

The figures in the margin indicate full marks.

Symbols indicate their usual meaning. Assume any data if necessary.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) A column, fixed at one end and free at the other end, having 80 mm × 80 mm square cross-section is subjected to an eccentric load of 50 kN at its free end with an eccentricity of 15 mm and a factor of safety of 2.0. Determine the maximum deflection and maximum stress developed in the column. With a plot show load-transverse deflection of free end of the same column. (15)
- (b) A rigid bar, hinged at one end, is supported by two identical springs as shown in Fig. 1(b). Each spring consists of 20 turns of 10 mm wire having a mean diameter of 150 mm. Compute the maximum shearing stress in the spring. Solve the problem considering the effect of curvature. Neglect the mass of the rigid bar. (20)
2. (a) A thick-walled cylinder is built up by shrinking a tube of 25.4 mm thickness on a hollow cylinder having an outside diameter of 150 mm and an inside diameter of 100 mm, thereby causing a contact pressure of 27.6 MPa. What is the greatest internal pressure that can be applied to the assembly without exceeding a tangential stress of 96.5 MPa at the inner surface? (15)
- (b) If an element is subjected to the state of stress as shown in Fig. 2(b), find the principal stresses and the maximum in-plane shearing stresses. Also determine the stress components on planes whose normals are at +60° and +150° with the x axis. Show all results on complete sketches of appropriate element. (20)
3. (a) The cross-section of a ring is the T section as shown in Fig. 3(a). The inside diameter of the ring is 396 mm. Determine the value of P that will cause a maximum stress of 124 MPa at section AB . Solve the problem using curve beam theory. (15)
- (b) In a reinforced concrete beam, $b = 305$ mm, $d = 457$ mm, and $n = 8$. If a maximum stress of 9.65 MPa is developed in the concrete when resisting a bending moment of 108 kN.m, (i) what stress is developed in the steel? (ii) what area of reinforcing steel is required? (20)
4. (a) A cantilever beam is subjected to a concentrated load P as shown in Fig. 4(a). Determine the deflection of the point of application of the load P by strain energy approach. (15)

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(b) A 60° strain rosette attached to the aluminum skin of an airplane fuselage measures the following strains: $\varepsilon_a = 10^{-4}$, $\varepsilon_b = -2 \times 10^{-4}$, $\varepsilon_c = 4 \times 10^{-4}$. If $E = 70$ GPa and Poisson's ratio $\nu = 1/3$, compute the principle stresses and the maximum shearing stress. (20)

SECTION - B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) The joint in Fig. for Q. No. 5(a) is fastened together using two bolts having a diameter of 10 mm. Determine the maximum force F that can be applied if the allowable normal and shear stresses in bolt are 450 MPa and 350 MPa, respectively. Also, what would be the maximum value of this force F if the stresses in plate material are considered? Consider the allowable normal and shear stresses in plate material as 300 MPa and 200 MPa, respectively. (18)

(b) On the free surface of a flip-chip microprocessor, the stress components at a point have been found as follows: (17)

$$\sigma_x = -80 \text{ MPa}, \sigma_y = -70 \text{ MPa}, \tau_{xy} = 50 \text{ MPa}$$

The Poisson's ratio and the modulus of elasticity of the material are 0.3 and 20 GPa, respectively.

(i) Write down the values of the remaining stress components at that point under plane stress condition.

(ii) Determine the values of strain components at that point in x- and y- reactions.

(iii) Also find the shear strain of the x-y plane.

6. (a) The center rod CD of the assembly as shown in Fig. for Q. No. 6(a) is heated from $T_1 = 30^\circ\text{C}$ to $T_2 = 180^\circ\text{C}$. Also, the two end rods AB and EF are heated from $T_1 = 30^\circ\text{C}$ to $T_2 = 50^\circ\text{C}$. At the lower temperature, the gap between C and rigid bar is 0.7 mm. Determine the force in rods AB and EF caused by increased in temperature. Rods AB and EF are made of steel, and each has a cross sectional area of 125 mm^2 . CD is made of aluminum and has a cross sectional area of 375 mm^2 . Also, $E_{st} = 200$ GPa, $E_{al} = 70$ GPa, $\alpha_{st} = 12 \times 10^{-6}/^\circ\text{C}$, and $\alpha_{al} = 23 \times 10^{-6}/^\circ\text{C}$. (20)

(b) A thin-walled cylinder with 200mm ID is subjected to an internal pressure of 100 bar, is made of steel material whose ultimate tensile strength is 550 MPa. Using a safety factor of 2, determine the minimum thickness required for this cylinder. Also, calculate the maximum stress developed in a spherical vessel of same ID with the same internal pressure. Use the thickness that you obtained in the previous step for cylindrical vessel. (15)

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7. (a) In a well drilling operation, the deep end of the drill pipe is subjected to a torsional resistance of 10 kN-m. Furthermore, the friction of soil creates a linear torque distribution (0 at the surface and 500 N-m at the deep end) along the pipe length. Determine the maximum shear stress developed in the pipe. Consider the pipe length of 60 m and the OD and ID of the pipe are 100 mm and 80 mm, respectively. What is the relative angle of twist of the free end with respect to the deep end? Consider, $G = 80 \text{ GPa}$ for the pipe material. (18)

(b) Draw the shear force and bending moment diagram of the beam loaded as shown in the figure for Q. No. 7(b). Also, write down the necessary equations to draw the diagrams. (17)

8. (a) A beam carries a concentrated load W and a total uniformly distributed load of $4W$ as shown in Fig. for Q. No. 8(a). If the allowable compressive stress in the beam is 120 MPa and the allowable shear stress is 80 MPa, determine the maximum value of W that can be applied. (15)

(b) The steel shaft ($E = 200 \text{ GPa}$) is used to support a rotor that exerts a uniform load of 5 kN/m within the region CD of the shaft as shown in Fig. for Q. No. 8(b). Determine the slope of the shaft at the bearing A, and deflection at the midpoint. The bearings exert only vertical reactions on the shaft. (20)

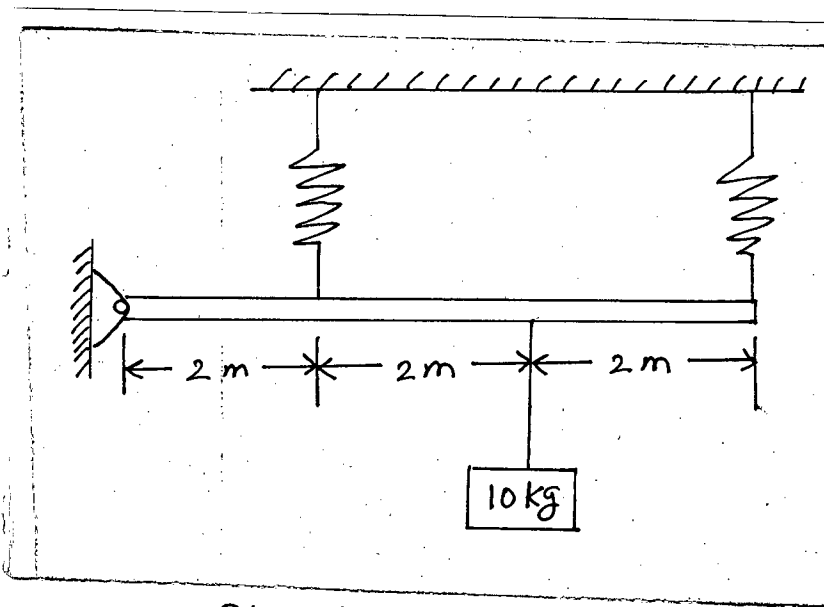


Fig. for. 1(b)

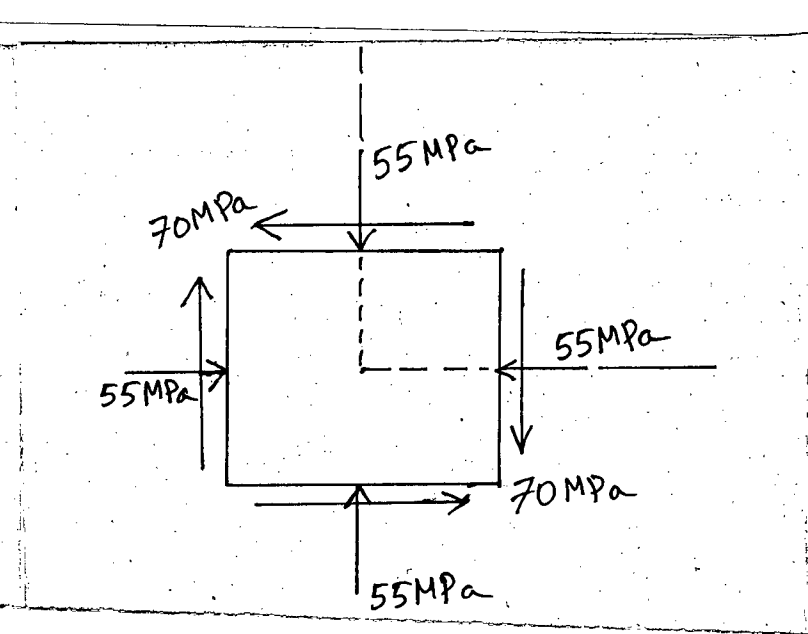
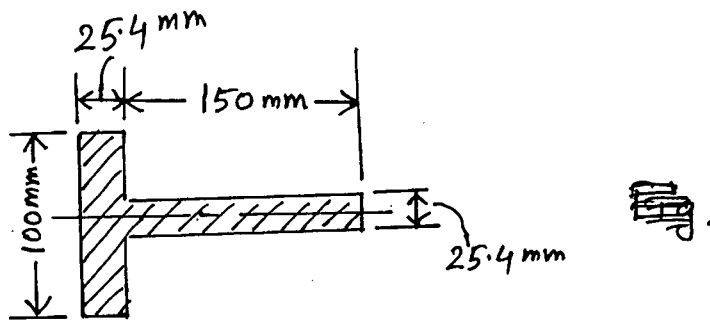
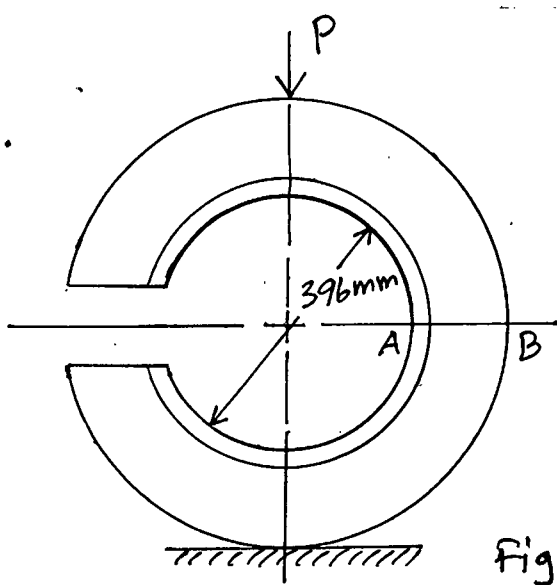


Fig. for. 2(b)



Section AB

Fig. for Q. 3(a)

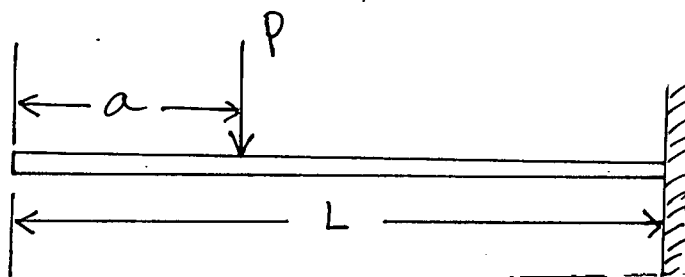


Fig. for Q. 4(a)

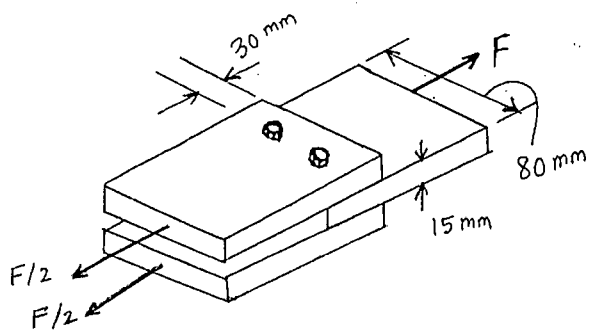


Fig. for Q. No. 5(a)

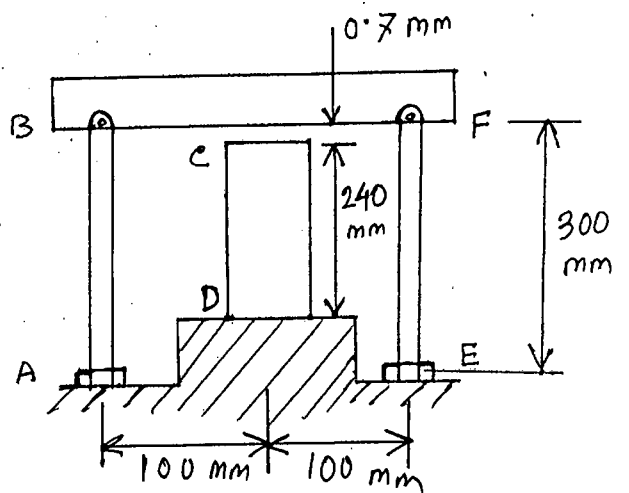


Fig. for Q. No. 6(a)

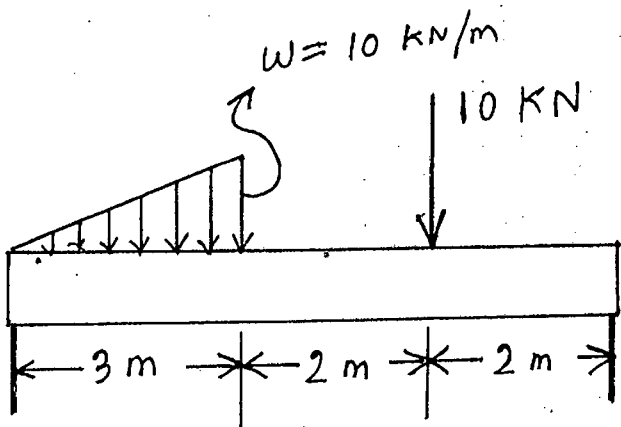


Fig. for Q. No. 7(b)

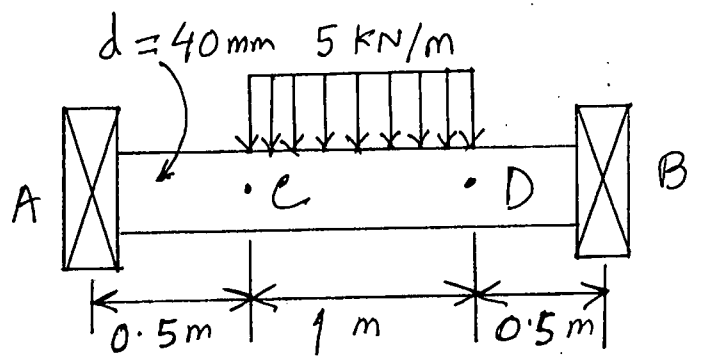


Fig. for Q. No. 8(b)

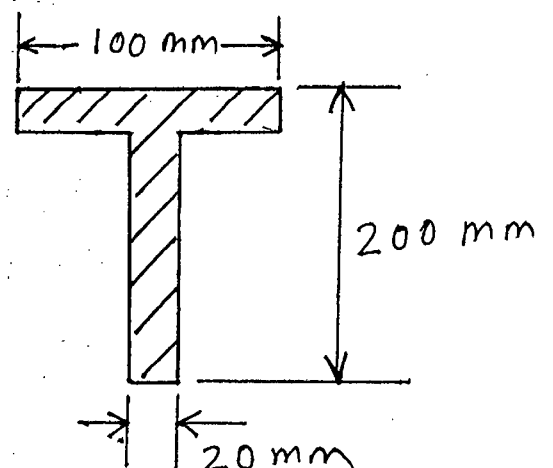
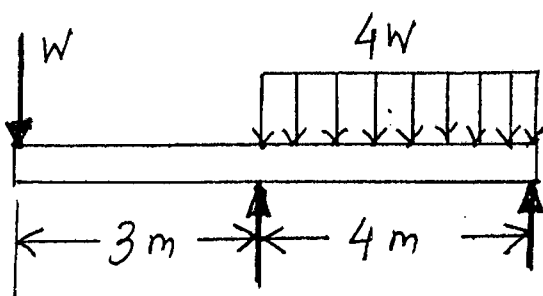


Fig. for Q. 8(a)

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Graphically show the iterative progress of Newton's method for the solution of $f(x) = 0$. (5)

- (b) The function $f(x) = x^3 + 4x^2 - 10$ has a unique root in $[1, 2]$. The function can be rearranged to the fixed point iteration form using simple algebraic manipulation as- (20)

$$(i) x = g_1(x) = \frac{1}{2} \sqrt{(10 - x^3)}$$

$$(ii) x = g_2(x) = x - \frac{x^3 + 4x^2 - 10}{3x^2 + 8x}$$

$$(iii) x = g_3(x) = x - x^3 - 4x^2 + 10$$

Calculate the root using the above three different forms and discuss on the convergence pattern.

- (c) If the above problem (Q. 1(b)) is solved using Bisection method, estimate the percent error after 5 iterations. (10)

2. (a) Solve the following system of linear equations using a suitable elimination method- (15)

$$3x_1 + x_2 - x_3 + 3x_4 = 4$$

$$2x_1 + x_2 - 2x_3 = -1$$

$$3x_2 + 2x_3 - 2x_4 = 4$$

$$x_1 + x_2 + x_3 + 5x_4 = -2$$

- (b) Write out the generalized expression of Jacobi iteration method for the solution of a system of linear algebraic equations. Also mention the convergence criteria for this approach. (10)

- (c) Briefly answer the following in context to the solution of system of linear algebraic equation- (10)

(i) Why are scaling and pivoting necessary in an elimination method?

(ii) Why is the Gauss-Jordan method advantageous over the Gauss-elimination method?

(iii) How does the Gauss-Siedal iteration method differ from the Jacobi method?

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3. (a) Derive the finite difference formula of first derivative with an error of $O(h^3)$ using forward difference approximation. (10)

(b) When a fluid flows over a surface, the shear stress τ (N/m^2) at the surface is given by the following expression- (15)

$$\tau = \mu \left. \frac{du}{dy} \right|_{\text{surface}}$$

where viscosity, $\mu = 0.00024$ Pa.s. u is the velocity parallel to the surface (m/s) and y is the distance normal to the surface (m). Measurements of the velocity of an air stream flowing above the surface are given in the following table:

y (m)	0.0	0.01	0.02	0.03	0.04
u (m/s)	0.00	45.56	70.16	90.38	100.00

Calculate the shear at the surface ($y = 0$) based on first-, second-, and third-order accurate approximations.

(c) Suppose there are n number of data points to be fitted in a linear curve in the following form- (10)

$$y = a_0 + a_1x$$

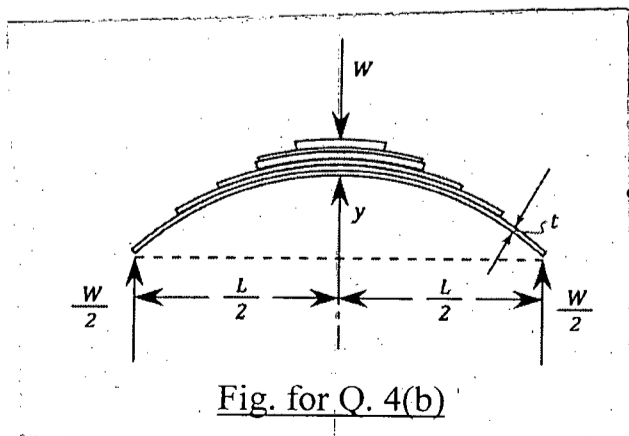
Determine the generalized expressions of a_0 and a_1 using least-squares regression.

4. (a) Mention the sources of errors which are associated with numerical solution of an engineering problem. (5)

(b) In the experiment of a leaf spring as shown in Fig. for Q. 4(b), the deflection can be calculated as

$$y = \frac{3 WL^3}{8 Enbt^3} \quad m$$

where W is the applied load on the spring, L is the length of the spring, b is width of the plate and t is the thickness of the plate. The uncertainties associated with the experimental measurement are ΔW , ΔL , Δb and Δt for W , L , b and t , respectively. n is the number of plates (= 6) and E is the modulus of elasticity of spring material which could be assumed as exact. Determine an expression of error in the calculation of spring deflection due to the above experimental uncertainties using second-order error analysis. (15)



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(c) Evaluate $f(x) = \frac{e^x - x - 1}{x^2}$ at $x = 0.01$. Use six-decimal digit arithmetic. Ensure no

loss of significance in your calculation. (5)

(d) How can you classify the “condition” of a system of linear algebraic equations?

Discuss graphically. (5)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

Symbols have their usual meaning. Assume any reasonable value for any missing data.

5. (a) Determine the minimum number of panels required to integrate the function, $x^3(\sin x + \cos x)$ between $x = 0$ and $x = 2$ to obtain an answer within 0.1% of the true answer, 3.657126, using:

(18)

(i) Simpson’s method

(ii) Trapezoidal method

(b) What is Richardson’s extrapolation scheme? Derive Richardson’s extrapolation formula for Simpson’s and Trapezoidal method of integration. How can this scheme be applied to numerical differentiation?

(17)

6. Determine the largest eigen-value and the corresponding eigen vectors for the homogeneous system shown

$$10x_1 + 4x_2 - x_3 = 0$$

$$4x_1 + 2x_2 + 3x_3 = 0$$

$$-x_1 + 3x_2 + x_3 = 0$$

Retain 3 decimal digits in the eigen value and the eigen vectors at each step. Explain how you would obtain the smallest eigen value and the corresponding eigen vectors.

(35)

7. (a) With necessary graphical and mathematical interpretations, compare and contrast the following methods of solution of DEQ:

(18)

(i) Heun’s method

(ii) Ralston’s method

(b) What do you understand by ‘First-order’ and ‘Second-order’ methods with reference to solution of DEQ? “An nth-order method will yield perfect results if the underlying solution is an nth-order polynomial, and the corresponding local truncation error will be of $O(h^{n+1})$ ” – Explain in detail.

(17)

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8. (a) The circuit shown in Figure for Q8 consists of a coil wound around an iron core, a resistance R , a switch SW , and a voltage source E . The magnetization curve may be obtained from

$$Ni = 0.5\phi + 0.003\phi^3 \dots \quad (1)$$

where, N = number of turns of coil

ϕ = flux in the core, kilolines

i = current, Amp

From Kirchhoff's law, the impressed voltage E is

$$E = Ri + N \frac{d\phi}{dt} (10)^{-5} \dots \quad (2)$$

where, R = resistance, Ω

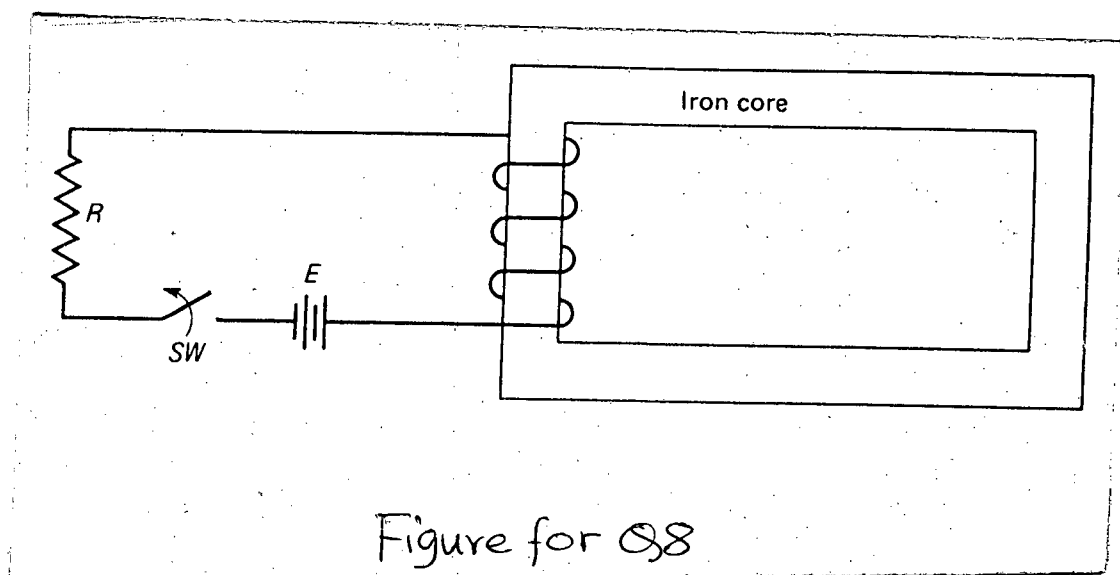
t = time, sec

For $N = 100$ turns and $R = 500 \Omega$, find the DEQ that governs the flux in the core.

Comment on the characteristics of the DEQ.

If $E = 20$ volts, find the first two steps of solution for the flux using (step size = 2.50 sec):

- (i) R-K Third-order method
- (ii) Classical form of R-k Fourth-order method.



SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Find all roots of $(-8 - 8\sqrt{3}i)^{1/4}$ in rectangular coordinates and exhibit the distinct roots graphically. (10)

- (b) Describe mathematically and graphically the region represented by $|z|^2 + 3\operatorname{Re}(z^2) \leq 4$. (6)

- (c) Test the continuity and differentiability of the following function at the points $z = 0$; (10 2/3)

$$f(z) = \begin{cases} \left(\frac{z}{z}\right)^2, & z \neq 0 \\ 0, & z = 0 \end{cases}$$

- (d) Show that $u(x, y) = x^2 - y^2 + \frac{x}{x^2 + y^2}$ is a harmonic function. Hence find $v(x, y)$ such that $f(z) = u(x, y) + iv(x, y)$ is an analytic function. Also express $f(z)$ in terms of z . (20)

2. (a) Solve $\cosh z = -2$ by equating the real and imaginary parts in the equation. (10)

- (b) Show that $\operatorname{Log}(-1 + i\sqrt{3})^2 \neq 2\operatorname{Log}(-1 + i\sqrt{3})$. (10)

- (c) Find the image of the rectangle with vertices $1, 4, 4 + 6i, 1 + 6i$ in the z -plane under the transformation $w = (1 + i)z + (2 - i)$. Sketch the graph of the rectangular region and its image. (15 2/3)

- (d) Evaluate $\int_C f(z) dz$ where $f(z)$ is defined as $f(z) = \begin{cases} 1, & y < 0 \\ 4y, & y > 0 \end{cases}$ and C is the arc from $z = -1 - i$ to $z = 1 + i$ along the curve $y = x^3$. (11)

3. (a) Use Cauchy's integral formula to evaluate the integral $\int_C \frac{dz}{(z^2 + 4)^2}$, where C is the circle $|z - i| = 2$, taken in the positive sense. (12)

- (b) Find Laurent's series expansion of the function $f(z) = \frac{2z - 3}{(2z - 1)(z - 2)}$ about $z = 1$ where $\frac{1}{2} < |z - 1| < 1$ is the region of convergence. (10 2/3)

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Contd ... Q. No. 3

(c) Evaluate the following integrals by Cauchy's residue theorem: (12+12)

(i) $\int_C \frac{dz}{z^3(z+4)}$ where $C : |z| = 2$

(ii) $\int_C \frac{1+z^2}{(z-1)^2(z+2i)} dz$ where $C : |z| = 3$

taken in positive sense in both the sense.

4. (a) Workout the following integrals using residues and contours:

(i) $\int_0^\infty \frac{x^3 \sin x}{(x^2+1)(x^2+9)} dx$ (16 $\frac{2}{3}$)

(ii) $\int_0^{2\pi} \frac{d\theta}{3-2\cos\theta+\sin\theta}$ (20)

SECTION - B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Construct a partial differential equation of the lowest order by eliminating arbitrary function 'ϕ' from (16 $\frac{2}{3}$)

$$\phi\left(x^2 + \tan^{-1} y - \frac{e^z}{z}, \frac{x^2}{\sqrt{1-x^2}} + ye^{2y} - e^{3z}\right) = 0$$

(b) Solve $p \cos(x+y) + q \sin(x+y) = z$ (15)

(c) Find the complete integral of $2zx - px^2 - 2qxy + pq = 0$ (15)

6. Solve the following higher order PDE's

(a) $(D_x^2 - D_x D_y - 12D_y^2)z = e^{2x-y} x^2 y$ (17)

(b) $(2D_x - D_y - 1)(D_x + 2D_y + 3)(3D_x - D_y + 3)z = \sin(x-y)$ (17)

(c) $(yD_y^2 - D_y)z = xy \log y$. (12 $\frac{2}{3}$)

7. (a) Expand in Fourier series the function $f(x) = x + x^2$ defined over the interval

$-\pi < x < \pi$ and hence show that $\sum_{n=1}^\infty \frac{1}{n^2} = \frac{\pi^2}{6}$ (16)

(b) Find the Fourier transform of $f(x) = \begin{cases} 1-|x|; & |x| < 1 \\ 0; & |x| > 1 \end{cases}$ and hence evaluate $\int_0^\infty \frac{\sin^4 x}{x^4} dx$ (15 $\frac{2}{3}$)

(c) Derive the Laplace's equation in polar coordinate from Cartesian co-ordinate. (15)

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8. (a) Use Fourier transform to solve

(23)

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} ; 0 < x < 4, t > 0$$

$$u_x(0,t) = u_x(4,t) = 0 ; t > 0$$

$$u(x,0) = 3x^2 ; 0 < x < 4$$

(b) Find the steady temperature inside a solid sphere of unit radius if one hemisphere of its surface is kept at temperature zero and the other at temperature unity.

(23 $\frac{2}{3}$)

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Normalizing produces a finer and more abundant pearlite in the structure than is obtained by annealing-why? (10)
- (b) Is it possible to prepare a cutting tool of good machinability from a full annealed hypereutectoid steel? – Justify your answer. If not, then suggest an alternative way. (12)
- (c) What are the advantages of nitriding compared with carburizing? Which compounds are responsible for the prosperities provided by a nitrided case? (8)
- (d) Discuss why normalized medium lamellar pearlite is harder and stronger than annealed coarse lamellar pearlite. (5)

2. (a) With necessary diagrams briefly describe the operating steps of any method, which you think suitable, in detecting sub surface cracks of a steel component. (12)
- (b) Name three important characteristics of martensitic transformation of steel. (8)
- (c) What are the effects of tempering on structure and properties of quenched high carbon steel? (10)
- (d) In a radiograph, what will be the difference in appearance of cracks and high density impurities? (5)

3. (a) What is coring? (5)
- (b) For a Fe-C Alloy containing 0.35 wt% C at temperature just below the eutectoid temperature determine the following: (20)
 - (i) the fraction of total ferrite and cementite phases.
 - (ii) the fraction of proeutectoid ferrite and pearlite.
 - (iii) the fraction of eutectoid-ferrite.

In Fe-Fe₃C diagram, Fe₃C contains 6.67% C. The solubility of carbon in ferrite is about 0.022% at eutectoid temperature. Eutectoid point is at 0.76 wt% C.
- (c) The unfilled space in austenite is much lower than that of ferrite. However the solubility of carbon in austenite is much greater than it is in ferrite-why? (7)
- (d) Draw the room temperature microstructure of a normalized hypereutectoid steel sample which contains 1.1% carbon. (3)

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4. (a) Compare and contrast among (a) White cast iron. (b) ferritic and pearlitic grey cast iron (c) bulls' eye malleable cast iron and (d) pearlitic ductile iron in term of (i) microstructure (ii) composition and (iii) Heat treatment. (25)
- (b) What do you understand by 18-4-1 steels? What microstructural feature makes such steels unique? (10)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) With the help of labelled diagrams, explain the sequence of steps in the Electric Arc Furnace Steelmaking process. (15)
- (b) Describe the chemistry of steel making in a Basic Oxygen Furnace. Use figures to clearly indicate how and when the different elements are removed or picked up. (20)
6. (a) Briefly describe a DRI process utilizing a Shaft furnace. (10)
- (b) What advantage do sintered carbide tools have over other conventional cutting tools? How do we make tungsten carbide cutting tools? (10)
- (c) Differentiate between brittle and ductile fracture mentioning their salient features. (5)
- (d) What is ductile-brittle transition? Explain the effect of crystal Structure and grain size on the ductile-brittle transition temperature (DBTT) of metallic materials. (10)
7. (a) What is dislocation? Explain the mechanism of slip in materials. Mention few factors that favour slip. (15)
- (b) Why are metals with FCC structure ductile and HCP brittle? (5)
- (c) Describe the mechanism of strengthening metals by grain size reduction. What happens beyond the Hall-Petch relation, i.e. when the grain size attains its value in the lower nanometer range, say less than 10 nm? (15)
8. (a) Name few aluminium ores and describe the Bayer Process with schematic diagram for the production of pure alumina in industrial scale. (14)
- (b) What are brass and bronze? How can the mechanical properties of brass be tailored by increasing zinc content and other alloying elements? (14)
- (c) Explain in short the dezincification and stress-corrosion cracking in brass. (7)
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SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) What do you mean by environment? Discuss different types of environment. (10)
- (b) Briefly discuss the potential consequences global warming. (15)
- (c) Write down the major pollution issues in Dhaka city. (10)

2. (a) What do you know about capitalism? Write down the positive and negative consequences of capitalism. (15)
- (b) Briefly describe the sources of social change. (10)
- (c) Write down the important characteristics of pre-industrial and industrial societies. (10)

3. (a) What do you understand by Urbanization and Over-urbanization. (8)
- (b) What is meant by mega city? Describe the factors that have led to the growth of cities. (15)
- (c) Explain with a brief criticism the demographic transition theory. (12)

4. Write short notes on any **THREE** of the following: (35)
- (a) Factors contributing to the emergence of sociology
- (b) Functionalist theoretical perspective
- (c) Culture as a normative system of a society
- (d) Differences between culture and civilization.

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) 'Globalization refers to the fact that we all increasingly live in one world, so that individuals, groups and nations become interdependent' - (Anthony Giddens). Discuss (15)
- (b) What types of mass media you usually use in your daily life? Explain how mass media influence you to create your ideology as a whole? (10)

6. (a) Critically discuss the 'modernization theory' and 'world system theory' of development. (15)
- (b) Identify the types of poverty in Bangladesh and cite examples from your own society. (10)
- (c) What are the key differences between crime and deviance in society? (10)

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7. (a) 'The forces of migration combine to push some individuals out of their homelands and to pull them to areas believed to be more attractive' – R. T. Schaefer. Discuss. (15)
- (b) Discuss the factors facilitating juvenile delinquency in society. (10)
- (c) Explain the recent general functions performed by family for an individual. (10)
8. Write short notes on any THREE of the following: (35)
- (a) Agents of socialization
- (b) Looking-glass self theory
- (c) Systems of social stratification
- (d) Types of social mobility
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SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) What is constitution? Discuss different types of constitution with examples. (15)
(b) How do you define nationalism? Discuss the merits and demerits of nationalism. (20)
2. (a) Explain the political rights and duties of a citizen in a state. (15)
(b) Analyze the role of opposition political party in parliamentary democracy. (20)
3. (a) Define bureaucracy. Discuss the functions of bureaucracy in a state. (15)
(b) What is unitary and federal form of government? Describe the differences between unitary and federal forms of government. (20)
4. Write short notes on any three (3) of the following: (35)
(a) Non-political Executive
(b) Good Governance
(c) Unicameral Legislature
(d) Presidential Government

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Distinguish between Nation-building and state-building. Do you think that the distribution of Pakistan led to the Birth of Bangladesh? Give your opinion. (20)
(b) Discuss the significance of eleven point government. (15)
6. (a) Define constitution. Discuss the fundamental principles of Bangladesh constitution. (20)
(b) Describe the rule-making process in Bangladesh. (15)
7. (a) Define political party. Discuss the functions of political parties in a democratic country.
(b) Make a comparative analysis between democracy and dictatorship.

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8. (a) Critically analyze the effectiveness of local govt. in Bangladesh in the context of it's structure and functions. **(20)**

(b) Write short notes on the following topics: **(15)**

(i) Socialism

(ii) Pressures group

(iii) Language movement.
