Reg. No. | | | | | | | | | |

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent Institution of MAHE, Manipal)

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE UP SEMESTER EXAMINATIONS, DECEMBER 2017
SUBJECT: LINEAR CONTROL THEORY [ELE 3101]
REVISED CREDIT SYSTEM

Time: 3 Hours | **Date: 19th December 2017** | **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Semi-log graph sheet will be provided

1A. Compute the transfer function for the system representation shown in **Fig. Q 1A** using Mason Gain Formula. ***(03)***

1B. Determine the rise time, peak time, percentage peak overshoot and settling time (2% tolerance) for a system depicted by the following closed loop transfer function

$$\frac{Y(s)}{R(s)} = \frac{8}{s^2 + 4s + 8}$$

(03)

1.C Draw the equivalent mechanical network and derive the transfer function $\boldsymbol{G(s) = \theta_2(s)/T(s)}$, for the system shown in **Fig. Q 1C**. ***(04)***

2A. Given the pole plot as shown in **Fig. Q 2A,** determine the following:

a) Damping ratio and natural frequency
b) Peak time and Settling time
c) Percentage overshoot ***(03)***

2B. The mathematical model of a system configured in unity feedback control loop is given as:

$$G(s) = \frac{K(s+4)}{s(s+1.2)(s+2)}$$

Determine:

a) The range of K that keeps the system stable.
b) The value of K that makes the system oscillate
c) The frequency of oscillation when K is set to that value which makes the system oscillate ***(03)***

2C. Block diagram of output speed control of electrical power from a turbine and generator pair is shown in **Fig. Q 2C**. Sketch the Nyquist diagram and using Nyquist criterion determine the range of **'K'** for the system to be stable. ***(04)***

3A. Sketch the root locus for a unity feedback system with the following open loop transfer function and comment on the range of **'K'** required for system to be stable.

$$G(s) = \frac{K(s+5)}{(s+1)^2}$$

(03)

3B. For the bode magnitude plot of a minimum phase system as shown in **Fig. Q 3B**, determine the transfer function of the system. ***(03)***

3C. Design a Phase lead compensator using frequency domain approach **(use semi-log graph sheet)** for a negative unity feedback system with the plant transfer function given as:

$$G(s) = \frac{K}{s(s+10)(s+1000)}$$

The design should satisfy the following specifications: Phase margin is at least 45^0 and Static error constant = 1000 s^{-1} ***(04)***

4A. Explain and realize a lead network using passive elements and also realize the same with an operational amplifier. Highlight the main difference between the two approaches. ***(03)***

4B. In a unity feedback control system, the plant transfer function in the forward path is given as:

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

Determine the value of the gain **'K'** which results in the overall system having a damping ratio of 0.25. ***(03)***

4C. A unity feedback system has an open loop transfer function given by the following expression and is operating with a dominant pole damping ratio of 0.707

$$G(s) = \frac{K\,(s+6)}{(s+2)(s+3)(s+5)}$$

Design a suitable PD controller so as to reduce the settling time by a factor of 2. Also compare the transient and steady state performance of the compensated and uncompensated systems. ***(04)***

5A. Justify appropriately whether, the transfer function $G_c(s) = {}^{(s+1)}\!/_{(s+2)}$ can indeed function as a lead compensator. Further, determine the frequency at which the phase of $G_c(s)$ is maximum. ***(03)***

5B. Represent the electrical network shown in **Fig. Q 5B,** in state space physical variable form if the output is current through the resistor. Convert the state space to represent the same electrical network in transfer function form. ***(03)***

5C. For the system described below, design a state feedback controller such that the compensated system has an overshoot of 10% and settling time of 3secs. Further design an observer which is ten times faster than the designed controller.

$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u\ ;\ y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$ ***(04)***

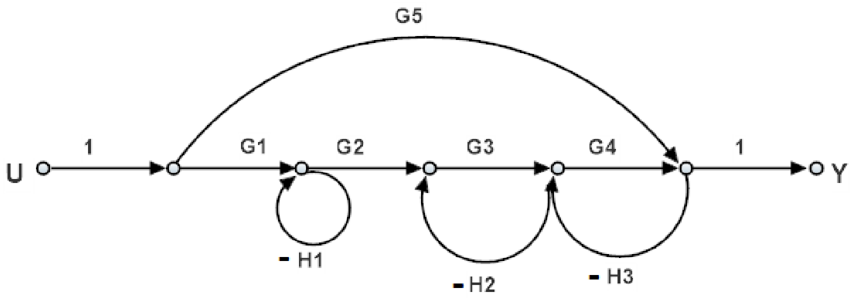

Fig. Q 1A

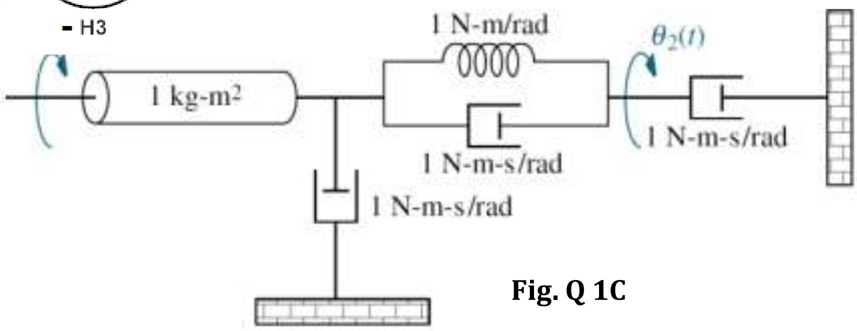

Fig. Q 1C

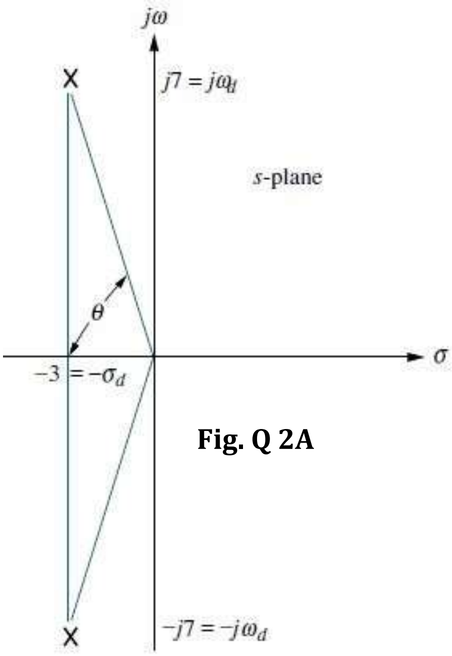

Fig. Q 2A

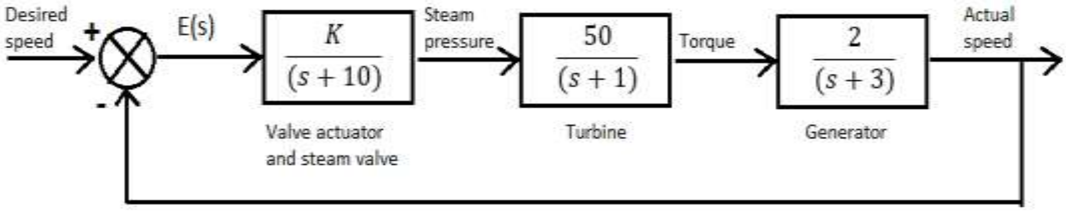

Fig. Q 2C

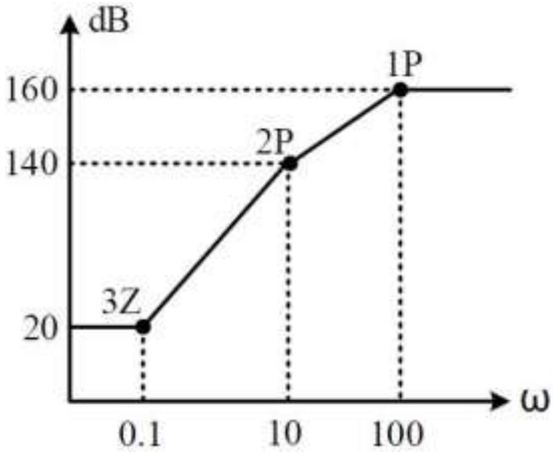

Fig. Q 3B

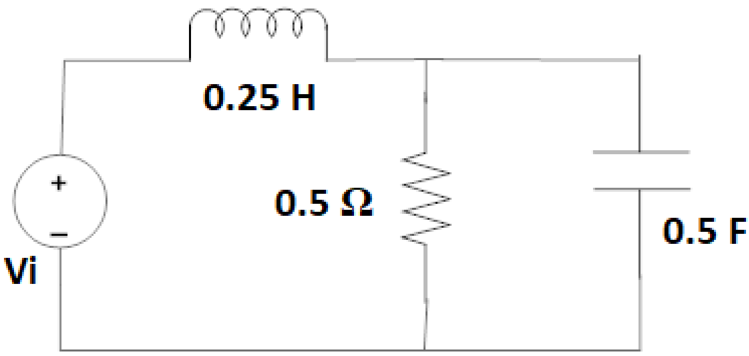

Fig. Q 5B