53 (IE 503) CNSY–I

2017

CONTROL SYSTEM–I

Paper : IE 503

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions out of **eight**.*

1. *(a)* What are the limitations of open-loop systems over closed-loop systems ? List the advantages of closed-loop system over open-loop system. 4

   (b) Differentiate between linear and non-linear systems with suitable example. 6

   (c) Derive an expression for the transfer function of an Armature Controlled dc Motor. 10

2. *(a)* Obtain the closed loop transfer function $C(s)/R(s)$ of the system whose block diagram is shown in *Figure : 01*. Verify the result using signal flow graph. 14

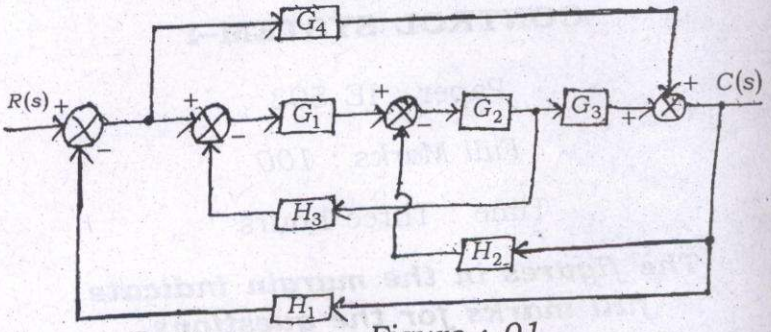

Figure : 01

(b) The front wheel of an aircraft is modelled by the following diagram shown in *Figure : 02*. Calculate $Y(s)/U(s)$. 6

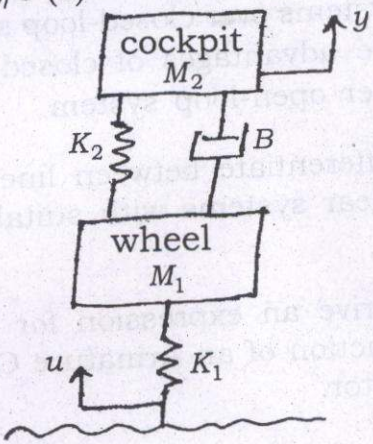

Figure : 02

3. (a) *Figure : 03* shows a positional control system for controlling the position of a shaft. The potentiometer error detector measures the deviation of the output shaft with respect to reference position θ_r. The error is amplified by means of an Amplifier, the output of which is fed to an armature controlled dc motor. The motor shaft is coupled to the load shaft through a gear.

The system parameters are as follows :

Error detector gain $K_e = 2V/rad$

Amplifier gain $K_A = 15V/V$,

$R_a = 0{\cdot}2 ohm$; L_a = negligible

Motor torque constant

$K_T = 20 \times 10^{-5} Nm/A$

Motor back e.m.f. constant

$K_b = 15 \times 10^{-5} V/(rad/sec)$

Equivalent moment of inertia referred to motor side $J_m = 10 \times 10^{-5} kg\text{-}m^2$

Equivalent coefficient of viscous friction referred to motor side :

$f_m = 10 \times 10^{-5} Nm/(rad/sec)$

Draw the block diagram and determine the overall transfer function relating the output and input. 12

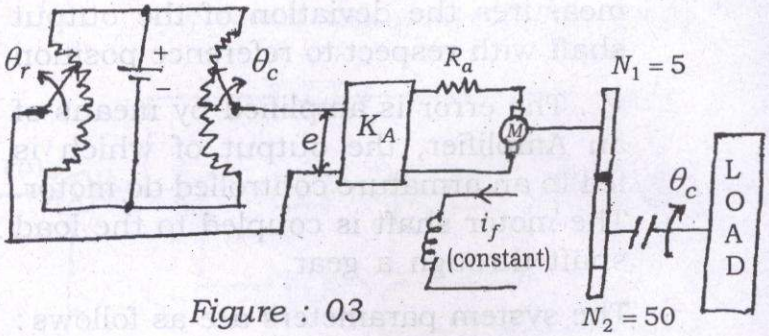

Figure : 03

(b) What is synchro and explain it with suitable example ? 8

4. *(a)* A Unity Feedback Control System has an amplifier with gain $K_A = 10$ and gain ratio, $G(s) = 1/s(s+2)$ in the Feed Forward path. A derivative feedback, $H(s) = sK_0$ is introduced as a minor loop around $G(s)$. Determine the derivative feedback constant, K_0, so that the system damping factor is 0·6. Also calculate rise time, peak time, maximum overshoot and the settling time when the system is subjected to a unit-step input. 12

(b) Consider a Unity Feedback System with a closed loop transfer function $\frac{C(s)}{R(s)} = \frac{Ks+b}{s^2+as+b}$.

Determine open loop transfer function $G(s)$. Show that steady state error with unit ramp input is given by $(a-K)/b$. 8

5. (a) Construct routh array and determine the stability of the system represented by the characteristic equation, $s^6+3s^5+5s^4+9s^3+8s^2+6s+4=0$.

Comment on the location of the roots of characteristics equation. 10

(b) The open-loop transfer function of certain Unity Feedback System is given by $G(s)=\frac{K}{s(s^2+8s+20)}$. Sketch the root locus for the given system. 10

6. *(a)* Determine the phase margin and gain margin of the system. 10

$$G(s) = \frac{20}{s(s+1)\left(s^2+2s+2\right)}$$

(b) Draw the Nyquist plot for the system whose open loop transfer function is

$$G(s)H(s) = \frac{K}{s(s+2)(s+10)}.$$

Determine the range of K for which closed loop system is stable. 10

7. *(a)* Sketch the bode plot of the following open loop transfer function and obtain gain cross-over frequency

$$G(s) = \frac{20}{s(1+3s)(1+4s)}$$ 12

(b) Obtain the response of undamped second order system for unit step input. 8

8. *(a)* Distinguish between open loop and closed loop system. 4

(b) What are the applications of Potentiometers and Tachogenerators ? 6

(c) How the system is classified depending on the value of damping ? 4

(d) What are frequency domain specifications and define all ? 6
