Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

V SEMESTER B.Tech (BME) DEGREE END SEM EXAMINATIONS NOVEMBER 2017

SUBJECT: PHYSIOLOGICAL CONTROL SYSTEM (BME 4009)
(REVISED CREDIT SYSTEM)
Wednesday, 22nd November 2017: 2 PM to 5 PM

TIME: 3 HOURS **Note: Answer ALL questions** **MAX. MARKS: 100**

Q1 **(a)** Describe the closed loop control system consisting of a human being placing an object on a table with his right hand. **5**

(b) The system shown in **Fig.Q1b**, has four inputs and one output. For this system, find the expression for the output C using block diagram reduction technique. **8**

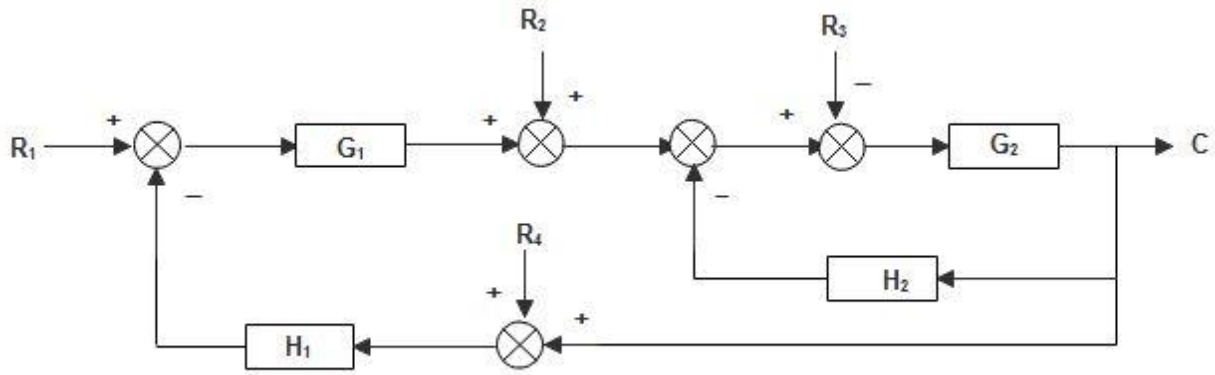

Fig.Q1b

(c) **Fig.Q1c** shows a block diagram representation of a feedback control system. Draw the Signal Flow Graph (SFG) of this system and find the transfer function $\frac{C(s)}{R(s)}$. **7**

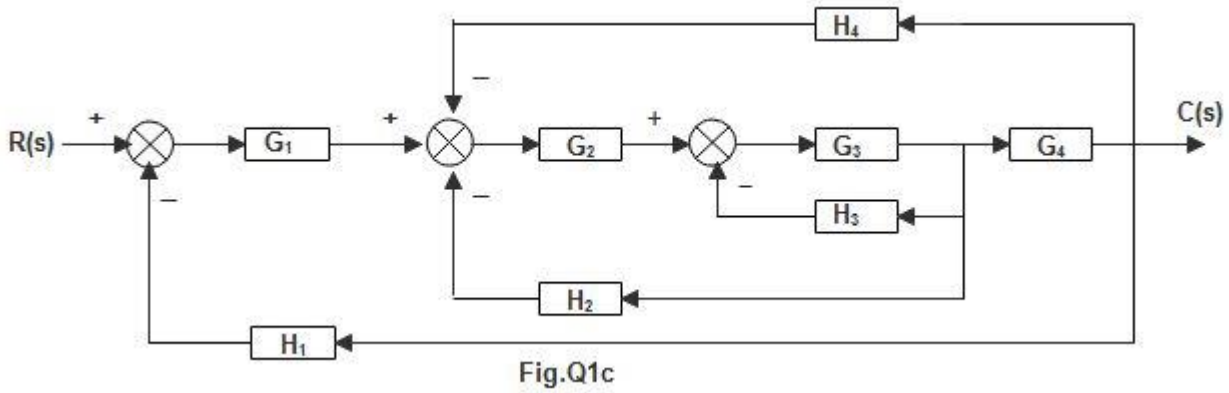

Fig.Q1c

Q2 **(a)** For the mechanical system shown in **Fig. Q2a**, write the system differential equations. Also construct the analogous electrical circuit based on force to current analogy and write the corresponding equations. **8**

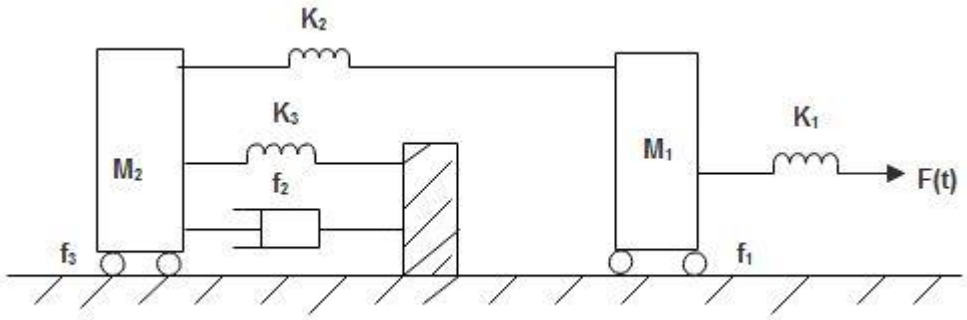

Fig.Q2a

(b) Derive the time response and steady state error pertaining to a unit ramp response of a first order feed-back control system. **6**

(c) A second order unity feedback control system is characterized by the following transfer function. **6**

$$\frac{C(s)}{R(s)} = \frac{225}{s^2 + 16s + 225}$$

Assuming the input to be a unit step voltage, calculate the value of:

(i) Damping ratio ζ.

(ii) Natural and damped frequencies.

(iii) Peak time $t_{p.}$

(iv) peak overshoot M_p

(v) Settling time t_s for 5% tolerance.

Q3 **(a)** A unity feed-back control system is characterized by the open loop transfer function **6**

$$G(s) = \frac{K}{s(s^2 + 10s + 36)}$$

Using Routh criterion find the range of the value of K for which the system is stable. Also determine value of K for which the system response is oscillatory and the value of frequency of oscillations at this value of K.

(b) A unity feedback control system is characterized by the open loop transfer function given by, **14**

$$G(s) = \frac{Ks}{(s^2 - s + 4.25)}$$

Sketch the root locus diagram of the system for K $\geq$0 and determine the marginal value of K for stability. Also find the point of intersection of root locus on the $j\omega$ axis.

Q4 **(a)** (i) Discuss briefly, the concept of gain margin and phase margin. **3**

(ii) A unity feedback control system has the open loop transfer function **12**

$$G(s) = \frac{4(s+1)}{s^2(1+\frac{s}{4})(1+\frac{s}{12})}$$

Construct the Bode plot, find the gain margin and the phase margin, and discuss the stability of the system.

(b) For the Bode magnitude plot shown in **Fig.Q4b**, find the open loop transfer function G(s). Also find the gain crossover frequency ω_G. **5**

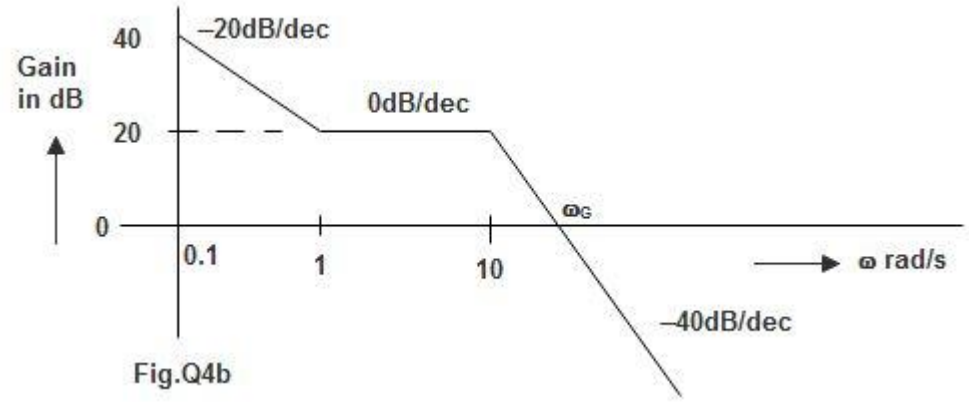

Fig.Q4b

Q5 **(a)** Consider the removal of a single tracer dose of I^{131} (Q_{Tot}) from the compartment by accumulation in the thyroid gland and by excretion into the urine in human body. Draw the compartment model and write the necessary differential equation associated with the model. Also solve for the expression of quantity of I^{131} in the compartment. **6**

(b) Since Sodium ions comprise the major portion of all the extracellular fluid. With the help of the block diagram, explain how the extracellular Sodium ion concentration is regulated in human body. **6**

(c) Discuss briefly, the various means by which the heat from the human body is lost to the external environment. **8**