

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 1st Year 1st Term Examination, 2021

Ch 1131  
(Chemistry)

Time: 3 Hours

Total Marks: 210

**N.B.:** i) Answer any THREE questions from each section in separate scripts.

ii) Figures in the right margin indicate full marks.

iii) Assume reasonable data if any missing.

**SECTION-A**

- |      |   |    |
|------|---|----|
| 1(a) | Why Ne <sub>2</sub> is not possible? Explain.   | 09 |
| 1(b) | What is resonance? Draw the resonating structures of CO <sub>2</sub> <sup>2-</sup> and O <sub>3</sub> and identify the most stable structure(s).  | 14 |
| 1(c) | Draw the molecular orbital structure of oxygen molecule and answer the following:<br>(i) How many bonding and anti-bonding orbitals are there in the molecule?<br>(ii) How many unpaired electrons are there?<br>(iii) How many σ and π bonds are there?                    | 12 |
| 2(a) | Briefly describe with examples inner orbital octahedral complex and outer orbital octahedral complex.   | 14 |
| 2(b) | What are the differences among Silicon, Silicone and Silica?  | 09 |
| 2(c) | “Intramolecular hydrogen bonding has no effect on boiling point” – Justify this statement.  | 06 |
| 2(d) | Discuss the limitations of valence bond theory.   | 06 |
| 3(a) | What type of corrosion may occur at Hardinge bridge (the largest railway bridge of Bangladesh)? Describe with mechanism.  | 12 |
| 3(b) | Define electroplating. Discuss the basic principle of electroplating with diagram.  | 10 |
| 3(c) | What are the roles of H <sub>2</sub> S in case of corrosion?  | 06 |
| 3(d) | How does Salt bridge work?  | 07 |
| 4(a) | “A Nucleus outside the stability band will decay by a mechanism that brings its N/Z ratio into the stable region” – Explain the term with N vs Z graph.   | 12 |
| 4(b) | Calculate both the total binding energy (MeV) and the binding energy per nucleon for <sup>12</sup> <sub>6</sub> C. Given that mass of <sup>1</sup> <sub>1</sub> P = 1.00728 amu, <sup>1</sup> <sub>0</sub> n = 1.00867 amu and <sup>12</sup> <sub>6</sub> C = 12.00000 amu. | 08 |
| 4(c) | Why is nuclear waste management and disposal important?   | 06 |
| 4(d) | How does radioactive equilibrium differ from chemical equilibrium?  | 09 |

## SECTION-B

- 5(a) Explain the term component. How many components are present in the following system? 10  
(i)  $\text{Water} \rightleftharpoons \text{Water - vapour}$   
(ii)  $\text{KCl(s)} + \text{H}_2\text{O} \rightleftharpoons \text{KCl(aq)}$ .
- 5(b) Draw the phase diagram of a two component system and indicate the phases present in the various parts of the diagram. 12
- 5(c) Mention some applications of phase rule. 05
- 5(d) An alloy AB containing 40% A in 1 kg. AB on cooling forms eutectic containing 60% A and 40% B and the rest of B. What is the amount of B formed during eutectic formation? 08
- 6(a) Explain why the boiling point of a solution containing a nonvolatile solute is higher than the boiling point of a pure solvent. 12
- 6(b) State Henry's law. Write down the meaning of each term involved in this law. 10
- 6(c) A liter of water at 25°C dissolves 0.0404 g O<sub>2</sub> when the partial pressure of the oxygen is 1.00 atm. What is the solubility of oxygen from air, in which the partial pressure of oxygen is 159 atm? 08
- 6(d) Define boiling – point elevation and freezing point depression. 05
- 7(a) For which of the following reactions is K<sub>C</sub> equal to K<sub>P</sub>? 12  
(i)  $4\text{NH}_3 + 5\text{O}_2 \rightleftharpoons 4\text{NO} + 6\text{H}_2\text{O}$   
(ii)  $2\text{H}_2\text{O}_2 \rightleftharpoons 2\text{H}_2\text{O} + \text{O}_2$   
(iii)  $\text{PCl}_3 + 3\text{NH}_3 \rightleftharpoons 3\text{HCl} + \text{P}(\text{NH}_2)_3$ .
- 7(b) Consider this equilibrium process: 16  
 $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$        $\Delta H^\circ = 92.5 \text{ kJ/mol}$   
Predict the direction of the shift in equilibrium when  
(i) The temperature is raised  
(ii) More Cl<sub>2</sub> gas is added to the reaction mixture  
(iii) Some PCl<sub>3</sub> is removed from the mixture  
(iv) The pressure on the gas is increased.
- 7(c) For the reaction 07  
 $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$   
K<sub>P</sub> is  $4.3 \times 10^{-4}$  at 375°C. Calculate K<sub>C</sub> for the reaction.
- 8(a) Consider the first-order reaction 12  
 $\text{A} \rightarrow \text{product}$   
(i) Derive the rate law for the reaction.  
(ii) Plot the rate of the reaction vs [A].  
(iii) Plot  $\ln[A]_0$  vs  $t$ .
- 8(b) Draw the potential energy profiles for 08  
(i) Exothermic reaction  
(ii) Endothermic reaction.
- 8(c) How can you calculate activation energy of a chemical reaction? 08
- 8(d) The decomposition of ethane to methyl radicals is a first-order reaction with a rate constant of  $5.6 \times 10^{-4} \text{ S}^{-1}$  at 700°C. Calculate the half-life of the reaction. 07

**KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY**

Department of Mechatronics Engineering

B. Sc. Engineering 1st Year 1st Term Examination, 2021

EEE 1131

(Electrical Circuits)

Time: 3 Hours

Total Marks: 210

**N.B.:** i) Answer any THREE questions from each section in separate scripts.

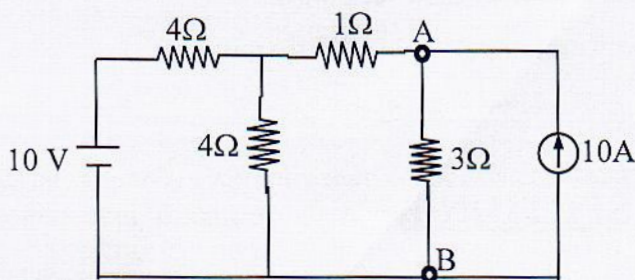
ii) Figures in the right margin indicate full marks.

iii) Assume reasonable data if any missing.

**SECTION-A**

1(a) State and explain Kirchhoff's voltage and current law with appropriate example. 10

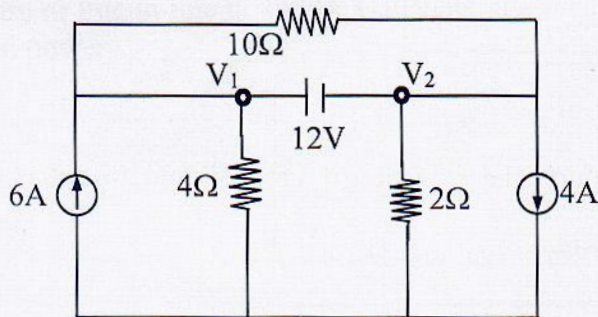
1(b) State the conditions for applying superposition theorem to a circuit. Use the theorem to find current through  $3\Omega$  resistor of the terminal AB shown in the figure. 12



1(c) Why star – delta conversion is necessary? Express the resistance of a delta network to star network. 13

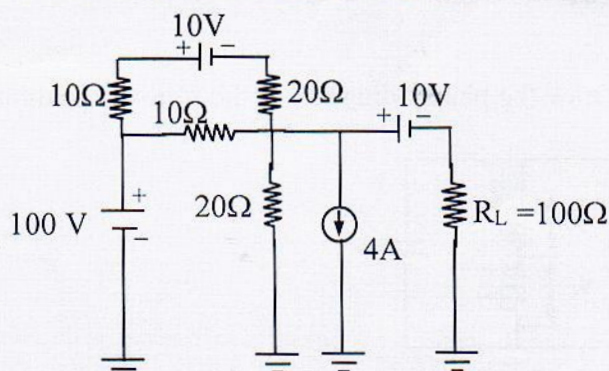
2(a) Define node, supernode and linear bilateral element. 10

2(b) Use nodal analysis to find the value of  $V_1$  and  $V_2$  as shown in the figure given below. 17



2(c) An electrical heater takes 1 kW from main supply with certain voltage. If the voltage is increased by 20%, the current through the heater is 8 Amp. (i) What was the original voltage? (ii) What is the resistance of the coil? 08

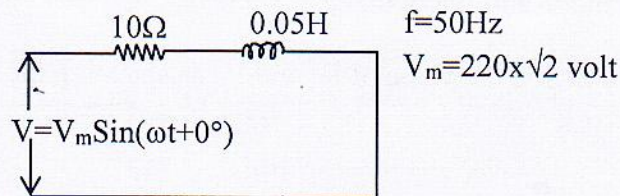
3(a) Determine the Thevenin equivalent circuit, for the circuit shown in the figure. 20



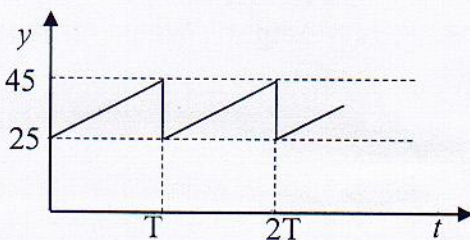
- 3(b) Define the following terms: 08  
 (i) Magnetic flux intensity, (ii) Ampere's circuital law.
- 3(c) Mention and explain the analogous parameters between electrical and magnetic circuits. 07
- 4(a) Classify and explain the losses in magnetic circuit. Mention the process for loss reduction in magnetic circuit. 10
- 4(b) A magnetic circuit with a uniform cross-sectional area of  $6 \text{ cm}^2$  consists of a steel ring with a mean magnetic length of  $80 \text{ cm}$  and an air gap of  $2 \text{ mm}$ . The magnetizing winding has  $540$  ampere-turns. Estimate the magnetic flux produced in the gap. The relevant points on the magnetization curve of cast steel are: 15
- |                         |      |      |      |      |      |
|-------------------------|------|------|------|------|------|
| B ( $\text{Wb/m}^2$ ) : | 0.12 | 0.14 | 0.16 | 0.18 | 0.20 |
| H (AT/m) :              | 200  | 230  | 260  | 290  | 320. |
- 4(c) Define protective relay. Explain the working principle of a trip circuit. 10

### SECTION-B

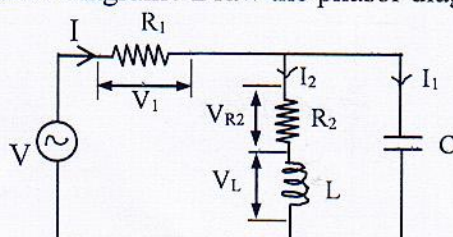
- 5(a) Define impedance. Derive the equation of impedance of RL branch. Show graphical representation of voltages, current and power variation in that branch. 15
- 5(b) Determine the total impedance, reactive voltamper of the RL series circuit shown in figure. Also sketch the  $v$  and  $i$  in rectangular domain. 10



- 5(c) Using the phasor approach, determine the current  $i(t)$  in a circuit described by the integrodifferential equation 10  
 $4i + 8 \int i dt - 3 \frac{di}{dt} = 50 \cos(2t + 75^\circ)$ .
- 6(a) What is the significance of rms and average value of a wave? Determine the rms and average value of the waveform shown in figure. 12

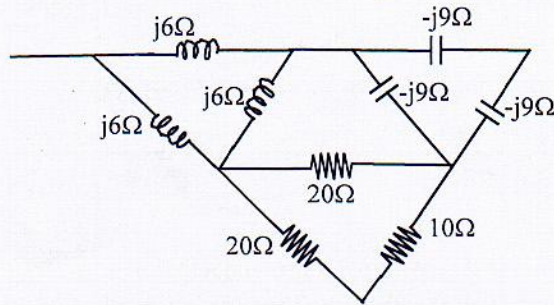


- 6(b) What is phasor diagram? Draw the phasor diagram of the following circuit. 10



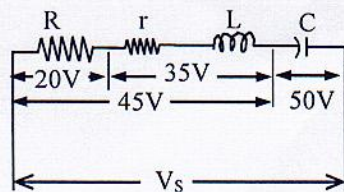
6(c) Calculate the value of  $Z_{ab}$  in the following network.

13



7(a) What is phase shifter circuit? Design an RC circuit to provide a phase shift of  $90^\circ$  leading. 08

7(b) In the circuit shown in figure  $C = 25.2 \mu\text{F}$ . When supplied from an AC source, it takes  $0.4\text{A}$ . If the voltage across different points are as shown in figure, find (i) the values of  $r$  and  $L$ , (ii) applied voltage, and its frequency, (iii) power factor of the circuit and active power. 14

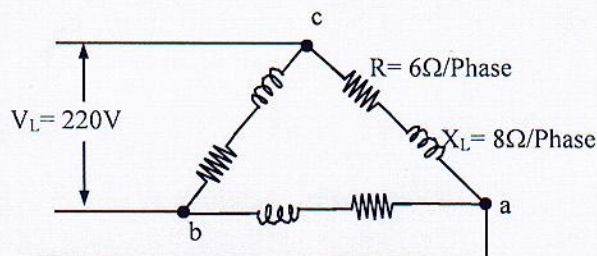


7(c) Explain the two wattmeter method of power measurement of a balanced 3 phase load with proper vector diagram. 13

8(a) Define power factor. Why low power factor is never desired by the generation and transmission companies? 10

8(b) Show that the line to line voltage in wye network is  $\sqrt{3}$  times of the phase voltage, however the line current is  $\sqrt{3}$  times of the phase current in delta network. Also draw the vector diagram. 18

8(c) The balanced  $3\phi$  load has  $R = 6\Omega$ ,  $X = 8\Omega$  per phase. The rms value of supply voltage per phase or line to line is  $220\text{V}$ . Calculate phase current, line current, power per phase and total power. 07



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**KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY**

Department of Mechatronics Engineering

B. Sc. Engineering 1st Year 1st Term Examination, 2021

Hum 1131

(Sociology and Engineering Ethics)

Time: 3 Hours

Total Marks: 210

**N.B.:** i) Answer any THREE questions from each section in separate scripts.

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iii) Assume reasonable data if any missing.

**SECTION-A**

- 1(a) What is meant by sociology? Is Sociology knowledge make you better Engineer? – Explain it. 10
- 1(b) How did Industrial revolution inspire for the development of sociology? – Explain. 15
- 1(c) Whose contribution is deemed to be the most influential for the development of sociology? 10
- 2(a) “Society as a web of social relationship” – Critically evaluate this idea of MacIver. 10
- 2(b) Which factors differentiate community from society? 10
- 2(c) Find out the major forms of social stratification. 15
- 3(a) How does cultural lag create social problems? 10
- 3(b) What are the factors responsible for cultural change in Bangladesh? 15
- 3(c) What do you think about the “Ethnocentrism”? Why is cultural relativism important? 10
- 4(a) What is meant by Institution? Explain the statement “religion as a social institution”. 10
- 4(b) Elucidate the various types of crime with example. 10
- 4(c) How does globalization influence our family structure? 15

**SECTION-B**

- 5(a) Define Engineering Ethics. How does ethics influence engineering profession? 15
- 5(b) What is the fundamental moral concept in ethics – the right or the good? Explain. 10
- 5(c) Can “Ethics” enrich your mentality? Why it is important for engineering students? 10
- 6(a) Where and how does professional ethics fit in Engineering? As engineering profession should take care of public safety welfare and health – describe it elaborately. 15
- 6(b) Discuss utilitarianism as a moral end – explain. 10
- 6(c) Critically examine the moral ideal of the “greatest happiness of the greatest number”. 10

- |      |   |    |
|------|---|----|
| 7(a) | What are the core ethical values of engineering? Show the differences between morality and ethics.  | 15 |
| 7(b) | What are the roles of code of ethics? Write down the IEEE fundamental codes of ethics with brief explanation.   | 20 |
| 8(a) | How does globalization influence Engineering ethics?  | 10 |
| 8(b) | Explain the three approaches of respect for persons.  | 10 |
| 8(c) | Differentiate among the rights, duties and responsibilities? As an engineer, what is your responsibilities to your society. Describe with engineering viewpoints. | 15 |

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 1st Year 1st Term Examination, 2021

Math 1131

(Calculus and Geometry)

Time: 3 Hours

Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.

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SECTION-A

- 1(a) Define explicit function and implicit function with example. A function  $f(x)$  is defined as follows: 13
- $$f(x) = \begin{cases} 5x - 4; & \text{for } 0 < x \leq 1 \\ 4x^2 - 3x; & \text{for } 1 < x < 2 \\ 3x + 4; & \text{for } x > 2. \end{cases}$$
- 1(b) Find  $\frac{dy}{dx}$  when  $(\tan x)^y + y^{\cot x} = 0$ . 10
- 1(c) Define maximum value of a function at a point. Find the extreme value of  $xy$  subject to the condition  $3x + 4y = 5$ . 12
- 2(a) State Rolle's theorem. Is the Rolle's theorem applicable for the function  $f(x) = \frac{4}{3+|x|}$  in the interval  $-1 \leq x \leq 1$ ? Justify your answer. 13
- 2(b) State Euler theorem on homogeneous function and verify it for the function  $f(xy) = y^3 \ln(x/y)$ . 12
- 2(c) Differentiate  $\tan^{-1}\left(\frac{\sqrt{1+x^2}-1}{x}\right)$  with respect to  $\cos^{-1}\left(\frac{1-x^2}{1+x^2}\right)$ . 10
- 3(a) If exist, find the inflection point for the function  $f(x) = 3x^3 - 3x^2 - 5x + 10$ . 10
- 3(b) If  $u = x^2 f(y/x, z/x)$ , then prove that  $x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} + z \frac{\partial u}{\partial z} = 2u$ . 12
- 3(c) Find the asymptotes of the curve  $(y-x)^2 x - 3y(y-x) + 2x = 0$ . 13
- 4(a) Find the equation of tangent and normal to the curve  $xy^2 = 4(4-x)$  at the point when it is cut by the line  $y = x$ . 12
- 4(b) Find the radius of curvature and center of curvature of the curve  $x^2 + 4y^2 = 25$  at the point  $(1, -1)$ . 13
- 4(c) Expand  $\ln(\sin x)$  in the powers of  $(x - 3)$ . 10



## SECTION-B

- 5(a) Find the spherical polar and cylindrical polar coordinates for the point  $(1, -3, -2)$ . 10
- 5(b) Define direction cosine and direction ratio of a line. A line makes angle  $\alpha, \beta, \gamma, \delta$  with four diagonals of a cube, then prove that  $\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma + \cos^2 \delta = \frac{4}{3}$ . 15
- 5(c) If two lines whose direction cosines are connected by the two relations  $al + bm + cn = 0$  and  $ul^2 + vm^2 + wn^2 = 0$ . Find the condition that they are parallel. 10

- 6(a) Find the equation of the planes through  $(0, 4, -3), (6, -4, 3)$  and which cuts off from the axes intersects whose sum is zero. 12
- 6(b) Find the condition that the line  $\frac{x-x_1}{l} = \frac{y-y_1}{m} = \frac{z-z_1}{n}$  may lie on a plane  $ax + by + cz + d = 0$ . 10
- 6(c) Find the equation of the plane perpendicular to each of the planes  $x - 4y + z = 0$  and  $3x + 4y + z = 2$  and at a distance unity from the origin. 13

- 7(a) Find the length and equation of the shortest distance between the lines  $\frac{x-1}{2} = \frac{y-2}{3} = \frac{z-3}{4}$  and  $\frac{x-2}{3} = \frac{y-4}{4} = \frac{z-5}{5}$ . 15

- 7(b) Find the distance of the plane  $7x + y + 2z = 16$  from the point  $(1, 1, -2)$  measured parallel to the line  $\frac{x}{3} = \frac{y}{2} = \frac{z}{-4}$ . 10

- 7(c) Evaluate  $\lim_{n \rightarrow \infty} \left[ \frac{1}{1+3n^2} + \frac{2}{2^2+3n^2} + \frac{3}{3^2+3n^2} + \dots + \frac{1}{4n} \right]$ . 10

- 8 Evaluate the following (any three) 35

(a)  $\int_0^{\pi/2} \sin x \sin 2x \, dx$ ,                      (b)  $\int_0^1 x \log(1 + 2x) \, dx$ ,

(c)  $\int_0^{\pi/2} \frac{dx}{5+4\cos x}$ ,                      (d)  $\int_0^{\pi/2} \log(\sin x) \, dx$

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 1st Year 1st Term Examination, 2021

MTE 1101

(Mechatronic Systems)

Time: 3 Hours

Total Marks: 210

**N.B.:** i) Answer any THREE questions from each section in separate scripts.

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**SECTION-A**

- 1(a) What is Mechatronics Engineering? How can a mechatronics engineer contribute to the fourth industrial revolution? – Explain. 10
- 1(b) List the key elements of a mechatronics system. What are the major advantages of mechatronic design approach over conventional approach? 15
- 1(c) Write short notes on: 10  
(i) Sensitivity; (ii) Reproducibility; (iii) Dead zone; (iv) Hysteresis; (v) Loading effect.
- 2(a) Define smart sensor. Write down the key differences between sensor and transducer. 07
- 2(b) Suppose you are designing a clean room monitoring device. In this purpose, you need to select a pressure sensor, on what basis you would select this sensor? 10
- 2(c) ‘A metal detector is a proximity sensor’, Justify your answer. 10
- 2(d) Write short notes on: (i) Dead time; (ii) Rise time; (iii) Non-linearity error, (iv) Limiting error. 08
- 3(a) Draw the block diagram of data acquisition system. Discuss the procedure of analog to digital data conversion. 13
- 3(b) In a Wheatstone bridge, a strain gauge is used as a Quarter Bridge. Derive the relation between the gauge factor and the change in output voltage when the bridge is unbalanced. 12
- 3(c) The output of a LVDT is connected to a 4V voltmeter through an amplifier whose amplification factor is 500. An output of 1.8 mV appears across the terminals of LVDT when the core moves through a distance 0.6 mm. If the millivoltmeter scale has 100 divisions and the scale can be read to  $\frac{1}{4}$  of a division, calculate: 10  
(i) The sensitivity of LVDT.  
(ii) The resolution of the instrument in mm.
- 4(a) Define actuator. Discuss a system that can control level of a liquid in a container by controlling the rate at which liquid enters it. 15
- 4(b) Write down the physical significance of CMRR. Design a circuit which acts like a differentiator with the help of Op-amp. 10
- 4(c) A single strain gauge having a resistance of  $120\Omega$  is mounted on a steel cantilever beam at a distance of 0.15m from the free end. An unknown force F applied at the free end produces a deflection of 12.7 mm of the free end. The change in gauge resistance is found to be  $0.152\Omega$ . The beam is 0.25m long and has a width of 20 mm. The Young Modulus for steel is  $200 \text{ GN/m}^2$ . Calculate the gauge factor. 10

## SECTION-B

- 5(a) What are the properties that make a system linear? Applying those properties, find out whether the system described by the following equation is linear or nonlinear. 12

$$y(t) \frac{dy}{dt} + 3y(t) = x(t)$$

- 5(b) Why are linearized system models important? The rate of flow of liquid  $q$  through an orifice is given by 11

$$q = C_d A \sqrt{\frac{2(P_1 - P_2)}{\rho}}$$

where,  $C_d$ ,  $A$ ,  $\rho$  and  $(P_1 - P_2)$  are discharge coefficient, cross-sectional area, fluid density and pressure difference respectively. Now linearize the above system equation for an operating point  $P = P_{o1} - P_{o2}$  when all possible variables can change.

- 5(c) For a rack-and-pinion system, the rotational motion of the pinion is transformed into the translational motion of the rack – Justify the statement by deriving the system equation. 12

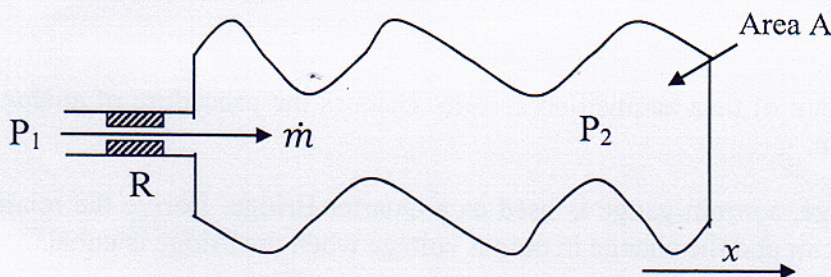
- 6(a) The following equation characterizes the dynamic response of a temperature measuring instrument: 08

$$\frac{dI_o}{dt} = C(I_i - I_o)$$

where,  $I_o$  = Indicated temp.,  $I_i$  = Input temp.

- (i) Determine the transfer operator form of the equation.
- (ii) Determine the order of the system.

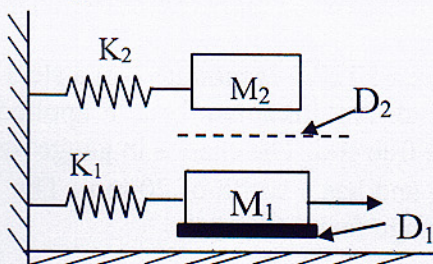
- 6(b) Find out the mathematical model for the system shown in figure that describes how the displacement  $x$  of the system changes with time when there is an input of a pressure  $P_1$ . Consider that the flow rate changes only slowly. 12



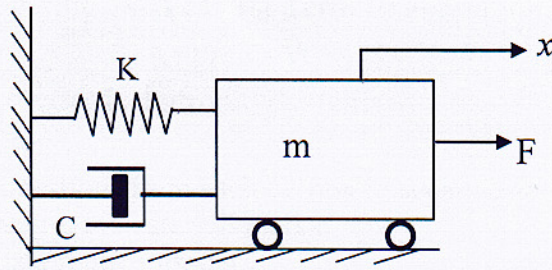
- 6(c) A series RLC circuit with  $R = 100\Omega$ ,  $L = 2.0\text{H}$ , and  $C = 20\mu\text{F}$  has a current  $i$  which varies with time when subject to a step input of  $V$ . Find out (i) the system differential equation, (ii) the undamped angular frequency, (iii) the damping factor, (iv) the damped angular frequency, and (v) the solution of the system equation if  $i = 0$  when  $t = 0$  and  $di/dt = 0$  when  $t = 0$ . 15

- 7(a) Define control system. Describe open loop and closed loop control system block diagram with example. 10

- 7(b) Draw the  $f-i$  analogous electrical circuit for the following system 13



- 7(c) For the system shown in figure, briefly explain each building block with its force and energy (or power) equations. Also, find out the state-space model of the system. 12



- 8(a) What do you mean by smart actuators? Describe the benefits and applications of smart actuators. 08
- 8(b) What is fluid power actuator? Explain the operation of basic components involved to derive the actuator in a hydraulic system with necessary schematic representation. 12
- 8(c) Why are stepper motors used in a robotic arm? Describe the construction and working principle of different types of stepper motors that ensure precise movement control. 15

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