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 the following questions. **20**

i) Distinguish between Line, End and Wavelength Standard.

ii) Distinguish between open loop and closed loop control system with suitable examples.

iii) Explain working LVDT with neat sketch.

iv) While measuring the speed of steam turbine with stroboscope, stationary image was observed for three consecutive stroboscope settings of 3000, 4000 and 5250 flashes per minute. Calculate the rotational speed of turbine.

2. (A) Reduce the following block diagram and find the transfer function. **10**

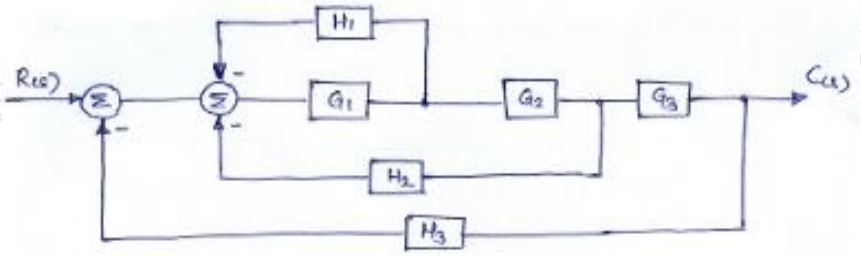


Fig.1

(B) What is Taylors principle, explains in detail? Write note on Hole Basis System and Shaft Basis System. **10**

3. (A) For a particular unity feedback system **10**

$$G(s) = \frac{10}{S(S+1)(S+5))}$$

Sketch the Bode Plot, Find ω_{gc}, ω_{pc}, GM and PM. Comment on stability.

(B) b) A unity feedback system characterized by an open loop transfer function **10**

$$G(s) = \frac{K}{S(S+2)(S^2+4S+5))}$$

Determine the gain K. so that the system will be stable.

4. (A) Explain principle of interference. How flatness can be checked with help of optical interferometer. **10**

(B) What are desired, Modifying, Interfering input? Explain with example of each. Also suggest method to minimize the effect of Modifying & Interfering inputs. **10**

5. (A) Draw the Root-Locus of the system having **10**

$$G(s)H(s) = \frac{K}{S(S+5)(S+10)}$$

(B) Draw neat labelled diagram of Taylor Hobson Talysurf and briefly explain working principle. State one major advantage and disadvantage of this instrument over Tomlinson surface meter . **10**

6. (A) What are the different elastic transducers used for pressure measurement? Illustrate working principle of any one transducer in detail. **10**

(B) Write short note on **(any Two**) **10**

i) Parkinson's gear tester

ii) Two wire method

iii) Optical encoder

Time: 3 hours Max. Marks: 80

Note: 1. Assume suitable data if necessary
2. Figures to the right indicate full marks
3. Question No. 1 is compulsory
4. Solve any **three** out of the remaining **five** questions

Q1. Solve any four

A	Derive an expression for the critical radius of insulation for the sphere.	**5**
B	State Fourier and Biot numbers? Also explain the significance of these numbers.	**5**
C	Draw a boiling curve and identify the different boiling regimes. Explain each regime in brief.	**5**
D	State and explain Fick's Law of diffusion.	**5**
E	Explain the valve timing diagram for four-stroke SI engines.	**5**
F	Explain EURO and BHARAT norms.	**5**

Q2.

A A Cylindrical tank of 1.0 m diameter and 5 m total length has hemispherical ends. It contains liquid oxygen, which has a boiling point and heat of vaporization of -180 °C and 210 kJ/kg, respectively. It is required to insulate the tank so as to reduce the boil-off rate of oxygen in a steady state to 14 kg/h. Determine the thermal conductivity of the insulating material if its maximum thickness is limited to 70 mm. Assume room temperature outside the insulation as 25 °C. **10**

B During the trial of a single-cylinder, four-stroke oil engine, the following results were obtained. **10**

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	1kJ/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.

Q3.

A Discuss the electrical analogy of combined heat conduction and convection in two-layer composite wall. **5**

B A steel ball 50 mm in diameter and at 900 °C is placed in a still atmosphere of 30 °C. Calculate the initial rate of cooling of the ball in °C per min. **5**

C Explain with neat sketch stages of combustion of the CI engine. **10**

Q4.

A A steel rod (k = 32 W/m°C), 12 mm in diameter and 60 mm long, with an insulated end, is to be used as a spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 W/m²°C. The temperature at the base of fin is 95°C. Determine: **10**
(i) The fin efficiency.
(ii) The temperature at the edge of the spine.
(iii) The heat dissipation.

B State and explain kirchoff's law. **5**

C With suitable example/ values prove that during the load test of an engine, increases in the load increases the mechanical efficiency of the engine. **5**

Q5.

A A counter-flow double pipe heat exchanger using superheated steam is used to heat water at the rate of 10500 kg/h. The steam enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperatures of water are 30°C and 80°C, respectively. If the overall heat transfer coefficient from steam to water is 814 W/m^2°C, calculate the heat transfer area. What would be the increase in the area if the fluid flows were parallel? **10**

B A 4-stroke motorcycle petrol engine cylinder consists of 15 hollow fins. If the outside and inside diameters of each fin are 200 mm and 100 mm, respectively, the average fin surface temperature is 475°C, and the atmospheric air temperature is 25°C, calculate the heat transfer rate from the fins When the motor cycle is running at a speed of 60 km/h. The fin may be idealised as a single horizontal flat plate of the same area. **10**
Assume characteristic length is 0.9 times the outside diameter.

$\overline{Nu} = 0.036(Re)^{0.8}\ (Pr)^{0.33}$

$\overline{Nu} = 0.54(Gr.Pr)^{0.25}$

The thermophysical properties of air at 250 °C are
k = 4.266 x 10^{-2} W/m °C, ν = 40.61 x 10^{-6} m^2/s, Pr = 0.677

Q 6.

A Explain with a neat sketch working of the battery ignition system. **5**

B Explain the Fouling of Heat Exchangers. **5**

C Calculate the heat transfer from a 60W incandescent bulb at 115°C to ambient air at 25°C. Assume the bulb is a sphere of 50 mm in diameter. Also, find the percentage of power lost by free convection. **5**

The correlation is given by: Nu = 0.60 (Gr.Pr)$^{1/4}$
The thermophysical properties of air at 70 °C are
k = 2.964 x 10^{-2} W/m °C, ν= 20.02 x 10^{-6} m^2/s Pr = 0.694

D Write down the general heat conduction equation in cartesian coordinates. State the assumptions and get the Fourier, Poisson's and Laplace equations from it. **5**

---

3 Hours **Total Marks: 80**

Note:

1. Question No. 1 is compulsory.
2. Attempt any three from the reaming five questions.
3. **Assume suitable data wherever required** with proper justification**.**

Q1 Attempt any four of the following. All sub-question carries equal marks

A	Differentiate between Porter and Hartnell governor.	5
B	Explain the effect of Gyroscopic couple on a naval ship during steering, pitching and rolling.	5
C	A connecting rod of mass m = 3x 10^{-3} kg and I =0.432x10^{-4} kgm^2 is suspended on a knife edge about the upper inner surface of a wrist-pin bearing, When disturbed slightly, the rod was observed to oscillate harmonically with ω_n = 6 rad/s. Determine the distance between the support and the C.G.	5
D	Define (a) Critical damping coefficient (b) Damping factor (c) Logarithmic Decrement (d) Significance of logarithmic decrement (e) Viscous Damping	5
E	Explain Correction Couple in dynamically equivalent system.	5
F	Plot variation between frequency ratio vs phase angle.	5

Q2

2A.Calculate natural frequency of simple pendulum by using Energy method. 08

2B. The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. The mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent of 20 N of load at the sleeve, determine how the speed range is modified. 12

Q3

3A. 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.

3B.A mass of 2 kg is to be supported on a spring having a stiffness of 10000 N/m. The damping coefficient is 5 N.sec/m. Determine the natural frequency of the system. Also find Logarithmic decrement & the amplitude after three cycles if the initial displacement is 0.35 cm. 10

Q4.

4A. 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 has 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

4B.A 35 Kg block is connected to a spring of stiffness 1.7 x 10^5 N/m. The coefficient of friction between block and surface on which its slides is 0.10. The block is displaced 10mm from equilibrium and released. Calculate amplitude of motion at the end of the first cycle. How many cycles of motion occur? 10

Q5.

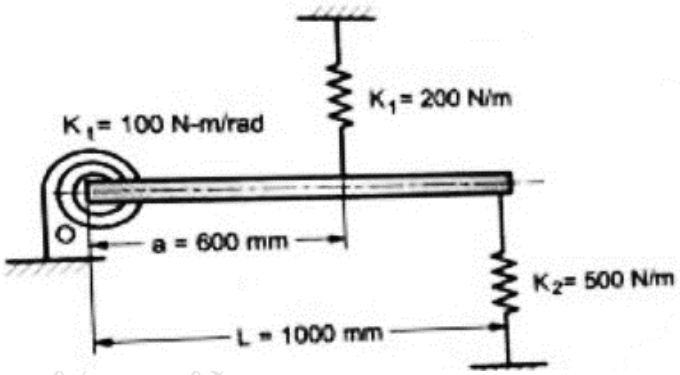
5A. If the peak amplitude of a single degree of freedom system under harmonic excitation is observed to be 0.5cm. If the undamped natural frequency of the system is 5Hz . And the static defection of the mass under the maximum force is 0.25cm, estimate the damping ratio of the system and peak frequency. 12

5B.A seismic instrument with natural frequency of 6Hz is used to measure vibration of machine running at 120 rpm. The instrument gives reading for relative displacement of mass as 0.05mm. Determine amplitude of displacement, velocity and acceleration of vibrating machine, by Neglecting damping. 08

Q6.

6A. The four masses m1, m2, m3 and m4 having their radii of rotation as 200 mm, 150 mm, 250 mm and 300 mm are 200 kg, 300 kg, 240 kg and 260 kg in magnitude respectively. The angles between the successive masses are 45 degree, 75 degree and 135 degree respectively. Find the position and magnitude of the balance mass required, if its radius of rotation is 200mm 0**8**

6B. Determine the natural frequency of vibration for a system in Fig. Take mass of the beam as 5 kg. 12



(3 Hours) **[Total Mark: 80]**

N.B. (1) Question No. 1 is compulsory.
(2) Attempt any **Three** Question from Q. No. 2 to Q. No.6
(3) Make suitable assumption if required.
(4) Illustrate answers with sketches wherever required.

Q.1 Solve any four (5 Marks each) **20**

a Explain with neat sketch parallel and counter type heat exchanger and write a short note on NTU.

b Explain heat pipe

c Explain the significance of critical radius of insulation in steam pipeline and electrical Conductors.

d Explain concept of black body and shape factor.

e Derive the generalized heat conduction equation in rectangular coordinates with assumptions.

2 A An insulated steam pipe of 160mm inner diameter & 180mm outer diameter is covered with First layer of insulation 40mm thickness & second layer of insulation 20 mm thick carries steam At 200^{o}C, K(pipe)=29 W/mK, K(first insulation) = 0.23 W/moC, K(second insulation)= 0.3W/mK h_i=11.6 W/m^{2o}C, h_o=23.2 W/m2^{o}C. If the temp. of the air surrounding the pipe is 25oC, Calculate the rate of heat loss from the pipe of 5m length. Also find the interface temperature. **10**

2 B A solid sphere of radius 5cm and thermal conductivity of 20 W/mK is heated uniformly through its volume at the rate of 2 x10^{6} W/m^{3}, and heat is dissipated by convection to ambient air at 25^{0}C with convection coefficient of 100 W/m^{2} K. Determine the steady state temperature at the centre and the surface of the sphere. Determine temp. Distribution Equation. **10**

3 A A copper cylinder of diameter 8 cm and length 20 cm is removed from liquid nitrogen bath at -196^{o}C & exposed to air at 25^{o}C. Find the time taken by the cylinder to attain the temperature of -100^{o}C. Assume h=15W/m^{2}K, ρ = 8000 kg/m^{3} , Cp= 4.0 kJ/kgK **10**

3 B A thermometer pocket is inserted in a pipe of 150 mm diameter carrying hot air. The pocket is made of brass (K=70W/mK). The inner and outer diameters of the pocket are 10 mm &15mm resp. The heat transfer coefficient between the pocket and air is given by N_u=0.174 (R_e)$^{0.618}$ K_{air}=0.035 W/mK and depth of pocket = 50mm , R_e of air flow=25000. Find the actual error in temperature measurement if the oil well is at 50^{o}C and air temp. is 150^{o}C. **10**

4 A With the help of dimensional analysis prove that for free convection. Nu = Φ (Re, Pr) **10**

4 B Air at 30^0C flows with a velocity of 5 m/sec over a plate maintained at 100^0C. The length, width & thickness of plate is 1000 X 500 X 20mm. If the thermal conductivity of the plate material is 30 w/m^0C. Calculate, **10**
1) Heat lost by the plate.
2) Bottom temperature of the plate for the steady state condition.

5 A Hot water at 2.5 kg/sec & 100^oC enters a concentric tube counter flow heat exchanger having a total area of 23 m^2 cold water at 20^oC enters at 5 kg/sec & the overall heat transfer coefficient is 1000W/m^{2o}K. Determine the total heat transfer rate & outlet temperature of hot & cold fluids. **10**

5 B Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperature of 427^oC & 27^oC respectively $\varepsilon_{hot\ plate} = 0.9$, $\varepsilon_{cold\ plate} = 0.6$. If a polished aluminum shield is placed between them, find the percentage reduction in the heat transfer $\varepsilon_{Shield} = 0.4$ **10**

6 Solve any four **20**
A Explain different regimes of boiling.
B Explain methods of enhancing heat transfer rate in convection mode
C Explain the method of evaluating overall heat transfer coefficient of water to air heat exchanger.
D Explain Heisler chart and its significance
E Explain numerical method of heat transfer.

(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 if required.

Q1 Solve any 4 **[Each 5 Marks]**

i) Why Finite Element Method is an approximate solution? Explain in brief how the accuracy of FEM results improve.

ii) Explain the Principle of minimum total potential with suitable example.

iii) Derive the shape function for One Dimensional Linear Element in Natural Coordinates.

iv)What is Convergence in FEA? Explain its types in brief.

v) What is the significance of Jacobian Matrix in FEA? Explain in brief.

vi)What do you mean by Consistent and Lumped mass matrix? Explain in brief with their importance.

Q2 a) Solve the following differential equation using Galerkin Method. [12]

$$-\frac{d}{dx}\left[(x-1)\frac{du}{dx}\right] = x^2\,; \quad 3 \le x \le 5$$

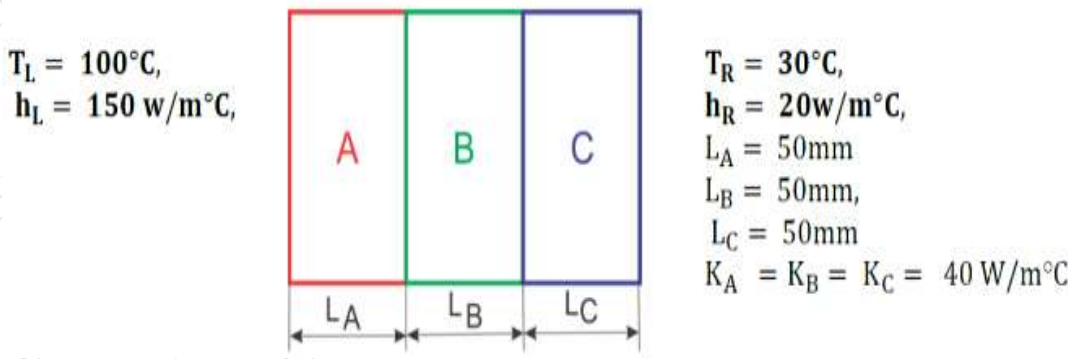
Boundary Conditions are; $u\,(5) = 10\ and\ u'(3) = 5$

Also compute the value of primary (u) variable at x = 3.5, 4.5

b) What are the sources of Errors in FEA? [04]

c) What is Boundary Condition? Explain its type in brief. [04]

Q3 a) Find the temperature at interfaces and heat transfer per unit area through the wall. [10]



Where K- denotes thermal conductivity, h- denotes heat transfer coefficient and T-temperature

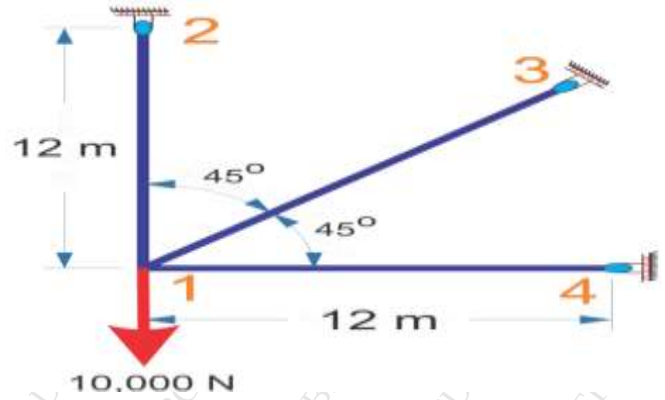
b) Develop the finite element equation for the most general element using Rayleigh Ritz Method for vertical bar with axial loading. The governing differential equation is given below [10]

$$\frac{d}{dx}\left(EA\frac{du}{dx}\right)+f=0 \quad ;0\le x\le L$$

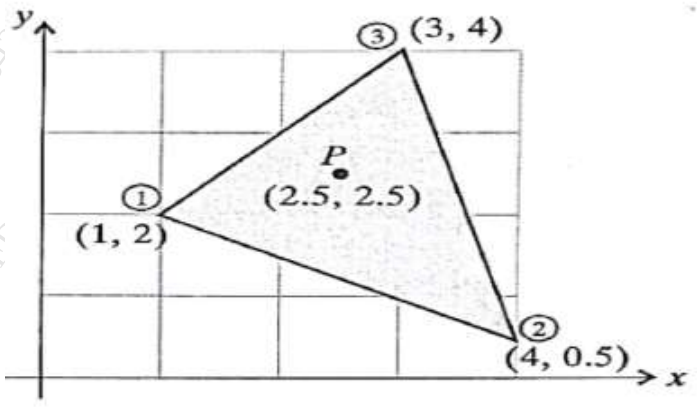
Where f is the weight of the bar. Consider one end of the bar to be fixed and other end free.

Q4 a) For the plane truss shown in figure. [12]

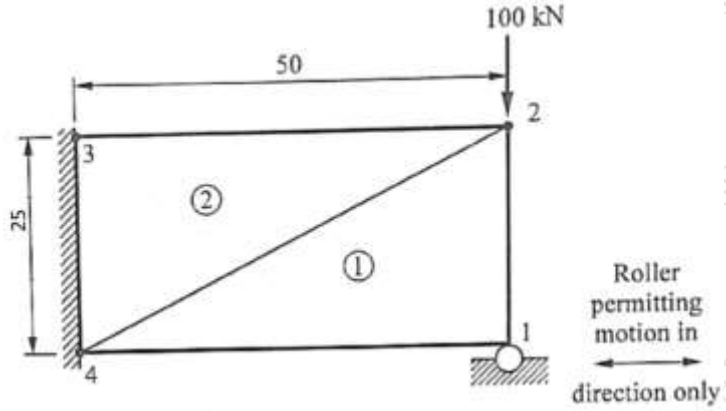
(i) Determine the displacement at nodes
(ii) Determine the stresses in each bar.



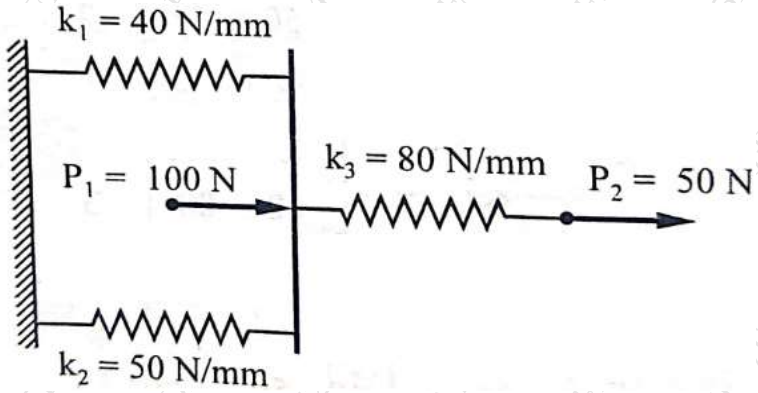
b) The triangular element used for ground water flow simulation is shown in below figure. The nodal coordinates are (x_1 = 1, y_1 = 2), (x_2 = 4, y_2 = 0.5), (x_3 = 3, y_3 = 4). The nodal values of hydraulic heads { Φ} at these nodes are [3.5, 2.2, 4.4] respectively. Find the values of hydraulic head Φ at point (2.5, 2.5) [08]



Q5 a) For 2D loaded plat shown in below figure below. Determine the displacements of nodes 1 and 2 and the element stresses using the plane stress conditions. Assume thickness as 10 mm, E = 225 GPa and poisons ratio = 0.25, All Dim are in mm [12]

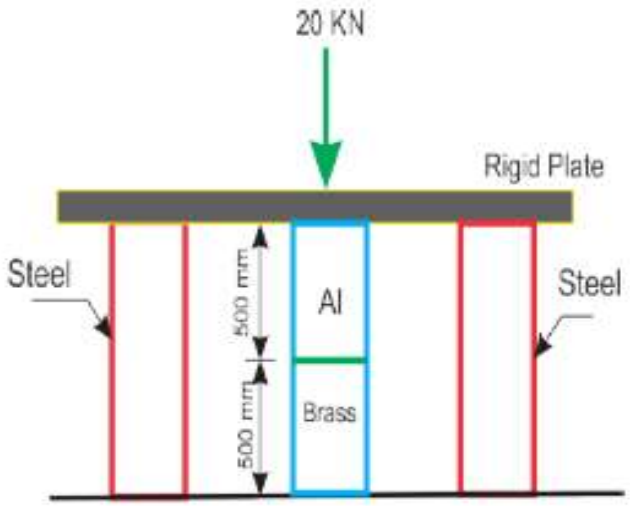


b) A three spring system with stiffness (k) and loads (p) are shown in figure. Calculate the displacement at nodal points. [08]



Q6 a) For a uniform cross-section bar shown in fig. below of length L = 1m made up of a material having E = 2 x 10^{11}N/m^2 and ρ = 7800 kg/m^3. Estimate the natural frequencies of axial vibration of the bar using both consistent mass matrices. Use a two element mesh. Given A = 30 x 10^{-06} m^2 [08]

b) For the given steel block supporting rigid plates shown in below fig, [12]
Determine displacement, Stress in the blocks.



Properties	Steel	Aluminium	Brass
C/s Area (mm^2)	200	370	
$E\ (N/mm^2)$	2×10^5	7×10^4	8.8×10^4

.....

Time: 3 Hrs **Marks : 80**

1) **Question No. 1 is compulsory.**
2) **Answer any three out of the remaining five questions.**
3) **Figures to the right indicate full marks.**
4) **Illustrate answers with neat sketches wherever required.**

Q. 1 Explain briefly any four **20**

a Robust design

b Engineering applications of optimization

c Integer Programming

d Genetic Algorithm

e Analytic Hierarchy Process (AHP) Method

Q2 a Explain design of experiments. Explain its application and state its importance. **10**

b A firm manufacture product P & Q which pass through machining and finishing departments. Machining has 90 hours available; finishing can handle up to 72 hours of work. Manufacturing one product P requires 6 hours in machining and 3 hours in finishing. Each product Q requires 3 hours in machining and 6 hours in finishing. If profit is Rs. 120/- per product P and Rs. 90/- per product Q. Formulate as goal programming problem to determine combination of product P & Q to realise profit of exactly Rs. 2100 **10**

Q3 a Find the maximum and minimum value of $y = 3x^5 - 5x^3$. **10**

b Solve LPP by simplex method **10**

Maximize: $Z = 40x_1 + 35x_2$ subjected to,

$$2x_1 + 3x_2 \leq 60$$
$$4x_1 + 3x_2 \leq 96$$
$$x_1, x_2 \geq 0$$

Q4 a Solve following problem by big M method **10**
Minimize $Z = 600x_1 + 500x_2$ subjected to,

$2x_1 + x_2 \geq 80$

$x_1 + 2x_2 \geq 60$, where $x_1, x_2 \geq 0$.

b Write the dual of the following primal LP problems **5**
Max $Z = 2x_1 + 5x_2 + 6x_3$
subject to (i) $5x_1 + 6x_2 - x_3 \leq 3$ (ii) $-2x_1 + 3x_2 + 4x_3 \leq 4$ (iii) x1 – 5x2 + 3x3 ≤ 1 (iv) $-3x_1 - 3x_2 + 7x_3 \leq 6$ and $x_1, x_2, x_3 \geq 0$

c State methods of normalization and explain any one. **5**

Q5 a Solve the following NLPP: Maximum $Z = 4x_1 + 6x_2 - 2x_1x_2 - 2x^2_2$ **10**
subjected to $x_1 + 2x_2 = 2$, $x_1, x_2 \geq 0$.

b Explain concept of dynamic programming and bellman's principle of optimality **10**

Q6 a Explain multi attribute decision making with suitable illustration **10**

b Explain briefly taguchi's loss function **5**

c A production process makes batteries for 9 +/- 0.25 volts applications at a cost of $ 0.75 each. Determine: **5**

a. Complete expression for loss function

b. Loss when a part is made at 9.10 V

****