

TE sem Vth mechanical R-19 scheme

Time: 3 Hours

Total Marks: 80

N.B.

1. Question No. 1 is compulsory
2. Answer any three questions from remaining questions
3. Assume suitable data if required
4. Figure to the right indicates full marks.

Q 1 Solve any four

[20]

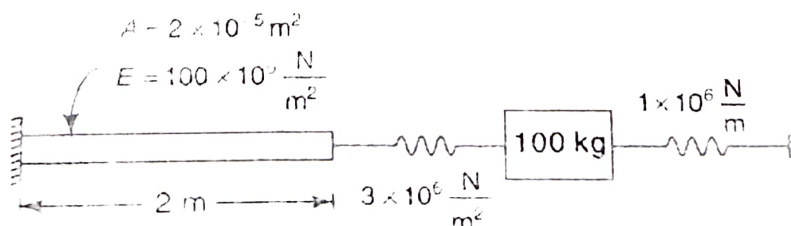
1. State the different type of governors. Explain construction and working of centrifugal Governor.
2. Explain two mass dynamical equivalent systems.
3. Explain Static and Dynamic Balancing
4. Compare Viscous and Coulomb damping.
5. Classify vibration measuring instruments? Explain anyone.

Q 2 A) A porter governor has equal mass each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 kg and the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150 mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find the range of speed, sleeve lift, governor effort and power of the governor in the following cases: [10]

- (i) When friction at sleeve is neglected?
- (ii) When friction at sleeve is equal to 10 N?

Q2 B) The connecting rod of a gasoline engine is 300 mm long between its centres. It has a mass of 15 kg and mass of inertia of 7000 kg-mm². Its centre of gravity is at 200 mm from its small end centre. Determine the dynamical equivalent two-mass system of the connecting rod if one of the masses is located at the small end centre [10]

Q 3 A) Determine the natural frequency for the given system as shown in Fig below [10]



Q3 B) Derive the equation for critical speed of a light shaft with a single disk without damping [10]

Q 4 A) A Vibrometer has a period of free vibration of 2 sec. It is attached to a machine with a vertical harmonic frequency of 1 Hz. If the Vibrometer mass has an amplitude of 3 mm relative to the vibrometer frame, what is the amplitude of vibration of machine? [10]

Q 4 B) A seismic instrument with natural frequency of 6Hz is used to measure vibration of machine running at 125 rpm. The instrument gives reading for relative displacement of mass as 0.05mm. Determine amplitude of displacement, velocity and acceleration of vibrating machine. Neglected damping. [10]

Q 5 A) A,B,C,D are four masses carried by a rotating shaft at radii 100mm,125mm, 200mm, and 150mm respectively. The planes in which masses revolve are spaced 600 mm apart and mass of B,C,D are 10kg, 5kg, 4kg respectively. Find the required mass and angular position of mass A in order to have complete balance. [10]

Q 5 B) The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 r.p.m. clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship: [10]

1. When the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h.
2. When the ship is pitching in a simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 40 seconds and the total angular displacement between the two extreme positions of pitching is 12 degrees.

Q 6 A) In Hartnell governor, the lengths of ball and sleeve arms of bell crank lever are 120 mm and 100 mm respectively. The distance of the fulcrum of the bell crank lever from the governor axis is 140 mm. Each governor ball has a mass of 4 kg. The governor runs at a mean speed of 300 rpm with the ball arms vertical and sleeve arms horizontal. For an increase of speed of 4%, the sleeve moves 10 mm upwards. Neglecting friction, Find [10]

- (i) The minimum equilibrium speed if the total sleeve movement is limited to 20 mm.
- (ii) Spring stiffness.
- (iii) The sensitiveness of the governor

Q 6 B) A vertical double acting steam engine has a cylinder 300 mm diameter and 450 mm stroke and runs at 200 r.p.m. The reciprocating parts have a mass of 225 kg and the piston rod is 50 mm diameter. The connecting rod is 1.2 m long. When the crank has turned through 125° from the top dead centre, the steam pressure above the piston is 30 kN/m^2 and below the piston is 1.5 kN/m^2 . Calculate the effective turning moment on the crank shaft. [10]

TE Sem V

Mechanical R-19 scheme

[Time: 03 Hours]

[Total Marks: 80

Note :

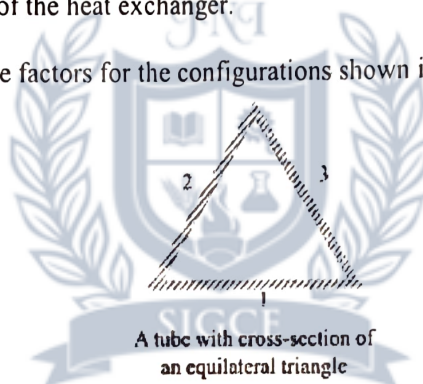
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- Figure to the right indicates full marks.
- Assume suitable data wherever required, but justify the same.

- | | | Marks |
|------|--|-------|
| Q. 1 | Solve ANY FOUR questions from following. (Each question carries 5 marks) | 20 |
| | a) State and explain Fourier's law of conduction.
b) Discuss the relation between thermal boundary layer and hydrodynamic boundary layer with respect to variation in Prandtl number.
c) Explain the concept of critical radius of insulation with reference to a cylinder.
d) Define overall heat transfer coefficient and explain its significance.
e) Explain knocking in SI engines and methods to suppress it.
f) Explain the term Volumetric Efficiency in internal combustion engines. | |
| Q. 2 | a) During the trial of a single-cylinder, four-stroke oil engine, the following results were obtained.
Cylinder diameter = 20 cm
Stroke = 40 cm
Mean effective pressure = 6 bar
Torque = 407 Nm
Speed = 250 rpm
Oil consumption = 4 kg/h
Calorific value of fuel = 43 MJ/kg
Cooling water flow rate = 4.5 kg/min
Air used per kg of fuel = 30 kg
Rise in cooling water temperature = 45°C
Temperature of exhaust gases = 420°C
Room temperature = 20°C
Mean specific heat of exhaust gas = 1 kJ/kg K
Specific heat of water = 4.18 kJ/kg K
Find the ip, bp and draw up a heat balance sheet for the test in kJ/h. | 8 |
| | b) A wall of a furnace is made up of inside layer of silica brick 120 mm thick covered with a layer of magnesite brick 240 mm thick. The temperatures at the inside surface of silica brick wall and outside surface of magnesite brick wall are 725°C and 110°C respectively. The contact thermal resistance between the two walls at the interface is 0.0035°C/W per unit wall area. If thermal conductivities of silica and magnesite bricks are 1.7 W/m°C and 5.8 W/m°C, calculate
(i) The rate of heat loss per unit area of walls, and
(ii) The temperature drop at the interface. | 12 |
| Q. 3 | a) Air at atmospheric pressure and 40°C flows with a velocity of $U = 5$ m/s over a 2 m long flat plate whose surface is kept at a uniform temperature of 120°C. Determine the average heat transfer coefficient over the 2 m length of the plate. Also find out the rate of heat transfer between the plate and the air per 1 m width of the plate. [The thermo-physical properties of air at 1 atm. and 80°C are $\nu = 2.107 \times 10^{-5}$ m ² /s, $k = 0.03025$ W/mK; $Pr = 0.6965$]. Use the following correlation: | 8 |
| | $\overline{Nu} = 0.664 (Re_L)^{1/2} (Pr)^{1/3}$ | |

- b) The air flow to a four cylinder, four-stroke oil engine is measured by means of a 5 cm diameter orifice having a coefficient of discharge of 0.6. During a test on the engine the following data were recorded : bore = 10 cm; stroke = 12 cm; speed = 1200 rpm; brake torque = 120 Nm; fuel consumption = 5 kg/h; calorific value of fuel = 42 MJ/kg; pressure drop across orifice is 4.6 cm of water; ambient temperature and pressure are 17 °C and 1 bar respectively. Calculate
- the thermal efficiency on brake power basis;
 - the brake mean effective pressure and
 - the volumetric efficiency based on free air condition.

- Q. 4 a) The temperature of an air stream flowing with a velocity of 3 m/s is measured by a copper-constantan thermocouple which may be approximated as a sphere of 2.5 mm in diameter. Initially the junction and air are at a temperature of 25°C. The air temperature suddenly changes to and is maintained at 215°C. Determine the time required for the thermocouple to indicate a temperature of 165°C. The thermal junction properties are: $\rho = 8750 \text{ kg/m}^3$, $c = 380 \text{ J/kg}^\circ\text{C}$, k (thermocouple) = 28 W/m°C and $h = 145 \text{ W/m}^2^\circ\text{C}$.
- b) The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperatures on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficients on both sides are 650 W/m² °C, calculate the area of the heat exchanger.

- Q. 5 a) Calculate the shape factors for the configurations shown in the Fig. 5



- b) Explain Willan's line method for measurement of frictional power. 5
- c) Illustrate the variation of temperature of hot fluid and cold fluid from inlet to outlet in case of a parallel flow heat exchanger and counter flow heat exchanger. 5
- d) Differentiate between the efficiency and effectiveness of an extended surface. 5
- Q. 6 a) Explain Nucleate boiling and Film boiling. 5
- b) Why is short ignition delay favourable for CI engines whereas it is undesirable for an SI engine? 5
- c) State and explain Fick's Law of diffusion. 5
- d) Explain different types of emission control norms implemented in order to control the air pollution due to IC engines. 5

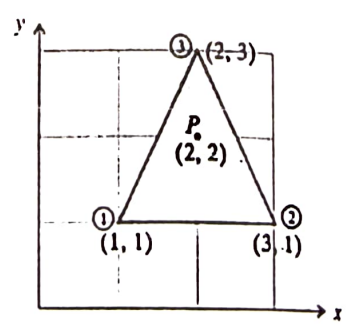
TEI sem 5th / R-19. C-scheme / Mechanical

Time: 3 Hours

Marks: 80

- Question No.1 is compulsory.
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	Marks
Q.1 Solve ANY FOUR questions from following. (Each question carries 5 marks)	20
a) Differentiate between Essential and Natural boundary conditions with suitable examples.	5
b) Summarize the properties of shape functions.	5
c) Explain lumped mass matrix, consistent mass matrix and HRZ lumping scheme with suitable examples.	5
d) Distinguish between h and p methods of mesh refinement with necessary illustrations.	5
e) Describe the significance of principle of minimum potential energy.	5
Q.2 a) Solve the following differential equation by Galerkin method and Sub-domain method for $y(0.5)$.	15
$\frac{d^2y}{dx^2} + y - 2 = 0; \quad 0 \leq x \leq 1$ $\text{BCS; } y(0) = y(1) = 0$	
b) Derive shape functions for linear bar element in local coordinates and show the variations over element domain.	5
Q.3 a) For the triangular element shown in figure, the nodal values of displacement are :	10
$u_1 = 2.0, u_2 = 3.0, u_3 = 5.0$ $v_1 = 1.0, v_2 = 2.0, v_3 = 3.0$	
Determine the displacement (i.e. u, v) of point P (2, 2) within the element.	



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- b) Solve the following differential equation by Rayleigh Ritz method. 10

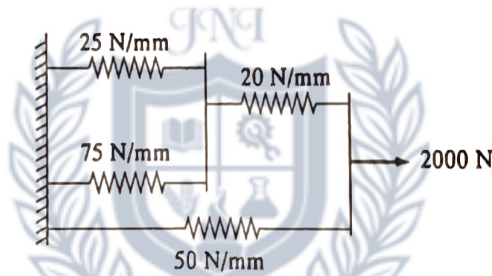
$$\frac{d^2y}{dx^2} - 10x^2 = 5 ; \quad 0 \leq x \leq 1$$

Given Boundary Conditions are: $y(0) = y(1) = 0$

- Q. 4 a) For a uniform cross-section bar of length $L = 1$ m made up of a material having $E = 2 \times 10^{11}$ N/m² and $\rho = 7800$ kg/m³, estimate the natural frequencies of axial vibrations of the bar using both consistent and lumped mass matrices. Use a two element mesh. If the exact solution is given by the relation. 10

$$\omega_i = \frac{i\pi}{2L} \sqrt{\frac{E}{\rho}} ; \quad i = 1, 3, 5, \dots \dots \dots \infty. \text{ Compare your answer and give your comments. } A = 30 \times 10^{-6} \text{ m}^2.$$

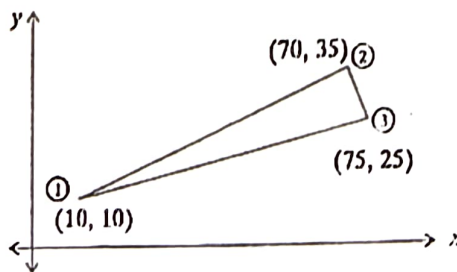
- b) Figure shows a cluster of four springs. Calculate deflections of each spring when a force of 2000 N is applied. Model the springs as 1-D element. 10



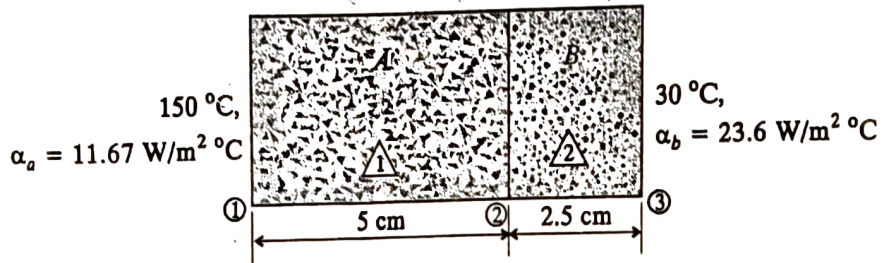
- Q. 5 a) The CST element has nodal coordinates (10, 10), (70, 35) and (75, 25) for node 1, node 2 and node 3 respectively. The element is 2 mm thick and is of material with properties $E = 70$ GPa. Poisson's ratio is 0.3. Upon loading of model the nodal deflections were found to be $u_1 = 0.01$ mm, $v_1 = -0.04$ mm, $u_2 = 0.03$ mm, $v_2 = 0.02$ mm, $u_3 = -0.02$ mm and $v_3 = -0.04$ mm. 10

Determine: -

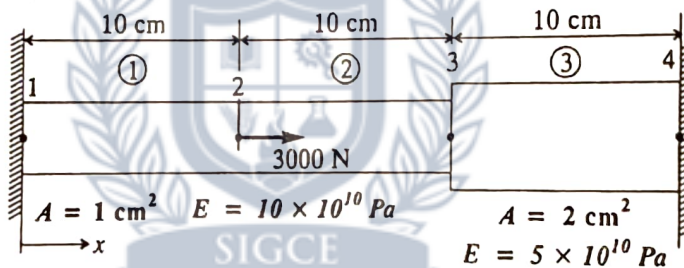
- i) The Jacobian for (x-y) - ($\xi - \eta$) transformation.
- ii) The Strain displacement relation matrix.



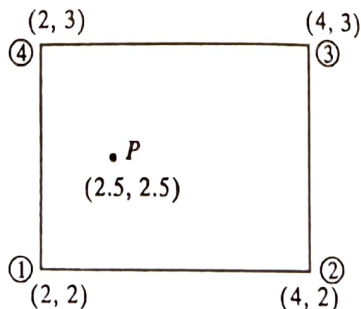
- b) Consider a plain composite wall which is made of two materials of thermal conductivity $k_a = 204 \text{ W/m } ^\circ\text{C}$ and $k_b = 46 \text{ W/m } ^\circ\text{C}$ and thickness $h_a = 5 \text{ cm}$ and $h_b = 2.5 \text{ cm}$. Material A adjoins a hot fluid at $150 \text{ }^\circ\text{C}$ for which heat transfer coefficient $\alpha_a = 11.67 \text{ W/m}^2 \text{ }^\circ\text{C}$ and the material B is in contact with a cold fluid at $30 \text{ }^\circ\text{C}$ and heat transfer coefficient $\alpha_b = 23.6 \text{ W/m}^2 \text{ }^\circ\text{C}$. Calculate rate of heat transfer through the wall and the temperature at the interface. The wall is 2 m high and 2.5 m wide.



- Q. 6 a) Determine the unknown reactions and displacement for the arrangement of bars shown in figure.



- b) Coordinates of nodes of a quadrilateral element are as shown in the figure. Temperature distribution at each node is computed as $T_1 = 100^\circ\text{C}$, $T_2 = 60^\circ\text{C}$, $T_3 = 50^\circ\text{C}$ and $T_4 = 90^\circ\text{C}$. Calculate temperature at point P (2.5, 2.5). Use local co-ordinate system.



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TE sem IVth Mechanical R-19 CScheme

Time: 3 Hours

Total Marks: 80

- N.B: 1) Question No. 1 is *compulsory*.
 2) Attempt any **THREE** questions out of remaining **FIVE** questions.
 3) Assume suitable data wherever necessary.
 4) Use of Graph paper is allowed.
 5) Figures to the right indicate full marks.

1. Answer of the following questions (*any Four*).

(20)

- Differentiate between systematic errors and random errors.
- What are optical flats? How can optical flats be used for checking flatness?
- The dead zone of a certain pyrometer is 0.15% of the span. The calibration is 500°C to 859°C. What temperature change may occur before it is detected?
- What is RTD? How does it work?
- Define control system. What the requirements of a good control system?
- Using Routh's criterion examine the stability of a control system whose characteristic equation is $S^5 + S^4 + 2S^3 + 2S^2 + 3S + 15 = 0$

2. (A) Explain the 'Three Wire Method' used in screw thread measurement. (10)

(B) Draw the root locus and comment on the stability of the control system having open loop transfer function as follows: (10)

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

3. (A) Explain generalized measurement system elements with block diagram. Describe functions with suitable examples (10)

(B) With neat sketch, explain the constructional features and working of (10)

- Ultrasonic Flow Meter
- Parkinson's Gear Tester

4. (A) Describe with neat diagrams the construction and working principle of *Ionization and Thermal Conductivity gauges* for pressure measurement. (10)

(B) A unity feedback system has (10)

$$G(s) = \frac{100}{S^2(0.5S + 1)(S + 2)}$$

- Type of system
- Error constants K_p , K_v , K_a
- Find steady state error for unit parabolic input

5. (A) Design a general type of Go and No Go plug gauge for inspecting a hole $25 \text{ d}8$. Given (10)
that:

$$i = 0.40 D^{1/3} + 0.001D \text{ micron}$$

- a) Tolerance for hole = $25 i$
b) Fundamental deviation of hole = $16 D^{0.44}$
c) Wear allowance = 10% gauge tolerance

- (B) Define the terms a) Rise time, b) Peak time, c) Settling time d) Peak overshoot with (10)
respect to transient response of a system.

6. Write short note on (any Four) 20

- a) Optical Encoder
b) Magnetic Flow Meter
c) LVDT
d) Repeatability and Reproducibility
e) Strain Gauge based load cell
f) Frequency Domain Specifications



T.E Vth Sem (R-19-20 scheme) Mechanical

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Total Marks: 80

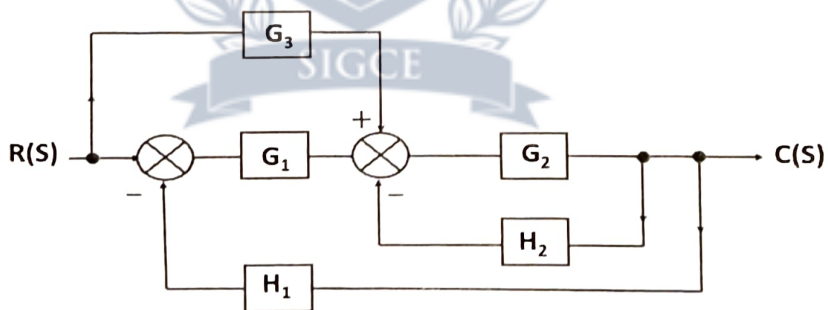
- N.B:
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 - 3) Assume suitable data wherever necessary.
 - 4) Use of Graph paper is allowed.
 - 5) Figures to the right indicate full marks.

1. Answer of the following questions (any Four). 20

- i) Define wavelength standard and state the significance of using it.
- ii) Explain different types of fits with suitable examples and sketches
- iii) Differentiate between roughness and waviness.
- iv) Define and explain i) Resolution; ii) Threshold; iii) Hysteresis
- v) Briefly explain the construction and working of a strain gauge load cell.
- vi) Using Routh's criterion examine the stability of a control system whose characteristic equation is $S^5 + S^4 + 2S^3 + 2S^2 + 3S + 15 = 0$

2. (A) Define Interferometry. Explain Laser Interferometer with neat sketch. 10

(B) Reduce the given block diagram to a it's canonical form and hence obtain equivalent transfer function, $\frac{C(s)}{R(s)}$. 10



3. (A) Explain generalized measurement system elements with block diagram. Describe functions with suitable examples. 10

(B) A unity feedback system has $G(s) = \frac{K}{s(2+s)(4+s)}$ 10

- a. If $r(t) = 2t$ and $K = 4$, find steady state error.
- b. If it is desired to have steady state error to be 0.4, find corresponding value of "K"
- c. Find steady state error if input is changed to $2+6t$, and value of K to 10.

4. (A) Explain principle, construction and working of *Parkinson Gear Tester* 10
 (B) Draw the root locus and comment on the stability of the control system having open loop transfer function as follows: 10

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

5. (A) What are encoders? With a neat sketch, explain the working of an incremental and absolute optical encoder. Give examples of their use. 10
 (B) Design a general type of Go and No Go plug gauge for inspecting a hole 25 d8. Given that: 10

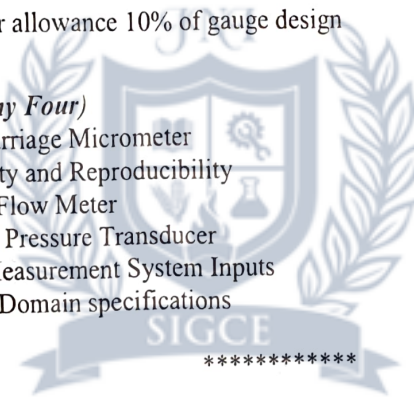
$$i = 0.40 D^{1/3} + 0.001D \text{ micron}$$

$$\text{Tolerance for hole} = 25 i$$

$$\text{Fundamental deviation of the hole} = 16 D^{0.44}$$

Wear allowance 10% of gauge design

6. Write short note on (*any Four*) 20
- i) Floating Carriage Micrometer
 - ii) Repeatability and Reproducibility
 - iii) Ultrasonic Flow Meter
 - iv) Capacitive Pressure Transducer
 - v) Types of Measurement System Inputs
 - vi) Frequency Domain specifications



TE Sem Vth Mechanical R-19 scheme

Time: 3 Hours

Marks: 80

Note :

- Question No.1 is compulsory.
- Solve ANY THREE questions from the remaining five questions.
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Q. 1 Solve ANY FOUR from the following.

- a) Show the formulation of a generalized transportation problem. (5)
- b) Show the conditions for the Positive definite, Positive semi-definite, Negative definite and Negative semi-definite functions. (5)
- c) Show the flowchart for the genetic algorithm. (5)
- d) Solve and decide the definiteness of the function
 $f(x) = -3x_1^2 + 2x_2^2 - 3x_3^2 - 10x_1x_2 + 4x_2x_3 + 6x_1x_3$ (5)
- e) Illustrate 'Design of Experiment'. (5)

Q. 2 a) Calculate maximum and minimum values of the function (10)

$$f(x) = 3x^4 - 4x^3 - 24x^2 + 48x + 15$$

b) Solve the following LPP by the simplex method. (10)

Minimize $7x_1 + 5x_2$
 S.T. $x_1 + x_2 \geq 4$
 $5x_1 + 2x_2 \geq 10$
 $x_1, x_2 \geq 0$

Q. 3 a) Solve using the Lagrange's multiplier method the following NLPP (10)

Optimize $Z = 6x_1^2 + 5x_2^2$
 S. T. $x_1 + 5x_2 = 7$
 $x_1, x_2 \geq 0$

b) List the non-traditional optimization techniques and explain any one in detail. (10)

Q. 4 a) A person has to select a house from given 3 alternatives he has with the details as given in the table. He considers 3 attributes of price, near to market and near to school with weights as 0.625, 0.125 and 0.25 respectively. Select the best alternative of house by SAW method. (10)

Alternative / Criteria	Price (Rs. Lakhs)	Near Market (km)	Near School (km)
House 1	100	1.5	2.75
House 2	140	1.0	3.5
House 3	80	1.7	3.0

b) Classify optimization problems in detail. (10)

- Q. 5 a) Apply Dynamic Programming to solve the following problem (10)
 Minimize $Z = x_1^2 + x_2^2 + x_3^2$
 S.T. $x_1 + x_2 + x_3 = 15$
 $x_1, x_2, x_3 \geq 0$

b) Describe the procedure of AHP method step wise in detail. (10)

- Q. 6 a) A company manufactures 2 products, radios and transistors, which must be processed through assembly & finishing departments. Assembly has 90 hours available, finishing can handle up to 72 hours of work. Manufacturing one radio requires 6 hours in assembly and 3 hours in finishing. Each transistor requires 3 hours in assembly and 6 hours in finishing. If profit is Rs. 120 per radio and Rs. 90 per transistor, determine the best combination of radios and transistors to realize profit of Rs. 2100. (10)

b) A sample of 100 arrivals of a customer at a retail sales depot is according to the following distribution. (10)

Time between arrivals (mins.)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Frequency	2	6	10	25	20	14	10	7	4	2

A study of the time required to service customer by adding up the bills, receiving payments and placing packages yields the following distribution.

Service time (mins.)	0.5	1.0	1.5	2.0	2.5	3.0
Frequency	12	21	36	19	7	5

Estimate the average of customer waiting time and average of idle time of the server by simulation for the next 10 arrivals.

Use random number for arrivals: 93, 22, 53, 64, 39, 07, 10, 63, 76, 35

Use random number for service: 78, 76, 58, 54, 74, 92, 38, 70, 96, 92

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TE sem V Mechanical R-19 C scheme

Time: 3 Hours

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 4) Use of Graph paper is allowed.
 5) Figures to the right indicate full marks.

1. Answer the following questions (*any Four*). (20)

- i) What is the relationship between sensitivity and range? What is the disadvantage of very sensitive instrument?
- ii) Differentiate between Primary, Secondary, Tertiary, Working standards.
- iii) Define interferometry. Explain why monochromatic light is used for interferometry and not the white light.
- iv) Illustrate the working principle of nozzle flapper for displacement measurement.
- v) Explain open loop and closed loop control systems.
- vi) Using Routh's criterion examine the stability of a control system whose characteristic equation is $S^8 + 5S^6 + 2S^4 + 3S^2 + 1 = 0$

2. (A) Explain the 'Three Wire Method' used in screw thread measurement. (10)

(B) Design a general type of Go and No Go gauges for component having 25 H/f₈ fit. (10)
 Given that:

$$i = 0.45\sqrt[3]{D} + 0.001D \text{ micron}$$

- a) The upper deviation for f shaft = $-5.5 D^{0.41}$
 - b) 25 mm falls in the diameter step of 18 and 30
 - c) Wear allowance = 10% gauge tolerance
3. (A) Describe with neat diagrams the construction and working principle of *Ionization and Thermal Conductivity gauges* for pressure measurement. (10)
- (B) Draw the root locus and comment on the stability of the control system having open loop transfer function as follows: (10)

$$G(s)H(s) = \frac{K}{S(S+1)(S+2)(S+3)}$$

4. (A) What are desired, modifying and interfering inputs? Explain with example. Also suggest the methods to minimize the effect of modifying and interfering inputs. (10)

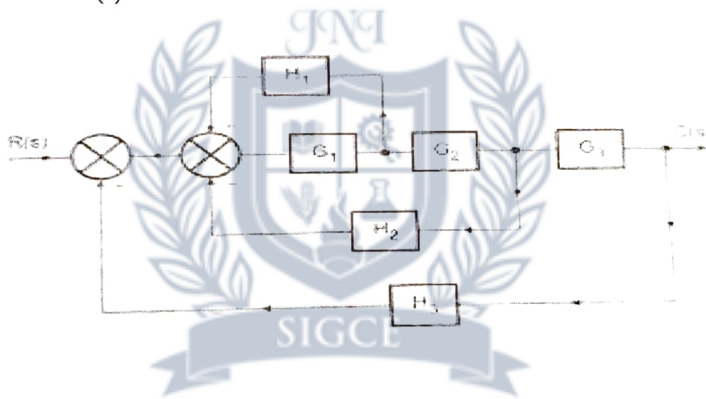
(B) A second order system is given by $\frac{C(s)}{R(s)} = \frac{25}{s^2 + 6s + 25}$ (10)

Find its rise time, peak time, peak overshoot and settling time to unit step input. Also find expression for its output response.

5. (A) With neat sketch, explain the constructional features and working of (10)

- i) LVDT
- i) Parkinson's Gear Tester

(B) Reduce the given block diagram to its canonical form and hence obtain equivalent transfer function, $\frac{C(s)}{R(s)}$. (10)



6. Write short note on (any Four) (20)

- i) Ultrasonic flow meter
- ii) Interference fit
- iii) Tomlinson surface tester
- iv) Frequency domain specifications
- v) Repeatability and Reproducibility
- vi) Strain gauge based load cells

TE sem II Mechanical R-19 e scheme

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Marks

Q. 1 Solve **ANY FOUR** questions from following. (Each question carries **5 marks**) **20**

- a) What is thermal diffusivity? How does thermal diffusivity influence transient heat conduction in solids?.
- b) Explain the following non dimensional numbers applied to heat transfer by convection:
 - (i) Nusselt Number
 - (ii) Prandtl Number
 - (iii) Grashoff Number
 Explain how the Prandtl number influences the relative thickness of the velocity and thermal boundary layer, also Show how the Grashof number acts as the equivalent of the Reynolds number in natural convection.
- c) A cylindrical wire carrying current is insulated to minimize heat loss. However, it is observed that after adding insulation, the wire's temperature increases. Explain this behavior and derive the condition for the critical radius of insulation.
- d) Explain Biot number and Fourier number applied to transient heat transfer, give significance.
- e) Define ignition lag and discuss how it affects engine knocking in SI and CI engines.
- f) Discuss the advantages and limitations of thermal and catalytic converters in automobile exhaust emission control systems.

- Q. 2 a) During a test on a single-cylinder, four-stroke diesel engine having a cylinder diameter of 22 cm and a stroke length of 45 cm, the following observations were made. The mean effective pressure recorded was 6.5 bar, the torque developed was 420 N·m, and the engine speed was 300 rpm. The fuel consumption during the trial was 4.2 kg per hour, and the calorific value of the fuel used was 42 MJ per kilogram. The cooling water was supplied at a rate of 5 kg per minute, and the air used per kilogram of fuel was 28 kg. The rise in temperature of the cooling water was observed to be 40°C, while the exhaust gases left the engine at a temperature of 410°C when the room temperature was 25°C. The mean specific heat of the exhaust gases was taken as 1.05 kJ/kg·K, and the specific heat of water was 4.18 kJ/kg·K.

From these data, determine the indicated power (I.P.) and brake power (B.P.) of the engine and prepare a complete heat balance sheet for the test on a kJ per hour and percentage basis.

- b) Composite insulation wall consists of three layers. These are held together by 2 cm diameter aluminium rivets per 0.1 m^2 of surface. The layers consist of 10 cm thick brick with hot surface at 190°C , 1 cm thick wood with cold surface at 20°C . These two layers are interposed by a third layer of insulating material 25 cm thick. 12

Assuming one dimensional heat flow, calculate the percentage increase in heat transfer rate due to rivets. The conductivity of materials are, $k_{\text{brick}} = 1 \text{ W/mk}$, $k_{\text{insulation}} = 0.2 \text{ W/mk}$, $k_{\text{wood}} = 0.2 \text{ W/mk}$, $k_{\text{Al}} = 220 \text{ W/mk}$.

- Q.3 a) A 6-cylinder 4-stroke C.I. engine develops 220 kW at 1500 r.p.m. with brake specific fuel consumption of 0.273 kg/kWh . Determine the size of the single hole injector nozzle if the injection pressure is 160 bar and the pressure in the combustion chamber is 40 bar. The period of injection is 30° of crank angle. Specific gravity of fuel = 0.85 and orifice discharge coefficient = 0.9. 8

A 4-cylinder, 4-stroke C.I. engine develops 180 kW at 2000 rpm with a brake specific fuel consumption (b.s.f.c.) of 0.26 kg/kWh .

Determine the size (diameter) of the single-hole injector nozzle if:

Injection pressure = 200 bar

Pressure in the combustion chamber = 60 bar

Period of injection = 25° of crank angle

Specific gravity of fuel = 0.84

Coefficient of discharge (C_d) = 0.88

Find:

1. Fuel flow rate per second
2. Fuel injected per cycle per cylinder
3. Injection duration (in seconds)
4. Orifice area and diameter of nozzle hole

- b) A flat plate measuring 0.8 m wide and 2 m long is to be maintained at a uniform surface temperature of 120°C , while air at 25°C flows over it in parallel direction. Determine the air velocity required such that the total rate of heat dissipation from both sides of the plate is 6 kW. 12

$$\overline{Nu} = \frac{\bar{h}L}{k} = 0.664(Re_L)^{1/2}(Pr)^{1/3} \quad \dots\dots\dots \text{for laminar flow}$$

$$\overline{Nu} = \frac{\bar{h}L}{k} = [0.036(Re_L)^{0.8} - 836](Pr)^{1/3} \quad \dots\dots\dots \text{for turbulent flow}$$

Take the following properties of air at 50°C : $\rho = 1.0877 \text{ kg/m}^3$, $k = 0.02813 \text{ W/m}^\circ\text{C}$, $c_p = 1007.3 \text{ J/kg}^\circ\text{C}$, $\mu = 2.029 \times 10^{-5} \text{ kg/ms}$ and $Pr = 0.7$

- Q.4 a) A rectangular fin, 8 mm thick and 60 mm long, is attached to a wall maintained at a uniform temperature of 150°C . The surrounding air temperature is 30°C . The fin material is brass with a thermal conductivity of $110 \text{ W/m}^\circ\text{C}$, and the convective heat transfer coefficient between the fin surface and air is $95 \text{ W/m}^2^\circ\text{C}$. 8

Assuming convective heat loss from the tip of the fin is significant, determine:

1. The temperature at the tip of the fin,
2. The total heat dissipated by the fin per metre width of the plate
3. The fin efficiency.

- b) In a counter-flow double-pipe heat exchanger, oil is used to heat water. Oil enters the exchanger at 120°C and leaves at 80°C , flowing at a rate of $25,000\text{ kg/h}$. The water enters at 40°C and is heated to about the same temperature as the outlet temperature of the oil, such that the log mean temperature difference (LMTD) approaches zero. Assume for $c_{p\text{ water}} = 4.2\text{ kJ/kg K}$, $c_{p\text{ oil}} = 2.1\text{ kJ/kg K}$. The overall heat transfer coefficient for the exchanger is $350\text{ W/m}^2\cdot\text{K}$. Determine: 12
1. The heat transfer rate (in kW).
 2. The required heat transfer area when the $\text{LMTD} \rightarrow 0$ (showing how the area tends to become extremely large).
 3. The effectiveness of the heat exchanger.
- Q. 5 a) The effective temperature of a body having an area of 0.12 m^2 is 527°C . Calculate the following: 5
- (i) The total rate of energy emission,
 - (ii) The intensity of normal radiation
- b) Explain Willan's line method for measurement of frictional power. 5
- c) Differentiate between the efficiency and effectiveness of an extended surface. 5
- d) Explain with sketches the temperature profiles for: 5
- (i) Boiler, (ii) Condenser, and (iii) Regenerative heat exchanger.
- Q. 6 a) What is the critical heat flux (CHF) or burnout point on a boiling curve? Discuss its physical significance and factors affecting it. 5
- b) A four-stroke, six-cylinder gas engine has a bore of 18 cm and a stroke of 32 cm , and runs at 250 rpm , firing every cycle. The air-fuel ratio is $5:1$ by volume, and the volumetric efficiency on the NTP basis is 78% . The temperature of the intake air is 30°C , and the intake pressure is 0.95 bar . 5
- (a) Determine the volume of gas consumed per minute under NTP conditions.
 - (b) If the calorific value of the gas is 9 MJ/m^3 at NTP and the brake thermal efficiency of the engine is 28% , calculate the brake power developed by the engine.
 - (c) If the mechanical efficiency of the engine is 80% , determine the indicated power and the indicated thermal efficiency.
- c) Explain the effects of engine variables (compression ratio, spark timing, mixture strength, and cooling) on knocking tendency. 5
- d) Explain the concept of mass transfer coefficient **and** its relationship with Fick's law. 5

TE sem V Mechanical R-19 Cscheme

Time: 3 Hours

Total Marks: 80

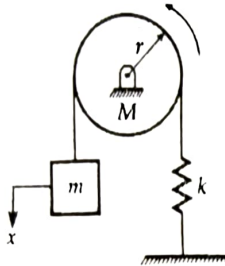
Instructions.

- i. Question No.1 is compulsory
- ii. Attempt any 3 out of the remaining questions
- iii. Use your judgement for unspecified data, if any but justify the assumption.
- iv. Numbers to the right indicate marks.

- Q1. Attempt any four of the following sub questions: (20)
- a. Explain the terms : Logarithmic decrement, Magnification factor. Also mention the significance of logarithmic decrement (5)
 - b. What do you mean by critical speed of a shaft, derive an expression for critical frequency for an undamped shaft. (5)
 - c. Why does gyroscopic couple occurs. Derrive an expression for Gyroscopic couple from first principle. (5)
 - d. Compare vibrometer and accelerometer on the basis of the following parameters: mass, natural frequency, practical applicability and error estimation. (5)
 - e. State the different types of governors. What is the difference between centrifugal and inertia type governors? (5)
- Q2.a A mass of 50 kg is suspended by a spring of stiffness 12 kN/m and acted on by a harmonic force of amplitude 40 N. The viscous damping coefficient is 100 N.s/m. Find : (10)
- (i) Resonant amplitude
 - (ii) Peak amplitude
 - (iii) Peak frequency
 - (iv) Resonant phase angle
 - (v) Peak phase angle
- Q2.b The mass of a turbine rotor of a ship is 8 tonnes and has a radius of gyration 0.6 m. It rotates at 1800 r.p.m. clockwise when looking from the stern. Determine the gyroscopic effects in the following cases: 1. If the ship travelling at 100 km/h steers to the left in a curve of 75 m radius, 2. If the ship is pitching and the bow is descending with maximum velocity. The pitching is simple harmonic, the periodic time being 20 seconds and the total angular movement between the extreme positions is 10° , and 3. If the ship is rolling and at a certain instant has an angular velocity of 0.03 rad/s clockwise when looking from stern. (10)
- Q3 a A vertical petrol engine 100 mm diameter and 120 mm stroke has a connecting rod 250 mm long. The mass of the piston is 1.1 Kg. The speed is 2000 r.p.m. On the expansion stroke with a crank 20° from top dead centre, the gas pressure is 700 KN/mm^2 . Determine net force on the piston, resultant load on the gudgeon pin, thrust on the cylinder wall, speed at which the gudgeon pin load would be reverse in direction. (10)
- Q3.b A vibratory system in a vehicle is to be designed with the following parameters: (10)
- $k = 100 \text{ N/m}$, $C=2 \text{ N-sec/m}$, $m=1\text{kg}$ Calculate the decrease of amplitude from its starting value after 3 complete oscillations and the frequency of oscillation.

Q4.a In a governor of the Hartnell type, the mass of each ball is 1.5 kg and the lengths of the vertical and horizontal arms of the bell crank lever are 100 mm and 50 mm respectively. The fulcrum of the bell crank lever is at a distance of 90 mm from the axis of rotation. The maximum and minimum radii of rotation of balls are 120 mm and 80 mm and the corresponding equilibrium speeds are 325 and 300 rpm. Find the stiffness of the spring and equilibrium speed when the radius of rotation is 100mm. (10)

Q4.b Find the natural frequency of the system shown in figure by no slip. (10)



Q5.a. A shaft carries four masses in parallel planes A, B, C and D in this order along its length. The masses at B and C are 18 kg and 12.5 kg respectively, and each has an eccentricity of 60 mm. The masses at A and D have an eccentricity of 80 mm. The angle between the masses at B and C is 100° and that between the masses at B and A is 190° , both being measured in the same direction. The axial distance between the planes A and B is 100 mm and that between B and C is 200 mm. If the shaft is in complete dynamic balance, determine:
1. The magnitude of the masses at A and D; 2. the distance between planes A and D; and 3. the angular position of the mass at D. (10)

Q5.b A machine of mass 1000 kg is acted upon by an external force of 3000 N at 1800 rpm. To reduce the effect of vibrations, isolators having static deflection of 2 mm under the machine weight and damping factor of 0.2 are used. Determine: (10)
(i) Amplitude of vibration of machine
(ii) Force transmitted to the foundation
(iii) Phase lag and
(iv) Phase angle between transmitted force and exciting force.

Q6.a Explain what do you mean by Dynamically Equivalent systems. State the conditions for systems to be dynamically equivalent. (6)

Q6.b Explain vibration-based condition monitoring and fault diagnosis in rotating machine (7)

Q6.c The natural frequency and the damping ratio of a vibrometer are 6 Hz and 0.22 respectively. What is the range of frequencies for the measurement error to be below 3%. (7)

TE sem V Mechanical R-19 Cscheme

(Time: 3 Hours)

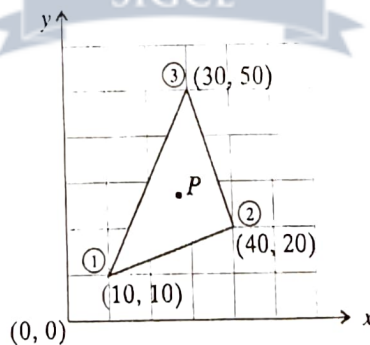
(Total marks: 80)

- N.B.:** 1) Question No. 1 is compulsory.
 2) Attempt any three questions out of the remaining five questions.
 3) Assume suitable data if required.

Q1 Attempt any four from the following.

- Explain the sources of errors in FEM. (5)
- Distinguish between plane stress and plane strain conditions along with the stress-strain relation matrices. (5)
- What do you mean by pre-processing, processing and post-processing with reference to FEM software package? (5)
- Explain p-method and h-method of mesh refinement with diagrams. (5)
- Explain different types of boundary conditions with suitable examples. (5)

- Q2 a) A triangular element has nodal coordinates (10, 10), (40, 20) and (30, 50) for nodes 1, 2 and 3 respectively. For the point P located inside the triangle, determine x and y coordinates if the shape functions, $\phi_1=0.15$ and $\phi_2=0.25$. (10)



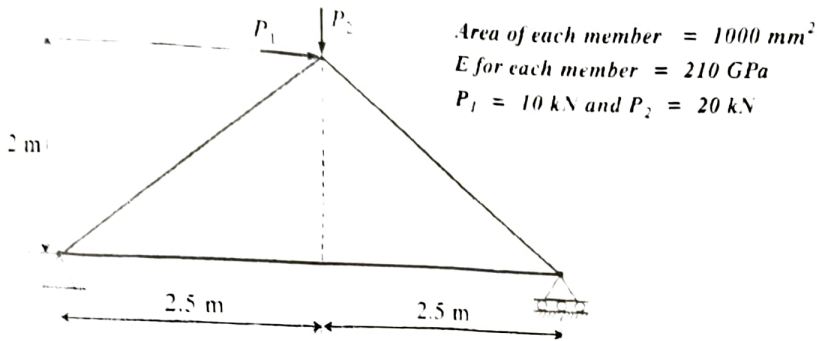
- b) Solve the following differential equation by Galerkin method and find $u(0.5)$.

$$\frac{d^2u}{dx^2} + u - x^2 = 0; \quad 0 \leq x \leq 1 \quad (10)$$

$$\text{BCS; } u(0) = 0, \quad u'(1) = 1$$

(10)

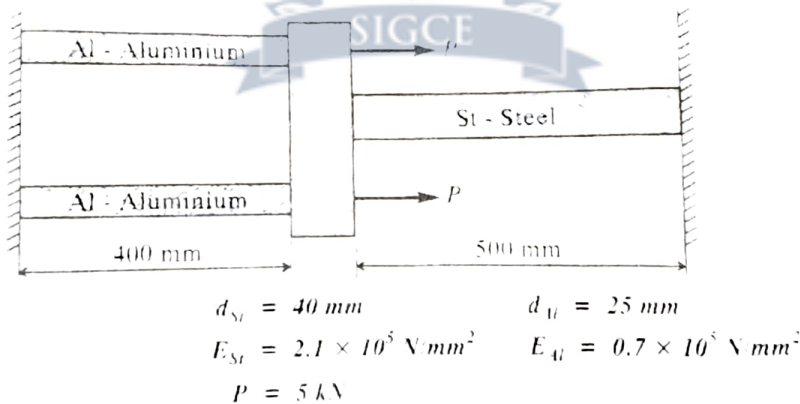
- Q3 a) Find nodal displacements, support reactions and element stresses for the following truss.



- b) Using the concept of serendipity, derive the shape functions for eight node rectangular element in natural co-ordinate system (ξ and η). (10)

- Q4 a) Find the natural frequency of axial vibrations of a bar of uniform cross section of 60 mm² and length of 1 meter using consistent mass matrix. Take E=200 GPa and density = 8000 kg/m³. Take two linear elements. (10)

- b) Determine the unknown reactions and displacement for the arrangement of bars shown in figure. (10)



- Q5 a) The governing differential equation for the steady state one dimensional conduction heat transfer with convection heat loss from lateral surfaces is given by: (15)

$$k \frac{d^2 T}{dx^2} + q = \left(\frac{P}{A} \right) h(T - T_\infty)$$

Where, k : coefficient of thermal conductivity of material, T : Temperature, q : Internal heat source per unit volume, P : Perimeter, A : Cross sectional area, T_∞ : Ambient temperature.

Develop the finite element formulation for linear element. Use Rayleigh-Ritz method mapped over general element. Derive the relevant element matrix equation.

b) Explain the procedure of Rayleigh-Ritz method based on PSTP. (5)

Q6 a) A CST element has nodal coordinates (10, 10), (70, 35) and (75, 25) for nodes 1, 2, and 3 respectively. The element is 2 mm thick and is of material with properties $E=70$ GPa. Poisson's ratio is 0.3. Upon loading of model the nodal deflection were found to be $u_1= 0.01$ mm, $v_1= -0.04$ mm, $u_2= 0.03$ mm, $v_2= 0.02$ mm, $u_3= -0.02$ mm, $v_3= -0.04$ mm. (10)

Determine:

The Jacobian for $(x-y) - (\xi-\eta)$ transformation

The Strain displacement relation matrix

The strains ξ_x , ξ_y and γ_{xy}

The element stresses

b) A composite wall consists of three materials, as shown in figure below. The outer temperature $T_0= 20$ °C. Convection heat transfer takes place on the inner surface of the wall with $T_\infty= 800$ °C and $H= 30$ W/m² °C. Determine temperature distribution in the wall. (10)

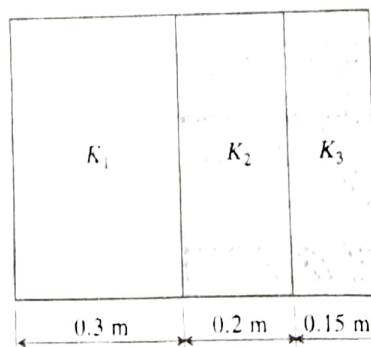
$$K_1 = 25 \text{ W/m}^\circ\text{C}$$

$$K_2 = 30 \text{ W/m}^\circ\text{C}$$

$$K_3 = 70 \text{ W/m}^\circ\text{C}$$

$$H \quad T_\infty$$

$$\uparrow \quad \uparrow$$



$$T_0 = 20^\circ\text{C}$$

Time: 3 hrs

Marks: 80

Note :

- Question No.1 is compulsory.
- Solve ANY THREE questions from the remaining five questions.
- Figure to the right indicates full marks.
- Assume suitable data wherever required, but justify the same.

- | | Marks |
|------|--|
| Q. 1 | Solve ANY FOUR from the following. |
| a) | Show the dual of the following primal- (5) |
| | Maximize $9x_1 + 10x_2$ |
| | S.T. $3x_1 + 3x_2 \leq 21$ |
| | $3x_1 + 4x_2 \leq 24$ |
| | $x_1, x_2 \geq 0$ |
| b) | Show the constraint surface diagram with the following: (5) |
| | Feasible region, unbounded region, Infeasible region |
| c) | What do you understand by full factorial and fractional factorial design? (5) |
| d) | A company manufactures two products X and Y which requires the resources (5) |
| | as machines M1 and M2 having the capacities of 50 and 25 hours respectively. |
| | Product X requires 1 hour of machine M1 and 2 hours of machine M2. Product Y requires 2 hours of |
| | machine M1 and 2 hours of machine M2. The profit contribution of products |
| | X and Y are Rs. 5 and Rs 4 respectively. Show the problem formulation for |
| | profit maximization. |
| e) | State bellman's principle of optimality and briefly explain concept of dynamic (5) |
| | programming |
| Q. 2 | Solve the following Simplex problem (10) |
| a) | $Z_{\max} = 6X_1 + 5X_2$ |
| | S.T. $X_1 + X_2 \leq 8$ |
| | $X_1 - X_2 \leq 4$ |
| | $X_1, X_2 \geq 0$ |
| b) | What is integer linear programming? How does the optimal solution of an (5) |
| | integer programming problem compare with that of the linear programming |
| | problem? |
| c) | Explain the Monte Carlo technique of simulation. (5) |

- Q. 3 a) Apply SAW to select suitable land (L1, L2,..) for waste material dumping. (10)
 having criteria as Cost (C1), distance from residential area (C2), distance (C3) from water resources as rivers, dams etc., and distance from main road (C4). Assume C1 as non-beneficial (NB), and rest all criteria as beneficial (B)

No	Alternative	C1(Rs in Cr) 0.35 (NB)	C2(Kms) 0.25 (B)	C3 (kms) 0.25 (B)	C4(kms) 0.15 (NB)
1	L1	4	3	5	4
2	L2	2	4	3	3
3	L3	4	4	2	3
4	L4	4	3	4	3

- b) Classify optimization problems in detail. (10)
- Q. 4 a) Apply Kuhn – Tucker method and solve (10)
 Maximize $Z = 10x_1 + 4x_2 - 2x_1^2 - x_2^2$
 S.T. $2x_1 + x_2 \leq 5$
 $x_1, x_2 \geq 0$
- b) Describe step by step procedure of Genetic Algorithm. Draw a flow chart (10) showing how a GA works. What are the termination conditions used in GA.
- Q. 5 a) A factory can manufacture two products A & B. The profit on one unit of A is (05)
 Rs. 80 and one unit of B is Rs. 40. The maximum demand of A is 6 units per week and of B it is 8 units per week. The manufacturer has set up a goal of achieving a profit of exactly Rs. 640 per week. Show only the formulation of the problem as goal programming.
- b) Elaborate concept of goal programming (05)
- c) Describe the procedure of AHP method step wise in detail. (10)
- Q. 6 a) Write a note on Design of Experiment. (5)
- b) Summarize the term 'Normalization' in MADM and list its different types. (5)
- c) Explain the concept of Taguchi loss function with an example. (5)
- d) Explain the terms 'Stationary Point' and 'Point of Inflection' with a graph. (5)
