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

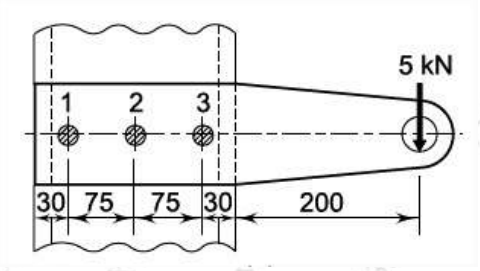
N.B. **(1)** All questions carry equal marks.
(2) Question **No. 1 is Compulsory**.
(3) Attempt **any three** questions from **remaining five** questions.
(4) Figures to the right indicate full marks.
(5) Draw neat sketches wherever necessary
(6) Use of **Standard Data Book** is permitted

Q.01. **Attempt any four out of six**. **20**

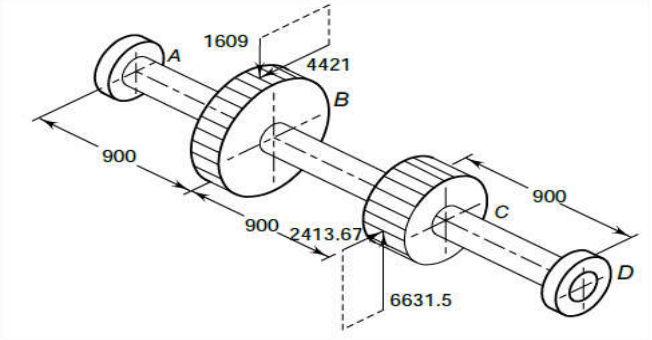
a) What are the advantages of knuckle joint.
b) Write the classification of the couplings.
c) Explain Aesthetics consideration in design.
d) How to select the material for spur gear and helical gear.
e) Explain endurance limit.
f) Explain nipping of leaf springs.

Q.02. A) Design a cotter joint to connect two steel rods of equal diameter. Each rod is subjected to axial tensile load of 50 kN. Select suitable material and draw neat sketch. **12**

B) A steel plate subjected to a force of 5 kN and fixed to a channel by means of three identical bolts is shown in Figure. The bolts are made from plain carbon steel 45C8 (Syt = 380 N/mm^2) and the factor of safety is 3. Specify the size of bolts. **08**



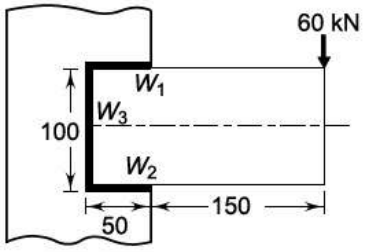
Q.03. A) The layout of an intermediate shaft of a gear box supporting two spur gears B and C is shown in Figure The shaft is mounted on two bearings A and D. The pitch circle diameters of gears B and C are 900 and 600 mm respectively. The material of the shaft is steel FeE 580 (Sut = 770 and Syt = 580 N/mm^2). The factors k_b and k_t of ASME code are 1.5 and 2.0 respectively. Determine the shaft diameter using the ASME code. Assume that the gears are connected to the shaft by means of keys. **12**



B) A machine component is subjected to fluctuating stress that varies from 40 to 100 N/mm^2. The corrected endurance limit stress for the machine component is 270 N/mm^2. The ultimate tensile strength and yield strength of the material are 600 N/mm^2 and 450 N/mm^2 respectively. Find the factor of safety using **08**
(i) Gerber theory
(ii) Soderberg line
(iii) Goodman line
Also, find the factor of safety against static failure.

Q.04. A) A rigid coupling is used to transmit 50 kW power at 300 rpm. There are six bolts. The outer diameter of the flanges is 200 mm, while the recess diameter is 150 mm. The coefficient of friction between the flanges is 0.15. The bolts are made of steel 45C8 (Syt = 380 N/mm^2) and the factor of safety is 3. Determine the diameter of the bolts. Assume that the bolts are fitted in large clearance holes. **08**

B) A welded connection, as shown in Figure, is subjected to an eccentric force of 60 kN in the plane of the welds. Determine the size of the welds, if the permissible shear stress for the weld is 100 N/mm^2. Assume static condition. **12**



Q.05. A) A helical tension spring is used in the spring balance to measure the weights. One end of the spring is attached to the rigid support while the other end, which is free, carries the weights to be measured. The maximum weight attached to the spring balance is 1500 N and the length of the scale should be approximately 100 mm. The spring index can be taken as 6. The spring is made of oil-hardened and tempered steel wire with ultimate tensile strength of 1360 N/mm^2 and modulus of rigidity of 81370 N/mm^2. The permissible shear stress in the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate **12**
(i) wire diameter; (ii) mean coil diameter; (iii) number of active coils;
(iv) required spring rate; and (v) actual spring rate.

B) Explain the estimation of beam strength for helical gear. **08**

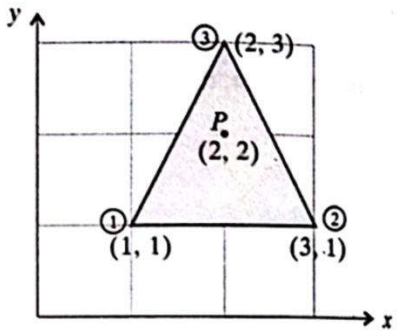
Q.06. A) Design a pair of spur gears with 20° full-depth involute teeth based on the Lewis equation. The velocity factor is to be used to account for dynamic load. The pinion shaft is connected to a 10 kW, 1440 rpm motor. The starting torque of the motor is 150% of the rated torque. The speed reduction is 4:1. The pinion as well as the gear is made of plain carbon steel 40C8 (Sut = 600 N/mm^2). The factor of safety can be taken as 1.5. Design the gears, specify their dimensions and suggest suitable surface hardness for the gears. **12**

B) Design a square key for fixing a gear on a shaft of 25 mm diameter. The shaft is transmitting 15 kW power at 720 rpm to the gear. The key is made of steel 50C4 (Syt = 460 N/mm^2) and the factor of safety is 3. For key material, the yield strength in compression can be assumed to be equal to the yield strength in tension. Determine the dimensions of the key. **08**

Time: 3 Hours **Marks: 80**

- **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** 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). $$\frac{d^2y}{dx^2} + y - 2 = 0; \quad 0 \le x \le 1$$ $$\text{BCS; } y(0) = y(1) = 0$$	**15**
	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 : $u_1 = 2.0, u_2 = 3.0, u_3 = 5.0$ $v_1 = 1.0, v_2 = 2.0, v_3 = 3.0$ Determine the displacement (i.e. u, v) of point P (2, 2) within the element.	**10**



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

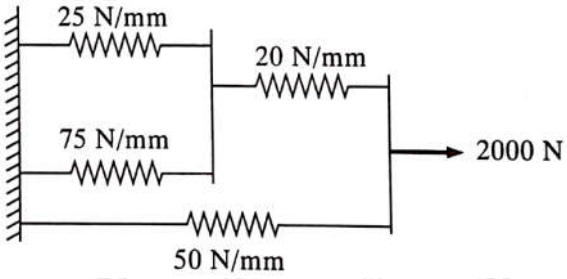
$$\frac{d^2y}{dx^2} - 10\,x^2 = 5 \quad ; \qquad 0 \le x \le 1$$

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 x 10^{11} N/m^2 and ρ = 7800 kg/m^3, 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**

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

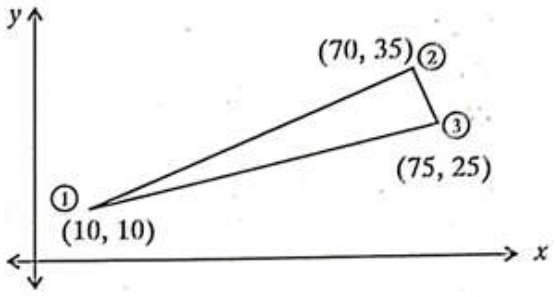


Q. 5 **a)** The CST element has nodal coordinates (10, 10), (70, 35) and (75, 25) for node 1, node 2 and node 3 respectively. The element is 2 mm thick and is of material with properties E = 70 GPa. Poisson's ratio is 0.3. Upon loading of model the nodal deflections were found to be u_1 = 0.01 mm, v_1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

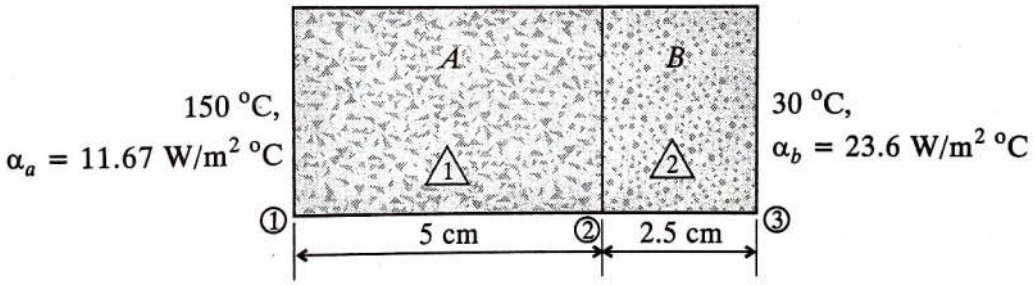
Determine: -

i) The Jacobian for (x-y) – (ξ – η) transformation.

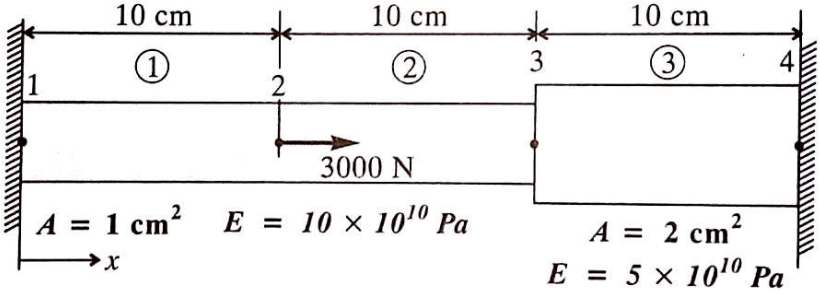
ii) The Strain displacement relation matrix.



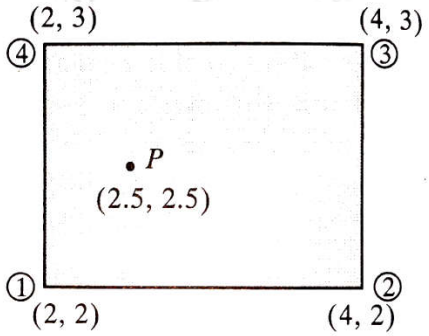
b) Consider a plain composite wall which is made of two materials of thermal conductivity k_a = 204 W/m °C and k_b = 46 W/m °C and thickness h_a = 5 cm and h_b = 2.5 cm. Material A adjoins a hot fluid at 150 °C for which heat transfer coefficient α_a = 11.67 W/m^2 °C and the material B is in contact 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. 6 **a)** Determine the unknown reactions and displacement for the arrangement of bars shown in figure. **10**



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°C, T_2 = 60°C, T_3 = 50°C and T_4 = 90°C. Calculate temperature at point P (2.5, 2.5). Use local co-ordinate system. **10**



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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) What is the difference between air standard cycle & fuel air cycle?

(b) Give reasons of black, blue and white colored smoke from exhaust of diesel engines.

(c) Define carburetor and factor affecting carburetion

(d) Describe the individual pump system used in CI engine.

(e) What is meant by supercharging? What is its effect on engine performance?

(f) Give a brief account of Exhaust Oxygen sensor

Q.2 **(a)** What are the different functions of the lubricating system? State the different lubricating systems used for I C Engines. Explain any one of them. **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)** Write short note on : Control of NOx emissions **05**

(b) 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°C
Exhaust gas temperature =300 0 C
Room Temperature = 20°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.

Q.4	**(a)**	With neat sketch explain the various types of fuel nozzle used in CI engine injection systems	**10**
	(b)	Discuss the use of the biogas as substitute fuel for SI engine, mention the modifications required with the engine system.	**10**
Q.5	**(a)**	State the types of electronic ignition system & explain capacitance discharge ignition system.	**10**
	(b)	What are the effects of an engine under cooling & over cooling? With a neat sketch explaining the principal & working of evaporative cooling system.	**10**

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

(a) Types of diesel fuel Injector

(b) SAE ratings of lubrication.

(c) Alternative fuels for IC engine.

(d) VCR Engine

(a) Atkinson Cycle

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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 systematic errors and random errors.

ii) What are optical flats? How can optical flats be used for checking flatness?

iii) The dead zone of a certain pyrometer is 0.15% of the span. The calibration is 500^0C to 859^0C. What temperature change may occur before it is detected?

iv) What is RTD? How does it work?

v) Define control system. What the requirements of a good control system?

vi) Using Routh's criterion examine the stability of a control system whose characteristic equation is $\mathbf{S^5 + S^4 + 2S^3 + 2S^2 + 3S + 15 = 0}$

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)

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

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)

i) Ultrasonic Flow Meter
ii) 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)

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

a. Type of system
b. Error constants K_p, K_v, K_a
c. 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 d8.** Given that: (10)

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

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

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

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

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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) What is the significance of the p-value in hypothesis testing?

(b) Mention two differences between correlation and regression

(c) What is a confidence interval?

(d) When do we use the t-distribution instead of the normal distribution?

(e) Define and explain different types of data (nominal, ordinal, interval, and ratio) with examples.

Q. 2. (a) Explain the method of least squares for fitting a straight line. (10)

(b) Given the following data, find the regression line of Y on X: (10)
X: 1, 2, 3, 4, 5
Y: 2, 4, 5, 4, 5

Q. 3. (a) Explain the steps involved in hypothesis testing. (10)

(b) A company wants to compare the average productivity of two machines. (10)
From Machine A, a sample of 10 items has a mean output of 50 units and a standard deviation of 4. From Machine B, a sample of 8 items has a mean of 53 units and a standard deviation of 5. Test at 5% level of significance whether the machines have equal productivity.

Q. 4. (a) Explain stratified sampling and cluster sampling. When would you use each? (10)

(b) A factory has three production units. The manager wants to know if the average output per hour differs among the units. The number of units produced per hour in a sample of workers is: (10)

- **Unit 1**: 40, 45, 42, 43
- **Unit 2**: 38, 41, 39, 40
- **Unit 3**: 46, 47, 45, 48

Use one-way ANOVA to test if there is a significant difference in productivity among the units.

Q. 5. (a) What is analysis of variance (ANOVA)? Describe its assumptions. (10)

(b) A company wants to test if **department** (Sales, Admin) and **shift** (Morning, Evening) influence employee productivity. The following data (units completed per day) are collected: (10)

	Morning	**Evening**
Sales	80, 85, 82	78, 76, 77
Admin	70, 72, 75	68, 65, 67

Conduct a two-way ANOVA and determine if:

a. There is a significant difference in productivity between departments.
b. Shift timings have a significant effect.
c. There is a department X shift interaction

Q. 6. (a) The following data gives the marks obtained by students in two subjects: (10)
Subject A: 35, 40, 45, 50, 55, 60, 65
Subject B: 30, 35, 40, 42, 43, 44, 45

(a) Compute Pearson's correlation coefficient.

(b) Comment on the strength and direction of the relationship.

(b) Explain Chi-square test (10)

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