Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

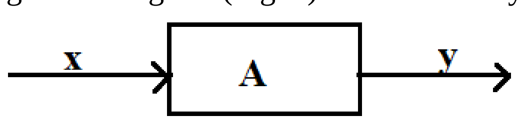
End Semester Examination (ONLINE), May 2020

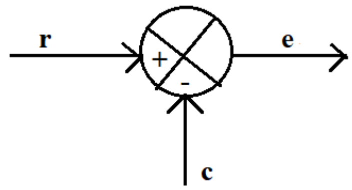
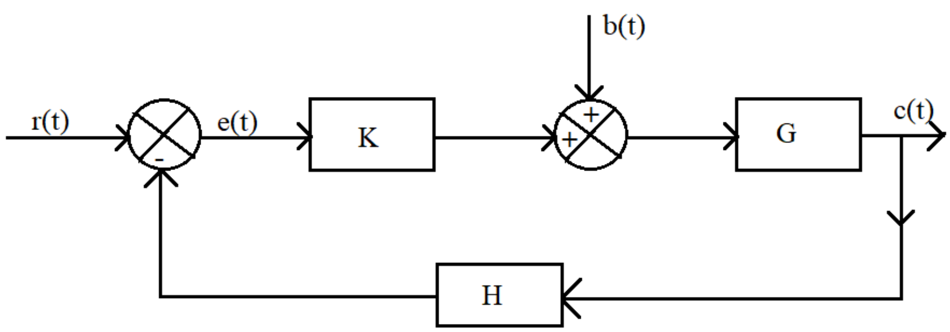
Programme Name: B.Tech. Mechanical **Semester : VIII**
Course Name : Automatic Control **Time : 03 hrs**
Course Code : MHEG486 **Max. Marks : 100**
Nos. of page(s) : 05

Instructions:

1. **There are total 21 questions in this question paper. Internal choice is provided in Q 17 only.**
2. **Section A contains 15 questions. Each question carries 2 marks. Thus, total marks is 30. The answers to the questions are to be provided in very few words or in one word.**
3. **Section B contains 5 questions. Each question carries 10 marks. Thus, total marks is 50. There is one internal choice. The questions are to be answered in not more than 40 words.**
4. **Section C contains only 1 compulsory question. Total marks is 20.**
5. **While writing equations, make use of brackets properly.**
6. **Assume any missing data.**

SECTION A

S. No.		Marks	CO
Q 1	Name the three types of controllers.	2	CO1
Q 2	Name the four different types of control action.	2	CO1
Q 3	Derivative control is always used along with: (a) proportional control, (b) integral control, (c) can be used independently.	2	CO1
Q 4	Proportional band is defined as: ______________________________	2	CO1
Q 5	Lower the value of proportional band, higher is the ____________________	2	CO1
Q 6	Derivative time is defined as: ______________________________	2	CO1
Q 7	Integral time is defined as: ______________________________	2	CO1
Q 8	On-Off control is like proportional control with proportional band = __________	2	CO1
Q 9	Polar plot is the plot of ____________ and ___________ of the transfer function in polar coordinates as frequency is changed from 0 to infinity.	2	CO3
Q 10	Represent the following block diagram (Fig. 1) mathematically.  Fig. 1	2	CO1
Q 11	Write down the mathematical relationship between the variables- r, c and e, shown in Fig. 2 below.	2	CO1

	 Fig. 2		
Q 12	The transfer function (T.F.) for a closed-loop control system is given as: $$T.F. = \frac{1}{1+D}$$ The phase angle (in degree) at $\omega = 1$ will be: _________ and the quadrant will be: ______________.	**2**	**CO3**
Q 13	The Routh criterion for stability states that: ___________________________________	**2**	**CO3**
Q 14	For a closed loop-transfer function with forward loop transfer function G and feedback loop transfer function H, the characteristic equation is given by: _________________	**2**	**CO1**
Q 15	'Rise time' is defined as the time ___________________________________	**2**	**CO2**
	SECTION B (Use not more than 40 words. Phrases can be used to answer the questions.)		
Q 16	Describe the procedure to perform the frequency response analysis of a control system. Differentiate between the various types of frequency response plots.	**10**	**CO3**
Q 17	a) For the system shown in Fig. 3 below, find out the steady state error due to unit ramp reference input. Take $= \frac{20}{4D+3}$, $G = \frac{1}{10D+1}$, b(t) = 0 and H = 1. Describe the steps for finding out the steady state error.  Fig. 3: A closed loop system **OR** b) If in the closed loop system shown in Fig. 3, a feedback loop transfer function, $H = 1 + D$ is added, then find the steady state error due to the unit ramp disturbance input. Take $= \frac{20}{4D+3}$, $G = \frac{1}{10D+1}$ and r(t) = 0. Describe the steps for finding out the steady state error.	**10**	**CO2**

Q 18 For the closed-loop control system shown below in Fig. 3, it is required to draw the polar plot using closed-loop frequency response. Find out the values of magnitude, phase angle and quadrant in Table 1 provided below Fig. 3.

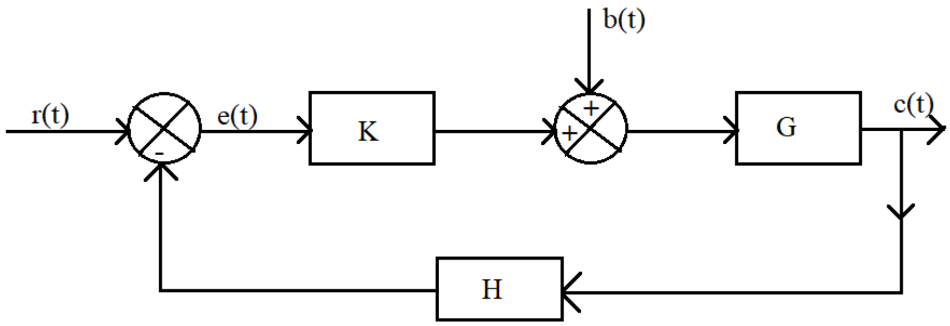


Fig. 3: A closed loop system

In Fig. 3, take b(t) = 0, H =1, damping ratio $\xi = \frac{1}{\sqrt{2}}$ and G = a second-order system.

Table 1: Table for Fig. 3

Frequency ratio	**Magnitude**	**Phase angle (degree)**	**Quadrant**
0	M1	An1	Qt1
0.5	M2	An2	Qt2
1	M3	An3	Qt3
2	M4	An4	Qt4
Infinity	M5	An5	Qt5

Comment on the shape of the polar plot.

10 **CO3**

Q 19 Discuss the application of Nyquist relation to stability of control systems. **10** **CO1**

Q 20 Discuss the various types of control systems. **10** **CO1**

SECTION C

Q 21 In the system of Fig. 4, the controlled variable is h_c, the level in the tank. Input motion *'z'* = $0.1h_r$, Port constant *'b'* of hydraulic servomotor = 400 cm^2/sec. Area A = 25 cm^2.
Area A_T = 1.2 m^2, Inflow rate $q_{in} = Ky$, K = 2.0 m/s^2.
Mass density *'ρ'* of liquid = 1000 kg/m^3.
Fluid resistance *'R'* = 10000 Ns/m^5.

20 **CO4**

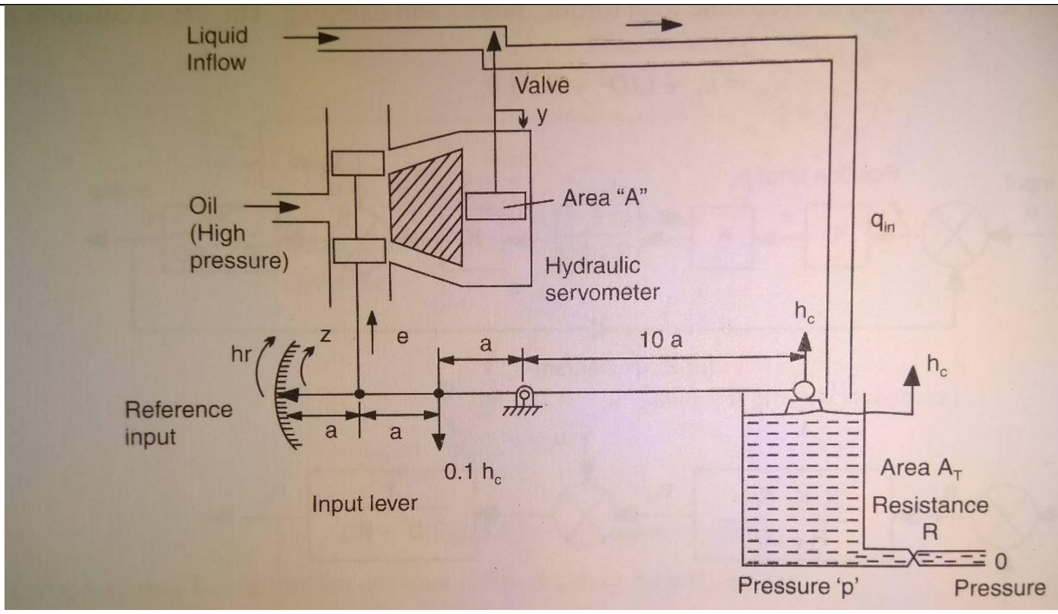


Fig. 4: Figure for Q. 21

Answer the following.

(i) Write down the error equation in terms of z and h_c.

Fill in the missing terms:

(ii) $q = (\quad)e$

(iii) $\frac{16e}{(\quad)} = y$

(iv) $q_{in} - q_0 = (\quad)h_c$

(v) $q_0 = \frac{(\quad)}{R}$

(vi) $q_{in} = (\quad)h_c$

If the block diagram for the system shown in Fig. 4 is represented as shown below in Fig. 5, answer the following.

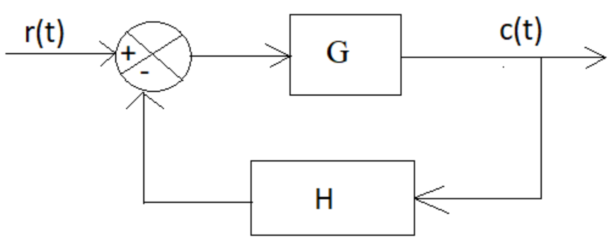


Fig. 5: Block diagram for system shown in Fig. 4

(vii) r(t) =

(viii) G =

(ix) c(t) =

(x) H =

(xi) Characteristic equation is:

(xii) The ‘zeros’ and ‘poles’ of the closed loop transfer function are:

(xiii) Without using Nyquist criterion, state whether the system is stable or not? Give reasons.

If the chosen ‘s-path’ for the purpose of Nyquist stability analysis is as shown in Fig. 6 given below, then find out the following.

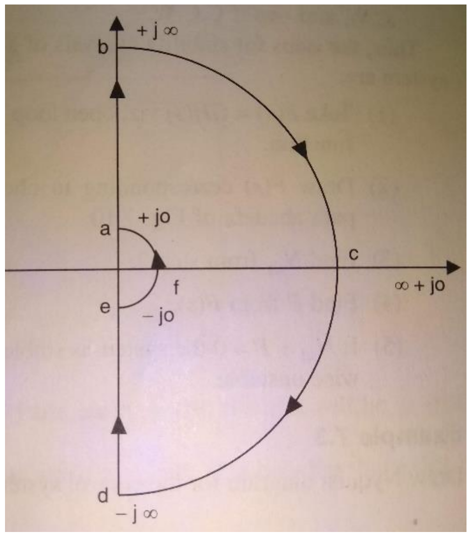


Fig. 6: The chosen ‘s-path’

(xiv) If the phase angle in ‘s-plane’ is denoted by ‘PA’ then for path ‘**bcd**’ in Fig. 6, $F(j\omega) = (\quad) < (\quad)$ where ‘<’ denotes the sign of angle.

(xv) If the phase angle in ‘s-plane’ is denoted by ‘PA’ then for path ‘**efa**’ in Fig. 6, $F(j\omega) = (\quad) < (\quad)$ where ‘<’ denotes the sign of angle.

(xvi) Refer to Fig. 7. It shows the F-plane path corresponding to **‘de’** of the chosen ‘s-path’ of Fig. 6. Identify the correct ‘F-path’.

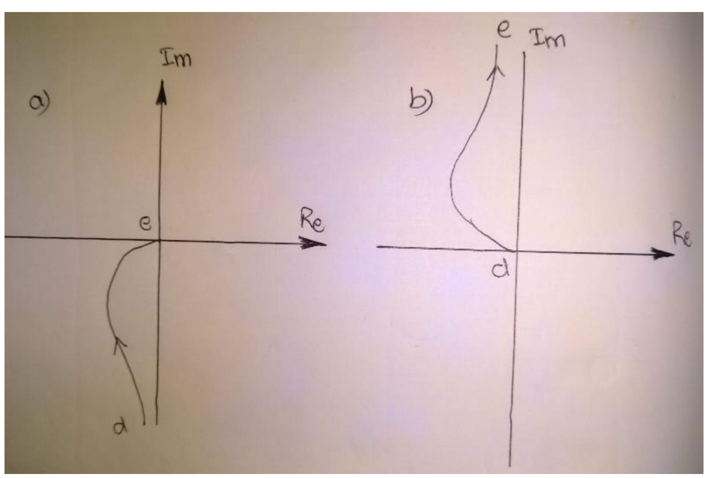


Fig. 7: Path in ‘F-plane’

(Note: In Fig. 7, ‘a)’ and ‘b)’ represent the bullets.)