ROLL NO. ___________________

Code: DE65 **Subject: CONTROL ENGINEERING**

DipIETE – ET (Current Scheme)

Time: 3 Hours **June 2019** **Max. Marks: 100**

PLEASE WRITE YOUR ROLL NO. AT THE SPACE PROVIDED ON EACH PAGE IMMEDIATELY AFTER RECEIVING THE QUESTION PAPER.

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q.1 must be written in the space provided for it in the answer book supplied and nowhere else.**
- **The answer sheet for the Q.1 will be collected by the invigilator after 45 minutes of the commencement of the examination.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or the best alternative in the following: **(2×10)**

a. Human system is an example of
(A) A multivariable feedback control system
(B) An open loop control system
(C) A single variable control system
(D) A complex control system

b. The differential equation $\frac{dy}{dx} = y^2$ is
(A) Linear **(B)** Non-linear
(C) Quasilinear **(D)** None of these

c. The advantage of Laplace transform is
(A) It gives total solution more systematically
(B) It gives solution in frequency domain only
(C) Initial conditions are incorporated in the very first step
(D) None of these

d. The starting point of the description of a linear system may be system's
(A) Transfer function **(B)** Dynamic equation
(C) Differential equations **(D)** Any one of **(A)**, **(B)** and **(C)**

e. Block diagrams can be used to represent
(A) Only linear systems
(B) Only non-linear systems
(C) Both linear and non-linear systems
(D) Time invariant as well as time variant systems

f. The equations based on which a signal flow graph is drawn must be
(A) Differential equations
(B) Algebraic equations
(C) Algebraic equations in the form of cause and effect relations
(D) Differential equations in the form of cause and effect relations

g. The steady state error of a first order system to a ramp input is equal to
   (A) The time constant of the system **(B)** Zero
   (C) Infinity **(D)** None of these

h. In q(s) plane the Nyquist plot is symmetrical about the
   (A) Imaginary axis **(B)** Real axis
   (C) Origin **(D)** None of these

i. The angle of departure from a real pole is always
   (A) Zero degree
   (B) 180 degree
   (C) Either zero or 180 degree
   (D) To be calculated for each problem

j. For a stable system
   (A) Gain margin must be positive but phase margin can be positive or negative
   (B) Phase margin must be positive but gain margin can be positive or negative
   (C) Both Gain and phase margin must be positive
   (D) One of them must be zero

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Explain open loop and closed loop Control System with example and block diagram. **(8)**

b. Explain Servomechanism and Regulator in feedback Control System. **(8)**

Q.3 a. Find the general solution of the differential equation $\frac{d^2y}{dx^2}+3\frac{dy}{dx}+2y=0$. Also find the particular solution subject to the initial conditions $y(0+)=1$ and $\frac{dy}{dx}(0+)=0$ **(8)**

b. Determine and plot unit step input response of a generalized second order
   (i) overdamped and
   (ii) underdamped control system **(8)**

Q.4 a. State and define the realizable conditions of a transfer function of a linear control system. The output of a control system is related to its input by $\left[s^4+2s^3+2s^2+(3+K)s+K\right]C(s)=K(s+3)R(s)$.
   (i) with $K=8$ and a step input, will the output response be stable?
   (ii) determine the limiting positive value that K can have for a stable output response **(8)**

b. Obtain the transfer function of the feedback control system shown in Fig. 1 using block diagram reduction technique **(8)**

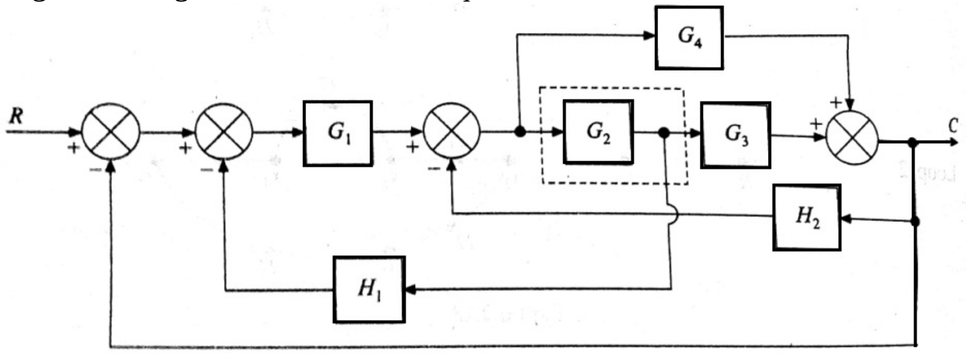

Fig. 1

Q.5 a. Derive Mason's gain formula for solving a signal flow graph. Compare its advantages and disadvantages with block diagram reduction technique. **(6)**

b. For the system represented by the following equations; $x = x_1 + \alpha_0 u$, $\frac{dx_1}{dt} = -\alpha_1 x_1 + x_2 + \alpha_2 u$ and $\frac{dx_2}{dt} = -\alpha_2 x_1 + \alpha_1 u$. Find the transfer function $X(s)/U(s)$ using signal flow graph technique. **(10)**

Q.6 a. For a closed loop system shown in Fig. 2, $G_1(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$ where $\omega_n = \frac{8\pi}{T}, T = 6.28 \text{ sec}$ and $\xi = 0.3$. Calculate the open loop and closed loop sensitivities for changes in A and H **(8)**

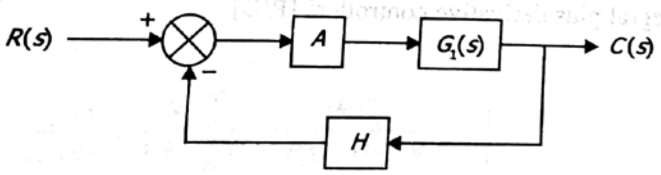

Fig. 2

b. Design a lead compensator for unity feedback system with an open loop transfer function $G_f(s) = \frac{K}{s(s+1)}$. Design specifications are $K_v = 10\, s^{-1}$ and $\phi_m = 35^\circ$ **(8)**

Q.7 a. Describe Nyquist stability criterion in detail with the help of relevant derivations **(6)**

b. Sketch the Nyquist plot and comment on the stability of the closed loop system whose open loop transfer function is $G(s)H(s) = \frac{K(s-4)}{(s+1)^2}$ **(10)**

Q.8 Sketch the root locus of the unity feedback system with open loop transfer function $G(s)H(s) = \frac{K(s+2)}{(s+1)^2}$. Show that part of the root locus is a circle. Find $\xi_{\min}$ and the corresponding value of K. Also find the transfer function for this $\xi_{\min}$. Determine the range of values of K for which the system is
(i) underdamped (ii) critically damped and (iii) overdamped. **(16)**

Q.9 Sketch the Bode plot for the transfer function $G(s)H(s) = \frac{80(s+5)}{s^2(s+50)}$ and determine the system gain crossover frequency, phase crossover frequency, gain margin and phase margin. Also determine the value of K for a phase margin of 45° **(16)**