

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (C U E T)
Level 4, Term-II, Examination 2023

Course No: ME455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 27/05/2025	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Marks

Section: A

- 1 a) What is mechatronics product? What are the elements of a mechatronics system? 10
- b) Draw a schematic diagram of a closed-loop system and mention the function of each component. 15
- c) What do you mean by sequence controller? Is washing machine system a sequence controller? Why or why not? 10

- 2 a) Define the term 'transfer function'. Two transfer functions $G(s)$ and $H(s)$ are connected in a feedback control system where $G(s)$ in feedforward path and $H(s)$ in feedback path. Find out the equivalent transfer function. 10
- b) Simplify the block diagram shown in Fig.2(b). Then obtain the closed-loop transfer function $C(s)/R(s)$ 15
- c) What do you mean by hydraulic inductance? Show that hydraulic inductance varies proportionally with length of hydraulic block. 10

- 3 a) Obtain a state-space representation of the system shown in Fig.3(a), where u is the input and y_1 and y_2 are the outputs. Assume that the rollers are frictionless. 15
- b) Why linearization is necessary? Linearize the nonlinear system $z = x^2 + 8xy + 3y^2$ in the region $2 \leq x \leq 4$, $10 \leq y \leq 12$. Find out the Linearization error at (4, 12). 10
- c) A closed-loop control system has the characteristics equation $s^5 + 3s^4 + 5s^3 + 4s^2 + s + 3 = 0$. Using Routh's stability criterion, determine whether the system is stable or unstable. If unstable how many unstable roots are there? 10

- 4 a) What types of signals are used as test signal? Find out unit-step response of a first order system. 13
- b) Draw a typical unit-step response of a 2nd order system and mention the related terminology. 11
- c) Consider the negative feedback system having the gain $G(s) = \frac{k}{s(s+1)(s+2)}$, $H(s) = 1$. Determine the root loci on the real axis. 11

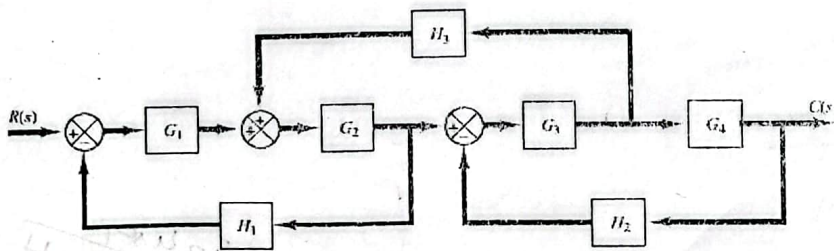


Fig. 2 (b)

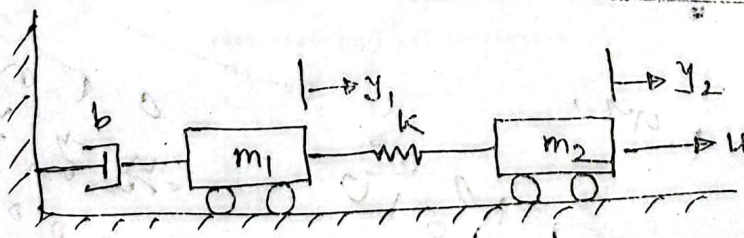


Fig. 3 (a)

Section: B

- 32
- 5 a) Describe and compare the characteristics of (i) proportional control, (ii) Proportional plus integral control, (iii) proportional plus integral plus derivative control. 15
- b) Consider the control system shown in Fig. 5(b) in which PID controller is used to control the system. The PID controller has the transfer function $G_c(s) = k_p(1 + 1/T_i s + T_d s)$. Design the PID controller. 20
- 25 6 a) Draw the ladder diagrams for the following logic functions: AND, NAND, OR, NOR 10
- b) Briefly describe the architecture of a PLC. 10
- c) Briefly explain (i) Latch circuit, (ii) Delay-on Timers and (iii) Counters. 15
- 30 7 a) Define the following term of a measurement system: (i) Accuracy, (ii) Hysteresis error, (iii) Sensitivity. 09
- b) Write notes on the following sensors: (i) Tactile sensor, (ii) Pneumatic sensor, (iii) Capacitive sensor. 15
- c) What will be the change in resistance of electrical resistance strain gauge with a gauge factor of 0.001? 11
- 8 a) Define directional control valve. Explain the working principle of spool valve. 08
- b) Explain the working principle of a variable reluctance stepper motor. 13
- c) Draw the schematic diagram of hydraulic power supply and pneumatic power supply system with proper labeling. 14

Handwritten notes:
 $k_p = 18$
 $T_i = 1.401$
 $T_d = 0.257$
 $k_i = 0.592$

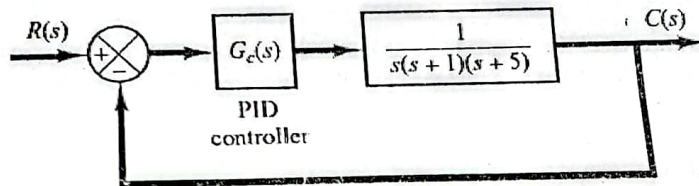


Fig. 5 (b)

Handwritten notes:
 $a_1 a_2 a_3 a_4 a_5$
 $1 + a_1 s^2 + a_2 s + a_3 =$
 $-a_2 s^2 +$
 $+ a_1 a_2 a_3 a_4 a_5$

***** The End *****

Handwritten notes:
 1.401
 1.000
 0.010

Handwritten notes:
 0.100
 0.010
 0.001
 0.000
 0.000
 0.000
 0.000

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (CUET)

Level 4, Term-II, Examination 2022

Course: ME 455	Full Marks: 210	Time: 3 hours
Course Title: Mechatronics	Date: 11/03/2024	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section - A

- Q.1 (a) What are the basic components of a mechatronics system? How can you differentiate a mechatronics system from a mechanical or electromechanical system? 10
- (b) Explain the difference between the open and closed loop control. 12
- (c) Engine management system is a sequence control system – explain why? 13

- Q.2 (a) Simplify the block diagram shown in Fig.2(a). Then obtain the closed loop transfer function $C(s)/R(s)$. 17

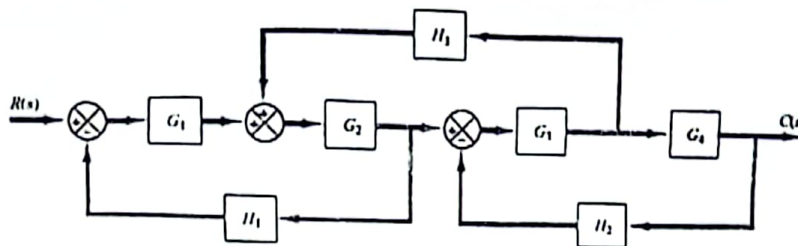


Fig.2(a)

- (b) Obtain a state-space representation of the system shown in Fig.2(b). 18

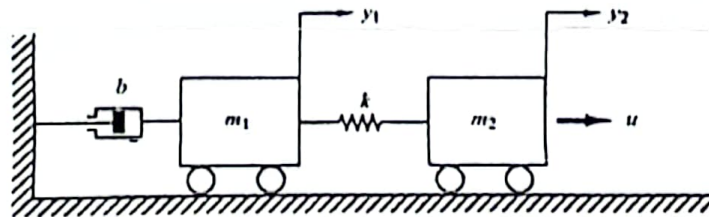


Fig.2(b)

- Q.3 (a) Why root locus plots are important? Mention the conditions for finding root locus. 12

A negative feedback system has $G(s) = \frac{k}{(s+1)(s+2)}$, $H(s) = 1$. Determine the root loci on the real axis.

- (b) Apply Routh's stability criterion on the feedback control system as in Fig. 3(b) and find out the value of k for stability.

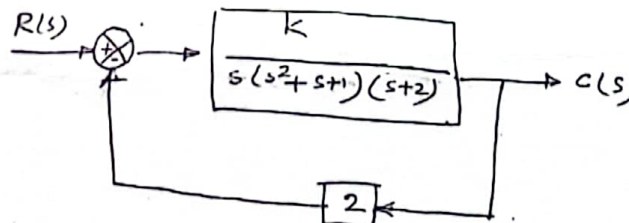


Fig.3(b)

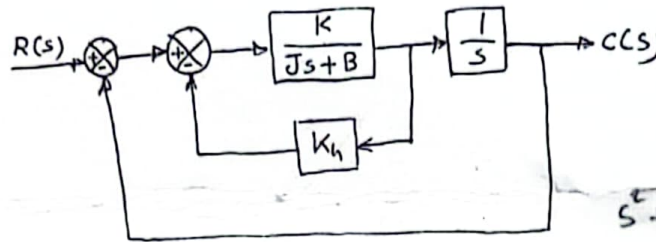
- (c) Linearize the nonlinear system $z = x^2 + 8xy + 3y^2$ in the region defined by $2 \leq x \leq 4$ and $10 \leq y \leq 12$ and find out the linearization error at $(4, 12)$.

P.T.O.

$z = 94x + 96y - 636$

12
1.44

- Q.4 (a) Define the building blocks of a hydraulic system. Show that hydraulic capacitance is proportional to cross-sectional area of the capacitor. 12
 (b) Draw a typical unit step response of 2nd order system with necessary terminology. 10
 (c) A servo system is shown in Fig. 4(c). Determine the values of gain k and velocity feedback constant k_h so that the maximum overshoot in the unit-step response is 0.2 and the peak time is 1 sec. with these values of k and k_h obtain in rise time and settling time. Assume that $J = 1 \text{ kg-m}^2$ and $B = 1 \text{ N-m/rad/sec}$. 13



Handwritten notes for Q.4(c):
 $M_p = e^{-\left(\frac{\zeta}{\omega_d}\right)\pi}$
 $t_p = \frac{\pi}{\omega_d}$

Handwritten characteristic equation:
 $s^2 + 2\zeta\omega_n s + \omega_n^2$

Fig. 4(c)

Section - B

- Q.5 (a) Briefly explain the effects of P, I and D controller on the second order response. 07
 (b) With an example show that the proportional control of a system without an integrator results in a steady-state error. 10
 (c) A PID controller has the transfer function $G_c = k_p \left(1 + \frac{1}{T_i s} + T_d s \right)$ which is connected in the feedback system as shown in Fig. 5(c). Using Ziegler-Nichols principle, determine the value of k_p , T_i and T_d . 18

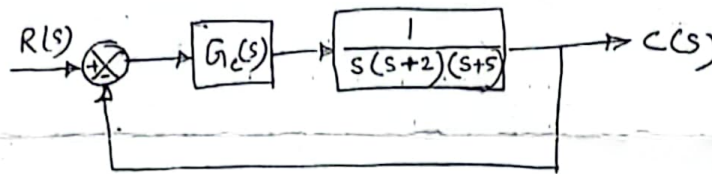


Fig. 5(c)

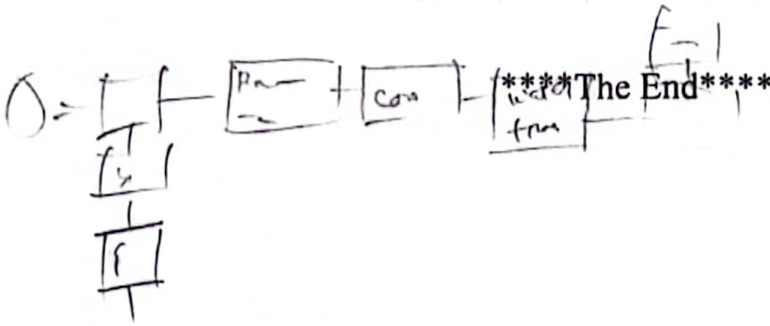
Handwritten notes for Q.5(c):
 $T_i = \infty, T_d = 0$
 Chou can
 Routh's wing
 $K_p \propto K_{en}$
 $K_p = 0.6 K_{en}$
 $T_i = 0.5 P_{en}$
 $T_d = 0.125 P_{en}$

- Q.6 (a) What is programmable logic controller? Draw the ladder diagram and the program instructions for the following logic functions: (i) AND, (ii) NAND and (iii) XOR. 12
 (b) Briefly describe the architecture of a PLC. 11
 (c) Explain briefly (any two) of the following: (i) Optical Isolator, (ii) Latch circuit, and (iii) Cascaded timers. 12

- Q.7 (a) What is transducer? How are transducers classified? 10
 (b) Explain how a capacitive sensor works? How does it work as a proximity sensor? 13
 (c) A strain gauge is bounded is bounded to a beam which is 12 cm long and has a cross sectional area of 3.8 cm^2 . The unstrained resistance and gauge factor of the strain gauge are 220Ω and 2.2 respectively. On the application of load the resistance of the gauge change by 0.015Ω . If the modulus of elasticity of steel is 207 GN/m^2 , calculate: (i) the change in length of the steel beam, (ii) the amount of force applied to the beam. 12

Handwritten notes for Q.7(c):
 $\text{Strain} = \frac{\text{Stress}}{E}$
 $\frac{\Delta L}{L_0} = \frac{\text{Strain}}{E}$
 $\frac{\Delta R}{R} = G \cdot \epsilon$
 $12 \text{ cm} \rightarrow 220 \Omega$

- Q.8 (a) Discuss the control of a double-acting cylinder with solenoid activation. 12
 (b) Draw the schematic diagram of hydraulic power supply and pneumatic power supply with proper labeling. 10
 (c) Explain the working principle of Variable Reluctance Stepper Motor. 13



Course No: ME 455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 05 / 03 / 2023	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section: A

Marks

- 1 ✓ a) Define the term "Mechatronics". What are the elements of a mechatronics system? 10
- b) Find out the components of closed-loop control system in water-flashing system for toilet. Also mention the function of each component. 15
- c) What is sequence control? Explain with an example. 10
- 2 ✓ a) Consider the characteristic equations 13
- $$s^4 + 2s^3 + (4 + k)s^2 + 9s + 25 = 0$$
- Using Routh's stability criterion, determine the range of K for stability.
- b) Compare between modern control theory and conventional control theory. 7
- c) Consider the block diagram in Figure 2(c). Simplify the diagram and find out $C(s)/R(s)$. 15

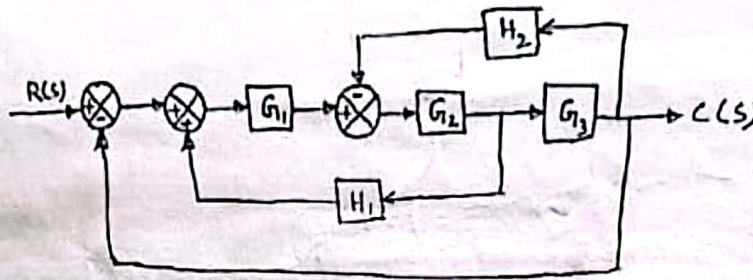


Figure 2(c)

3. a) Consider the negative feedback system having the gain 17

$$G(s) = \frac{k}{(s+1)(s+2)}, \quad H(s) = 1$$

For the system

- (i) Determine the root loci on the real axis.
- (ii) Determine the asymptotes of the root loci.
- (iii) Draw the root loci.
- b) Find out the state-space model for the system shown in Figure 3(b) where u is the input and y_1 and y_2 are the corresponding output. Assume the rollers are frictionless. 18

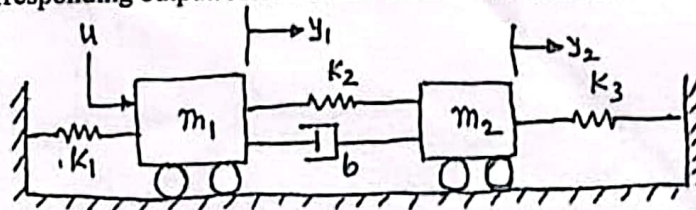


Figure 3(b)

4. a) Draw the ladder diagrams to represent 10
- (i) AND
- (ii) OR
- (iii) NOR
- (iv) NAND
- (v) XOR
- logic functions respectively.
- b) Draw the functional block diagram of a PLC and explain the PLC architecture. 15
- c) Why linearization is done? Linearize the nonlinear system $z = x^2 + 4xy + 6y^2$ in the region defined by $8 \leq x \leq 10, 2 \leq y \leq 4$. Find the linearization error at point (10, 4). 10

Please Turn Over

5. a) Define the following term of a measurement system
 (i) Accuracy
 (ii) Sensitivity
 (iii) Repeatability
 (iv) Resolution
- b) Draw a typical unit-step response of a 2nd order system and show related specifications of the response. 12
- c) Describe the principle and working of piezoelectric sensor. 15
6. a) Define the building blocks of a fluid system used to formulate the mathematical modeling. 10
- b) Derive the relationship between the output, the potential difference across the resistor, and the input for circuit shown in Figure 6(b). 13
- c) Based on the Figure 6(c), develop equations describing how the temperatures T_1 and T_2 will vary with time. 12

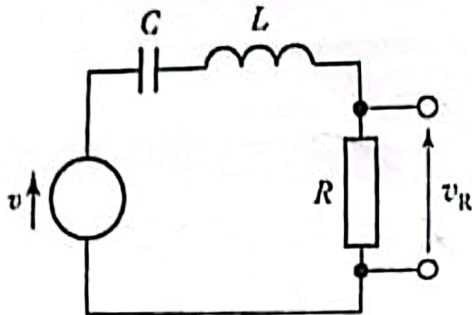


Figure 6(b)

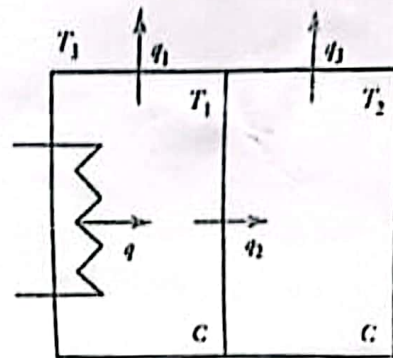


Figure 6(c)

7. a) Mention the advantages and disadvantages of Servo motor. 10
- b) Explain the working principle of variable Reluctance Stepper motor. 15
- c) Draw the schematic diagram of hydraulic power supply and pneumatic power supply with proper labeling. 10
8. a) Discuss the control of a double-acting cylinder with solenoid activation. 12
- b) Mention the working principle of poppet valve. 8
- c) Consider the control system shown in Figure 8(c), in which a PID controller is used to control the system. The PID controller has the transfer function 15

$$G_c(s) = K_p \left(1 + \frac{1}{T_i s} + T_d s \right)$$

Design the controller.

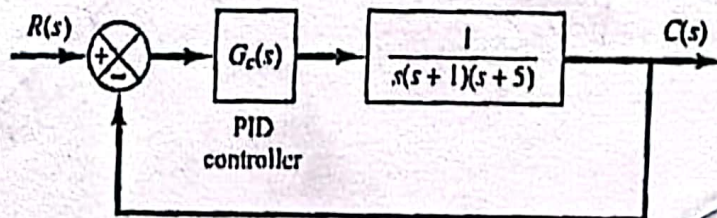


Figure 8(c)

*****END OF QUESTION*****

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (C U E T)
 Level 4, Term II Examination 2020

Course No: ME 455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 10 / 04 / 2022	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section: A

Marks

1. a) What is mechatronics? What are the objectives of mechatronics? 10
- b) Differentiate between open-loop control system and closed-loop control system. 10
- c) The engine management system is a sequence control mechanism – Justify the statement. 15

2. a) Two transfer function $G(s)$ and $H(s)$ are connected in a feedback system where $G(s)$ is on the feed forward path and $H(s)$ is connected in feedback path. 15
 - (i) What should be open-loop transfer function?
 - (ii) What should be feed forward transfer function?
 - (iii) Find out the closed-loop transfer function of the system.
- b) Find out the overall transfer function $C(s)/R(s)$ for the control system as shown in Figure 2(b). 10

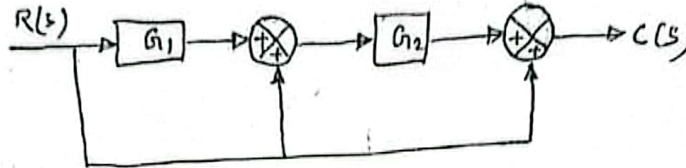


Figure 2(b)

- c) Simplify the block diagram as in Figure 2(c) and find out the equivalent transfer function. 10

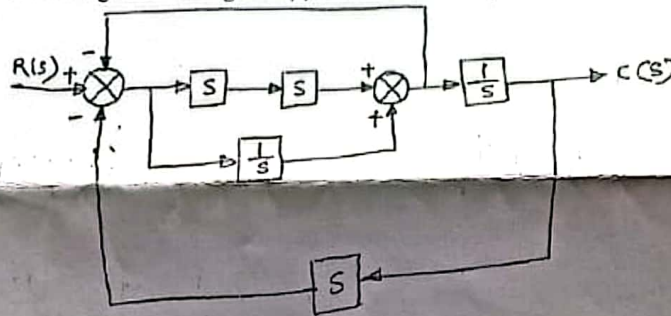


Figure 2(c)

- a) Write down the standard form of state-space equation. Also mention the names of each matrix and vector in the equations. Draw the block diagram of the state-space equations. 18
- b) For a typical spring-mass-damper system, the characteristic equations can be expressed as follows: 17

$$m_1 \ddot{y}_1 + b \dot{y}_1 + k(y_1 - y_2) = 0$$

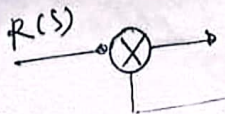
$$m_2 \ddot{y}_2 + k(y_2 - y_1) = u$$

$$1 + 2s + s^2/s$$

when the output variables are y_1 and y_2 . Obtain a state-space representation of the system.

- a) What are the basic building blocks for mechanical and electrical systems? Find the analogies between electrical and mechanical system. 12
- b) What is pneumatic capacitance and pneumatic inertance? Show that pneumatic inertance is inversely proportional to cross-sectional area of a pipe when its length is constant. 12
- c) Why linearization is necessary? Linearize the nonlinear system $z = x^2 + 8xy + 3y^2$ in the region defined by $2 \leq x \leq 4$, $10 \leq y \leq 12$. 11

Please Turn Over



Section: B

5. a) A control system has the following characteristics equation: $3s^7 + 9s^6 + 6s^5 + 4s^4 + 7s^3 + 8s^2 + 2s + 6 = 0$. Using Routh's stability criteria determine whether the system is stable or unstable. If unstable, how many poles are in the right half of s -plane. 15
- b) Draw a typical unit-step response of a second order system and show related specifications of the response. 10
- c) Consider a system having 10

$$G(s) = \frac{k}{s(s+1)(s+2)} \quad \text{and} \quad H(s) = 1$$

Determine the root loci on the real axis for the system.

6. a) How a proportional controller rectify the error in a system? 10
- b) Determine the range of k for stability of a unity feedback control system whose open-loop transfer function is $G(s) = \frac{k}{s(s+1)(s+2)}$. 10
- c) Consider a PID controlled system shown in Figure 6(c). Determine the value of k_p , T_i and T_d for the controller using Ziegler-Nichols tuning rule. 15

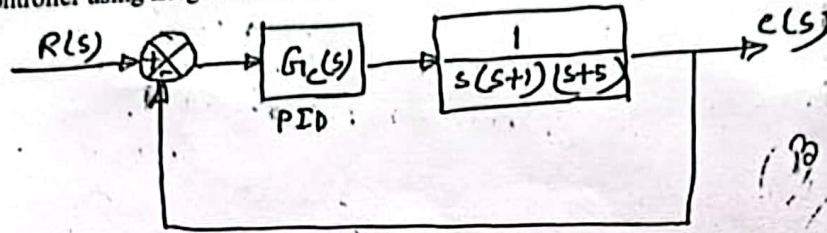


Figure 6(c)

7. a) Write down the selection criteria of a PLC. 10
- b) Draw the ladder diagram and output diagram for the following logic gates: 12
 (i) AND (ii) OR (iii) NAND.
- c) Measurement is an important subsystem of a mechatronics system – why? Discuss briefly. 13
8. a) What is the difference between a sensor and transducer? 10
- b) What is Hall effect? Explain with a neat sketch the principle of Hall effect sensor. 12
- c) Explain the significance of the specifications for a strain gauge pressure sensor as given below: 13
- Range : 70 to 1000 kPa, 2000 to 70,000 kPa
- Supply voltage : 10V d.c. or a.c. rms.
- Full range output : 40 mV
- Non-linearity and hysteresis : $\pm 0.5\%$ full range output
- Temperature range : -54°C to $+120^\circ\text{C}$
- Thermal zero shift : 0.03% full range output / $^\circ\text{C}$

*****END OF QUESTION*****

Department of Mechanical Engineering
Chittagong University of Engineering & Technology (C U E T)
Level 4, Term II Examination 2018

Course No: ME 455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 04/07/2019	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Marks

Section: A

1. a) What do you understand by the term 'Mechatronics'? How do you state the approach of mechatronics? 09
- b) Write down the basic elements of a closed-loop control system. Identify these elements in a system used to maintain a constant water level in a tank. 13
- c) How do you differentiate a sensor from a transducer? Write down the selection criteria of a sensor. Make a list of various types of sensor. 13

2. a) Derive an expression of the transfer function for a closed-loop control system. 06
- b) What is transfer function of a system? Determine the closed-loop transfer function for the block diagram in Figure 2(b). 15
- c) Using the Mason's gain formula, obtain the overall transfer function of the signal flow graph as shown in Figure 2(c). 14

3. a) Derive the differential equations describing the relationship between the inputs u_1 and u_2 , the output y_1 and y_2 for the system shown in Figure 3(a). 18
- b) Develop of a mathematical model of the system describing how the output is related to the input. The system is shown in Figure 3(b). 17

4. a) Consider the mechanical system shown in Figure 4(a). Find the state-space model for this single-input, single-output linear system. 15
- b) Why linearization is important? Linearize the nonlinear equation: $z = x^2 + 8xy + 3y^2$ in the region defined by $2 \leq x \leq 4$, $10 \leq y \leq 12$. 12
- c) Draw the schematic diagram of control of a double-acting cylinder. 08

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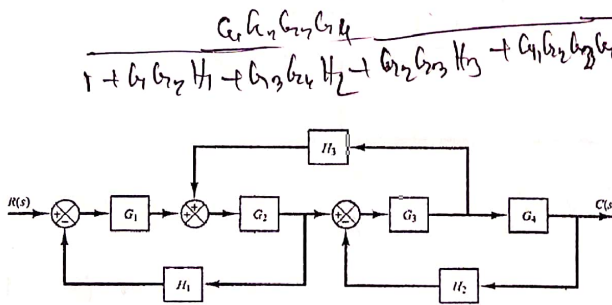


Fig. 2(b)

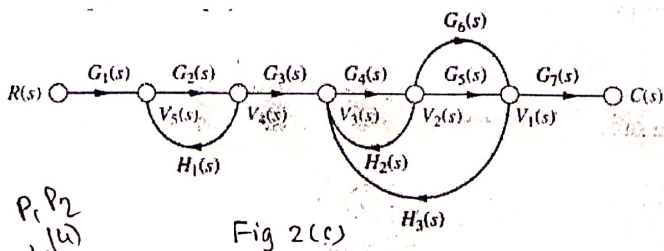


Fig 2(c)

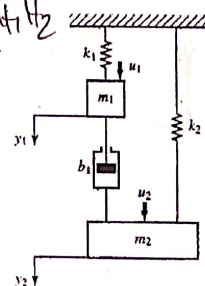


Fig 3(a)

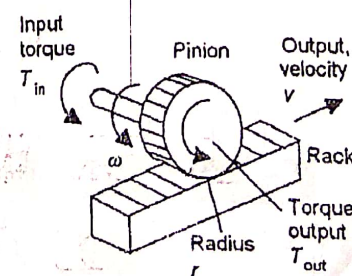


Fig 3(b)

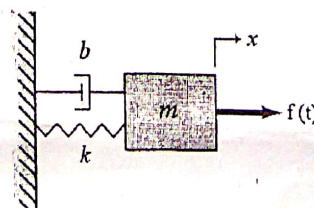


Fig. 4(a)

$$r \frac{d(\omega - v/r)}{dt} = \frac{r(T_{in} - cvr)}{mr^2 + I}$$

$$\frac{dv}{dt} =$$

$$\dot{x} = Ax + Bf$$

$$x = e^{Ax} + Df$$

$$\begin{bmatrix} 0 & 1 \\ -\frac{k}{m} & -\frac{b}{m} \end{bmatrix} \begin{bmatrix} 0 \\ 1/m \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$$

Section: B

5. a) A servo system exhibits a standard second-order response against a step input. Considering the value of damping ratio of 0.6 and undamped natural frequency of 5 rad/sec, calculate the value of i) rise time ii) peak time iii) maximum overshoot iv) 5% settling time. 15
- b) Determine the range of K for stability of a unity feedback control system whose open-loop transfer function is $G(s) = \frac{K}{s(s+1)(s+2)}$. 14
- c) Draw the second-order response curve against step input for the condition: i) $0 < \zeta < 1$ ii) $\zeta = 1$ and iii) $\zeta > 1$. 06
6. a) Determine the magnitude and phase of the output from a system when subjected to a sinusoidal input of $5\sin(4t + 60^\circ)$ if it has a transfer function of $G(s) = \frac{4}{s+1}$. 12
- b) Why root-locus method is used in control engineering? Write down the angle and magnitude conditions of the method. 08
- c) Consider a PID controlled system shown in Fig 6(c). Determine the values of K_p , T_i and T_d using Ziegler-Nichols tuning rule: 15
7. a) Define the following terms for transducer:
i) Range and span ii) Sensitivity iii) Repeatability iv) Resolution v) Non-linearity error. 10
- b) Explain the working principle of the following transducers (any three):
i) Optical encoder ii) Pyro electric sensors iii) LVDT iv) Ultrasonic sensor 15
- c) Briefly explain the working principle of pneumatic sensor. 10
8. a) What is PLC? Draw the ladder diagram and output diagram for the following logic gates:
i) AND ii) OR iii) NAND iv) NOR v) XOR 15
- b) Consider a control system for a bottle filling system that detects the position of a bottle via a limit switch than waits for 0.5 sec and then fills the bottle until a photodetector detects the filled condition of the bottle. After the bottle is filled, the buzzer sounds and the control program will again wait for 0.7 sec, before moving to the next bottle. Until the limit switch signals, the feed motor M1 runs while there are fixed rollers which carry the filled bottle. Motor M2 keeps running after the process has been started. The diagram of the system is shown in Fig 8(b). Enlist the inputs and outputs of the system. Then construct the ladder diagram and explain it. 20

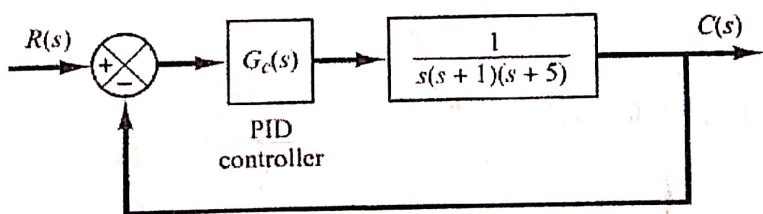


Fig. 6(c)

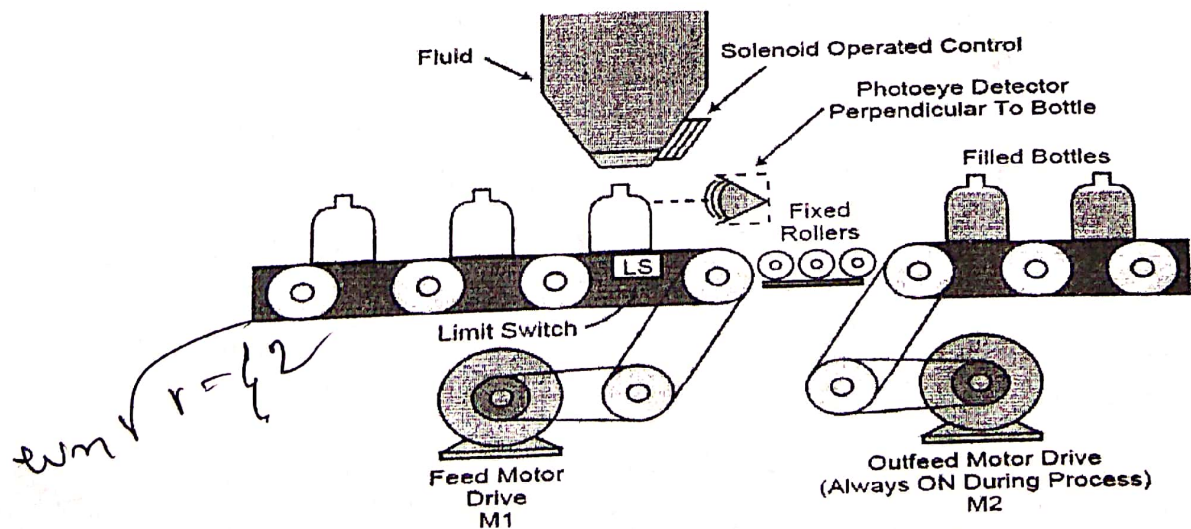


Fig. 8(b)

$\frac{0.20}{\sqrt{17}} \sin(4t - 15.96)$
 $\frac{4}{\sqrt{17}} - 75.96$
 2.31
 $18, 1.405, 15$
 0.275
 $0.075 \times \frac{(s+1)(s+2)}{s}$

$\frac{30-KD}{6}$

$\omega_m \sqrt{r=42}$

Section: B

15. a) Draw a standard 2nd order response of a system against a step input. Also, define delay time, 13
 rise time, peak time and settling time for the response.
 b) Compare between modern control theory and conventional control theory. 10
 c) A system is subjected to a unit-step input shown in Fig.5(c). Determine the values of K and T 12
 from the response curve.

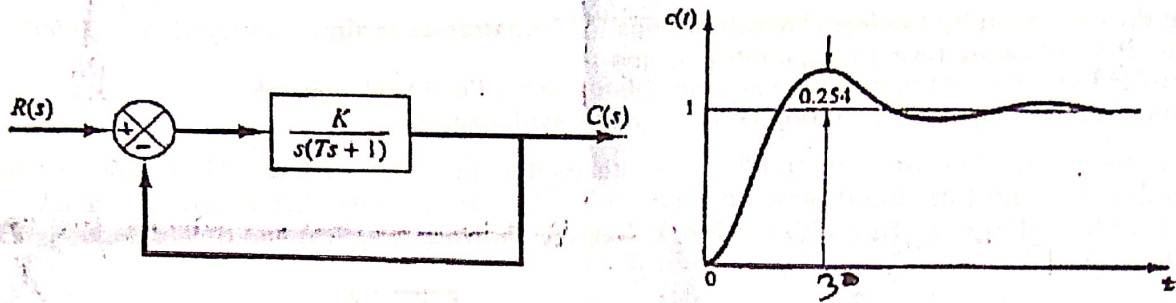


Fig.5(c)

16. a) Consider the characteristics equation $S^4 + 2S^3 + (4+K)S^2 + 9S + 25 = 0$. Using the Hurwitz 12
 stability criterion, determine the range of K for stability.
 b) What is sinusoidal transfer function? Consider the system shown in Fig.6(b) for a sinusoidal 11
 input $x(t) = X \sin \omega t$. Find out the steady state output $y_{ss}(t)$.
 c) Why root-locus method is used in control engineering? What are the angle and magnitude 12
 conditions of the method? Find out the root locus on real axis for the control system shown in
 Fig.6(c).

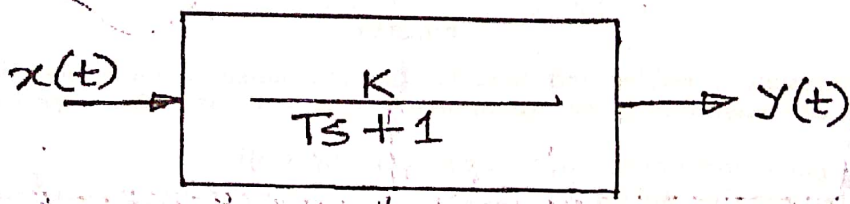


Fig.6(b)

17. $1 = \frac{K}{Ts+1}$

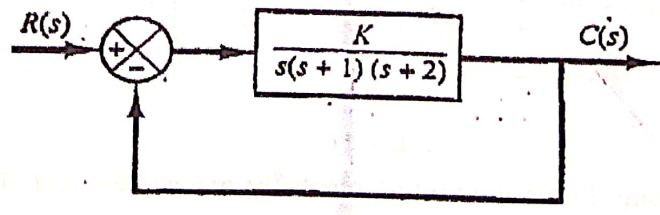


Fig.6(c)

17. a) Show that a proportional controller with an integrator eliminates the steady state error 12
 completely.
 b) Determine whether the following network is lead or lag. The control network is given by: 10
 $G(s) = \frac{s+1/T_1}{s+1/T_2}$
 c) What are the applications of PID controllers? Describe first method of Ziegler-Nichols rules 13
 for tuning PID controller.
 8. a) How PLC is programmed? Show 4 ways of programming considering a suitable example. 15
 b) Explain the following terms: 10
 (i) Hydraulic inertance
 (ii) Pneumatic capacitance
 c) How fluid pressure can be measured using sensor? Give example. 10

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (C U E T)
 Level 4, Term II, Examination 2016

Course No: ME455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 30/07/2017	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section: A

- | | <i>Marks</i> |
|---|--------------|
| 1. a) What do you mean by the term "Mechatronics"? Write down the applications of it. | 10 |
| b) What is a control system? What are the basic elements of a closed loop control system? Show in a block diagram. | 12 |
| c) What is Transfer function? Two transfer functions are connected in a feedback system. $G_1(s)$ is in Feed forward and $G_2(s)$ is in Feedback. Find out the closed loop Transfer function. | 13 |
| 2. a) What is block diagram? Simply the block diagram as in Figure 2(a) and obtain $C(S) / R(S)$. | 18 |
| b) State the difference between modern control theory and conventional control theory. | 05 |
| c) Obtain the state-space model of the mechanical system as shown in Figure 2(c), where $u(t)$ is the input and $y(t)$ is the output. | 12 |
| 3. a) What is signal flow graph? Write down the properties of signal flow graph. Draw a signal flow graph for the following set of equations | 15 |
| $x_1 = a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + b_1u_1$ $x_2 = a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + b_2u_2$ $x_3 = a_{31}x_1 + a_{32}x_2 + a_{33}x_3$ | (6) |
| where u_1 and u_2 are input variables and x_1, x_2 and x_3 are output variables. | |
| b) Why linearization is done? Linearize the non-linear equation $z = xy$ in the region $5 \leq x \leq 7, 10 \leq y \leq 12$. Find the percent of error if the linearized equation is used to calculate the value of z when $x = 5, y = 10$. | 14 |
| c) Define (i) MIMO system (ii) Time variant system (iii) Steady state error. | 06 |
| 4. a) What do you mean by transient response and steady-state response? Show a typical 2 nd order response against a step input with necessary terminology. | 10 |
| b) Find the response of a unit-Ramp input for a first order system as shown in Figure 4(b). Also plot the response against time. | 11 |
| c) Determine the value of K and H of the closed-loop system shown in Figure 4(c) so that the maximum overshoot in unit step response is 25% and the peak time is 2 sec. Assume that $J = 1 \text{ kg-m}^2$. | 14 |

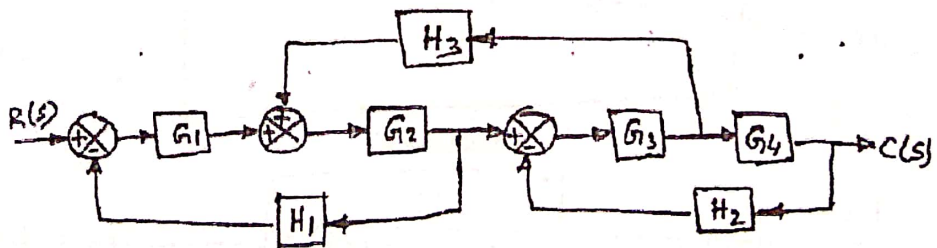


Figure 2(a)

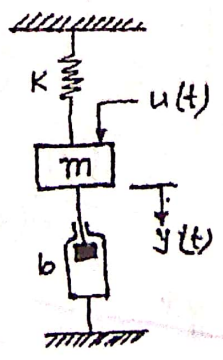


Figure 2(c)

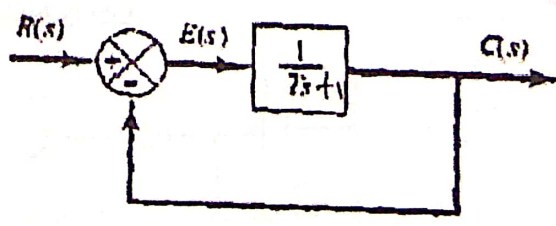


Figure 4(b)

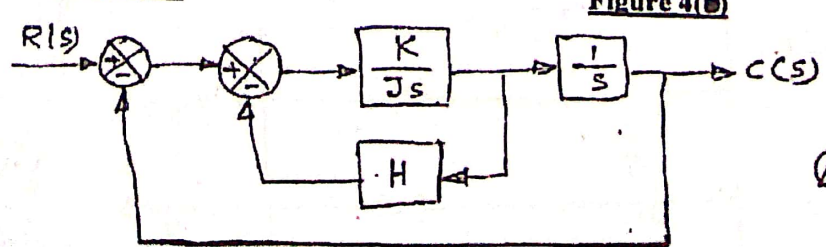


Figure 4(c)

$e^{-\zeta \omega_n t} \sin(\omega_d t)$
 $\zeta = \frac{\sigma}{\omega_n}$
 $\omega_d = \omega_n \sqrt{1-\zeta^2}$

$t_p = \frac{\pi}{\omega_p}$

$e^{-\zeta \omega_n t} \sin(\omega_d t)$

Section: B

5. a) Show that the proportional control of a system without an integrator will result in a steady-state error with a step input. 11
 b) State the 2nd principle of Ziegler-Nichol tuning rules for PID controller. Apply it for the 24
 control system shown in Figure 5(b) where controller, $G_c(s) = K_p \left(1 + \frac{1}{T_i s} + T_d s \right)$.

PADUUSORCSOESTF

6. a) Define the term "Poles" and "Zeros". Using Routh's stability criteria, find out the value of K 15
 for stability of the control system as shown in Figure 6(a).
 b) What are the advantages of Root locus method? Find out the root locus on real axis for the 15
 control system shown in Figure 6(b).
 c) What do you mean by absolute stability and relative stability? 05
7. a) Define dynamic characteristics of a sensor showing required figure. 10
 b) Explain the working principle of LVDT with necessary schematic diagram. 10
 c) Write short note on (i) Strain Gauge (ii) Optical Encoder (iii) Tactile sensor. 3x5=15
8. a) What are the extra-ordinary features of PLC? 08
 b) Draw the functional block diagram of a PLC and describe different units. 15
 c) Describe the ladder diagram shown in the Figure 8(c) 12

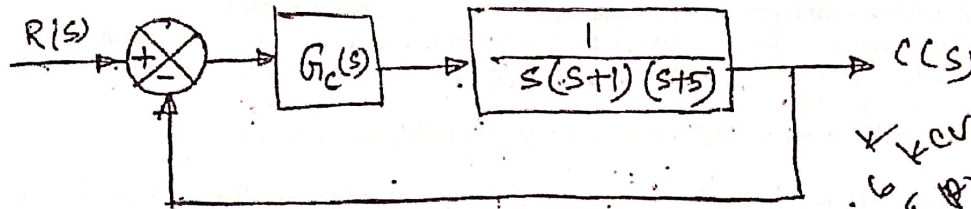


Figure 5(b)

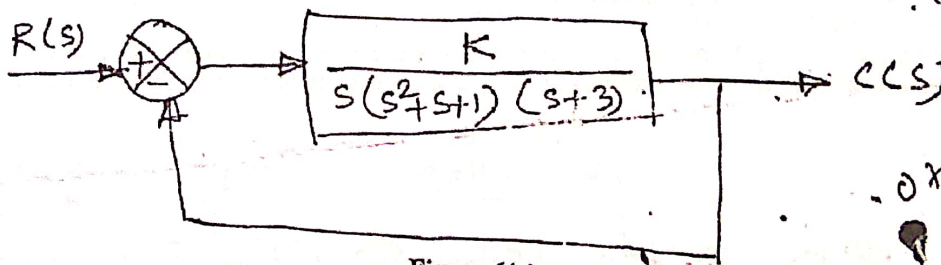


Figure 6(a)

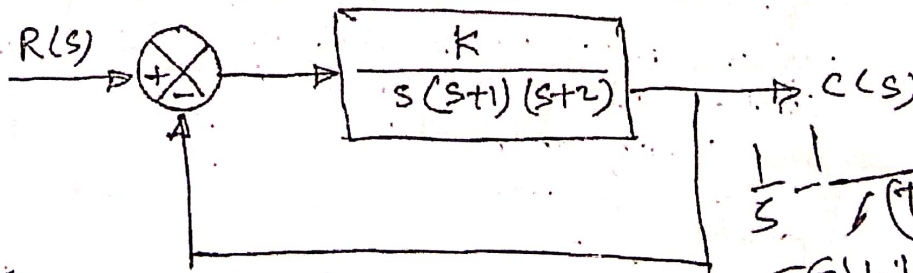


Figure 6(b)

K/s
6 Kev T1
5 Pr T1
125 Pr. Td
0.75 Kev Per (s+K/s)

$$\frac{1}{s} \cdot \frac{K}{(s+1)(s+2)}$$

$$\frac{T(s)+1+K}{T(s)(s+1+K)}$$

$$\frac{T(s)(s+1+K)}{T(s)(s+1+K)}$$

$$\frac{K}{Ts+1}$$

C1 + Gc1 + Gc2 + Gc3 + Gc4 + Gc5

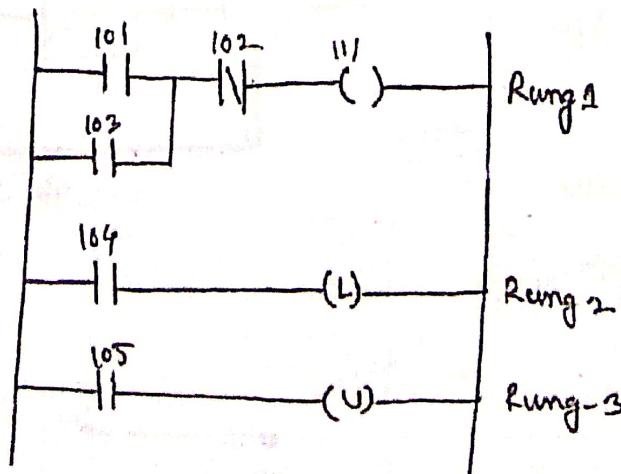


Figure 8(c)

Per 2/K
W
K/(s+1)
K/(s+2)
K/(s+1)(s+2)

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (C U E T)
 Level 4, Term 2, Examination 2015

Course No: ME 455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 28/11/2016	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section: A

Marks

1. a) What is Mechatronics? The advancement of mechatronics is like the movement of Amoeba- Explain. 10
- b) Make a comparison between open loop and close loop control system with example. 12
- c) Show the steps of control system design process. 13
2. a) Write down the standard equations of state space modeling and give the name of each vector and matrix. Also draw the block diagram of the equations. 12
- b) For a system in Fig 2(b), Define (i) Open loop transfer function (ii) Feed forward transfer function (iii) Closed loop transfer function. 11

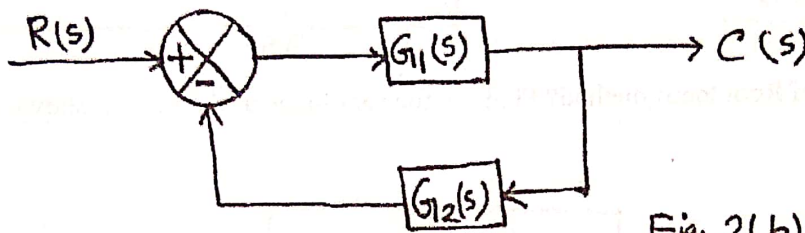


Fig. 2(b)

- c) Obtain a state-space representation of the system shown in Fig 2(c). The output variables are y_1 & y_2 and input is u . Here b is the damping co-efficient, K is the spring constant, m_1 and m_2 are the mass of the cars. 12

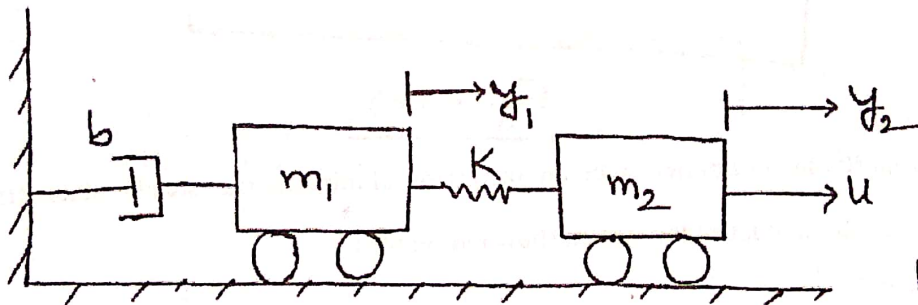


Fig. 2(c)

3. a) Simplify the block diagram shown in figure 3(a) and obtain transfer function $Y(S)/U(S)$. 16

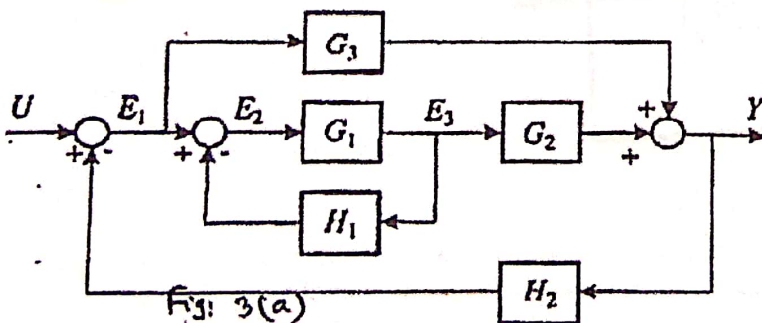


Fig: 3(a)

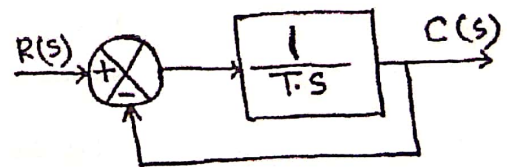
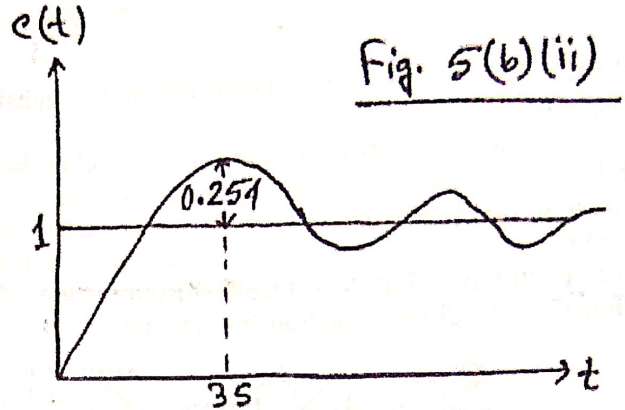
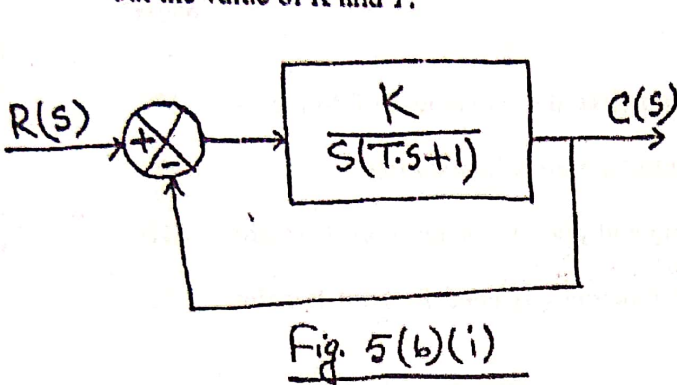


Fig. 4(c)

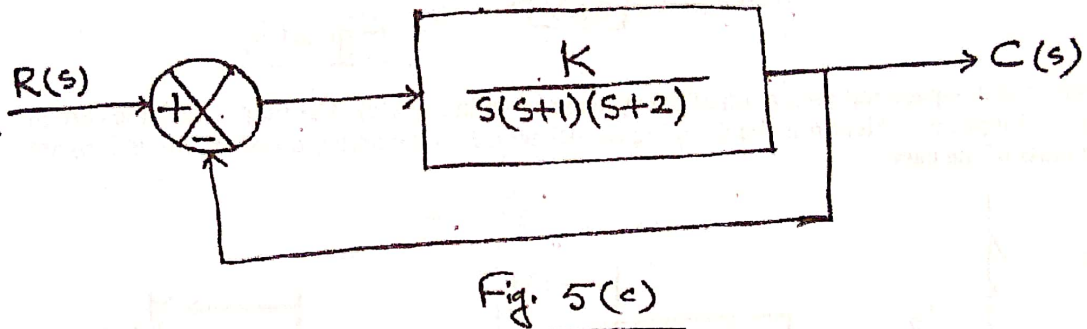
- b) Why linearization of a non-linear system is necessary? Linearize the non-linear equation $y = m^2 + 8mn + 3n^2$, in the region defined by $2 \leq m \leq 4$, $10 \leq n \leq 12$ 13
- c) Define: i) SISO system ii) MIMO system iii) Time variant system 06
4. a) What do you mean by transient response and steady state response? What types of test signals are used? Show with figures 10
- b) What do you understand from a signal flow graph? Draw a signal flow graph for $x_1 = a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + b_1u_1$ where u_1 is the input and x_1, x_2, x_3 are output variables. After drawing the signal flow graph, identify input node, output node, mixed node and transmittance. 08
- c) Find the response of a unit step input for a first order system as shown in Fig 4(c). Also plot the response against time. 12
- d) Define: i) Absolute stability ii) Relative stability 05

Section: B

5. a) What do you understand by the term "Poles" and "Zeroes"? What are the necessary and sufficient conditions for stability according to Routh's criteria. Following this find out the value of K for stability of the characteristics equation $S^4 + KS^3 + S^2 + S + 1 = 0$ 12
- b) A system shown in Fig 5(b)(i) gives a response as Fig 5(b)(ii) against a unit step input. Find out the value of K and T . 12



- c) What are the advantages of Root locus method? Find out the root locus of the system shown in Fig 5(c) on real axis. 11



6. a) Show that a proportional controller with an integrator eliminates the steady state error completely. 11
- b) Design a PID Controller to control the system shown in fig 6(b) 18

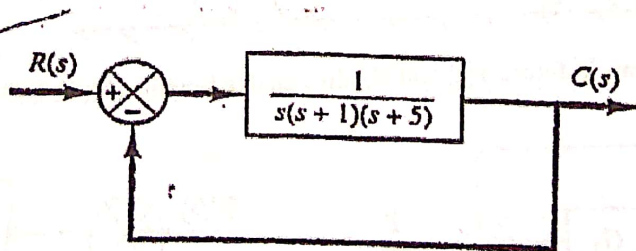


Fig.: 6(b)

- c) Why frequency response analysis is done? 06
7. a) How can you differentiate between transducer and sensor? Discuss static and dynamic characteristics of sensor. 15
- b) Explain the working principle of LVDT 12
- c) Write short notes on any two: i) Strain gauge ii) Proximity sensor iii) Optical encoder 08
8. a) What are the outstanding features of PLC over other controllers? What are the general specifications for selecting a perfect PLC? What are the main components of a PLC unit? 15
- b) What is Ladder diagram? Draw the symbols of following relay type instruction: i) Examine 'on' ii) Examine 'off' iii) Energize output iv) Latch v) Reset vi) Open branch vii) Close branch 10
- c) Write short notes on (any two): i) Lead-lag network ii) Tactile sensor iii) Capacitive sensor iv) Relay 2x5=10

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (CUET)
 Level-4, Term-II, Final Examination 2014

Course No: ME455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 21/05/2015	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section - A

- 1a. What is Mechatronics? The advancement of mechatronics is like the movement of Aemiba- Explain, 10
- 1b. What are the basic building blocks of hydraulic system? Find out an expression for hydraulic capacitance. 13
- 1c. Compare closed loop control system with open loop control system. 12
- 2a. What is transfer function? How do cascaded, parallel and feedback systems' transfer function can be obtained? 15
- 2b. A mechanical system is expressed by a mathematical model as follows: $m\ddot{y} + b\dot{y} + ky = u$ where u is the input and y is the output. Find out the state space model. 10
- 2c. Make a comparison between modern control theory and conventional control theory. 10
- 3a. Simplify the block diagram shown in Figure 3a and obtain closed loop transfer function. 15
- 3b. Why linearization is done? A system is expressed by $Z = x^2 + 4xy + 6y^2$. Linearize the equation in the region $8 \leq x \leq 10, 2 \leq y \leq 4$ 10
- 3c. A system expressed by the following linear equations: 10
 $x_1 = a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + b_1u_1$; $x_2 = a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + b_2u_2$; $x_3 = a_{31}x_1 + a_{32}x_2 + a_{33}x_3$
 Where x_1, x_2 & x_3 are system parameters and u_1, u_2 & u_3 are the input. *Draw the Sfg!*

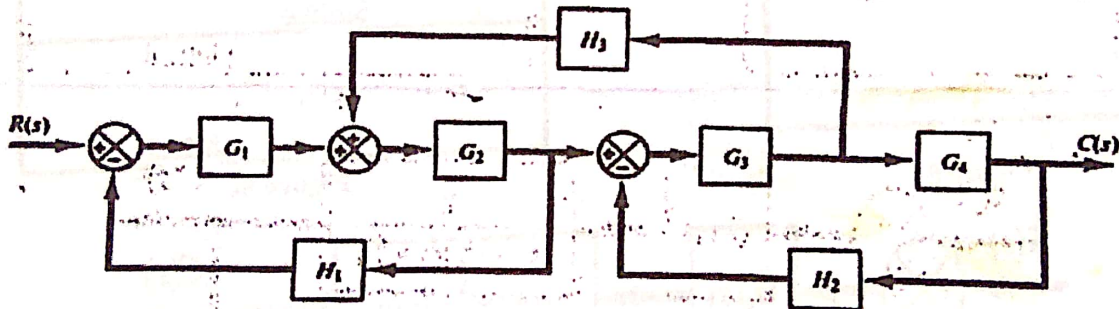


Figure 3a

- 4a. Explain Routh's stability criteria and determine the range K for stability using for 13
 $S^4 + KS^3 + S^2 + S + 1 = 0$
- 4b. Show that a system having a proportional controller without integral always shows a steady state 12
 error.
- 4c. Why test signals are used? Briefly describe the test signals that are generally used. 10

Section - B

- 5a. Show a typical step response of a second order system and define its various parameters. 13
- 5b. For the system shown in Figure 5b(i) is subjected to a unit step input, the system output responds is 12
 shown in Figure 5b(ii). Determine the value of K and T from the response curve. Assume $\xi = 0.4$
- 5c. Discuss root locus method with angle and magnitude conditions. Consider a system shown in 10
 Figure 5c and determine the root loci on the real axis.

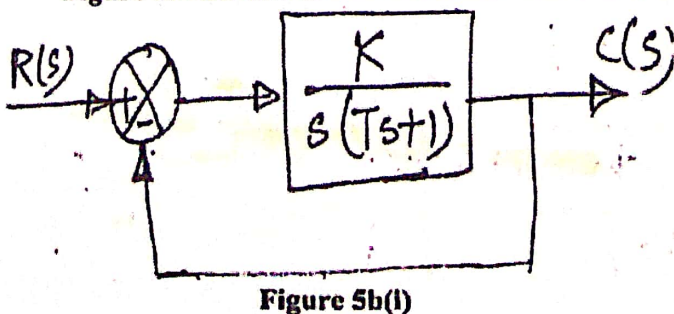


Figure 5b(i)

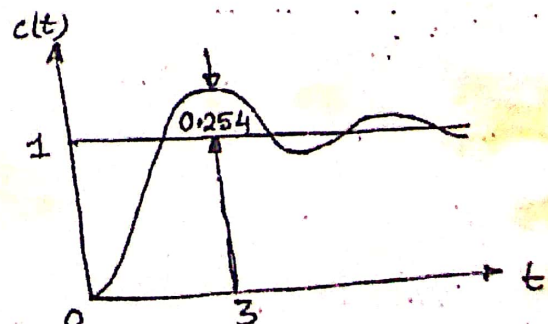


Figure 5b(ii)

6a.

Consider the control system shown in Figure 6a, where $G(S) = K_p \left(1 + \frac{1}{T_i S} + T_d S \right)$. Find out the value of K_p , T_i and T_d using Ziegler-Nichols method.

6b.
6c.

Write short notes on 'Bode plot'.

Consider the network given by $C(s) = \frac{s + \frac{1}{T_1}}{s + \frac{1}{T_2}}$. Determine whether this network is a lead network or lag network.

10
10

- 7a. What are the advantages and disadvantages of hydraulic control system? 08
- 7b. Make a list of performance terminology of sensor and explain any five. 14
- 7c. Explain the working principle of LVDT. 13
- 8a. What is PLC? Write down some important features and advantages of using PLC? 10
- 8b. Draw the functional block diagram of PLC. 13
- 8c. Assume that there is a main gate (gate 1) and an inside gate (gate 2) in a commercial house as shown in Figure 8c. Three people A, B and C are responsible to take care of these matters. A has a key to operate the switch 101 and B has a key to operate switch 102. When they operate their respective switch then output contact 111 become energized and this opens the gate 1. C has a key to operate the switch 103. When C operates his switch the contact 112 will be energized and this will open the gate 2. Now develop a PLC diagram using (i) Instructions, (ii) Ladder diagram, (iii) Logic circuit, (iv) Sequential function chart to control this process. 12

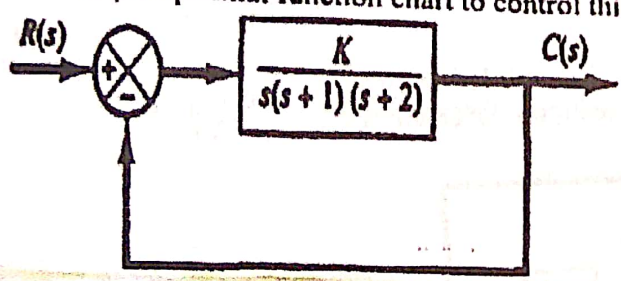


Figure 5c

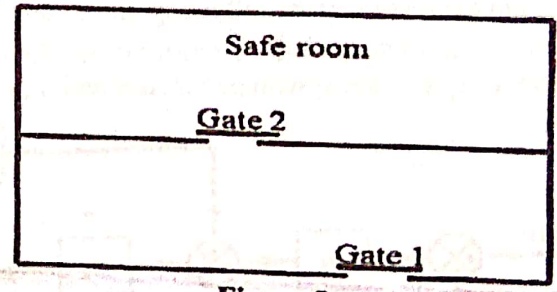


Figure 8c

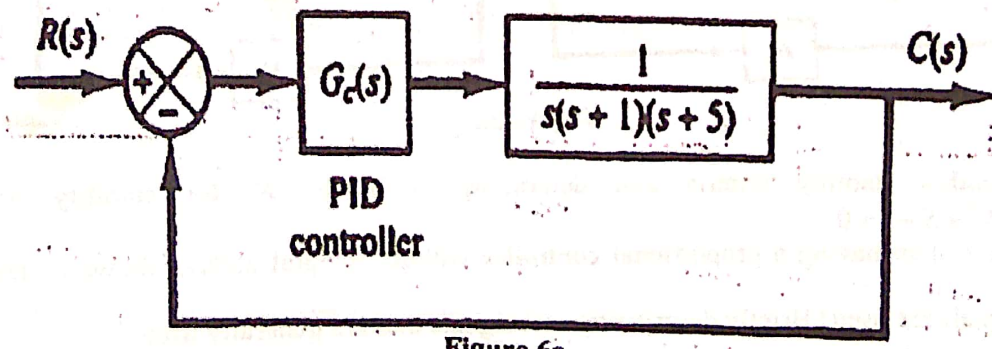


Figure 6a

Department of Mechanical Engineering
Chittagong University of Engineering and Technology (CUET)
Level-4, Term-II, Final Examination 2013

Course No: ME455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 18/06/2014	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section - A

- 1a. What do you mean by the term 'Mechatronics'? What fields are incorporated in it? 10
- 1b. Explain the elements of a closed loop system. 13
- 1c. Make a comparative study between open loop control system and closed loop control system. 10

- 2a. What are the basic building blocks for hydraulic system? What do you mean by pneumatic capacitance? 3+2+
Find the components (C_1 & C_2) of it. 10
- 2b. Write the general form of state-space equation and give the name of each matrix. Also, draw a block diagram for the state-space equation. 2+3+
3
- 2c. Obtain mathematical model of the mechanical system shown in Figure 2c. 12

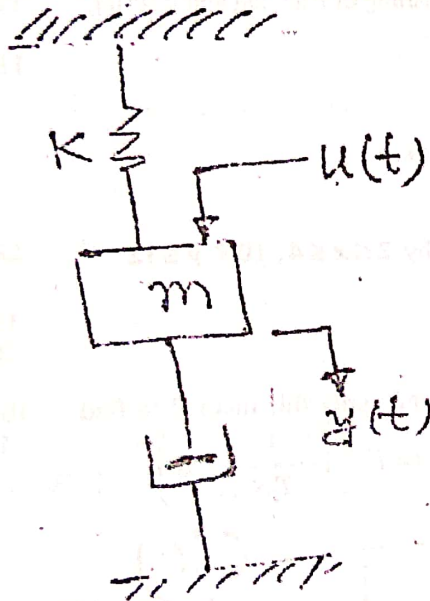


Figure 2b

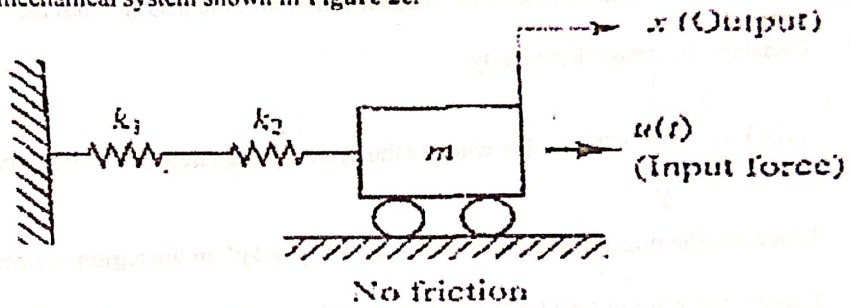


Figure 2c

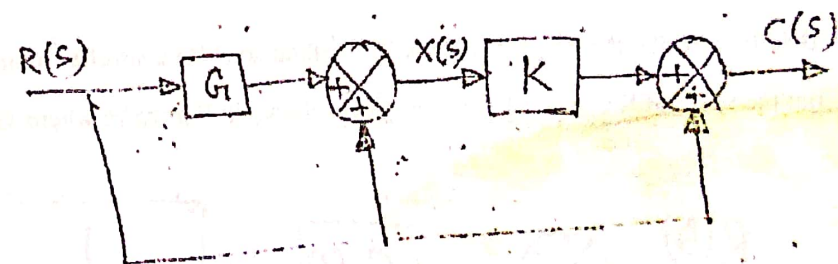


Figure 3a

- 3a. What is a block diagram? Simplify the block diagram and find out the closed loop transfer function $C(S)/R(S)$. 2+8
- 3b. Mention three important characteristics of signal flow graph. Using Mason's gain formula find out the closed loop transfer function for the system as shown in Figure 3b. 15
- 3c. Determine the range of K for stability for the system shown in Figure 3c using Routh's stability criteria. 10

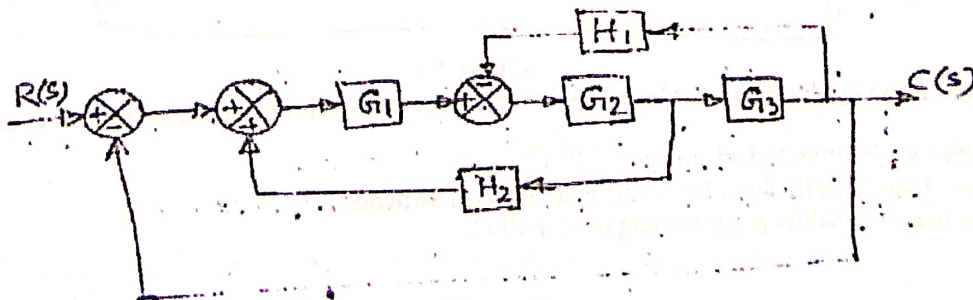


Figure 3b

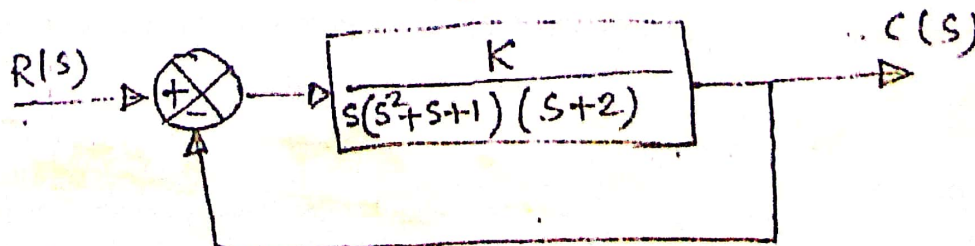


Figure 3c

- 4a. What do you mean by transient response and steady state response? Draw a standard unit step response curve for a 2nd order showing its various parameters. 12
- 4b. Why test signals are used? Briefly describe the test signals that are generally used. 10
- 4c. Consider the system shown in Figure 4c, where $\xi = 0.6$ and $\omega_n = 5 \text{ rad/sec}$. Obtain the rise time, peak time, maximum overshoot and settling time when the system is subjected to a unit step response. 13

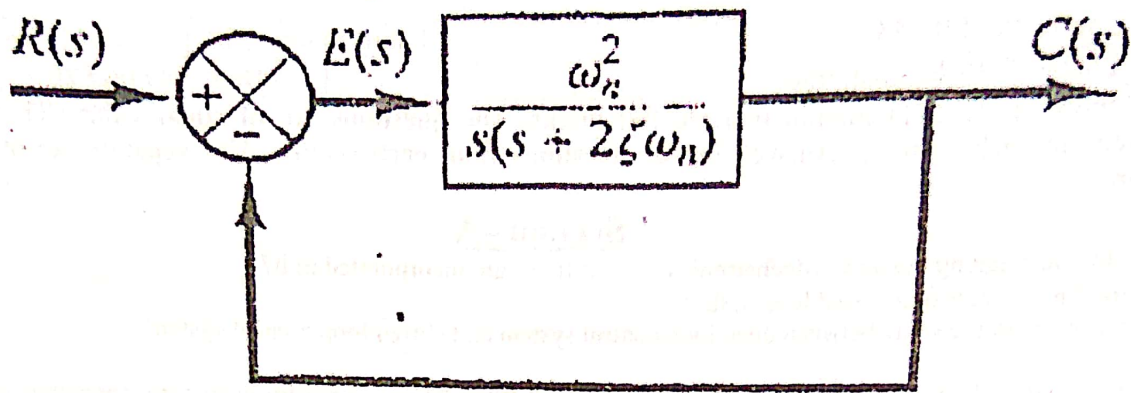


Figure 4c

Section -B

- 5a. What do you mean by sinusoidal transfer function? And also find out the meaning of lead, lag and lead-lag network. 12
- 5b. Consider the network given by $G(s) = \frac{s + \frac{1}{T_1}}{s + \frac{1}{T_2}}$; Determine whether the system is lead network or lag network. 11
- 5c. Linearize the non-linear equation $Z = x^2 + 8xy + 3y^2$ in the region defined by $2 \leq x \leq 4, 10 \leq y \leq 12$ 12
- 6a. Explain the principle and operation of optical encoders. 15
- 6b. Describe the LVDT and tactile sensor. 20
- 7a. Briefly describe the Ziegler-Nichols 2nd method for PID controller tuning and apply this method to find out the value of K_p, T_i and T_d for the system shown in Figure 7a where $G(s) = K_p \left(1 + \frac{1}{T_i s} + T_d s \right)$ 10+
15

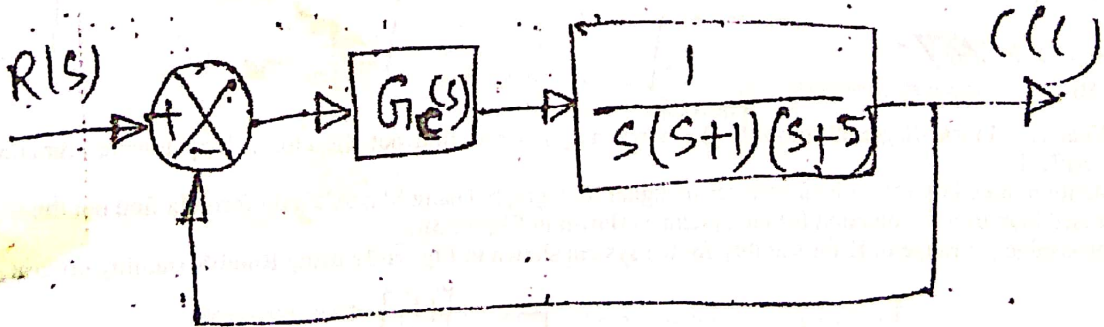


Figure 7a

- 7b. What do you mean by the term 'root locus'? Why root locus method is so important for control engineers? 10
- 8a. What are the key features and advantages of PLC? 10
- 8b. What is switching? Briefly describe the different types of switches. 12
- 8c. Explain the basics of ladder programming used in PLC. 13

Course No: ME 455	Date: 14/07/2013	Course Title: Mechatronics
Full Marks: 210		Time: Throo (03) hours

The figures in the right margin indicate full marks. There are four (04) questions in each section. Answer any three (03) questions from each section. Please use separate script for each section.

Section A

Marks

- 1 a) What do you mean by mechatronics system? What are the key elements of it? 10
- b) Define and differentiate the controlled variable, manipulated variable and disturbance variable. 10
- c) Briefly describe the basic elements of a closed loop system. What are the differences between an open loop and closed loop control? 15

- 2 a) What are the basic building blocks of mechanical and electrical system? Find the analogy among them. 10
- b) Obtain a state space representation of the mechanical system shown in figure 2(b) 15

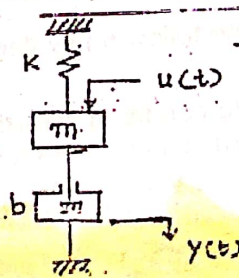


Figure: 2(b)

Handwritten notes:
 in the
 mass
 system
 for
 C=30V
 R=10
 C=20

- 3 a) Briefly state the Mason's gain formula. Construct a signal flow graph for a system which is expressed by following equations, where u_1 and u_2 are inputs 10

$$\begin{aligned} x_1 &= a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + b_1u_1 \\ x_2 &= a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + b_2u_2 \\ x_3 &= a_{31}x_1 + a_{32}x_2 + a_{33}x_3 \end{aligned}$$

- 3 a) What is hydraulic inrtance? Find the expression for it. Compare it with electrical system. 10
- b) Briefly discuss the advantage and disadvantage of hydraulic system. 10
- c) Why linearization is done? Linearize the non linear equation $z = x^2 + 8xy + 3y^2$ in the region defined by $2 \leq x \leq 4$, $10 \leq y \leq 12$. 10
- d) What will be the equivalent transfer function if transfer function $G_1(s)$ is used in feed forward path and $G_2(s)$ is used in feedback. 05-



- 4 a) Why test signals are used? Breifly describe various types of test signals. 10
- b) Find out a response curve for a first order system against a unit step response. 13
- c) Determine the values of K and k of the closed loop system whose transfer function is 12

$$\frac{C(s)}{R(s)} = \frac{K}{Js^2 + Kks + K}$$

Handwritten note: $\frac{2\sqrt{Kk} \xi - \omega}{\omega_n}$

So that, the maximum overshoot in unit step response is 20 % and the peak time is 3 sec (Assume that $J = 1 \text{ kg - m}^2$).

Section B

- 5 a) Explain the terms 'absolute stability', 'critically stable' and 'relative stability'. 10
- b) What is the outcome of Routh stability criterion? Write down the procedure of Routh stability criterion. Consider the following characteristic equation: 15

$$s^4 + 2s^3 + (4+k)s^2 + 9s + 25 = 0$$

Using Routh stability criterion, determine the range of k for stability

- c) Show that the use of integral controller nullifies the steady state error for unit step response. 10
- 6 a) Using Ziegler - Nichols method find out the value of K_p , T_i and T_d for the system shown in figure 6 (a). 15

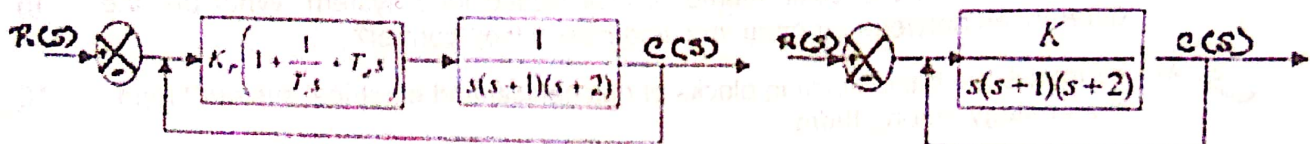


Figure 6(a)

Figure 6(b)

- b) Find out whether the following system is lead or lag network. 08
- c) State the magnitude condition and angle condition for root locus. Find out the root locus on the real axis for the close loop system as shown in figure 6(c). 12

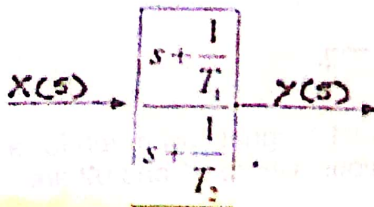


Figure 6(c)

$\angle s - (s + 1/Ti) - 1'$

- 7 a) Write down the outstanding feature of PLC for using as controller. 10
- b) Draw the schematic diagram of the internal structure of PLC. 12
- c) What are the widely used programming languages of PLC? List the symbols that are used for ladder diagram. 13
- 8 a) Define sensor and transducer. Regarding the performance of transducers, explain the following terms. 20
- i) Range and Span
 - ii) Accuracy
 - iii) Sensitivity
 - iv) Stability
 - v) Repeatability

$v_p = K_{ps} \omega + 1$

- b) Explain the working principle of linear variable differential transformer with necessary schematic diagram. 15

Chittagong University of Engineering and Technology (C U E T)
Department of Mechanical Engineering
Level 4, Term II, Examination 2011

Course No: ME 455	Full Marks: 210	Time: 03 hours
Course Title: Mechatronics	Date: 06/09/2012	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 questions from each section. Use separate script for each section.

Section: A

- | | | Marks |
|---|---|---------------|
| 1 | a) What is 'Mechatronics' system? Briefly describe the method of mechatronics system design. | 12 |
| | b) Explain the difference between open loop and closed loop control system by using necessary block diagram of each. | 11 |
| | c) Two systems having transfer function of $G_1(s)$ and $G_2(s)$. Find the equivalent transfer function when these are connected in feedback. | 12 |
| 2 | a) A control system has the block diagram as shown in Fig. 2(a). Simplify this diagram and obtain the closed-loop transfer function. | 15 |
| | b) What is signal flow graph? Write down the property of signal flow graph. Using Mason's gain formula find out the closed-loop transfer function for the control system as shown in Fig. 2(b). | 2+4+
14=20 |
| 3 | a) Define state variables, state vector and state space for system modeling. Construct the state space model for a system which has the transfer function as $\frac{s^2 + 7s + 2}{s^3 + 9s^2 + 26s + 24}$. | 15 |
| | b) Consider the liquid-level system as shown in Fig. 3(b).
i) Draw the block diagram of each element ii) Connect signals properly to construct the whole block diagram iii) Simplify the block diagram. | 20 |
| 4 | a) What do you mean by 'non-linear' system? Linearize the nonlinear equation $z = x^2 + 4xy + 6y^2$ in the region defined by $8 \leq x \leq 10, 2 \leq y \leq 4$. | 14 |
| | b) Draw a typical transient and steady state response for a unit step to a second order system and mention its different specifications. | 08 |
| | c) A system shown in Fig. 4 (c) (i) is subjected to unit-step input. The output is shown in Fig. 4 (c) (ii). Determine the values of K and T from the response curve. | 13 |

Section: B

- | | | |
|---|---|-------------|
| 5 | a) Show that only a proportional controller in the feed forward path always gives a steady state error in the step response. | 12 |
| | b) A system has the characteristic equation $s^4 + 2s^3 + (4+k)s^2 + 9s + 25 = 0$. Determine the range of k for stability using the Hurwitz stability criterion. | 16 |
| | c) What do you mean by 'a system is critically stable'? Explain | 07 |
| 6 | a) Define PLC showing its architecture. | 15 |
| | b) Differentiate between different types of switches. | 10 |
| | c) What are the widely used programming languages of PLC? Explain the meaning of the ladder diagram in Fig. 6 (c). | 10 |
| 7 | a) Define the following terms for a transducer
i) Range ii) Error iii) Sensibility iv) Stability | 12 |
| | b) Mention the characteristics which are responsible for the selection of a sensor. | 10 |
| | c) Explain the working principle of LVDT by depicting necessary figures: | 13 |
| 8 | a) Explain Ziegler-Nichols rules (First method) for tuning PID controllers. | 15 |
| | b) Write short notes on any Four:
i) Tactile sensor ii) RTD iii) Sinusoidal transfer function iv) Bode plot v) Pressure sensor vi) Root Lucas | 4 x
5=20 |

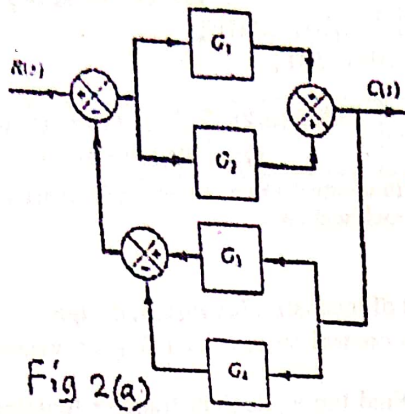


Fig 2(a)

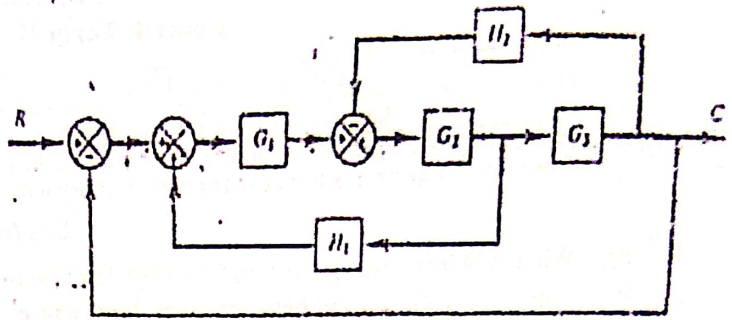
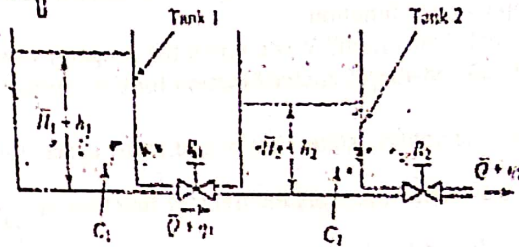
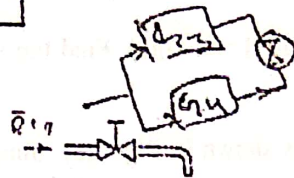


Fig. 2(b)



Q : Steady-state flow rate
 h_1 : Steady-state liquid level of tank 1
 h_2 : Steady-state liquid level of tank 2

Fig. 3(b)

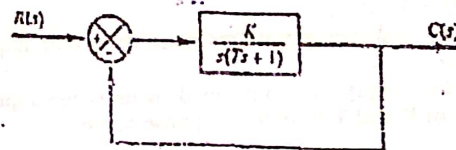


Fig. 4(c)(i)

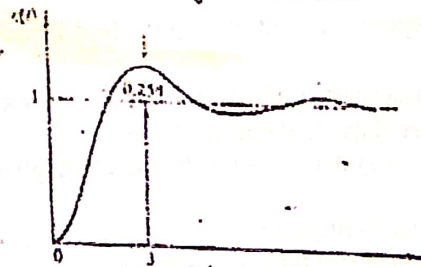


Fig. 4(c)(ii)

101	102	111	
103			
104	112		
105	112		

Runq 1

Runq 2

Runq 3

Fig. 4(c)

(Contd)

$1 + (K/Ts + 1) (G_3^-)$

$$\frac{K}{Ts + 1}$$

— THE END —

$$1 + \frac{K}{Ts + 1}$$

$$\frac{K}{Ts + 1 + K}$$

$$\frac{K}{s(Ts + 1)}$$

06603004

Chittagong University of Engineering and Technology (C U E T)
Department of Mechanical Engineering
Level 4, Term 2, Examination 2009

Course No: ME 455	Full Marks: 210	Time: 03 hours
Course Title: Control Engineering and Mechatronics	Date: 23/05/2010	

The figures in the right margin indicate full marks. The questions are of equal value. There are 04 questions in each section. Answer any 03 question, from each section. Use separate script for each section.

Section: A

- 1 a) Define control system. What are the differences between closed-loop and open-loop control system? 10
- b) What is system modeling? Find the analogies between the electrical and mechanical building blocks. 10
- c) What are the basic steps to design a feed back control system? Define the following: 15
- i) Controlled parameters ii) Manipulated parameters iii) System disturbances.
- 2 a) Define transfer function. 05
- b) Draw a block diagram of a closed-loop system and derive an equation of transfer function from that diagram. $\rightarrow B$ 15
- c) What is state space modeling? Why it is done? Find the state-space model of the system shown in Fig. 3(c). 15
- 3 a) Define: i) Hydraulic inductance ii) Pneumatic capacitance. 08
- b) What do you mean by block diagram? Simplify the block diagram as shown in Fig. 3(b) and find the overall transfer function. 15
- c) What is signal flow graph? Why it is necessary? Construct a signal flow graph using the following set of algebraic equations: 12
- $y_1 = a_{11}y_1 + a_{12}y_2 \dots \dots \dots (1)$
 $y_2 = a_{21}y_1 + a_{22}y_2 \dots \dots \dots (2)$
 $y_3 = a_{31}y_1 + a_{32}y_2 + a_{33}y_3 \dots \dots \dots (3)$
 $y_4 = a_{41}y_1 + a_{42}y_2 \dots \dots \dots (4)$
- 4 a) What are the typical test signals? For the system in Fig. 4(c), find out and plot the response of unit-step input. 12
- b) Draw a typical unit-step response of a second order system and show delay time, rise time, peak time, maximum overshoot and settling time. 08
- c) For the system shown in Fig. 4(c), where $\zeta = 0.6$ and $\omega_n = 5$ rad/s. Determine the rise time (t_r), peak time (t_p), maximum overshoot (M_p), and settling time (t_s), when the system is subjected to a unit-step response. 15

Section: B

- 5 a) State the Routh's stability criteria and using this find the range of K for stability of the system having the following characteristic equation: 15
- $s^4 + 2s^3 + (4+k)s^2 + 9s + 25 = 0$
- b) According to the Root-Locus plots, mention the angle and magnitude conditions of the system shown in Fig. 5(b) 10
- c) What is compensator? Make a list of compensators that are generally used. Compare between series and parallel compensation. 10
- 6 a) What do you mean by controller tuning? Classify industrial controllers that are generally used. 08
- b) Write down the Ziegler-Nichols rules for tuning PID controllers briefly. 12
- c) Consider a control system shown in Fig. 6(c) in which a PID controller is used to control the system. 15
- The PID controller has the transfer function $G_c(s) = k_p (1 + \frac{1}{T_i s} + T_d s)$. Using 2nd method of Ziegler-Nichols tuning rules find out the controller parameters.
- 7 a) Define 'sensor' and 'transducer'. Explain the terms used to define the performance of sensor. 13
- b) What are the considerations needed in selecting displacement, position or proximity sensor. 10
- c) What is LVDT? Explain with schematic diagram. 12
- 8 Write short notes on any Five: 5 x 5 = 25
- i) Tactile sensor ii) PLC iii) Interfacing iv) Poles and zeros v) Optical encoders vi) Proximity switches vii) Strain gauge load cell

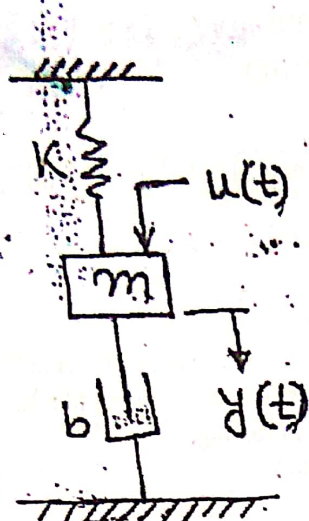


Fig 2(c)

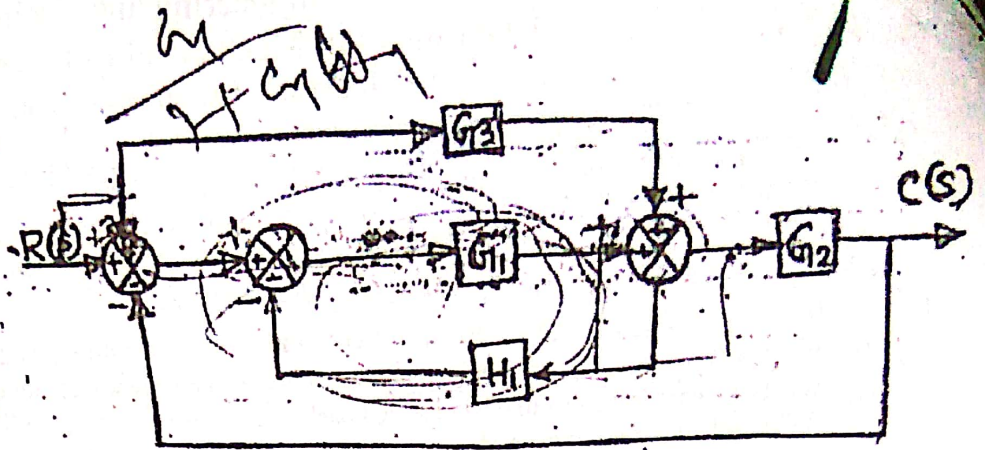


Fig. 3(b)

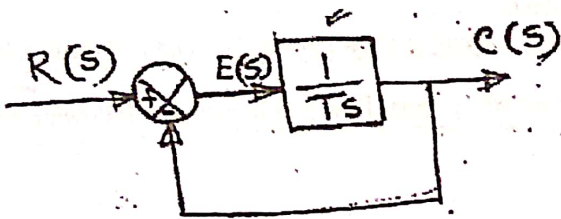


Fig. 4(a)

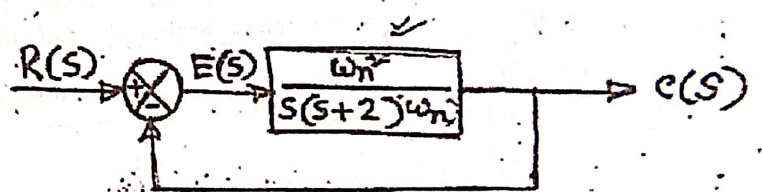


Fig. 4(c)

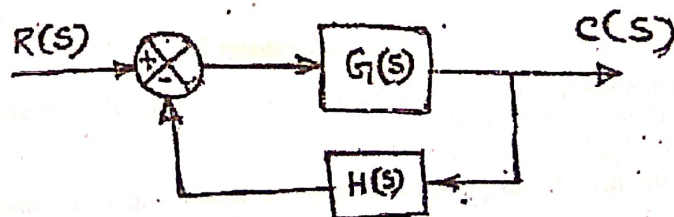


Fig. 5(b)

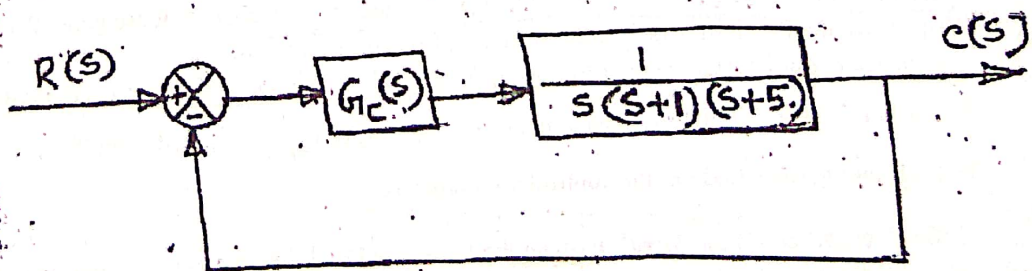


Fig. 6(c)