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 (*any Four*). **20**

i) What is Metrology? Explain different types of standards.

ii) With respect to surface roughness parameters explain the following terms:
i) Ra; ii) Ry; iii) Rz

iii) Define:
i) Sensitivity
ii) Precision
iii) Threshold

iv) Explain the working of LVDT with a neat sketch.

v) Distinguish between open loop and closed loop control systems.

vi) Using Routh's criterion examine the stability of a control system whose characteristic equation is $\mathbf{4S^5 + 2S^4 + 4S^3 + 8S^2 + 2S + 10 = 0}$

2. (A) Explain with a neat sketch the N.P. L. flatness interferometer. **10**

(B) Design a general type of Go and No Go plug gauge for inspecting a hole 25 D8. Given that: **10**

$\mathbf{i = 0.40\sqrt[3]{D} + 0.001D}$ micron

Tolerance for hole = **25 i**

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

Wear allowance 10% of gauge design

3. (A) Explain the term clearance fit with respect to limit fit diagram **05**

(B) Derive necessary expression to calculate the best wire diameter. **05**

(C) Draw the Root-Locus of the system having **10**

$$G(s)H(s) = \frac{K}{S(S+1)(S+4)}$$

4. (A) Define gauge factor of strain gauges. Derive an expression for gauge factor. **05**

(B) Briefly, discuss drift. **05**

(C) A system has transfer function given by **10**

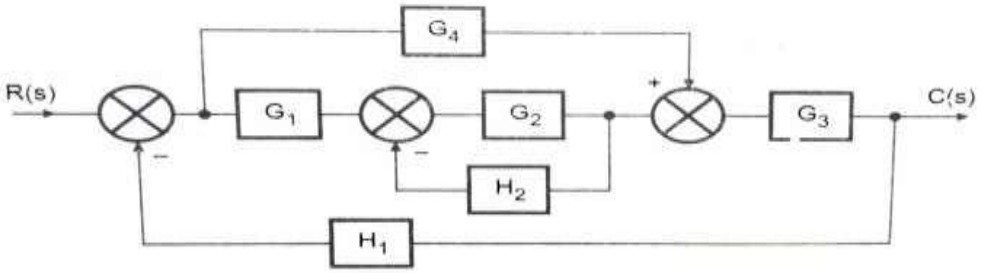
$$G(s)H(s) = \frac{100\,(s+2)}{s(s+1)(s+4)}$$

Determine:

i) Type of system
ii) Error constants K_p, K_v and K_a
iii) Steady state error for input magnitude 2

5. (A) Explain generalized measurement system elements with block diagram. Describe its function with suitable examples. **10**

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



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

i) Mc-Leod Gauge
ii) RTD
iii) Magnetic Flow Meter
iv) Frequency Domain Specifications
v) Parkinson's Gear Tester
vi) Range and Span

Duration:[03 Hours] **[Total Marks: 80]**

N. B : (1) Question no.1 is **Compulsory**.
(2) Solve any **THREE** from question no.2 to 6.
(3) Use illustrative diagrams wherever possible.
(4) Assume suitable data if necessary and mention it clearly.

Q.1 Solve **Any Four** questions :

a) Name the various modes of heat transfer and also explain its governing laws. **5**

b) What do you understand by'Fin' ? Enlist the various types of fin? Also draw sketches for any three types of fins. **5**

c) State and Explain the following radiation laws- **5**

i) Planck's law
ii) Kirchhoff' law

d) Differentiate between Four stroke cycle and Two stroke cycle engines. **5**

e) State the modes of Mass Transfer. State & explain the Fick's law of diffusion. **5**

Q.2 **a)** The wall of a cold storage consists of three layers-an outer layer of ordinary bricks,0.25m thick, a middle layer of cork,0.1m thick and an inner layer of cement,0.06m thick. The thermal conductivities of the materials are 0.7W/m.K,0.043W/m.K and 0.72W/m.K, respectively. The temperature of the outer surface of the wall is 30^0C and that of inner is -15^0C.Calculate: **10**

i) Steady state rate of heat gain per unit area
ii) Temperature at the interfaces of composite wall
iii) The percentage of total heat resistance offered by individual layers

b) Derive an expression for log mean temperature difference (LMTD) in a parallel flow heat exchanger. State your assumptions. **10**

Q.3 **a)** Water at the rate of 0.8 kg/s at 90^0C flows through a steel pipe having 25mm ID and 30mm OD passing through the room. The outside surface temperature of the pipe is 84^0C and temperature of the surrounding air is 20^0C.The room pressure is 1 atm and the pipe is 15m long. How much heat is lost by free convection in the room.? **12**

You may use correlation

$Nu = 0.53\ (Gr.Pr)^{0.25}$ for $10^4 < Gr\ Pr < 10^9$

$= 0.10\ (GrPr)^{1/3}$ for $10^9 < Gr\ Pr < 10^{12}$

Take the properties of air as

$\mu = 1.9606 \times 10^{-5}$ kg/ms, k = 13.02W/m^{0}C , ρ = 1.0877 kg/m^3,Cp=1007.3 J/kg.K

k =0.02813W/m.K,

b) One end of the copper rod 15 cm long and 0.6 cm in diameter is connected to a wall maintained at 300^0C and the other end protrudes into a room whose air temperature is 20^0C.If the tip of the rod is insulated, Estimate -i) Heat loss by the rod. ii) The heat transfer efficiency of copper rod. Take h=28W/m^{2}K ,k=370W/mK. **08**

Q.4 **a)** In an open heart surgery, under hypothermic conditions, the patient blood is cooled before the surgery and rewarmed afterwards. It is proposed that a concentric tube, counter flow heat exchanger of length 0.5 m be used for this purpose with the thin walled inner tube having a diameter of 55mm. If the water at 60^0C and 0.10 kg/s is used to heat the blood entering the heat exchanger at 18^0C and 0.05kg/s, what is the temperature of blood leaving the heat exchanger? The overall heat transfer coefficient is 500W/m^2.K and specific heat of the blood is 3500J/kg.K, Specific heat of water is 4200 J/kg.K **10**

b) Explain the stages of combustion in SI engines with the help of pressure - crank angle diagram. **10**

Q.5 **a)** In a test of single cylinder four stroke oil engine with Bore 300mm and Stroke 450 mm , the following observations were made: **12**

Duration of Test	= 60 min
Engine speed	= 200 RPM
Fuel consumption	=7 kg
Calorific value of fuel	= 45000 kJ/kg
Average speed	=200 rpm
Indicated mean effective pressure	=5.867 bar
Net Brake load	=130 kg
Brake drum diameter	=1650 mm
Total weight of jacketed of cooling water	= 500 kg
Temperature rise of jacketed cooling water	=40^0C
Temperature of exhaust gases	=300^0C
Air consumption	=300kg
Specific heat of exhaust gases	=1.004kJ/kg.K,
Specific heat of water	= 4.19 kJ/kg.K
Room temperature	=25^0C

Determine: i) Mechanical Efficiency ii) Brake thermal efficiency iii) Draw up heat balance sheet on minute and percentage basis

b) What do you understand by the hydrodynamic and thermal boundary layer? Illustrate with reference to flow over a flat heated plate. **08**

Q.6 **(a)** A solid copper sphere of 10 cm diameter (ρ = 8954 kg/m^3, Cp=383 J/kg.K , k= 386 W/mk) ,initially at a uniform temperature ti=250^0C, is suddenly immersed in a well stirred fluid which is maintained ar a uniform temperature ta=50^0C.The heat transfer coefficient between the sphere and the fluid is h= 200 W/m^2K.Determine the temperature of the copper sphere at τ =5 min after the immersion. **08**

b) With a neat sketch explain the construction and working of Simple Carburetter. **06**

c) Enumerate various methods to control engine emission. Explain any one method in brief with neat sketch. **06**

****

Time: 3 Hours **Total Marks:80**

Note:

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.

Q1 Solve any four

a) How optimization problems can be classified (5)

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) $x_1 - 5x_2 + 3x_3 \leq 1$ (iv) $-3x_1 - 3x_2 + 7x_3 \leq 6$ and $x_1, x_2, x_3 \geq 0$

c) Illustrate difference in linear and nonlinear optimization problem with suitable example. (5)

d) State methods of normalization and explain any one. (5)

e) Explain Taguchi's loss function (5)

Q2 a) Solve the following problem by simplex method (10)
Maximize $Z = 30x_1 + 20x_2$
Subject to $x_1 + x_2 <= 40$
$x_1 - x_2 <= 20$
$x_1, x_2 >= 0$

b) A company manufactures around 200 bikes. Depending upon the availability of raw materials and other conditions, the daily production has been varying from 196 to 204 bikes , whose probability distribution is as given below: (10)

Production/day	196	197	198	199	200	201	202	203	204
Probability	0.05	0.09	0.12	0.14	0.20	0.15	0.11	0.08	0.06

The finished bikes are transported in a specially designed three-storied lorry that can accommodate only 200 mopeds. Using the following 10 random numbers: 82, 89, 78, 24, 53, 61, 18, 45, 23, and 50, simulate production for 10 days
(a) What will be the average number of bikes made in 10 days?
(b) What will average number of bikes waiting in company to be transported in 10 days

Q3 a) Using the Lagrange's multiplier method solve the following NLPP (10)
Optimize $Z = 4x_1^2 + 2x_2^2 + x_3^2 - 4x_1x_2$
S.T. $x_1 + x_2 + x_3 = 15$
$x_1, x_2, x_3 \geq 0$

b) A company sells two different products A and B, making a profit of Rs 40 and Rs 30 per unit, respectively. They are both produced with the help of a common production process and are sold in two different markets. The production process has a total capacity of 30,000 man-hours. It takes three hours to produce a unit of A and one hour to produce a unit of B. The market has been surveyed and company officials feel that the maximum number of units of A that can be sold is 8,000 units and that of B is 12,000 units. Subject to these limitations, products can be sold in any combination. Formulate this problem as an LP model to maximize profit. (5)

c) State various Linear programming methods and state its suitability with illustration (5)

Q4 a) What are the various non-traditional optimisation techniques? Explain any one with illustration. (10)

b) Discuss in brief some applications of Optimization in Engineering (5)

c) A manufacturing firm produces two types of products: A and B. The unit profit from product A is Rs 200 and that of product B is Rs 150. The goal of the firm is to earn a total profit of exactly Rs 900 in the next week. The demand of A and B are upto maximum 30 and 40 quantities respectively. Formulate as a goal programming model. (5)

Q5 a) Following table shows the various alternatives of Material (M1, M2,..) for piston cyinder, and corresponding attributes as Cost (A1), tensile strength (A2), thermal conductivity (A3), and machinability index (A4) Suggest suitable material using SAW method. Assume equal weight of 0.25 for the all attributes, A1 as non-beneficial and rest all as beneficial attributes for the following case. (10)

No	Alternative	M1(Rs/kg)	A2 (MPa)	A3 (W/m-K)	A4
1	M1	300	110	142	100
2	M2	350	100	125	110
3	M3	375	120	100	105
4	M4	400	130	120	120
5	M5	315	125	135	115

b) Find the maxima and minima, if any, of the function $f(x) = 4x^3 - 18x^2 + 27x - 7$ (5)

c) Explain concept of Dynamic programming (5)

Q6 a) Explain design of experiments. Explain its application and state its importance. (10)

b) What we mean by full factorial and fractional factorial experiments. (5)

c) Explain concept of robust design (5)

Time: 3 hrs **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	Derive the relation for Gyroscopic couple during pitching of ship and discuss its effect.	5
C	Discuss different types of damping.	5
D	Explain dynamically equivalent system with correction couple.	5
E	Plot variation between frequency ratio vs magnification factor and conclude graph.	5

Q2

2A. Find the natural frequency of a half solid cylinder of mass m and radius r when it is slightly displaced from the equilibrium position and released. 10

2B A Porter governor has rotating mass of each ball 5 kg and mass on the sleeve is 30 kg. Upper links are 250 mm long and lower links are 350 mm long.The upper ends of upper links and lower ends of lower links are hinged at 40 mm from the governor axis. Find equilibrium speed of the governor in rpm when the governor rotates at 130 mm radius. 10

Q3

3A. The turbine rotor of a ship has a mass of 2000 kg and it rotates at a speed of 3000 rpm clockwise when seen from stern .The radius of gyration of the rotor is 0.5 m . 10
1.Determine the gyroscopic couple and its effect, if the ship is steering to the right in a curve of 100 m radius at a speed of 16.1 knots. Assume 1 knot = 1855 m/hr.
2.Calculate the gyroscopic couple and its effect when the ship is pitching in SHM, with the bow falling with its maximum velocity. The period of pitching is 50 sec and the total angular displacement between the two extreme positions is 12^0. Find maximum acceleration during the pitching motion.

3B. An underdamped shock absorber is to be designed for a motorcycle of mass 200 kg, such that during a road bump, the damped period of vibration is limited to 2 sec and the amplitude of vibration shoud reduce to one-sixteen in one cycle. 10
Find spring stiffness and damping coefficient of the shock absorber.

Q4.

4A. In a vertical double acting steam engine ,the connecting rod is 4.5 times the crank .The mass of reciprocating parts is 120 kg and the stroke of the piston is 440 mm.The engine runs at 250 rpm.If the net load on the piston due to steam pressure is 25 KN when the crank has turned through an angle of 120^0 from the TDC , Determine 10

1.thrust in connecting rod 2.thrust on cylinder 3.tangential force on crank pin

4.thrust on bearing 5.turning moment on crankshaft

4B. A 30 Kg block is connected to a spring of stiffness 1.5×10^5 N/m. The coefficient of friction between block and surface on which its slides is 0.15. The block is displaced 12 mm 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 0.6 cm. If the undamped natural frequency of the system is 6 Hz. And the static defection of the mass under the maximum force is 0.3 cm, estimate the damping ratio of the system and peak frequency. 12

5B.A seismic instrument with natural frequency of 7 Hz is used to measure vibration of machine running at 100 rpm. The instrument gives reading for relative displacement of mass as 0.07mm. 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 250 mm, 150 mm, 200 mm and 350 mm are 250 kg, 350 kg, 240 kg and 200 kg in magnitude respectively. The angles between the successive masses are 40-degree, 70 degree and 130 degree respectively. Find the position and magnitude of the balance mass required, if its radius of rotation is 150 mm. 08

6B. i) Write short note on partial balancing in reciprocating masses. 07

ii) Discuss fault diagnosis. 05

****

Time : 3 Hrs **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.*

Q. 1 Solve **ANY FOUR** questions from following. **Marks 20**

i) Explain iso-parametric, sub-parametric and super-parametric element.

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

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

iv) Explain Jacobian matrix. And describe the significance of Jacobian Matrix in co-ordinate transformation.

v) Explain plane stress and plane strain conditions applied to elasticity problems.

vi) Explain the sources of error in FEM.

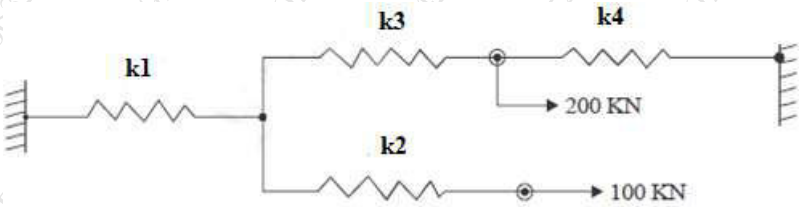
Q. 2 a) Solve following differential equation using galerkin method **10**

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

Boundary Conditions: y(0) = 1, y(1) = 2, find y(0.3)

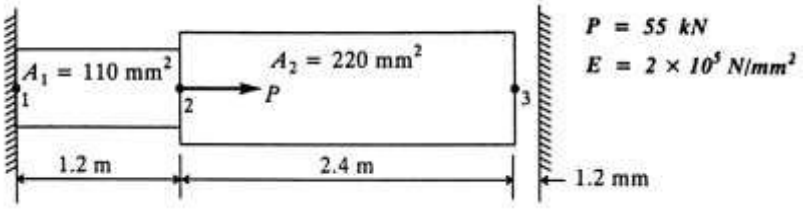
b) Using the concept of serendipity, derive the shape functions for four node rectangular element in natural co-ordinate system (ξ and η). **10**

Q. 3 a) Determine the displacement at nodes by using principle of minimum potential energy approach **10**



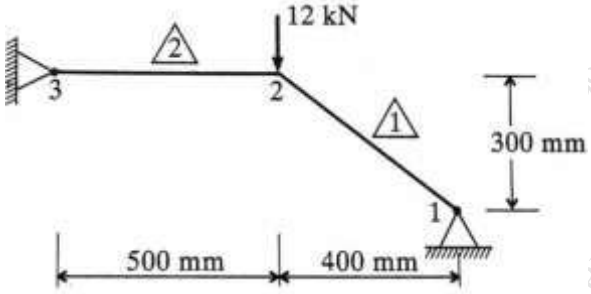
Where, k1=100 N/mm ; k2=300 N/mm ; k3=150N/mm ; k4=200 N/mm

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



Q. 4 a) Find the natural frequency of axial vibrations of a bar of uniform cross section of 30 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**

b) Find nodal displacement, reaction forces and stresses in each element for a truss given below. Take E= $2x10^5$ N/mm^2 and A = 200 mm^2. **10**



Q. 5 **a)** Calculate linear interpolation functions for linear triangular element whose vertices are A(2, 5), B(1, -1) and C(3, 4). **08**

b) Consider the steady laminar flow of a viscous fluid through a long circular cylindrical tube. The governing equation is **12**

$$-\frac{1}{r}\frac{d}{dr}\left(r\mu\frac{dw}{dr}\right)=\frac{P_0-P_L}{L}\equiv f_0$$

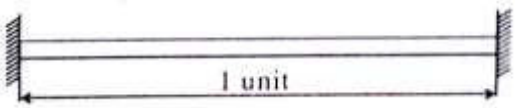
Where, w is axial (z-axis) component of velocity, μ is the viscosity, and f_0 is the gradient of pressure (includes static pressure and gravitational force). The boundary conditions are:

$$\left(r\frac{dw}{dr}\right)\Big|_{r=0}=0, \qquad w(R_0)=0$$

Using symmetry and two linear elements or one quadratic element, determine the velocity field and compare with exact solution at nodes:

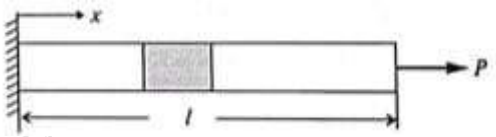
$$w_e(r)=\frac{f_0R_0^2}{4\mu}\left[1-\left(\frac{r}{R_0}\right)^2\right]$$

Q. 6 **a)** Determine the two natural frequencies of transverse vibration of a beam fixed at both ends as shown in figure. Use both Lumped and Consistent mass matrices 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**



b) Derive the element matrix equation for a simple bar fixed at one end and loaded axially at the other end, as shown in figure. The cross-section area of the bar is A, and the modulus of elasticity is E. The governing differential equation is given by: **10**

$$\frac{d}{dx}\left[EA\frac{du}{dx}\right]=0\,; \qquad \text{for} \quad 0<x<l$$



Duration: 3hrs **[Max Marks: 80]**

N.B.: (1) Question No 1 is Compulsory.
(2) Attempt any three questions out of the remaining five.
(3) All questions carry equal marks.
(4) **Assume suitable data, if required and state it clearly**.

Q.1) Explain any four of the following. **20**

1. Write briefly guidelines for Design of Experiment.
2. Explain Signal to Noise ratio.
3. How will you test Hypothesis using T-Test.
4. Explain One Half fraction of 2^k Design.
5. Explain Taguchi Loss Function.

Q.2) Explain the following. **20**

1. The following are the burning times (in minutes) of chemical flares of two different formulations. The design engineers are interested in testing the mean burning times of both the flares. Test the hypothesis that the mean burning times are equal. Use $\alpha = 0.05$.

Type 1		Type 2	
65	82	64	56
81	67	71	69
57	59	83	74
66	75	59	82
82	70	65	79

2. Explain the Addition of center Points to the 2k Design.

Q.3) Explain the following. **20**

1. Explain the Taguchi Methodology in details.
2. Define Latin square design. Give an example of Latin square of order 4. Mention the Advantages and disadvantages of a Latin square design.

Q.4) Explain the following. **20**

1. The breaking strength of a fiber is required to be at least 150 psi. Experience has indicated that the standard deviation of breaking strength is $\sigma = 3$ psi. A random sample of four specimens is tested. The results are y1=145, y2=153, y3=150 and y4=147.State the hypotheses that you think should be tested in this experiment. Test these hypotheses using $\alpha = 0.05$. What are your conclusions? Construct a 95 percent confidence interval on the mean breaking strength.
2. Explain Response Surface Methodology.

Q.5) Explain the following. **20**

1. List the Various types of Shainin Tools. Explain Any one of them in Details.
2. Explain a Single Replicate of 2k Design.

Q.6) Explain the following. **20**

1. Explain in details procedure for testing the Hypothesis.
2. Explain Multiple linear regression model.

****