

FE | Sem-I | All branch | c-2019 | Dec-2023

(Time: 3 hours)

Max.Marks:80

- N.B (1) Question No.1 is compulsory
(2) Answer any three questions from Q.2 to Q.6
(3) Figures to the right indicate full marks.

- 1 (a) If $\tan(\alpha + i\beta) = x + iy$ then show that $\tanh 2\beta = \frac{2y}{1+x^2+y^2}$ 5
- (b) If $z = \sin^{-1}(x - y)$, $x = 3t$, $y = 4t^3$ prove that $\frac{dz}{dt} = \frac{3}{\sqrt{1-t^2}}$ 5
- (c) If $y = x^2 \sin x$, prove that

$$y_n = (x^2 - n^2 + n) \sin\left(x + \frac{n\pi}{2}\right) - 2nx \cos\left(x + \frac{n\pi}{2}\right)$$
 5
- (d) Find the real root of the equation $x^3 - 2x - 5 = 0$ by Newton-Raphson method, correct to three places of decimals. 5
- 2 (a) Find k such that the following system of equations has 6
 (1) Unique solution (2) many solutions (3) no solution.
 $kx + y + z = 1, x + ky + z = 1, x + y + kz = 1$
- (b) Solve $x^6 + 1 = 0$ using De Moivre's theorem. 6
- (c) Solve by Gauss-Seidel method with an accuracy of 0.0001 8
 $5x + y - z = 10; 2x + 4y + z = 14; x + y + 8z = 20$
 (5 iterations only)
- 3 (a) Solve the equations $x_1 + x_2 - x_3 + x_4 = 0$ 6
 $x_1 - x_2 + 2x_3 - x_4 = 0$ $3x_1 + x_2 + x_4 = 0$
- (b) Prove that $\left[\frac{1 + \sin\left(\frac{\pi}{8}\right) + i \cos\left(\frac{\pi}{8}\right)}{1 + \sin\left(\frac{\pi}{8}\right) - i \cos\left(\frac{\pi}{8}\right)} \right]^8 = -1$ 6

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- (c) If $u = \frac{x^2 y^2}{x^2 + y^2} + \cos^{-1}\left(\frac{x+y}{\sqrt{x}+\sqrt{y}}\right)$ find $x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y}$ using Euler's theorem. 8
- 4 (a) Prove that $A - A^{\theta}$ is skew Hermitian where

$$A = \begin{bmatrix} 3i & -1+i & 3-2i \\ 1+i & -i & 1+2i \\ -3-2i & -1+2i & 0 \end{bmatrix}$$
 6
- (b) Find the extreme values of $f(x, y) = xy(3 - x - y)$ 6
- (c) Show that $\frac{\sin 6\theta}{\sin 2\theta} = 16 \cos^4 \theta - 16 \cos^2 \theta + 3$ 8
- 5 (a) Expand in powers of x using Maclaurin's series and find the values of a, b, c where $\log \sec x = ax^2 + b \frac{x^4}{4} + c \frac{x^6}{6} + \dots$ 6
- (b) If $u = f(e^{x-y}, e^{y-z}, e^{z-x})$, then prove that $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} = 0$ 6
- (c) If $\tan(\theta + i\phi) = \tan \alpha + i \sec \alpha$, then show that

$$e^{2\phi} = \cot \frac{\alpha}{2}, 2\theta = n\pi + \frac{\pi}{2} + \alpha.$$
 8
- 6 (a) Find non-singular matrices P and Q such that PAQ is in the normal form of A. Hence find rank of A where $A = \begin{bmatrix} 1 & 2 & 3 \\ 3 & 2 & 1 \\ 1 & 2 & 3 \\ 2 & 1 & 3 \end{bmatrix}$ 6
- (b) Show that $\log(-\log i) = \log \frac{\pi}{2} - i \frac{\pi}{2}$ 6
- (c) If $y = \frac{x}{x^2 + a^2}$ prove that $y_n = \frac{(-1)^n n! \sin^{(n+1)} \theta}{a^{(n+1)}} \cos(n+1)$ where

$$\theta = \tan^{-1}\left(\frac{a}{x}\right)$$
 8

[Max Marks: 60]

Time: 2hrs

- N.B. : (1) Question No 1 is Compulsory.
 (2) Attempt any three questions from Q2. to Q6.
 (3) Assume suitable data, if required and state it clearly.
 (4) Figures to the right indicate marks.

Q1.

- Attempt any **FIVE** [15]
- Find the miller indices of the plane in a cubic crystal having intercepts a , $b/2$, infinity and draw the plane for the same.
 - Explain with reason if it is a bright or dark fringe at the edge in wedge shaped thin film set up in reflected light system.
 - What is the probability of an electron being thermally excited to conduction band in Silicon at 20°C if the bandgap is 1.12 eV . (Given: $k=8.6 \times 10^{-5}\text{ eV/K}$)
 - Define the following terms: Wave packet, Phase velocity and Group velocity.
 - What is energy density and power density?
 - What are Multiferroic materials? Differentiate between Type I and Type II Multiferroics.

Q2.

- Explain the construction and working of Light Emitting Diode with the help of neat diagrams. State the merits, demerits and applications. [8]
- Derive the equations for optical path difference in a parallel thin film in reflected light system. Also find the conditions for maxima and minima. [7]

Q3.

- Derive the expression for interplanar spacing in cubic crystals. The unit cell dimension of NaCl is 5.63 \AA . If x-ray beam of wavelength 1.1 \AA falls on a family of planes with a separation of $\frac{a}{\sqrt{5}}$, how many orders of diffraction are visible? [8]
- Write the expression for Schrodinger's time dependent equation of matter waves and derive Schrodinger's time independent equation. [7]

Q4.

- Distinguish between Type I and Type II superconductors. [5]
- Define liquid crystals. Explain different phases with the help of neat diagrams. [5]
- A copper strip 0.02m wide and 2mm thick is placed in a magnetic field $B=2.5\text{ Wb/m}^2$. If current of 300Amp is set up in the strip, calculate Hall voltage and charge density that appears across the strip. Given, $R_H=6 \times 10^{-7}\text{ m}^3/\text{C}$ [5]

Q5.

- Explain the construction and working of electrolytic double layer capacitor (EDLC) with diagram. [5]
- Show that fermi energy level is placed in the center of the energy bandgap in intrinsic semiconductor. [5]
- An electron is bound in a one-dimensional potential well of width 5 \AA but of infinite height. Find its energy values in the ground state and in first two excited states. [5]

- Q6. (a) Explain the effect of doping concentration on fermi level in n-type semiconductor. [5]
- (b) State de' Broglie hypothesis and derive an expression for de' Broglie wavelength. Mention three properties of matter waves. [5]
- (c) In Newton's rings experiment the diameter of n^{th} and $(n+10)^{\text{th}}$ bright rings are 5.2mm and 8.5mm respectively. Radius of curvature of the lower surface of lens is 200cm. Determine the wavelength of light? [5]

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Time: 2 hours

Maximum marks: 60

NB:

1) Question No.1 is Compulsory

2) Attempt any Three questions from the remaining Five questions

3) Figures to the right indicate full marks

4) Atomic weight: Ca = 40, Mg = 24, S = 32, Cl = 35.5, C = 12, H = 1, O = 16, Na = 23.

Q.1 Attempt any five of the following:

(15)

- Write any three advantages of transfer moulding method.
- What happens when temporary hard water is boiled? Give equations to explain.
- What is reduced phase rule?
- Why Be_2 molecule does not exist?
- What are the characteristics of aromatic compounds?
- Explain hydrogen bonding.
- A 25 ml of waste water sample which was refluxed with 0.1 N $\text{K}_2\text{Cr}_2\text{O}_7$ in presence of H_2SO_4 and Ag_2SO_4 . The unreacted dichromate required 5.5 ml of 0.1N FAS solution. A blank of distilled water on refluxing with dichromate solution required 15 ml of 0.1N FAS solution. Calculate COD of waste water sample in ppm.

Q.2) a) Draw a neat phase diagram of the one component system and explain (6)
with reference to curves, areas, and triple point.

b) What is glass transition temperature? Explain the factors influencing (5)
glass transition temperature.

c) Discuss reverse osmosis in detail. (4)

Q.3) a) Explain the bond order and magnetic behaviour of NO molecule on (6)
the basis of MOT.

b) What are real gases? Explain the correction in the pressure term in (5)
ideal gas equation.

c) A polymer consists of 9 polymer chains as shown below. Calculate (4)
the number-average molecular weight of the polymer.

Number of polymer (N_i)	1	3	2	1	2
Molecular weight of each polymer (M_i)	100	200	400	500	600

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- Q.4) a) Explain the following terms with one example each. (6)
 (i) Phase (ii) Component (iii) Degree of freedom
 b) Explain Huckel's rule of aromaticity and classify the following (5)
 molecules in aromatic, anti-aromatic, and non-aromatic.



(i)



(ii)



(iii)

- c) Write the function of any four additives with one example of each (4)
 required for compounding of plastic.
- Q.5) a) Give the preparation, properties, and uses of (6)
 (i) PMMA (ii) Kevlar
 b) Draw the shapes of p-orbitals and d-orbitals. (5)
 c) 20 ml of standard hard water sample (containing 1.2 mg of pure (4)
 CaCO_3 per ml) required 35 ml of EDTA solution. 50 ml of hard water
 sample required 30 ml of EDTA solution. 100 ml of hard water sample
 after boiling required 25 ml of same EDTA solution. Calculate total and
 permanent hardness of water in ppm.
- Q.6) a) Explain the ion-exchange method for softening of hard water. What (6)
 are its advantages and disadvantages?
 b) i) Draw the Molecular Orbital diagram of O_2 molecule. (3)
 ii) Distinguish between thermoplastic resins and thermosetting resins
 (any 2 points). (2)
 c) i) Identify phase/s present in the system having two miscible liquids. (1)
 ii) An alloy of tin and lead contains 73% tin. Find the mass of eutectic (3)
 in 1kg of solid alloy, if the eutectic contains 64% of tin.

Duration: 3 hours

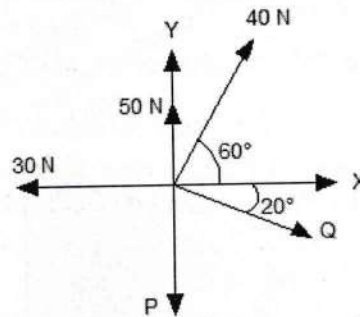
Total: 80 Marks

Note :

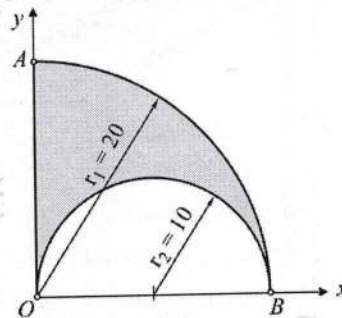
- Question No.1 is compulsory.
- Solve ANY THREE questions from the remaining five questions.
- Figure to the right indicates full marks.
- Assume suitable data wherever required, but justify the same.
- Take $g = 9.81 \text{ m/s}^2$.

Q.1 Solve ANY FOUR questions from following. (Each question carries 5 marks). 20

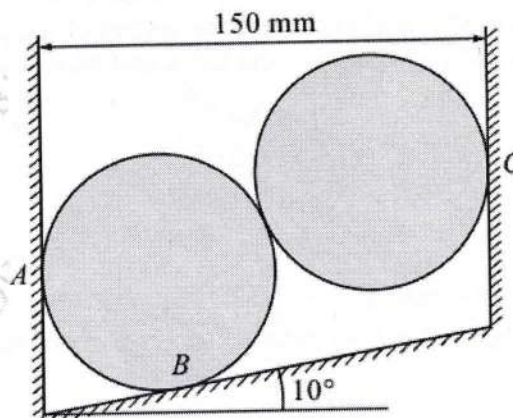
- a) Determine forces P & Q such that resultant of given system in figure is zero.



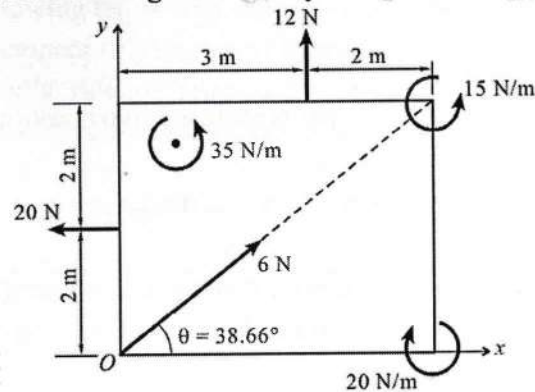
- b) Define the Instantaneous Centre of Rotation and write the properties of Instantaneous Centre of Rotation.
- c) Acceleration of a particle moving along a straight line is represented by the relation $a = 50 - 36t^2$. Determine the velocity of the particle when it has travelled 52 m and the time taken by it before it comes to rest again.
- d) Define angle of repose and prove that angle of friction = angle of repose
- e) Determine the centroid of the shaded area



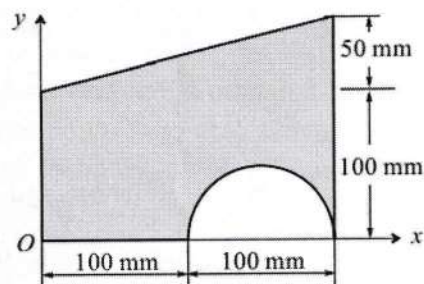
- Q.2 a) Two identical cylinders of weight 200 N and diameter 100 mm are placed as shown in figure. Determine the support reactions at A, B and C. 8



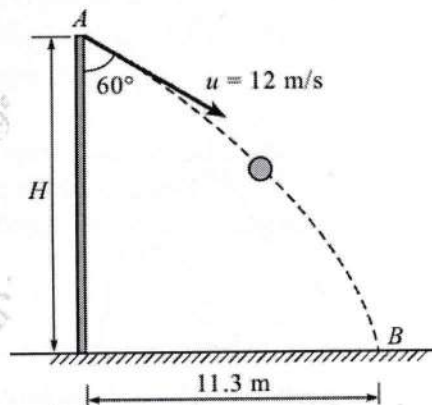
- b) Calculate the resultant of the given force system and locate it with respect O. 6



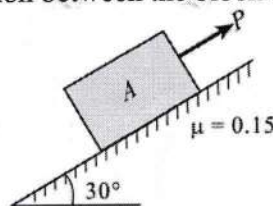
- c) Determine the "x" and "y" coordinates of the Centroid for the shaded area shown. 6



- Q.3 a) A ball is thrown with a speed of 12 m/s at an angle of 60° with a building strikes the ground 11.3 m horizontally from the foot of the building. Determine the height of the building. 8

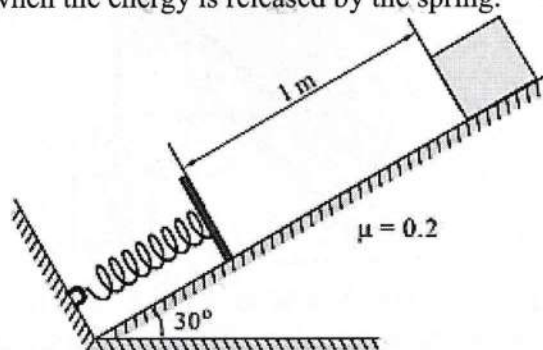


- b) A block of 1000 N is placed on an inclined surface (30 degrees to horizontal). Determine the force required to prevent the sliding of the block down the plane if the coefficient of friction between the block and surface is 0.18. 6

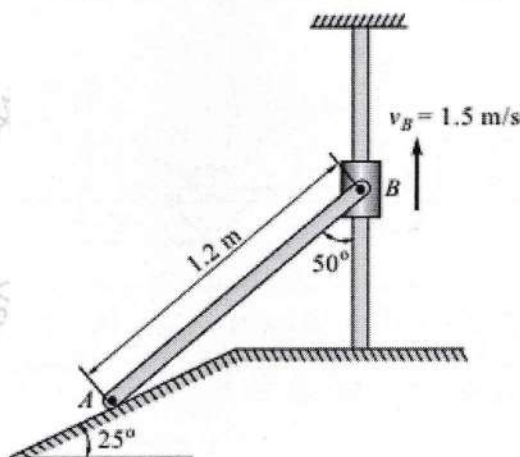


- c) A particle follows the path $y = 5 + 0.3x^2$ with a constant speed of 10 m/sec. Determine the components of velocity when $x = 2$ m and the acceleration of the particle. 6

- Q4 a) A 20 N block is released from rest. It slides down a rough incline having coefficient of friction 0.2 and compresses the spring having modulus 1000 N/m. Determine the maximum compression of the spring and the distance moved by block when the energy is released by the spring. 8

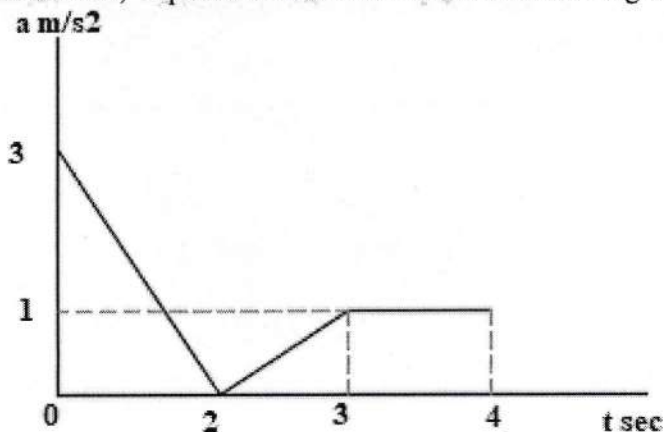


- b) The collar "B" moves upwards with a constant velocity of 1.5 m/sec. At the instant shown determine (1) the angular velocity of rod "AB" (2) the velocity of the end "A". AB=1.2 m 6

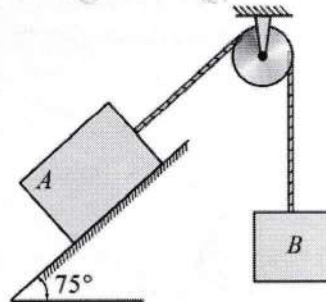


- c) A glass ball is dropped on to a smooth horizontal floor from which it bounces to a height of 9m in the first bounce. On the second bounce, it attains a height of 6m. Calculate the coefficient of restitution between the glass and the floor. Also determine the height from where the glass ball was dropped. 6

- Q5. a) The a-t curve is shown for a particle moving in a straight line. Show the v-t and s-t diagram for 0-4 sec, if particle has started from rest from origin. 8

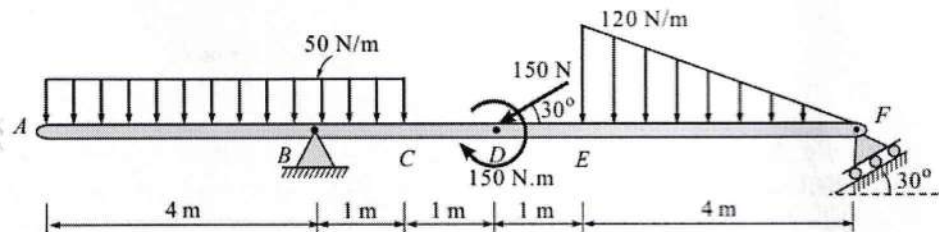


- b) A block 'A' of mass 6 Kg resting on inclined plane is connected by string passing over smooth pulleys with another block 'B' of mass 12 Kg as shown in figure. If $\mu=0.2$, Calculate the tension in string and the acceleration of each block. 6

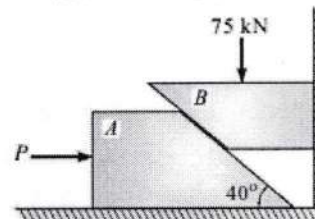


- c) A force $F = 3i - 4j + 12k$ N acts at a point "A (1,-2,3) m. Calculate (i) Moment of the force about the origin. (ii) Moment of the force about a point B(2,1,2) 6

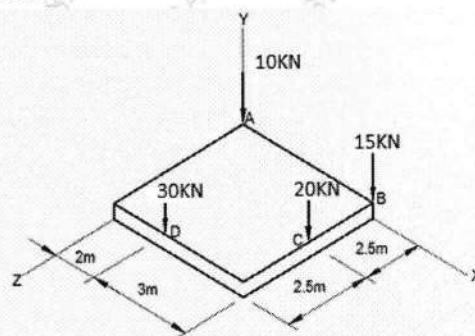
- Q6 a) A beam is loaded and supported as shown in figure. Find the support reactions at supports B and F. 8



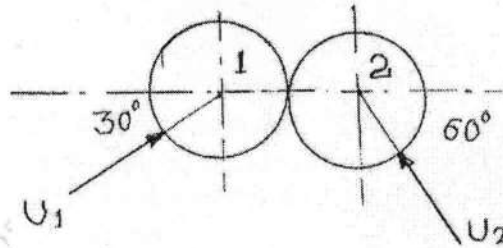
- b) Block A weighs 25 kN and the block B weighs 18 kN. Coefficient of friction for all contact surfaces is 0.11. Determine the value of "P" for holding the system in equilibrium. 6



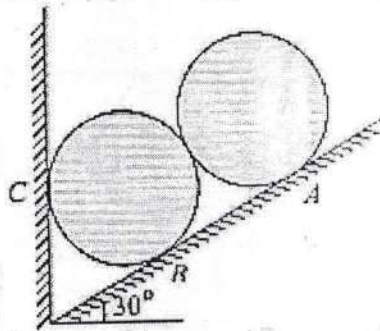
- c) Determine the resultant of the system of parallel forces and determine the position on X-Z plane. 6



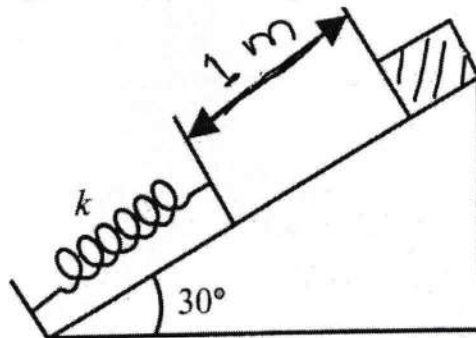
Q.6 a) Two smooth spheres 1 and 2 having a mass of 2 kg and 4 kg respectively collide with initial velocities 2 m/s and 4 m/s respectively as shown in figure. If the coefficient of restitution for the spheres is 0.8, determine the velocities of each sphere after collision. [8]



b) Two identical rollers of mass 50 Kg are supported as shown in fig. To maintain the equilibrium, determine support reactions. [6]



c) A 20 N block is released from rest. It slides down the rough incline of coefficient of friction 0.2. Determine the maximum compression of the spring. Take stiffness of spring, k as 1000 N/m. [6]



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Time: 3 Hours

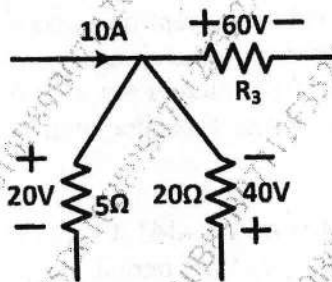
Total Marks: 80

1. Q.1 is compulsory
2. Answer any three out of the remaining questions
3. Assumptions made should be clearly stated

I. Answer any four

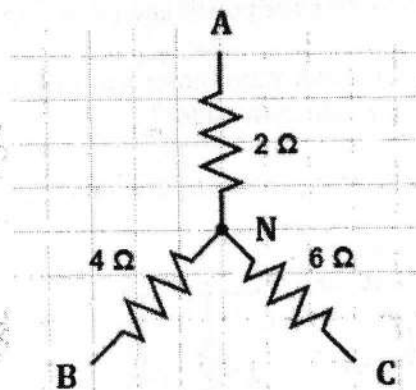
(a) An inductor of $0.2H$ and resistance of 10Ω are connected in series to a $230V(RMS), 50Hz$ sinusoidal supply. Calculate (i) reactance of the inductor, (ii) impedance of coil, (iii) RMS value of current, (iv) RMS value of voltage across resistance and (v) maximum current. **05**

(b) Find value of R_3 in the figure given below by applying Ohm's law and Kirchhoff's laws. **05**



(c) Draw a neat diagram of two wattmeter method of power measurement in three phase circuits for resistive load and state any two advantages. **05**

(d) Draw the equivalent delta network. Mention the formula used for the conversion. **05**

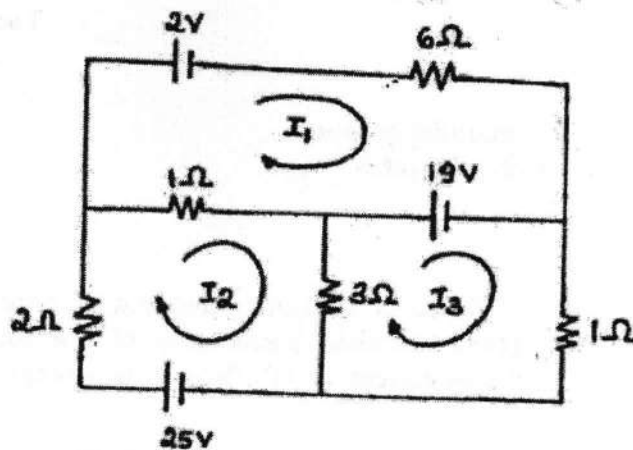


(e) Compare core type and shell type single phase transformer. **05**

II. A) Prove that the power in a balanced three phase circuit can be deduced from the readings of the wattmeters in two wattmeter method of power measurement. How to find reactive power from these wattmeter readings? **10**

B) Find the currents I_1, I_2, I_3 and the current through 3Ω using mesh analysis? **10**

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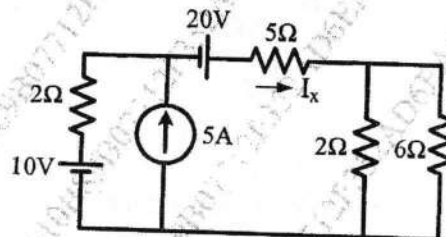
III. A) A coil having a resistance of 5Ω and an inductance of $0.1H$ is connected in series with a $50\text{-}\mu F$ capacitor. An alternating voltage of $200V$ is applied to the circuit. At what value of frequency will the current be a maximum? Calculate the following for this frequency: (i) impedance of the circuit and current; (ii) reactance of inductor and reactance of capacitor, (iii) voltages across coil and voltages across capacitor, (iv) voltage magnification across capacitor with respect to the supply voltage. 10

B) An alternating voltage is represented by $v(t) = 141.4 \sin(377t)$ V. Find (i) RMS value of voltage; (ii) frequency in Hz, (iii) time period in sec.; (iv) instantaneous value of voltage at $t = 3\text{ms}$ and (v) the time taken for the voltage to reach $70.7V$ for the first time. 10

IV. A) A balanced load of phase impedance 100Ω and power factor 0.8 is connected in delta to a $400V$, 3-phase supply. Calculate (i) resistance and reactance per phase; (ii) line current; (iii) active power; (iv) reactive power and (v) apparent power. 10

B) State different parts of a three-phase induction motor and mention the function of each part. What are the two types of induction motor? 10

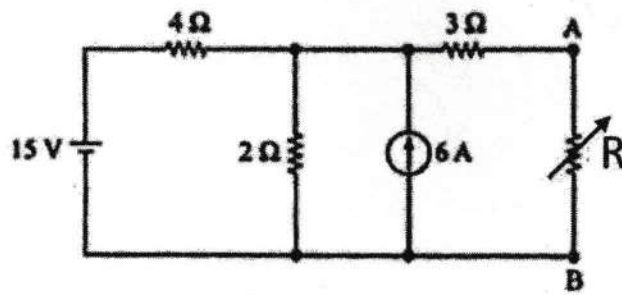
V. A) Find the current through 5Ω (I_x) using Superposition theorem. 10



B) Two impedances $14 + j5\Omega$ and $18 + j10\Omega$ are connected in parallel across $200V$, 50 Hz, single phase supply. Determine: (i) Admittance of each branch in polar form; (ii) Current in each branch in polar form; (iii) power factor of each branch; (iv) active power in each branch and (v) reactive power in each branch. 10

VI. A) Find the value of the resistance R using maximum power transfer theorem and find the value of maximum power transferred. 10

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- B) i) Derive the emf equation of a single-phase transformer. 05
ii) Find the number of turns on the secondary and value of flux in a 25kVA, 3000/240V single phase transformer with 500 turns on the primary. The primary winding is connected to 3000V, 50Hz supply. Neglect all voltage drops. 05

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