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# MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
*(A constituent unit of MAHE, Manipal)*

**FIRST SEMESTER M.TECH. (CONTROL SYSTEMS)**

**END SEMESTER DEGREE EXAMINATIONS, FEBRUARY - 2021**

## NAVIGATION GUIDANCE AND CONTROL [ICE 5153]

TIME: 3 HOURS　　　　26-02-2021　　　　MAX. MARKS: 50

**Instructions to candidates :*Answer ALL questions and missing data may be suitably assumed.***

1A. Explain the terms (i) Phugoid mode (ii) Short period mode with reference to longitudinal dynamics of an aircraft.

1B. The short period equation for a particular air plane can be expressed as $\begin{bmatrix}\dot{\alpha}\\ \dot{q}\end{bmatrix} = \begin{bmatrix}\frac{Z_\alpha}{u} & 1\\ M_\alpha & M_q\end{bmatrix}\begin{bmatrix}\alpha\\ q\end{bmatrix}$.

Suppose $\frac{Z_\alpha}{u}$ = -1. Determine $M_\alpha$ and $M_q$ so that damping ratio $\xi$=0 and undamped natural frequency is 2 rad/sec.

1C. Simplified model of aircraft longitudinal dynamics is given by $\frac{Z_\alpha}{u}$ =-1, $\frac{Z_E}{u}$=-0.1, $M_q$= - 0.5, $M_\alpha$ = -0.5, $M_E$ =-9, $\frac{X_\alpha}{u}$ = -14 , $\frac{X_E}{u}$ = -1, u = 69 m/s. All other coefficients are negligible. Find the transfer functions $\frac{\theta}{\delta_E}$ and $\frac{u}{\delta_E}$.

(2+3+5)

2A Differentiate the terms i) Altitude hold mode ii) Mach hold mode

2B The Dutch roll motion can be approximated using the following state model

$$\begin{bmatrix}\dot{\beta}\\ \dot{\gamma}\end{bmatrix} = \begin{bmatrix}\frac{y_\beta}{v} & \frac{y_r}{v}-1\\ N_\beta & N_\gamma\end{bmatrix}\begin{bmatrix}\beta\\ \gamma\end{bmatrix} + \begin{bmatrix}\frac{y_R}{v}\\ N_R\end{bmatrix}\delta_R;$$

Where $y_\beta$ = -7.8 ft/sec$^2$, $y_r$ = 2.47 ft/sec, $N_\beta$ = 0.64 sec$^{-2}$, $N_\gamma$ = - 0.34 sec$^{-1}$, v = 154 ft/sec, $y_R$ = - 5.36 ft/sec , $N_R$ = -0.616 sec$^{-2}$. Determine the Dutch roll eigen values. What is the damping ratio and the undamped natural frequency of oscillation?

2C Explain a scheme to reduce pitch up phenomena. Also with block diagrams explain pitch orientational control system of an aircraft.

(2+3+5)

3A With necessary diagrams, explain (i) Terrestrial navigation (ii) Celestial Navigation.

3B Consider a radar with antenna gain of 4000 and radiated power 90 MW. The wavelength of the transmitted energy is 0.05m and minimum detectable signal is $10^{-14}$ Watts. If an object is located 150 kms from the radar, what should be the minimum radar cross section of the object for detection to be possible?

3C For a unity feedback system with G**(s) = K/s(s+1)(s+2).** Design a PID controller using root locus method that will yield 20% overshoot and settling time 1sec for a step input and zero steady state error for step and ramp inputs. Realize the PID controller.

(2+3+5)

4A What is the function of a seeker stabilization loop in the guidance system? Also explain the term miss distance.

4B Design a PI Controller for the system $\boldsymbol{G(s) = 100/ (S+1)(S+2)(S+5)}$ to meet the PM requirement of $60^o$ at a frequency of 0.5 rad/sec. Use frequency domain design approach.

4C The open loop transfer function of a unity feedback control system is given by G(s) = **100/s(s+8).** It is desired to have the peak overshoot be limited to 9.5% and natural frequency of oscillation to be 12 rad/sec. Design a suitable lead compensator.

(2+3+5)

5A List any four applications of RADAR.

5B Sketch the beat frequency curve of a triangular frequency modulated CW Radar for an approaching target. Find equation for the beat frequency as a function of time.

5C Position and velocities of two aircraft, A and B are shown in Fig.Q5C. Aircraft A carries CW radar transmitting at 400 MHz frequency and tracking aircraft B. (i) What is the Doppler frequency shift recorded by the radar in aircraft A ? (ii) Is this shift positive or negative? (iii) What should be the flight direction of aircraft B for the Doppler frequency shift to be zero?

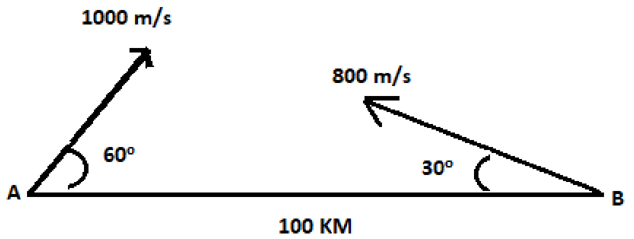


Fig.Q5C

(2+3+5)

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