[Time: 03 Hours] **[Total marks: 80]**

N.B.

1) **Question No.1 is compulsory**
2) attempt any three out of remaining questions
3) Draw neat sketches to illustrate your answers
4) Figures to the right indicate full marks.
5) Use of **Standard Data Book** is permitted

Q1 Answer any **four** of the following **20**

a) Explain the use of preferred numbers in engineering design.
b) What is cotter? Why taper is provided on the cotter.
c) Discuss various types of threads used for power screw.
d) Explain Notch sensitivity and Endurance limit related to design of machine elements subjected to variable loads.
e) List and explain the important factors that influence the magnitude of factor of safety

Q2 a) Design a knuckle joint to withstand a tensile load of **25kN,** if the permissible stresses are **56MPa** in tension, **40MPa** in shear and **70MPa** in compression. **15**

b) Explain the nipping of the leaf spring with neat sketch **05**

Q3 a) Design a cast iron protective type flange coupling to transmit **15kW** at **900rpm** from an electric motor to compressor. The service factor may be assumed as **1.35**, the permissible stresses are as follows: allowable shear stress for shaft, bolt and key materials **40MPa**; allowable crushing stress for bolt and key **80N/mm^2** and allowable shear stress for cast iron **8N/mm^2**. **12**

b) Design a helical valve spring for an operating load range of **600N to 1200N**. The compression at the maximum load is **30mm**. Take the spring index **6** and permissible endurance shear stress for spring material as **480Mpa** and yield stress in shear is **960Mpa** and G = **80kN/mm^2** **08**

Q4 a) A horizontal nickel steel shaft rests on two bearings, A at the left and B at the right end and carries two gears C and D located at distances of **250mm** and **400mm** respectively from the centre line of the left and right bearings. The pitch diameter of the gear C is **600mm** and that of gear D is **200mm**. The distance between the centre line of the bearings is **2400mm**. The shaft transmits **20kW** at **120 r.p.m**. The power isdelivered to the shaft at gear C and is taken out at gear D in such a manner that the tooth pressure F_{tC} of the gear C and F_{tD} of the gear D act vertically downwards. Find the diameter of the shaft, if the working stress is **100MPa** in tension and **56MPa** in shear. The gears C and D weigh **950**N and **350N** respectively. The combined shock and fatigue factors for bending and torsion may be taken as **1.5** and **1.2** respectively. **14**

b) Define stress concentration and discuss the various methods to reduce the effect of stress concentration. **06**

Q5 a) Determine the size of the circular bar using soderberg equation with **FoS=2.5**. if it is subjected to tensile force varying **300kN** to **550kN**. It is made of carbon steel 35C8 with σ_{yt}**=320N/mm²** and σ_{ut}**=600N/mm²**. **10**

b) A solid circular shaft of **30mm** diameter is welded to a vertical plate by fillet weld all around. It carries a vertical load **10kN** at a distance 100mm from the plane. Determine the size of the weld is permissible shear stress for the weld is **90N/mm²**. **10**

Q6 a) Design a pair of helical gears for transmitting **22 kW**. The speed of the driver gear is **1800 r.p.m**. and that of driven gear is **600 r.p.m**. The helix angle is **30°** and profile is corresponding to **20°** full depth system. The driver gear has 24 teeth. Both the gears are made of cast steel with allowable static stress as **50MPa**. Assume the face width parallel to axis as 4 times the circular pitch and the overhang for each gear as **150 mm**. The allowable shear stress for the shaft material may be taken as **50 MPa**. The form factor may be taken as **0.154–0.912/T_E**, where **T_E** is the equivalent number of teeth. The velocity factor may be taken as, **350/(350+v)** where **v** is pitch line velocity in **m/min**. The gears are required to be designed only against bending failure of the teeth under dynamic condition. **15**

b) Compare the weight, strength and stiffness of a hollow shaft of the same external diameter as that of solid shaft. The inside diameter of the hollow shaft being half the external diameter. Both the shafts have the same material and length **05**

(3 hours) **Total marks: 80**

- ***Question No.1 is compulsory.***
- *Solve **ANY THREE** questions from the **remaining five questions.***
- *The 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**

i) Explain general FEM procedure.

ii) Define shape function and enlist the properties of shape functions.

iii) Explain h-method and p-method of FEM.

iv) Describe the significance of Jacobian Matrix in co-ordinate transformation.

v) Explain the principle of minimum total potential.

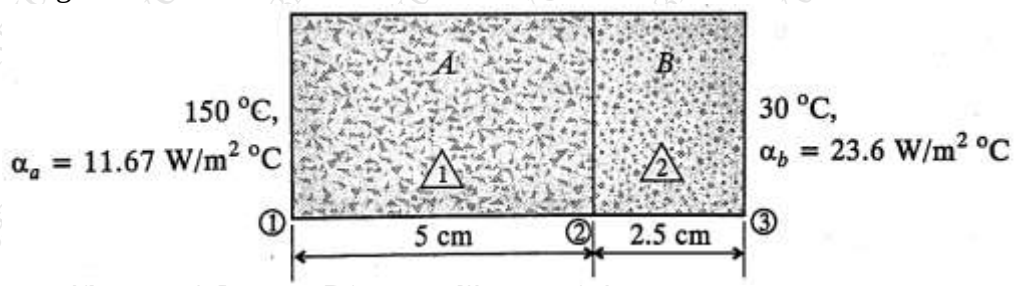
vi) Explain iso-parametric, sub-parametric and super-parametric elements.

Q. 2 a) Solve following differential equation using galerkin method **10**

$$3\frac{d^2y}{dx^2} - \frac{dy}{dx} + 8 = 0 \; ; \; 0 \le x \le 1$$

Boundary Conditions: y(0) = 1, y(1) = 2, find y(0.6)

b) Consider a plain composite wall which is made of two materials of thermal conductivity k_a = 204 W/m°C and k_b = 46 W/m°C and thickness h_a = 5 cm and h_b = 2.5 cm. Material A adjoins a hot fluid at 150°C for which heat transfer coefficient α_a = 11.67 W/m^2 °C and the material B is in contact with a cold fluid at 30°C and heat transfer coefficient α_b = 23.6 W/m^2 °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. **10**



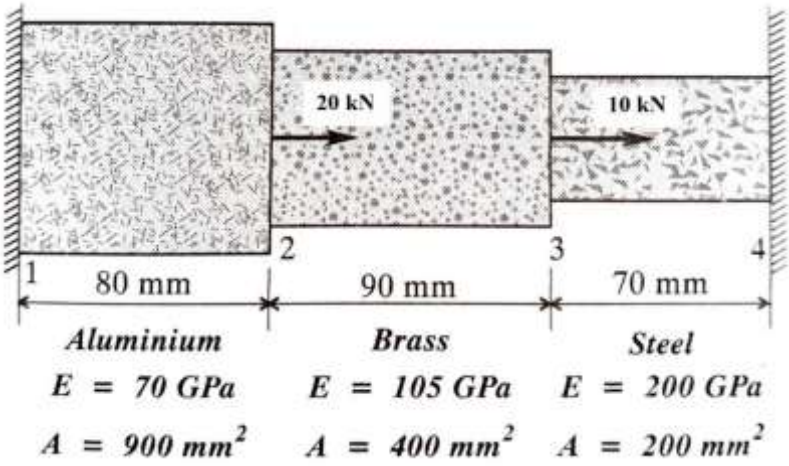
Q. 3 a) Solve the following differential equation by Rayleigh Ritz method. **10**

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

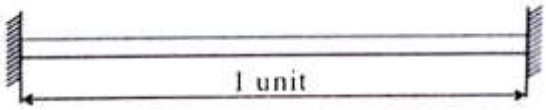
Given boundary conditions are: $y(0) = y(1) = 0$

b) Find the natural frequency of axial vibrations of a bar of uniform cross section of 50 mm^2 and length of 1 meter using consistent mass matrix. Take E = 200 GPa and density = 8000 kg/m^3. Take two linear elements. **10**

Q. 4 **a)** Determine the unknown reactions, displacement and element stresses for the stepped bar shown in the figure below. **10**

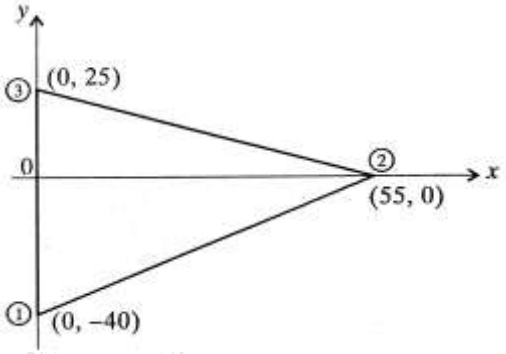


b) Determine the two natural frequencies of transverse vibration of a beam fixed at both ends as shown in figure. Use consistent mass matrix and comment on the results. Divide the whole domain into two elements of equal lengths. [Take EI = 10^6 units, ρA = 10^6 units] **10**



Q. 5 **a)** Using the concept of serendipity, derive the shape functions for eight node rectangular element in natural co-ordinate system (ξ and η). **10**

b) The nodal displacements for the CST element shown in the figure are given as: **10**
u_1 = 1 mm, u_2 = 0.5 mm, u_3 = 2 mm
v_1 = 1 mm, v_2 = 0.5 mm, v_3 = 2 mm
Evaluate the stress for the element. Take Young's Modulus (E) = 200 GPa, Poisson's Ratio (ν) = 0.3 and thickness (t) = 1 cm.



Q. 6 **a)** A CST element ABC having vertices A(10, 10), B(10, 50), C(40, 10), and nodal temperatures 50 ^{0}C, 60 ^{0}C, and 80 ^{0}C respectively. Determine shape functions and nodal temperature at (20, 20). **10**

b) The following differential equation arises in connection with heat transfer in an insulated rod. **10**

$$\frac{d}{dx}\left(-K\frac{dT}{dx}\right) = q; \qquad 0 \le x \le L$$

$$\text{BCS; } T(0) = T_0 \text{ and } \left[K\frac{dT}{dx} + \beta(T - T_\infty)\right]_{x=L} = 0$$

Where T is temperature, K is thermal conductivity and q is the heat generation. Take the following data;
L= 0.1m, K=0.1 W/m^{0}C, β= 25 W/m$^{2\,0}$C, $q = \bar{q} = 0$, T_0=50^{0}C and T_∞=5^{0}C.
Solve the problem using two linear finite elements for temperature values at x=L/2 and x=L. Derive the element matrix equation for the same.

Time: 3Hrs **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) List any five engineering applications of optimization. **(5)**

b) Show the formulation of a generalized transportation problem. **(5)**

c) Explain the branch and bound technique. In this technique when is the node said to be fathomed? **(5)**

d) What do you understand by full factorial and fractional factorial design? **(5)**

e) Explain the concept of Taguchi loss function with an example. **(5)**

Q. 2 a) Solve the following Simplex problem **(10)**

Maximize $Z = 2x_1 + 5x_2$

S.T. $x_1 + 4x_2 \leq 24$

$3x_1 + x_2 \leq 21$

$x_1 + x_2 \leq 9$

$x_1, x_2 \geq 0$

b) Determine maximum and minimum values of the function **(10)**

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

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

Optimize $Z = 6{x_1}^2 + 5{x_2}^2$

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

Time between arrival (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

Q. 5 a) Apply dynamic programming method and solve **(10)**

Maximize $Z = y_1y_2y_3$

S.T. $y_1 + y_2 + y_3 = 5$

$y_1, y_2, y_3 \geq 0$

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

Q. 6 a) Write the dual of the following primal problem **(5)**

Maximize $Z = x_1 - x_2 + 3x_3$

S.T. $x_1 + x_2 + x_3 \leq 10$

$2x_1 - x_2 - x_3 \leq 2$

$2x_1 - 2x_2 - 3x_3 \leq 6$

$x_1, x_2, x_3 \geq 0$

b) A firm produces three products. These products are processed on three different machines. The time required to manufacture one unit of each of the three products and the daily capacity of the three machines are given in the table below. The profit per unit for product 1, 2 and 3 is Rupees 4, 3 and 6 respectively. Formulate the mathematical linear programming model that will maximize the daily profit. **(5)**

Machine	Time per unit (Minutes)			Machine Capacity (Minutes / Day)
	Product 1	Product 2	Product 3	
M1	2	3	2	440
M2	4	-	3	470
M3	2	5	-	430

c) Write a note on Design of Experiment. **(5)**

d) Determine the quadratic form of matrix $A = \begin{bmatrix} 4 & -5 & 7 \\ -5 & -6 & 8 \\ 7 & 8 & -9 \end{bmatrix}$ **(5)**

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(3 Hours) **Total Marks: 80**

Note:

1. **Question No. 1 is compulsory**.
2. Attempt any **THREE** out of the remaining **FIVE** questions.
3. Assume suitable data if necessary.
4. **Use of Statistical Tables is allowed.**

Q. 1. Write short notes on **any FOUR** questions. **(20)**

(a) Explain non-parametric test with example

(b) Explain spearman's rank correlation

(c) Describe any one type of sampling with example

(d) Explain level of significance and confidence level

(e) Explain F ratio and its interpretation

Q. 2. (a) An automobile company decided to introduce a new car whose mean petrol consumption is claimed to be lower than that of existing auto engine. It was found that the mean petrol consumption for 50 cars was 10 km per liter with a standard deviation of 3.5 kW per liter. Test for the company at 5% level of significance, the claim that in the new car petrol consumption is 9.5 km per liter on the average. **(10)**

(b) Three different kinds of food are tested on three groups of rats for 5 weeks. The objective is to check the difference in mean weight (in grams) of the rats per week. Apply one-way ANOVA using a 0.05 significance level to the following data: **(10)**

Food I	Food II	Food III
8	4	11
12	5	8
19	4	7
8	6	13
6	9	7
11	7	9

Q. 3. (a) Determine the Karl Pearson's coefficient of correlation for the following data: **(10)**

X	12	16	20	24	28	32	36
Y	6	9	12	15	18	21	24

(b) Fit a second-degree parabolic curve to the following data using least square method **(10)**

X :	1	2	3	4	5	6	7
Y :	-5	-2	5	16	31	50	73

Q. 4. (a) 7 fair dice are thrown 729 times. How many times do you expect at least four dice to show three or five? **(10)**

(b) Explain Quota sampling with example **(10)**

Q. 5. (a) Calculate Fitting straight line - Curve fitting using Least square method **(10)**

X :	5	4	3	2	1
Y :	1	2	3	4	5

(b) As per the survey on cars owned by each family in the locality, the data has been arranged in the following table where O_i= observed value (actual value), E_i= expected value. **(10)**

Number of Cars	$\mathbf{O_i}$	$\mathbf{E_i}$
One Car	30	25.6
Two Cars	14	15
Three Cars	6	5.2
Total	50	

Q. 6. (a) Explain steps in Two-way ANOVA with example **(10)**

(b) A 2 m long wire of 1 mm diameter was measured to be 2.002 m after loading a certain weight. Suppose the change in diameter is 10^{-8} m. What is the Poisson's ratio for the material? **(10)**

[Total Marks: 80] **Duration: 3 Hours**

Instructions :

[1] Question No.**1 is compulsory**.
[2] Answer **any three** from the remaining five questions.
[3] Assume suitable data whenever required with proper justification.
[4] Answers to questions should be grouped and written together.
[5] Figures to the right indicate full marks.

Q.1 **Attempt any four of the following. All sub-questions carry equal marks** **20**

(a) Explain assumptions in Air standard cycles and fuel air cycles.

(b) Define carburetor and factor affecting carburetion

(c) Explain why turbocharged engines may have inferior values of power output and fuel consumption than naturally aspirated engines especially at low speed.

(d) Write short note on : Control of NOx emissions

(e) Compare Two stroke & four stroke Engine

(f) Explain Exhaust Oxygen sensor

Q.2 **(a)** What are the effects of an engine under cooling & over cooling? With a neat sketch Explain the principal & working of evaporative cooling system. **10**

(b) The following are results of the test conducted on an SI engine for one hour duration: No. of cylinders = 6, power developed = 80 KW, Speed = 3100 rpm, Capacity of engine= 730 cc per cylinder. Fuel consumption = 28 kg, C.V of fuel = 44 MJ/ kg, Air fuel ratio = 13. Intake temperature = 27°C, & Intake pressure= 0.88 bar. Determine volumetric efficiency, brake thermal efficiency and brake torque. **10**

Q.3 **(a)** Describe the phenomenon of combustion in CI engines and in detail the various stages in it. **10**

(b) Explain Battery Ignition system. Why is a capacitor required to connect across the breaker point? What is the effect on intensity of spark as speed increases? **10**

Q.4 **(a)** Explain electronically controlled CRDI System in detail. **10**

(b) Explain the types of combustion chambers used in SI engines and compare them. Why is the maximum diameter of SI engine combustion chambers limited ? **10**

Q.5 **(a)** In a test of a single cylinder 4 stroke diesel engine with bore 400 mm and stroke 450 mm, the following observations were made: **15**

Duration of test = 1 hr

Fuel Consumption = 7.5 kg

Indicated mean effective press = 3.75 bar

Calorific value of fuel = 44500 KJ/Kg

Total Air consumption = 361 kg

Total Revolutions = 12000

Net brake load = 1500 N

Brake drum diameter = 180 cm

Rope diameter = 3 cm

Quantity of cooling water used = 600 kg

Temperature rise = 42^0 C

Exhaust gas temperature = 300^0 C

Room Temperature = 20^0 C

Cp for exhaust gases = 1.01 KJ/KgK

Calculate:

1) Mechanical Efficiency 2) Indicated and Brake thermal Efficiency 3) Draw heat balance sheet on minute basis.

(b) Explain SAE Rating of lubrication **05**

Q.6 Write Short notes on (Any Four) **20**

(a) Biodiesel as an Alternative fuel for I C Engine
(b) Atkinson Cycle
(c) Types of diesel fuel Injector
(d) Wankel engine.
(e) ECM

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)**

i) Differentiate between primary, secondary and tertiary standards.

ii) Explain roughness and waviness with suitable diagram.

iii) Define: Accuracy, Precision, Span and Range of measuring instruments.

iv) What is RTD? How does it work?

v) Define the term transfer function with its significance in control system.

vi) Write a note on *Frequency domain specifications.*

2. (A) Define the term gauge factor of a strain gauge with its significance. **(05)**

(B) Describe with neat diagrams the working of *McLeod gauge* for the pressure measurement. **(05)**

(C) Find the shaft and hole dimensions with tolerance for a **90 H8 e9 pair** with the following data: **(10)**

90 mm lies in the diameter step of **80 to 100 mm**
Upper deviation for e shaft = $\mathbf{11\ D^{0.41}}$
Tolerance unit $\mathbf{i = 0.45\ D^{1/3} + 0.001D}$ micron

Also find the type of fit produced.

3. (A) Classify control system with suitable examples. **(05)**

(B) What is difference between unilateral and bilateral tolerances? Why is unilateral tolerance preferred over bilateral tolerance? **(05)**

(C) Describe with neat diagrams the working principle of the magnetic flow meter and ultrasonic flow meter for flow measurement. **(10)**

4. (A) What is the difference between direct and indirect measuring instrument? Give one example of each type. **(05)**

(B) A system is represented by the characteristic equation **(05)**

$$P(S) = S^6+S^5+8S^4+12S^3+20S^2+16S+16 = 0,$$

Determine the stability of the system by using Routh's criterion.

(C) Define *Interferometry*. Describe with neat sketch the working principle of Laser interferometer. **(10)**

5. (A) Describe with neat sketch ***'Two Wire Method'*** in screw thread measurement. **(10)**

(B) Define desired input, modifying input and interfering input for measuring instruments with suitable examples. Also suggest the methods to minimize the effect of modifying and interfering input. **(10)**

6. (A) A unity feedback system is characterized by open loop transfer function **(10)**

$$G_{(S)} = \frac{25}{S(S+5)}$$

For a unit step input, determine a) Rise time, b) Peak time, c) Settling time d) Peak overshoot.

(B) A system is characterized by transfer function **(10)**

$$G_{(S)}\,H_{(S)} = \frac{K}{S\,(S+5)\,(S+10)}$$

Determine the stability of the system by using root locus method.
