TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING

ELECTRICAL AND ELCTRONICS ENGINEERING DEPARTMENT

UNIVERSITY EXAMINATION FOR:

BTECH ELECTRONIC AND INSTRUMENTATION

EEE2451 CONTROL SYSTEM 1

END OF SEMESTER EXAMINATION

SERIES: MAY 2016

TIME: 2 HOURS

DATE:

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE

(a) A process plant consist of two tanks of capacitance C_1 and C_2. If the flow rate into the top tank is Q3 find the transfer function relating this flow to the level in the bottom tank. Each tank has a resistance R in its outlet pipe. **(10 marks)**

(b) Derive the transfer function of the circuit of Fig. Q1(b). (6mark)

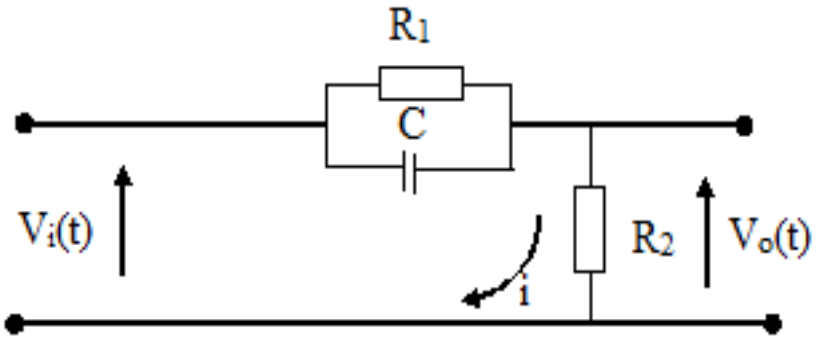


Fig. Q1(b)

(c) A mechanical accelerometer is shown in Fig. Q1(c). The position x of the mass M with respect to the accelerometer case is proportional to the acceleration of the case. Determine the transfer function between the input acceleration and the output x.

(6 marks)

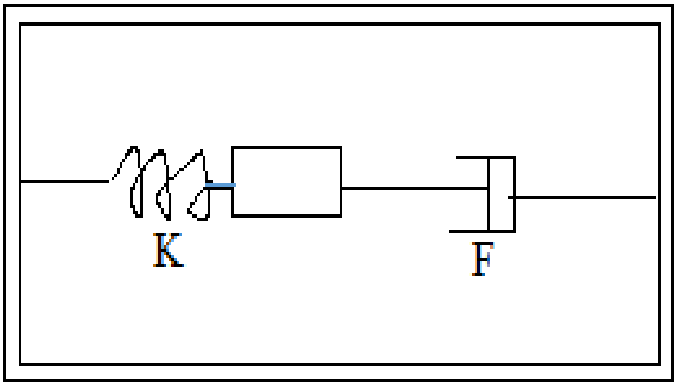
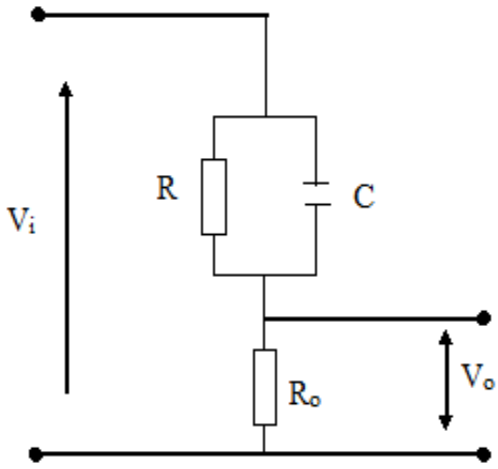


Fig. Q2(c)

(d) The circuit of Fig. Q1(d) is used in an amplifier of a control system. Derive an expression for the transfer function of the circuit. If $V_i = 10\sin 10t$ *volts*, $R = 50k\Omega$, $R_o = 5k\Omega$ *and* $C = 1F$ Calculate the output voltage in magnitude and in phase relative to V_i.

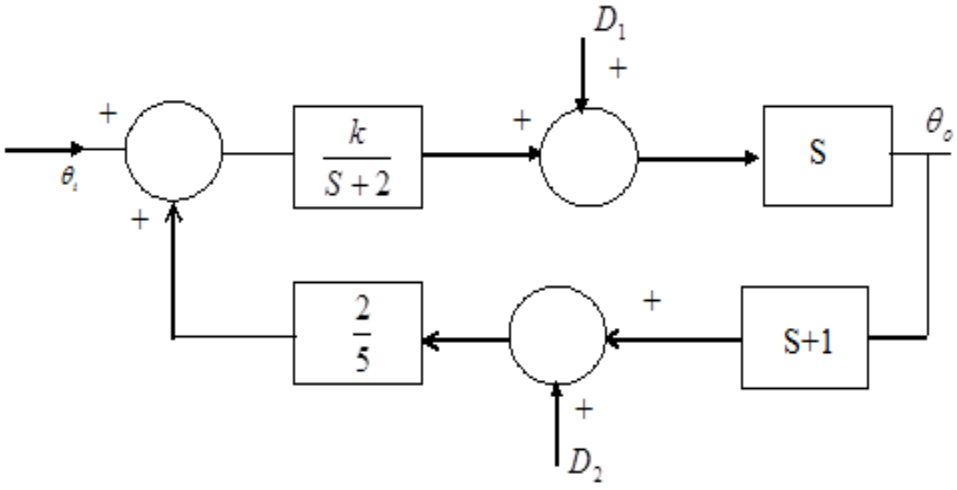


(8 marks)

Fig Q1(d)

Question TWO

(a) Determine the output θ_o for the system of Fig. Q2(a) using block diagram reduction methods and hence the transfer function. (10 (marks)



(b) Fig. Q2(b) is a block diagram of a multi loop control system. Determine the transfer function **(10 marks)**

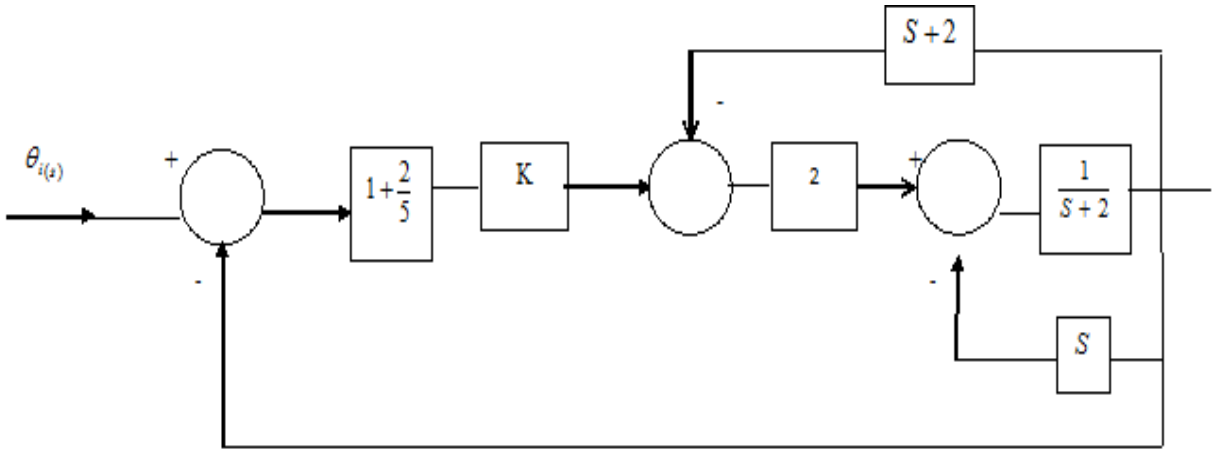


Fig. Q2(b)

Question THREE

(a) Obtain the signal flow graph for the block diagram of Fig. Q3(a) and obtain the closed-loop transfer function by using Mason's rule. **(10 marks)**

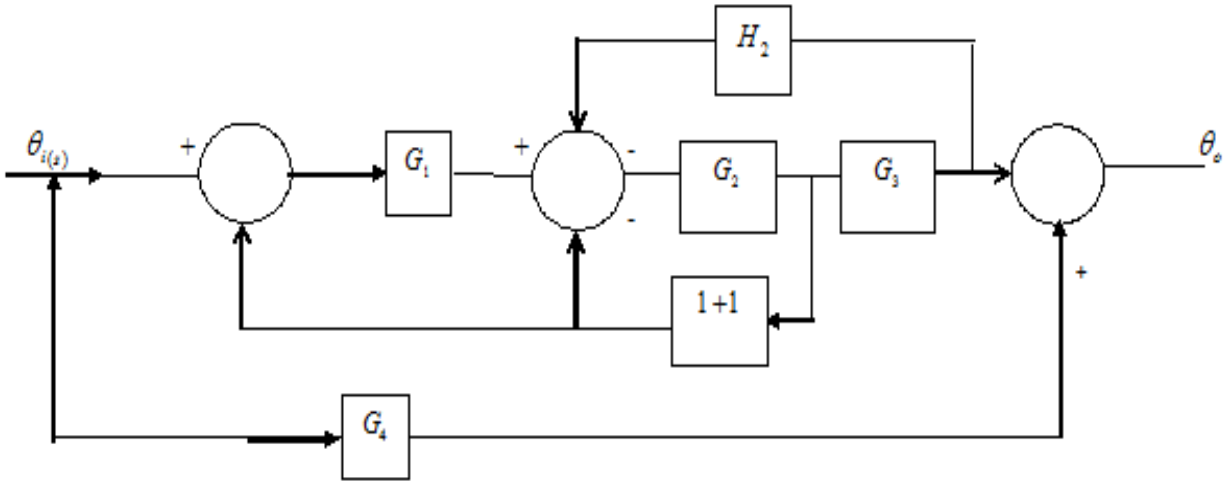


Fig. Q3(a)

(b) (i) State the advantages of signal flow graphs over block diagrams.

(ii) Describe the function of nodes and branches.

(iii) Draw a block diagram for the signal flow graph shown in Fig. Q3(b) and find the transfer function between θ_o *and* θ_i **(10 marks)**

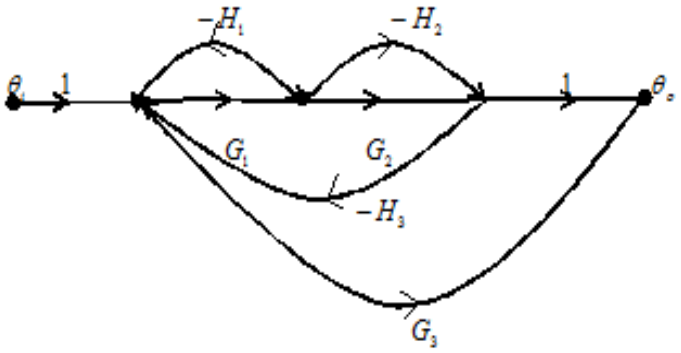


Fig. Q3(b)

Question FOUR

(a) Fig. Q4a(i) shows a mechanical vibratory system. When 8.9N of force is applied to the system, the mass oscillates as shown in Fig. Q4a(ii). Determine M, F and K of the system for this response curve. (10 marks)

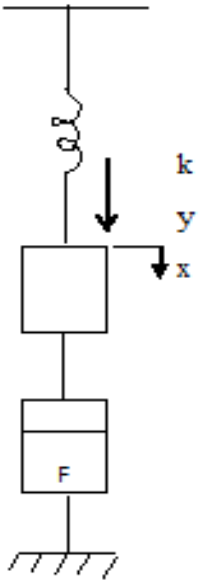


Fig Q 4a(i)

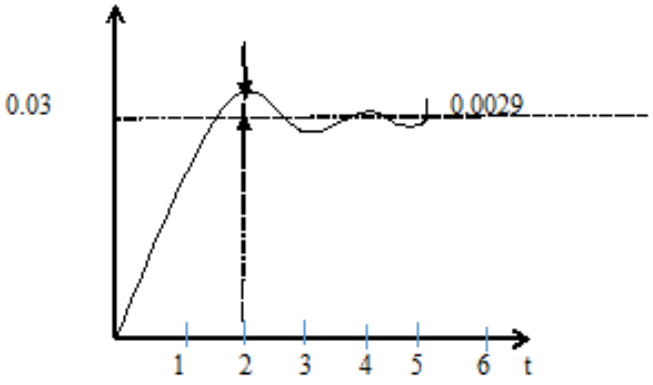


Fig. Q4a(ii)

(b) A servo mechanism, designed to control the angular position of a rotatable mass, is stabilized by means of acceleration feedback. The moment of inertia of the system is $10^{-4}\,Nm$ and the motor torque T_m is given by $T_m = 4\times10^{-3}\left[\theta_e + Ks^2\theta_O\right]N_m$.

(i) Draw the block diagram of the system and develop the control equation.
(ii) Determine the value of k in order that the damping is critical.
(iii) Calculate the steady-state error for an input signal of 1.26rad S^{-1}.

(10 marks)

Question FIVE

(a) The open-loop transfer function of a control system is given by:

$$G(s) = 7 \big/ s(1+0.5s)(1+0.167s)$$

Plot the bode diagram and determine the gain and phase margins and error constant. A lag network having a transfer function $(1+s\alpha T)/(1+sT)$ $(\alpha<1)$ is to be introduced as a series compensator to give a gain margin of at least 15dB and a phase margin of 45^o. Find suitable values of α and T.

(14 marks)

(b) The open loop transfer functions for two systems are:

(i) $\dfrac{K_1}{s^2(1+0.1s)}$

(ii) $\dfrac{K_2}{(1+s)(1+0.1s)}$

Using Routh's array determine values of K for which the system is stable.

(6 marks)