(3hours) [Total marks: 80]

N.B. 1) Question No. 1 is compulsory.
2) Answer **any Three** from remaining
3) Figures to the right indicate full marks

1. a) Find Laplace transform of $f(t) = e^{-4t} \sin 3t . \cos 2t$. 5

b) Show that the set of functions $f(x) = 1, g(x) = x$ are orthogonal on $(-1,1)$. Determine the constants a and b such that the function $h(x) = -1 + ax + bx^2$ is orthogonal to both $f(x)$ and $g(x)$. 5

c) Evaluate $\int_c (z^2 - 2\bar{z} + 1)dz$ where C is the circle $|z| = 1$. 5

d) Compute the Spearman's Rank correlation coefficient ***R*** and Karl Pearson's correlation coefficient ***r*** from the following data, 5

x	12	17	22	27	32
y	113	119	117	115	121

2. a) Using Laplace transform, evaluate $\int_0^\infty e^{-t} \int_0^t \frac{\sin u}{u} du\, dt$. 6

b) Find an analytic function $f(z) = u + iv$, if 6

$$u = e^{-x}\{(x^2 - y^2)\cos y + 2xy \sin y\} .$$

c) Obtain Fourier series of $f(x) = x^2$ in $(0,2\pi)$. Hence, deduce that – 8

$$\frac{\pi^2}{12} = \frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + + \cdots .$$

3. a) Using Bender –Schmidt method, solve $\frac{\partial^2 u}{\partial x^2} - \frac{\partial u}{\partial t} = 0$, subject to the conditions,

$u(0,t) = 0, u(4,t) = 0, u(x,0) = x^2(16 - x^2)$ taking $h = 1$, for 3 minutes. 6

b) Using convolution theorem, find the inverse Laplace transform of 6

$$F(s) = \frac{s^2 + s}{(s^2 + 1)(s^2 + 2s + 2)}$$

c) Using Residue theorem, evaluate

i) $\int_0^{2\pi} \frac{d\theta}{2 + \cos\theta}$ ii) $\int_C \frac{z^2}{(z+1)^2(z-2)} dz$, $C: |z| = 1.5$ 8

4. a) Solve by Crank –Nicholson simplified formula $\frac{\partial^2 u}{\partial x^2} - 16\frac{\partial u}{\partial t} = 0$, 6
$u(0,t) = 0,\ u(1,t) = 200t,\ u(x,0) = 0$ taking $h = 0.25$ for one-time step.

b) Obtain the Laurent series which represent the function

$f(z) = \frac{4z+3}{z(z-3)(z+2)}$ in the regions, i) $2 < |z| < 3$ ii) $|z| > 3$ 6

c) Solve $(D^2 - 3D + 2)y = 4e^{2t}$ with $y(0) = -3$ and $y'(0) = 5$ where $D \equiv \frac{d}{dt}$ 8

5. a) Find the bilinear transformation under which $1, i, -1$ from the *z*-plane are mapped onto $0,1,\infty$ of *w*-plane. 6

b) Find the Laplace transform of

$f(t) = \begin{cases} t, & 0 < t < \pi \\ \pi - t, & \pi < t < 2\pi \end{cases}$ and $f(t + 2\pi) = f(t)$. 6

c) Obtain half range Fourier cosine series of $f(x) = x, 0 < x < 2$. Using Parseval's identity, deduce that – 8

$$\frac{\pi^4}{96} = \frac{1}{1^4} + \frac{1}{3^4} + \frac{1}{5^4} + \cdots.$$

6. a) Using contour integration, evaluate: 6

$$\int_{-\infty}^{\infty} \frac{x^2 + x + 2}{x^4 + 10x^2 + 9}\, dx$$

b) Using least square method, fit a parabola, $y = a + bx + cx^2$ to the following data, 6

x	-2	-1	0	1	2
y	-3.150	-1.390	0.620	2.880	5.378

c) Determine the solution of one-dimensional heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$ under the boundary conditions $u(0,t) = 0,\ u(l,t) = 0,\ u(x,0) = x, (0 < x < l), l$ being the length of the rod. 8

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

N. B. : (1) Question No. **1** is **compulsory**.
(2) Solve any **three** out of the remaining **five** questions.
(3) Assume suitable data if required and state it clearly.
(4) Use of Steam Table and Mollier diagram is permitted.

1. Attempt any **four** out of the following **20**

(a) State and prove Carnot Theorem.

(b) Explain the working principle of Roots blower. Also draw P-V diagram for it.

(c) What is the difference between heat and internal energy?

(d) Why is Carnot cycle not practicable for a steam power plant?

(e) Calculate the state of steam (i.e. whether it is dry, wet or superheated), when steam has a pressure of 15 bar and specific volume of 0.12 m^3/kg.

2. **(a)** In a gas turbine unit, the gases flow through the turbine is 15 kg/s and the power developed by the turbine is 12000 kW. The enthalpies of gases at the inlet and outlet are 1260 kJ/kg and 400 kJ/kg respectively, and the velocity of gases at the inlet and outlet are 50 m/s and 110 m/s respectively. Calculate : **10**
(i) The rate at which heat is rejected to the turbine, and
(ii) The area of the inlet pipe, given that the specific volume of the gases at the inlet is 0.45 m^3/kg.

(b) Show that the heat transfer through a finite temperature difference is irreversible. **5**

(c) A system at 500 K receives 7200 kJ/min from a source at 1000 K. The temperature of atmosphere is 300 K. Assuming that the temperatures of system and source remain constant during heat transfer find out : **5**
(i) The entropy produced during heat transfer ;
(ii) The decrease in available energy after heat transfer.

3. **(a)** Three reversible engines of Carnot type are operating in series between the limiting temperatures of 1100 K and 300 K. Determine the intermediate temperatures if the work output from engines is in proportion of 3 : 2 : 1. **10**

(b) Explain the principle of increase of entropy. **5**

(c) Derive the first and second T-dS equations. **5**

4. **(a)** In a thermal power plant operating on an ideal Rankine cycle, superheated steam produced at 5 MPa and 500^0C is fed to a turbine where it expands to the condenser pressure of 10 kPa. If the net power output of the plant is to be 20 MW, determine: i) heat added in boiler, in kJ/kg ii) the thermal efficiency. iii) the mass flow rate of steam in kg/sec. **10**

(b) Show that the efficiency of the Otto cycle depends only on the compression ratio. **5**

(c) Define volumetric efficiency of a compressor. On what factors does it depend? **5**

5. **(a)** One kg of air at 1 bar and 300 K is compressed adiabatically till its pressure becomes 5 times the original pressure. Subsequently it is expanded at constant pressure and finally cooled at constant volume to return to its original state. Calculate the heat and work interactions and change in internal energy for each process and for the cycle. **10**

(b) State the Zeroth law of thermodynamics. What is it's significance? **5**

(c) Deduce the expression for available energy from a finite energy source at temperature T when the ambient temperature is T_o. **5**

6. **(a)** An oil engine takes in air at 1.01 bar, 20^0C and the maximum cycle pressure is 69 bar. The compression ratio is 18. Calculate the air standard thermal efficiency based on the dual combustion cycle. Assume that the heat added at constant volume is equal to the heat added at constant pressure. **10**

(b) A single stage, single acting air compressor running at 1000 rev/min delivers air at 25 bar. For this purpose the induction and free air conditions can be taken as 1.013 bar and 15^0C, and the FAD as 0.25 m^3/min. The clearance volume is 3% of the swept volume and the bore/stroke ratio is 1.2/1. Calculate: **10**

(i) the bore and stroke;
(ii) the volumetric efficiency;
(iii) the indicated power;
(iv) the isothermal efficiency;

Take the index of compression and re-expansion as 1.3.

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

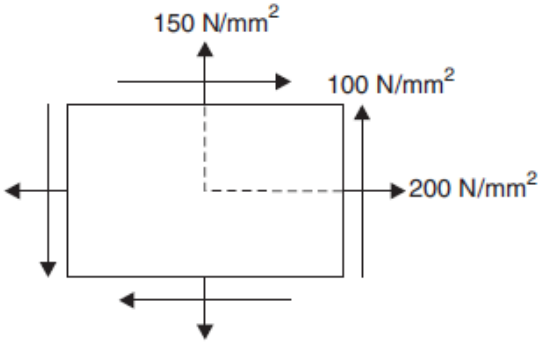
N.B. 1. Question No.1 is compulsory.
2. Answer any three questions from remaining questions.
3. Assume suitable data if required.
4. Figure to the right indicates full marks.

Q.1 Answer any four of the following. 20

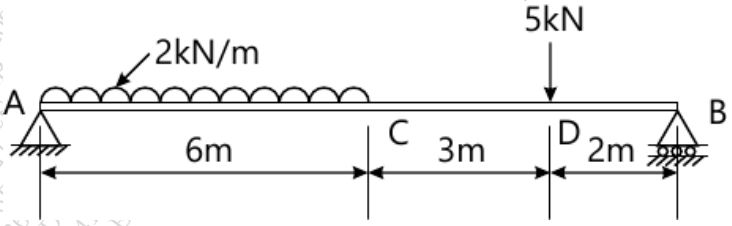
a. Derive an expression for the strain energy due to suddenly applied load.
b. Derive the relation between load, shear force and bending moment.
c. Write the assumptions made in theory of pure torsion and derive torsional formula.
d. Draw shear stress distribution diagram for symmetry I section, T section and rectangular section.
e. Write the assumption for simple bending and derive the flexural formula.
f. Find the maximum power that can be transmitted through 50 mm diameter shaft at 150 rpm, if the maximum permissible shear stress is 80 N/ mm^2.

Q.2 a. A bar of brass 20 mm is enclosed in a steel tube of 40 mm external diameter and 20 mm internal diameter. The bar and the tubes are initially 1.2 m long and are rigidly fastened at both ends. If the temperature is raised by 60°C, find the stresses induced in the bar and tube. 10
Given: $E_s = 2 \times 10^5$ N/mm^2
$E_b = 1 \times 10^5$ N/mm^2
$\alpha_s = 11.6 \times 10^{-6}$/°C
$\alpha_b = 18.7 \times 10^{-6}$/°C.

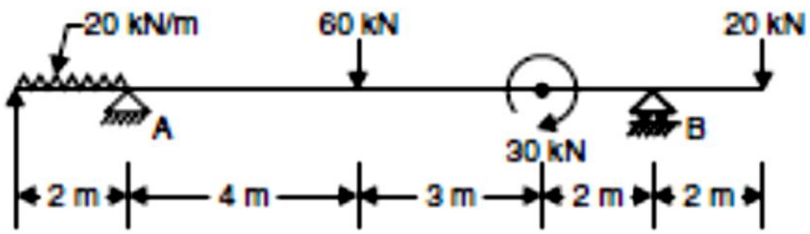
b. The state of stress at a point in a strained material is as shown in Fig. Determine 10
(i) the direction of principal planes
(ii) the magnitude of principal stresses and
(iii) the magnitude of maximum shear stress.
Indicate the direction of all the above by a sketch.



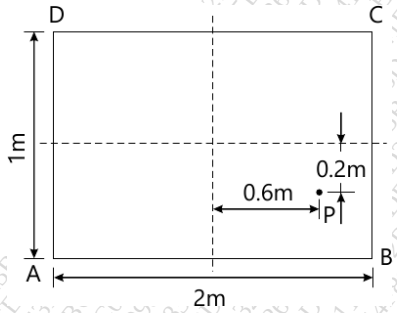
Q.3 a. Find slope at point A & B deflections at points C & D for a beam as shown in fig. Also find the maximum deflection. Take, E=200 GPa & I=10^8 mm^4 10



b. Draw SF and BM diagrams for the beam shown in figure. 10



Q.4 a. A vertical column of rectangular section is subjected to a compressive load of P=800 KN as shown in fig. Find the stress intensities at the four comers of the column. 10



b. A propeller shaft is required to transmit 50 kW power at 500 rpm. It is a hollow shaft, having an inside diameter 0.6 times of outside diameter and permissible shear stress for shaft material is 90 N / mm^2. Calculate the inside and outside diameters of the shaft. 10

Q.5 a. A cylindrical shell is 3m long and 1.2m in diameter and 12mm thick is subjected to internal pressure of 1.8 N/mm^2 calculate change in dimensions and volume of shell. Take E=210 kN/mm^2 1/m=0.3 10

b. A simply supported beam of length 3 m and a cross section of 100 mm×200 mm carrying a UDL of 4 kN/m. find 10

1. Maximum bending stress in the beam.
2. Maximum shear stress in the beam.
3. The shear stress at point 1 m to the right of the left support and 25 mm below the top surface of the beam.

Q.6 a. A 400 mm long bar has rectangular cross-section 10 mm × 30 mm. This bar is subjected to 10

(i) 15 kN tensile force on 10 mm × 30 mm faces,
(ii) 80 kN compressive force on 10 mm × 400 mm faces, and
(iii) 180 kN tensile force on 30 mm × 400 mm faces.
Find the change in volume if E = 2 × 105 N/mm^2 and 1/m= 0.3.

b. A hallow cylindrical CI column is 4 m long with both end fixed. Determine the minimum diameter of the column, if it has to carry a safe load of 250 KN with a FOS of 5. Take internal diameter as 0.8 times the external diameter E=200 GN/m^2. 10

Total Marks- 80 **Duration: 3 Hours**

N.B. 1) First Question (Q.1) is Compulsory.
2) Attempt any 3 questions from the remaining 5 (Q.2 - Q.6) questions.
3) Figures to the right indicate full marks
4) Proportionate and labelled free-hand sketches would do

Q. 1 a)	Draw and discuss working of Explosive Welding technique with its applications, advantages and limitations.	**10**
b)	What's a pattern? How's it different from casting? Discuss various allowances on pattern and the material alternatives for pattern making.	**10**
Q. 2 a)	Draw and explain Geometry of a Single Point Cutting Tool.	**10**
b)	Explain working of Submerged Arc Welding with its applications, advantages and limitations.	**10**
Q. 3 a)	Discuss physics of electric welding arc with the help of diagrams.	**10**
b)	Explain the working principle of resistance spot welding process with the help of diagrams.	**10**
Q. 4 a)	Explain the imposition of directional solidification in sand casting.	**10**
b)	Draw and explain significance of various elements of gating system in sand casting.	**10**
Q. 5 a)	Draw and explain working of screw injection moulding of polymers with its applications, advantages and limitations.	**10**
b)	Draw and explain various operations possible on Centre Lathe.	**10**
Q. 6	Write short notes on (Any four)	**20**

a) Various soldering techniques.
b) Pressurized and Non-pressurized gating system in founding practice.
c) Electron Beam Welding.
d) Reaction moulding of polymers.
e) Classification of manufacturing processes.
f) Quick return mechanism on shaper.

Time: 3 hours Marks [80]

NB: 1. **Q.1 is compulsory**
2. Solve any **three** from the remaining .
3. All questions carry equal marks

Q.1 Answer any **four**: **20**

1. Define composite and discuss its classification.
2. Discuss the differences and similarities between slip and twinning.
3. Why FCC metals are in general more ductile than BCC and HCP metals?
4. What are MR fluids? Where are they used?
5. What are limitations of Plain carbon steel? Explain the alloying effect on phase transformations.

Q.2

1. Define critical cooling rate. Describe various cooling curves on TTT diagram. How such curves are drawn? What factors affect critical cooling rate? **10**
2. What is strain hardening? Explain the phenomenon on the basis of dislocation theory. Also discuss role of Frank reed source in strain hardening. **10**

Q.3

1. What is fatigue of metals? Explain the method of testing the metals for fatigue. Draw and discuss the S-N diagram. **10**
2. Define creep. Draw the creep curve and explain the stages of creep. Discuss the development of creep resisting materials. **10**

Q.4

1. Draw Fe-Fe_3C equilibrium diagram and label the temperatures, composition and phases. **10**
2. Describe the cooling of the 0.4%C steel from liquid state to room temperature. Calculate the phases in this steel obtained at room temperature. **10**

Q.5

1) Define hot and cold working. Compare the two processes giving a few examples for each. **10**
2) What is Hardenability? What are factors affecting hardenability? Explain Jominy End Quench test. **10**

Q.6 Answer any **four-** **20**

1) Discuss the importance of heat treatments.
2) A slowly cooled steel contains 40% ferrite and 60% pearlite at room temperature. Determine the amount of total ferrite and cementite present in the alloy.
3) Discuss the Rule of mixtures and its use.
4) What are smart materials? Discuss a few of them giving applications for the same.
5) Discuss with a neat diagram any one method used for nanomaterial synthesis.
