| Name:<br>Enrolment No: | UPES |
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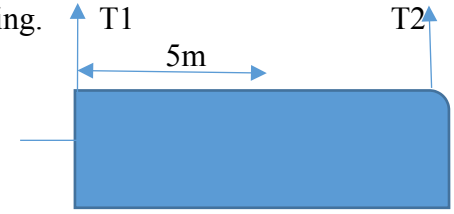
**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**End Semester Examination, December 2018**

**Course: Flight Mechanics-II (ASEG-401)** **Semester: VII**
**Programme: B-Tech ASE,ASEA**
**Time: 03 hrs.** **Max. Marks: 100**
**Instructions: Make use of *sketches/plots* to elaborate your answer. The Question Paper contain 3 Sections- Section A, B and C**

**SECTION A (5 x 4 = 20 Marks)**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q 1 | How dihedral for low wing configuration contributes lateral stability of an aircraft. Derive it. | **5** | **CO3** |
| Q 2. | X-36 research aircraft does not have vertical stabilizers. Explain & derive it. | **5** | **CO3** |
| Q 3. | Center of pressure of an aircraft lies at a distance of 4.45m from its nose tip and center of gravity lies at 4.39 m. If the wing chord length is 1.00m. Determine static margin of the aircraft. | **5** | **CO1** |
| Q 4. | Define dorsal fin. How it contributes in providing directional stability. | **5** | **CO4** |
| | **SECTION B (10 x 4 = 40 Marks)** | | |
| Q 5. | A twin jet engine has following data (Asymmetric power):<br>Thrust of per engine = 10,000N<br>Span wise distance between two engine= 10m<br>Wing area=50m$^2$<br>Wing span=10m<br>$Cn_{\delta r}$ = -0.001/degree<br>Max rudder deflection= +- 20 degree<br>Determine rudder deflection to maintain zero sideslip at 100 m/s in level flight at sea level with one engine not working.   | **10** | **CO3** |
| Q 6. | Consider the wing body model. The area and chord of the wing are 0.5m$^2$ and 0.2 m respectively. Assume horizontal tail is added to this model. the distance from the airplanes COG to the tail AC is 0.14 m, the tail area is 0.04m$^2$ , tail setting angle is 3.5$^0$the tail lift slope is 0.1 per degree ,$\epsilon_0$ =0 and d$\epsilon$/d$\alpha$ =0.35 , a =0.08 , h – h $_{acwb}$ | **10** | **CO4** |

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| | =0.12 ,C $m_{,cg}$ = -0.024 . if $\alpha = 12^0$. (a) calculate $Cm_{,cg}$ for the airplane model.<br><br>b) Does this model have longitudinal static stability and balance? If a=0.08 , , h – $h_{acwb}$ =0.11, VH =0.34 , at =0.1per degree, d€/dα =0.35,C $m_{,acwb}$ = -0.032 ,$€_0$ =0,tail setting angle is $3.7^0$ | | |
| Q 7. | a) Differentiate stick fixed and stick free longitudinal stability with necessary diagram.<br><br>b) If the slope of Cm Verses CL curve is -0.10, C.G is located at 0.36 and the pitching moment at zero lift is equal to 0.08, determine a) trim lift coefficient b) stick fixed neutral point. | **10** | **CO2** |
| Q 8. | Derive second order differential equation for over damped motion, un-damped motion along with displacement Vs time plot of individual motions.<br><br>OR<br><br>Derive second order differential equation for critically damped motion with displacement Vs time plot.<br><br>b) The differential equations for constrained center of gravity pitching motion of an airplane is computed to be<br><br>$\ddot{\alpha} + 4\dot{\alpha} + 36\alpha = 0$<br><br>Find the following:-<br><br>A) $\zeta$ damping ratio<br>B) $\omega_d$ damped natural frequency rad/s<br>C) $\omega_n$ natural frequency, rad/s | **10** | **CO1** |
| **SECTION-C (20 x 2 = 40 Marks)** | | | |
| Q 9. | An aircraft is ready for take-off when it is detected that a cross-wind of 8m/s is blowing across the runway .Determine the rudder angle required to maintain steady normal heading along the runway at unstick point using the following data.<br>Wing loading= $2500N/m^2$<br>Span= 25m<br>Wing area= $70m^2$<br>Unstick velocity=1.2 $V_{stall}$ | **20** | **CO3** |

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|---|---|---|---|
| | $C_{Lmax}$= 1.8<br>Lift-curve slope of vertical tail= 0.08/deg<br>$Cn_{\beta}$ = 0.012/deg<br>Vertical tail volume ratio= 0.25<br>$\eta$ =0.9<br>Assume that 1 deg of rudder deflection changes the vertical tail incident by 0.4 degree. | | |
| Q10. | Derive Six degree of freedom rigid body force and moment Equations in body frame of references.<br><br>Explain body and Inertial axes system & derive Euler rates in terms of the body angular velocities.<br><br>OR<br><br>a. Derive frequency and damping ratio for long- period and short-period motions.<br>b. Define Terminology:- Spiral divergence, dutch roll, directional divergence, Phugoid motion & short period motion.<br>c. Determine $\omega_n$, $\zeta$ for short period and phugoid approximations if following data is given :<br>$X_u$ = -0.045s$^{-1,}$ $X_w$= 0.036s$^{-1}$ $X\dot{w}$ =0 $Z_u$ =-0.369s$^{-1}$ $Z_w$= -2.02s$^{-1}$<br>$Z\dot{w}$ =0 $M_u$=0 $M_w$= -0.05 M $\dot{w}$= -0.0651 $X_q$ =0<br>$Z_q$=0 $M_q$= -2.05s$^{-1}$ $U_0$ =176ft/s | **20** | **CO2** |

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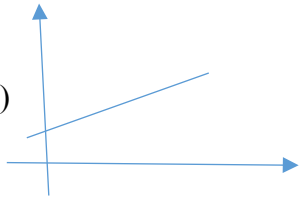
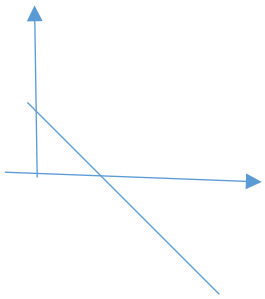
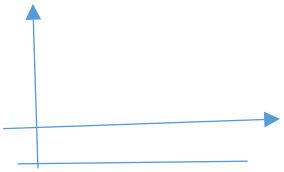
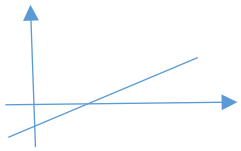
**SECTION A (5 x 4 = 20 Marks)**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q 1 | Vertical tail is placed beneath the fuselage then explain directional stability criterion. | **5** | **CO1** |
| Q 2. | Which of the following represents a graph of $C_{M,\,ac}$ (X-axis : Angle of attack,α ; Y-axis: Moment coefficient about ac, $C_{M,\,ac}$.<br>a)  <br>b)  <br>c)  <br>d)  <br>Calculate $C_{m,\alpha}$ if aircraft is disturbed by a gust which increases the angle of attack by $2^0$ . As a result a nose down pitching moment coefficient is 0.032 is produced about c.g of an aircraft. | **5** | **CO3** |
| Q 3. | Center of pressure of an aircraft lies at a distance of 4.47m from its nose tip and center of gravity lies at 4.37 m. If the wing chord length is 1.00m. Determine static margin of the aircraft. | **5** | **CO3** |
| Q 4. | Explain following Terminology:- a) Adverse Yaw Effect b) Control in crosswind take-off and landing with necessary sketches. | **5** | **CO4** |
| | **SECTION B (10 x 4 = 40 Marks)** | | |
| Q 5. | a) Differentiate stick fixed and stick free longitudinal stability with necessary diagram. | **10** | **CO3** |

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|---|---|---|---|
| | b) If the slope of Cm Verses CL curve is -0.10, C.G is located at 0.34 and the pitching moment at zero lift is equal to 0.07, determine a) trim lift coefficient b) stick fixed neutral point. | | |
| Q 6. | A twin jet engine has following data (Asymmetric power):<br>Thrust of per engine = 10,000N<br>Span wise distance between two engine= 10m<br>Wing area=50m$^2$<br>Wing span=10m<br>$Cn_{\delta r}$ = -0.001/degree<br>Max rudder deflection= +- 20 degree<br>Determine rudder deflection to maintain zero sideslip at 100 m/s in level flight at sea level with one engine not working. T1 T2<br>5m<br>  | **10** | **CO1** |
| Q 7. | Consider the full size airplane model. The airplane has wing area 19m/s2, weight of 22700N and elevator control effectiveness of 0.04 .Calculator elevator deflection angle necessary to trim the airplane at a velocity of 61 m/s at sea level if a=0.08 , Cm,o = 0.06 ,VH=0.34 , ∂Cm,cg /∂$\alpha_a$ =-0.0133 | **10** | **CO2** |
| Q 8. | a)Derive second order differential equation for over damped motion, un-damped motion along with displacement Vs time plot of individual motions.<br><br>OR<br><br>a)Derive second order differential equation for critically damped motion with displacement Vs time plot.<br><br>b) The differential equations for constrained center of gravity pitching motion of an airplane is computed to be<br><br>$\ddot{\alpha} + 4\dot{\alpha} + 36\alpha = 0$<br><br>Find the following:-<br><br>a) $\zeta$ damping ratio<br>b) $\omega_d$ damped natural frequency rad/s<br>c) $\omega_n$ natural frequency, rad/s | **10** | **CO4** |
| **SECTION-C(20 x 2 = 40 Marks)** | | | |

| | | | |
|---|---|---|---|
| Q 9. | An aircraft is ready for take-off when it is detected that a cross-wind of 8m/s is blowing across the runway .Determine the rudder angle required to maintain steady normal heading along the runway at unstick point using the following data.<br>Wing loading= 2500N/$m^2$<br>Span= 25m<br>Wing area= 70$m^2$<br>Unstick velocity=1.2 $V_{stall}$<br>$C_{Lmax}$= 1.8<br>Lift-curve slope of vertical tail= 0.08/deg<br>$Cn_\beta$ = 0.012/deg<br>Vertical tail volume ratio= 0.25<br>$\eta$ =0.9<br>Assume that 1 deg of rudder deflection changes the vertical tail incident by 0.4 degree. | **20** | **CO3** |
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