UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, April/May 2018

Course: Automatic Flight Control **Semester: II**
**Program: M. Tech ASE+UAV**
Time: 03 hrs **Max. Marks: 100**

Instructions:

SECTION A

S. No.		Marks	CO
Q1	Explain force equation of aircraft in rotating frame of reference.	4	CO1
Q2	Derive the orientation transformation matrix between Inertial and rotating frame of reference.	4	CO1
Q3	Find Steady-state roll rate equation of aircraft in pure rolling motion.	4	CO2
Q4	Determine the stability of the system with characteristics equation $s^3+6s^2+12s+8=0$	4	CO3
Q5	What is the function of Autopilot in aircraft?	4	CO4

SECTION B

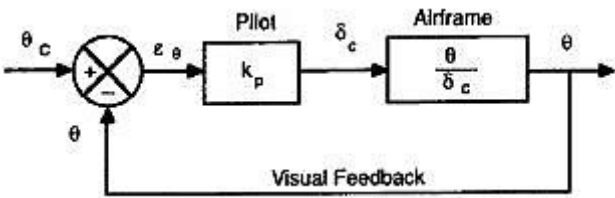| Q6	Explain *Short Period*, *Phugoid*, and Dutch Roll Aircraft motions.	10	CO1
Q7	Derive linearized force equation in x-direction of Aircraft in body fixed axis system.	10	CO2
Q8	For the given figure, linear control system with feedforward path, Find $\dfrac{C(s)}{R(s)}$	10	CO3
Q9	What is ILS (Instrument Landing system) system? Explain function of ILS system using control system *block diagram*.	10	CO4
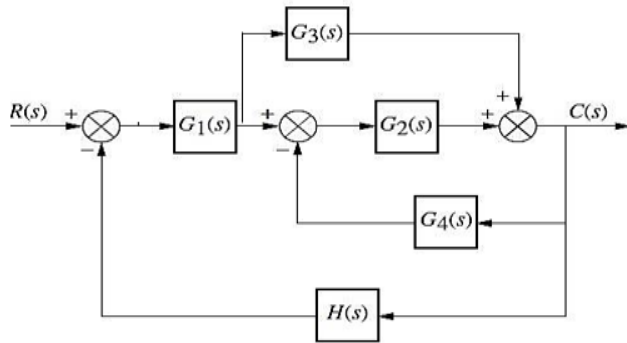
Q10	**Or** What is SAS (Stability Augmentation system) of aircraft? Explain SAS system using control system *block diagram*	**10**	**CO4**

SECTION-C		

Q 11	A) Calculate the roll response of the aircraft to a 5 degree step change in airleron deflection. Assume the airplane is flying at sea level with a velocity of 87 m/s. The aerodynamic and geomentric chataterisitcs are: **Example Problem 5.1.** Calculate the roll response of the F104A to a 5° s change in aileron deflection. Assume the airplane is flying at sea level wit velocity of 87 m/s. The F104A has the following aerodynamic and geome characteristics: $$C_{l_p} = 0.285 \text{ rad}^{-1} \qquad S = 18 \text{ m}^2$$ $$C_{l_{\delta a}} = 0.039 \text{ rad}^{-1} \qquad b = 6.7 \text{ m}$$ $$I_x = 4676 \text{ kg·m}^2$$ $$\frac{b}{2u_0} = \frac{6.7}{2(87 \text{ m/s})} = 0.039 \text{ s}$$	**10**	**CO1**
	B) Derive Aircraft characteristics equations for *Short Period* and *Phugoid* motions using given Aircraft equations of motion in state space form as $$\begin{bmatrix} \Delta\dot{u} \\ \Delta\dot{w} \\ \Delta\dot{q} \\ \Delta\dot{\theta} \end{bmatrix} = \begin{bmatrix} X_u & X_w & 0 & -g \\ Z_u & Z_w & u_0 & 0 \\ M_u + M_{\dot{w}}Z_u & M_w + M_{\dot{w}}Z_w & M_q + M_{\dot{w}}u_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta u \\ \Delta w \\ \Delta q \\ \Delta\theta \end{bmatrix}$$ $$+ \begin{bmatrix} X_\delta & X_{\delta_T} \\ Z_\delta & Z_{\delta_T} \\ M_\delta + M_{\dot{w}}Z_\delta & M_{\delta_T} + M_{\dot{w}}Z_{\delta_T} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta\delta_T \end{bmatrix}$$ Give equations for damping ration and natural frequency of each motion.	**10**	**CO2**

Q12	Sketch the root locus of loop transfer function G(s)H(s)=k/s(s+3)(s+10). Add a simple pole, (s+2), to G(s)H(s) , and Add a simple zero, (s+2), to G(s)H(s) examine the resulting system stability.	20	CO3

<div align="center">or</div>

Q13	The Wright "Flyer" was statically and dynamically unstable. However, because the Wright brothers incorporated sufficient control authority into their design they were able to fly their airplane successfully. Although the airplane was difficult to fly the combination of the pilot and airplane could be made to be a stable system. The closed loop pilot is represented $$\frac{\theta}{\delta_c} = \frac{11.0(s+0.5)(s+3.0)}{(s^2+0.72s+1.44)(s^2+5.9s-11.9)}$$ Pure gain, K_p and the pitch attitude canard deflection. Determine the root locus plot of the closed loop system. For what range of pilot gain is the system stable.	20	CO4