sum M_{CG} = 0$ ----------- (3)

(B) Climbing Flight:

$\sum F_{flight\ path} = 0$; T – D - Wsin $\theta = 0$ --------- (1)

$\sum F_{Perpendicular\ to\ flight\ path} = 0$; L = Wcos θ -----------(2)

$\sum M_{CG} = 0$ ----------- (3)

(C) Gliding Flight :

$\sum F_{flight\ path} = 0$; D = Wsin θ --------- (1)

$\sum F_{Perpendicular\ to\ flight\ path} = 0$; L = Wcos θ -----------(2)

$\sum M_{CG} = 0$ ----------- (3)

(2) Ans.

Stability criteria of longitudinal stability:

$\frac{dC_{m,CG}}{d\alpha} < 0$ or $\frac{dC_{m,CG}}{dC_L} < 0$ ---statically stable

$\frac{dC_{m,CG}}{d\alpha} = 0$ or $\frac{dC_{m,CG}}{dC_L} = 0$ --- Neutral

$\frac{dC_{m,CG}}{d\alpha} > 0$ or $\frac{dC_{m,CG}}{dC_L} > 0$ ---statically unstable

Stability criteria of directional stability:

$\frac{dC_n}{d\beta} > 0$ or $\frac{dC_n}{d\psi} < 0$ ---statically stable

$\frac{dC_n}{d\beta} = 0$ or $\frac{dC_n}{d\psi} = 0$ --- Neutral

$\frac{dC_n}{d\beta} < 0$ or $\frac{dC_n}{d\psi} > 0$ ---statically unstable

Stability criteria of lateral stability:

$\frac{dC_l}{d\beta} < 0$ --- Stable

$\frac{dC_l}{d\beta} = 0$ --- Neutral

$\frac{dC_l}{d\beta} > 0$ --- Unstable

Note: Each term should be explained by taking the example of flight motion and ability of flight to acts against the disturbance.

(3) Ans:

Assumptions:

(a) Flow is incompressible.
(b) Relations between various coefficients is linear.
(c) Longitudinal motion is independent on directional and lateral motion.
(d) Aircraft structure is rigid.

Static stability:

It represents initial tendency of aircraft to returns to equilibrium state after disturbance.

If any mechanical system such as an aircraft disturbed from equilibrium position then new forces and moments generated about the CG. If the consequence of resultant forces and moments is such that

Case (i) the body returns to its equilibrium state, then it is statically stable.

Case (ii) the body remains in new equilibrium position, then it is statically neutral.

Case (iii) the body continuously diverges from its equilibrium position, then it is statically unstable.

These three cases are presented in figure 1.

Dynamic stability:

In the study of dynamic stability we are concerned with the time history motion of the vehicle after it is disturbed from equilibrium point. If the aircraft is dynamically stable it must be statically stable.

Case (i) if initial disturbance being dissipated with time means amplitude of disturbance reduces with time then it is dynamically stable and oscillation of airplane is damped.

Case (ii) if initial disturbance being increases with time and oscillation becomes undamped then it is said to be dynamically unstable.

Different time history of aircraft motion is presented in figure (2)

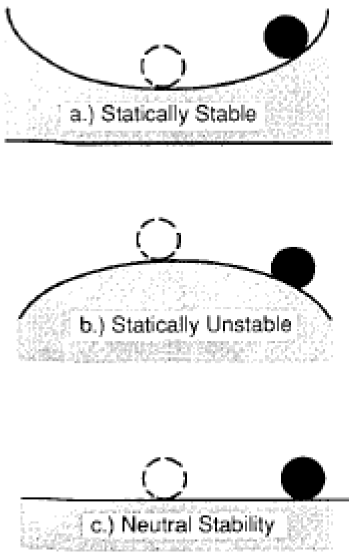

Figure 1

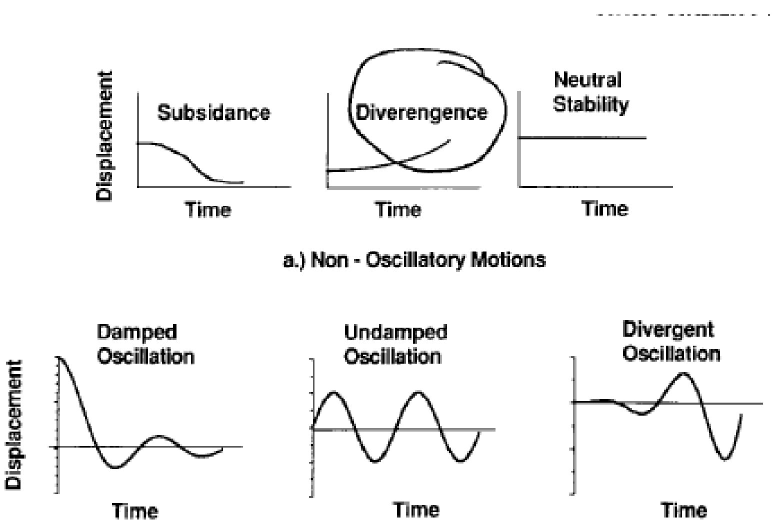

Figure 2

(4) Ans:

P = Roll rate

q = Pitch rate

r = yaw rate

$C_m =$ Pitching moment coefficient = $\frac{2M}{\rho V^\wedge 2SC}$

$C_l =$ Rolling moment coefficient = $\frac{2L}{\rho V^\wedge 2Sb}$

$C_n =$ Yawing moment coefficient = $\frac{2N}{\rho V^\wedge 2Sb}$

Where,

M = Pitching moment

L = Rolling moment

N = Yawing moment

S = Wing planform area

b = Wing span

C = Wing Chord

V = Relative wind speed

P = Density of air

u = Velocity along X-axis

v = Velocity along y-axis

w = Velocity along X-axis

V = (u^2 + v^2 + w^2) ^ (1/2)

$C_L =$ Lift coefficient = $\frac{2L}{\rho V^\wedge 2S}$

$C_D =$ Drag coefficient = $\frac{2D}{\rho V^\wedge 2S}$

$C_Y =$ Side force coefficient = $\frac{2F}{\rho V^\wedge 2S}$

α = Angle of attack

β = Side slip angle

γ = Flight path angle

ψ = Yaw angle, θ= Pitch angle, ϕ = Roll angle

Part B

(1) Ans:

Figure 3, represents the wing of an airplane placed at an absolute angle of attack α_w

Distance of aerodynamic center of wing from its L.E. is X_{ac} , distance of CG of aircraft from wing LE is given as X_{CG}, and the chord of wing is given by C.

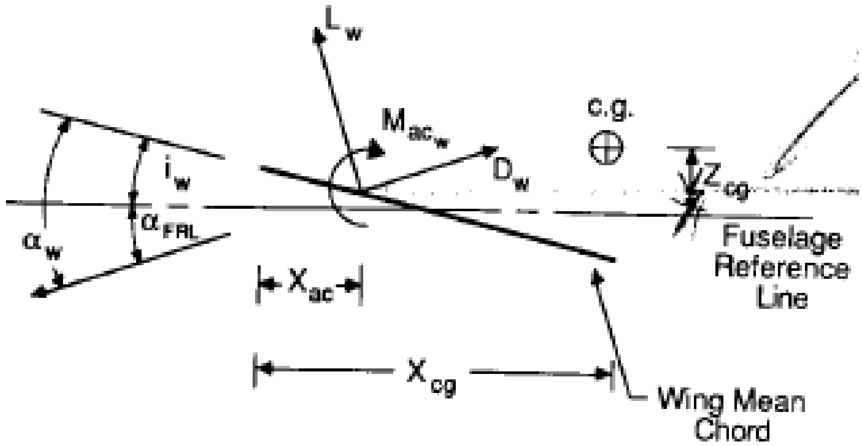

Figure 3

Taking moment about CG,

$M_{CG} = M_{ac} + L \cos(\alpha_w - i_w)(X_{CG} - X_{ac}) + L \sin(\alpha_w - i_w)(X_{CG} - X_{ac}) +$

$D \sin(\alpha_w - i_w)(X_{CG} - X_{ac}) - D \cos(\alpha_w - i_w)(Z_{CG} - Z_{ac})$

Dividing all the terms by ρV^2S/2, We get

$C_{m,CG} = C_{m,ac} + C_L \cos(\alpha_w - i_w)(X_{CG}/c - X_{ac}/c) + C_L \sin(\alpha_w - i_w)(Z_{CG}/c - Z_{ac}/c) +$

$C_D \sin(\alpha_w - i_w)(X_{CG}/c - X_{ac}/c) - C_D \cos(\alpha_w - i_w)(Z_{CG}/c - Z_{ac}/c)$

By neglecting small terms, we get

$C_{m,CG} = C_{m,ac} + C_L (X_{CG}/c - X_{ac}/c)$ --------- (1)

Differentiating equation (1) w.r.t. C_L

$\frac{dC_{m,CG}}{dC_L} = (X_{CG}/c - X_{ac}/c)$ ------- (2)

Case (1) If $X_{CG} < X_{ac,}$ then airplane is statically stable.

Case (ii) If $X_{CG} > X_{ac}$, then aircraft is statically unstable.

Case (iii) If $X_{CG} = X_{ac}$, then aircraft is statically neutral.

(2) Solution

$C_{m,CG} = C_{m,ac} + C_L\left(\frac{X_{CG}}{C} - \frac{X_{AC}}{C}\right)$ -----------------(1)

Lift slope, $a_w = \frac{dC_L}{d\alpha} = \frac{0.52-0}{5+1.5}$ = 0.08 per degree

We know that, $C_L = a_w(\alpha - \alpha_{L=0})$-----------------(2)

From equation 1 and 2, we can write

$C_{m,CG} = C_{m,ac} + a_w(\alpha - \alpha_{L=0})\left(\frac{X_{CG}}{C} - \frac{X_{AC}}{C}\right)$----------(3)

Given data,

At $\alpha = 1^o$, $C_{m,CG}$ = -0.01 and at $\alpha = 7.88^o$, $C_{m,CG}$= 0.05

X_{CG} = 0.35C

Putting these values in equation (3) and solving, we get

Xac = 0.24C and $C_{m,ac} = -0.032$

(3) Solution:

Given, S=1.5 m^2 , C = 0.45 m , V = 100 m/s, M_0 = -12.4 N-m

At another AOA, L = 3675 N, M_{CG} = 20.67 N-m

We Know that,

$$C_L = \frac{2L}{\rho * V^2 * S} \quad \text{and} \quad C_m = \frac{2M}{\rho * V^2 * S * c}$$ -------(A)

By putting the given values in equation (A)

C_{m0} = - 0.0029, $C_{m,CG}$ = 0.0049, and C_L = 0.3998

From Equation

$C_{m,CG} = C_{m,ac} + C_L\left(\frac{X_{CG}}{C} - \frac{X_{AC}}{C}\right)$

0.0049 = -0.0029 + 0.3998 $\left(\frac{X_{CG}}{C} - \frac{X_{AC}}{C}\right)$

$X_{CG} - X_{AC} = 0.02C$

C.G. is located behind the aerodynamic center at a distance 2% of chord.

(4) Solution:

Given, $\frac{dC_m}{dC_{L,W}} = -0.15$, $C_{m,0} = C_{m,ac}$ = 0.08, X_{CG} /C =0.3

$C_{m,CG} = C_{m,ac} + C_L\left(\frac{X_{CG}}{C} - \frac{X_{AC}}{C}\right)$---------(1)

Differentiating equation (1) w.r.t. C_L and putting the values,we get

$-0.15 = 0.3 - \frac{X_{AC}}{C}$

$\frac{X_{AC}}{C} = 0.45$

For trim,

$C_{m,CG} = 0$ and $C_L = C_{L,trim}$

From (1), $0 = 0.08 + C_{L,trim}(0.3-0.45)$

$C_{L,trim} = 0.533$ Ans