TIME: 2 Hours MARKS: 60

N.B 1) Question no 1 is Compulsory.

2) Attempt any three questions from **Q.2 to Q.6**

3) Assume suitable data wherever required.

4) Figures on the Right indicates marks.

Q.1 Attempt any five questions from the following [15]

(a) Draw (0 0 2), ($\bar{1}$ 0 0), (0 1 1)

(b) Explain any three properties of matter waves.

(c) Differentiate between Direct and Indirect band gap semiconductor.

(d) Explain any three conditions for Sustained Interference.

(e) A source is emitting 150W of red light of wavelength of 600nm. How many photons per second are emerging from the source?

(f) Explain the Meissner effect with application.

(g) Explain Magneto Resistance with application.

Q.2 (a) Show that Non- Existence of electron in the Nucleus, Find the uncertainty in the position of electron . The speed of an electron is measured to be 4.0×10^3 m/s to an accuracy of 0.002% . [8]

(b) Define the Fermi energy level , Show that in intrinsic semiconductor Fermi level is at the centre of Forbidden energy gap. Draw the position of Fermi level in intrinsic, P-type and N-type semiconductor. [7]

Q.3 (a) Explain with diagram Bragg's X Ray Spectrometer . Calculate the interplaner spacing between the family of planes (1 1 1) in crystal of lattice constant $3A^0$. [8]

(b) Prove that the Diameter of the n^{th} dark ring in Newton's ring setup is directly proportional to the square root of the ring number . In Newton's Rings reflected light of wavelength 5×10^{-5} cm. The diameter of the 10^{th} dark ring is 0.5 cm. Calculate radius of curvature R. [7]

Q.4 (a) Derive one dimensional time independent Schrodinger Equation. [5]

(b) Differentiate between Type I superconductor and Type II superconductor. [5]

(c) Find Resistance of an intrinsic Ge rod of dimensions (1cm long , 1mm wide and 1mm thick) at 300K . For Ge $n_i = 2.5 \times 10^{19}/m^3$, $\mu_n = 0.39 m^2/v\text{-}s$, $\mu_p = 0.19 m^2/v\text{-}s$ [5]

Q.5 (a) Derive the condition for maxima and minima due to interference of light reflected from thin film of uniform thickness. [5]

(b) Explain Hall Effect . Derive the equation for Hall Voltage. [5]

(c) Calculate the lowest three energy states of an electron confined in potential well of width $10A^0$. [5]

Q.6 (a) Explain multiferroics and its different types. [5]

(b) A soap film $4x10^{-5}$ cm thick is viewed at angle of 35^0 to normal. Calculate Wavelength of light in the visible spectrum which will be absent from the Reflected light ($\mu = 1.33$) [5]

(c) The Coefficient (Rh) of semiconductor is $3.22 \times 10^{-4} m^3 c^{-1}$. Its resistivity is 9×10^{-3} Ω m . Calculate the mobility and concentration of carriers. [5]

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

Note:

1) Question No.1 is compulsory
2) Attempt any three out of remaining five questions
3) Figures to the right indicate full marks

Q1.

a) If $\sin(\theta + i\varphi) = tan\alpha + isec\alpha$, then show that $\cos 2\theta \, . cosh2\varphi = 3$ **[5]**

b) If $u = \log(tanx + tany)$, then show that $sin2x\frac{\partial u}{\partial x} + sin2y\frac{\partial u}{\partial y} = 2$ **[5]**

c) Express the matrix A = $\begin{bmatrix} 0 & 5 & -3 \\ 1 & 1 & 1 \\ 4 & 5 & 9 \end{bmatrix}$ as the sum of a symmetric and skew symmetric matrix. **[5]**

d) Expand $\sqrt{1 + sinx}$ in ascending powers of x upto x^4 term. **[5]**

Q2.

a) Find non-singular matrices P and Q such that PAQ is in normal form where, **[6]**

A=$\begin{bmatrix} 4 & 3 & 1 & 6 \\ 2 & 4 & 2 & 2 \\ 12 & 14 & 5 & 16 \end{bmatrix}$. Also find the rank of A.

b) If $z = f(x, y)$ and $x = u\, coshv,\ y = u\, sinhv$; prove that **[6]**

$$\left(\frac{\partial z}{\partial x}\right)^2 - \left(\frac{\partial z}{\partial y}\right)^2 = \left(\frac{\partial z}{\partial u}\right)^2 - \frac{1}{u^2}\left(\frac{\partial z}{\partial v}\right)^2$$

c) Prove that $Log\left[\frac{(a-b)+i(a+b)}{(a+b)+i(a-b)}\right] = i(2n\pi + tan^{-1}\frac{2ab}{a^2-b^2})$. Hence evaluate $Log\left(\frac{1+5i}{5+i}\right)$ **[6]**

Q3.

a) If α *and* β are the roots of the equation $z^2 sin^2\theta - z\ sin\ 2\theta + 1 = 0$, then prove that $\alpha^n + \beta^n = 2\cos n\theta\ \ cosec^n\theta$ and $\alpha^n\beta^n = cosec^{2n}\theta$ **[6]**

b) Solve the following equations by Gauss–Seidal Method ; **[6]**

$15x + 2y + z = 18$, $2x + 20y - 3z = 19$, $3x - 6y + 25z = 22$,

Take three iterations.

c) Prove that if z is a homogeneous function of two variables x and y of degree n, then $x^2\frac{\partial^2 z}{\partial x^2} + 2xy\frac{\partial^2 z}{\partial x \partial y} + y^2\frac{\partial^2 z}{\partial y^2} = n(n-1)z$. Hence find the value of $x^2\frac{\partial^2 z}{\partial x^2} + 2xy\frac{\partial^2 z}{\partial x \partial y} + y^2\frac{\partial^2 Z}{\partial y^2}$ at $x = 1, y = 1$ when z $= x^6\ tan^{-1}\left(\frac{x^2+y^2}{x^2+xy}\right) + \frac{x^4+y^4}{x^2y^2}$ **[8]**

Q4.

a) If tan $(\alpha + i\beta) = \cos\theta + i\sin\theta$ then prove that $\alpha = \frac{n\pi}{2} + \frac{\pi}{4}, \beta = \frac{1}{2}\ \log\left(\frac{\pi}{4} + \frac{\theta}{2}\right)$ **[6]**

b) Expand $x^5 + x^3 - x^2 + x - 1$ in powers of $(x-1)$ and hence find the value of **[6]**

1) $f\left(\frac{9}{10}\right)$

2) $f(1.01)$

c) For what values of λ and μ , the equations, **[8]**

$x + y + z = 6$; $x + 2y + 3z = 10$; $x + 2y + \lambda z = \mu$

1) have a unique solution

2) have infinite solution

Find the solution in each case for a possible value of μ and λ.

Q5.

a) Find the nth derivative of $y = \frac{1}{x^2 + a^2}$ **[6]**

b) Discuss the maxima and minima of $x^3 + xy^2 - 12x^2 - 2y^2 + 21x + 16$ **[6]**

c) Prove that if A and B are two unitary matrices then AB is also unitary. Verify the result when

$A = \frac{1}{\sqrt{3}}\begin{bmatrix} 1 & 1+i \\ 1-i & -1 \end{bmatrix}$ and $B = \begin{bmatrix} \frac{1+i}{2} & \frac{-1+i}{2} \\ \frac{1+i}{2} & \frac{1-i}{2} \end{bmatrix}$ **[8]**

Q6.

a) If $x = \cosh\left(\frac{1}{m}\log y\right)$, prove that **[6]**

$(x^2 - 1)y_{n+2} + (2n+1)x\, y_{n+1} + (n^2 - m^2)\, y_n = 0$

b) Find a root of the equation $xe^x = \cos x$ using the Regular Falsi Method correct to three decimal places. **[6]**

c) 1) Expand $sin^4\theta\, cos^2\theta$ in a series of multiples of θ. **[4]**

2) If one root of $x^4 - 6x^3 + 18x^2 - 24x + 16 = 0$ is (1+i); find the other roots. **[4]**

Time: 2 Hrs **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, N = 14, Cl = 35.5, C = 12, H = 1, O = 16, Na = 23.

Q.1) Attempt any **five** of the following: **(15)**

a)What are the characteristics of aromatic compounds?

b) What happens when temporary hard water is boiled? Explain giving examples

c)Distinguish between thermoplastic and thermosetting resins.

d) Give difference between bonding and antibonding orbitals.

e)What is the temporary and permanent hardness of water sample having the following impurities in ppm: $Ca(HCO_3)_2$= 32.4, $CaSO_4$= 13.5, $Mg(HCO_3)_2$= 29.2.

f) Discuss the reduced phase rule.

g) What is a real gas?

Q2) a) Explain the application of phase rule to one component system with an appropriate graph, areas and the triple point. **(6)**

b) What is compounding of plastics? Discuss the below mentioned constituents with appropriate examples: **(5)**

i) Fillers ii) Pasticizers

c) Write notes on: **(4)**

i) BOD ii) COD

Q3) a) Draw the Molecular Orbital diagram of Be_2. Give its electronic configuration .Explain why it does not exist . **(6)**

b) (1) Identify the most important intermolecular interaction in each of the following: (i) CCl_4 (ii) HF **(2)**

(2) Explain the correction for volume term in the ideal gas equation. **(3)**

c) A polymer consists of 9 polymer chains as given below: **(4)**

No. of polymer(N1) :	1	3	2	1	2
Mol. Wt. of each polymer:	200	100	300	500	400

Calculate the number – average molecular weight of the polymer

Q4) a) Discuss the following with examples: **(6)**
i) Phase ii) Components iii) degree of freedom

b) Give the KeKule structure for benzene. Discuss the problems with the structure. (any **two**) **(5)**

C) Write notes on: supercritical fluids and critical temperature **(4)**

Q5) a) Give the preparation, properties and uses of: **(6)**
i) Kevlar ii) PMMA

b)What are atomic orbitals? Explain the *s*-orbitals and *p*-orbitals. **(5)**

c) 1gm of $CaCO_3$ was dissolved in 1 litre of distilled water. 50ml of solution required 45ml EDTA for titration. 50ml of hard water required 25 ml of EDTA for titration. The water sample after boiling and filtering consumed 15ml of EDTA for titration. Calculate the total and permanent hardness of the sample. **(4)**

Q6) Explain the ion-exchange method for softening of water giving the following details: **(6)**
Diagram, process and Reactions

b) Calculate the number of phases in the following examples: **(1)**
i) Rhombic Sulphur ⟶ Monoclinic sulphur

ii) An alloy of tin and lead contains 73% tin. Find the mass of eutectic in 1kg of solid alloy, if the eutectic contains 64% of tin. **(4)**

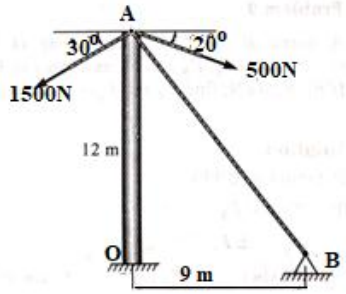
C) i) Give the Molecular Orbital diagram of nitric oxide (NO) molecule. **(2)**
ii) Discuss: Glass transition temperature **(2)**

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

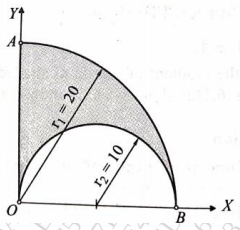
N.B.: (1) Question **No. 1** is compulsory.
(2) Attempt any **THREE** questions from the remaining **FIVE** questions.
(3) Assume suitable data if necessary and mention the same clearly.
(4) Take g=9.81 m/s^2

Q.1 Answer any **FIVE** questions

a. The top end of a pole is connected by three cables having tension 500 N, 1500 N and a guy wire 'AB' as shown in figure below. Determine tension in cable 'AB' if the resultant of the concurrent force is vertical. [4]



b. Locate the centroid of the shaded area obtained by cutting a semicircle of diameter 20 mm from the quadrant of a circle of radius 20 mm as shown in Figure below. [4]



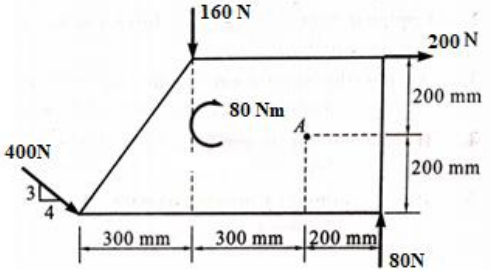
c. A body weighing 1000 N is lying on a horizontal plane. Determine the necessary force to move the body along the plane if the force is applied at an angle of 45 degrees to the horizontal with a coefficient of friction 0.24 [4]

d. The motion of a particle is defined by the relation x= t^3- $3t^2$+2 t+5 where x is the position expressed in meters and time in seconds. Determine (i) velocity and acceleration after 5 seconds (ii) maximum or minimum velocity and corresponding displacement. [4]

e. A steel ball of mass 8 kg is dropped onto a spring of stiffness 600 N/m and attains a maximum velocity of 2.5 m/s. Find (i) the height from it is dropped and (ii) the maximum deflection of spring. [4]

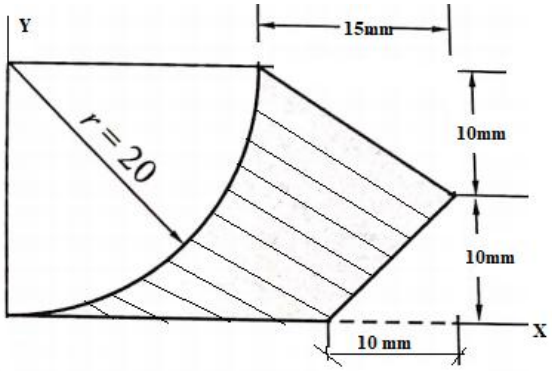
f. A ladder AB of length l=4.8 m rests on a horizontal floor at A and leans against a vertical wall at B. If the lower end A is pulled away from the wall with a constant velocity 3 m/s, what is the angular velocity of the ladder at the instant when A is 2.4 m from the wall. [4]

Q.2 a. Find the resultant of the force system acting on the plate as shown in Fig, where does this resultant act with respect to point A? [8]

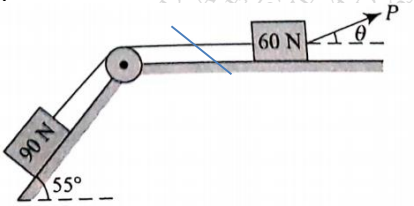


TURN OVER

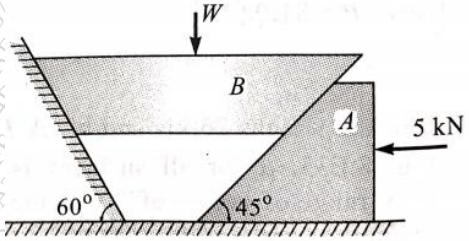
b. Find the centroid of the shaded area with reference to X and Y Axes. [6]



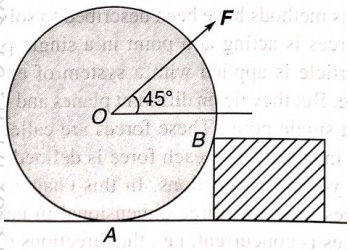
c. Two bodies A and B weighing 90N and 60N respectively placed on an inclined plane are connected by the string which is parallel to the plane as shown in Fig. Find the inclination of the minimum force P for the motion to impend in the direction of "P". Take μ=0.2 for the surface of contact. [6]



Q.3 a. A horizontal force of 5KN is acting on the wedgw as shown in the figure. The coefficient of friction at all rubbing surfaces is 0.25. Find the load "W" which can be held in position. The weight of block "B" may be neglected. [8]



b. A road roller of radius 36cm and weight 6000N, which is of cylindrical shape, is pulled by a force F, acting at an angle of 45^0 as shown in the figure below. It has to cross an obstacle of height 6cm. Calculate the force "F" required to just cross over the obstacle. [6]

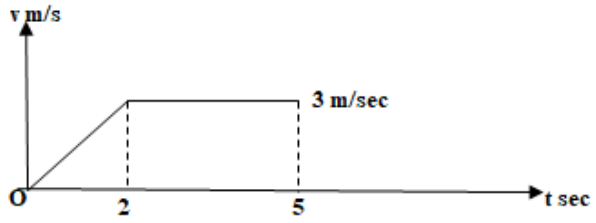


c. At the instant t=0, a locomotive start to move with uniformly accelerated speed along a circular curve of radius r=600 m and acquires, at the end of the first 60 seconds of motion, a speed equal to 24kmph. Find the tangential and normal acceleration at the instant t=30 s. [6]

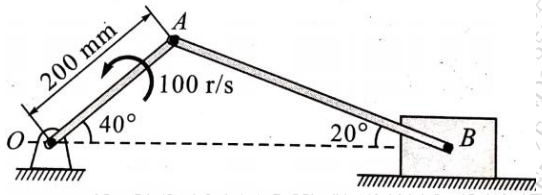
Q.4 a. A particle is thrown with an initial velocity of 10 m/s at a 45^0 angle with horizontal. If another particle is thrown from the same position at an angle $60^0$with the horizontal, find the velocity of the latter for the following situation: [8]
(i) Both have the same range.
(ii) Both have the same time of flight.

TURN OVER

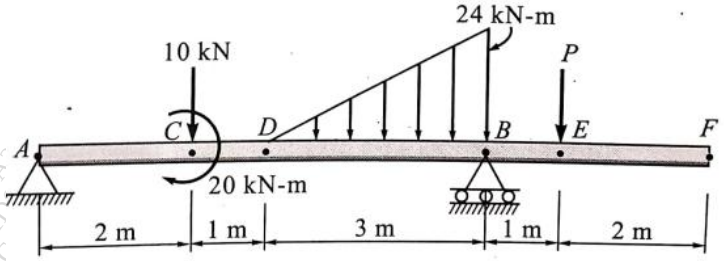
b. The motion of a particle is represented by the velocity-time diagram as shown in the graph shown below. Draw acceleration-time and displacement – time graphs. [6]



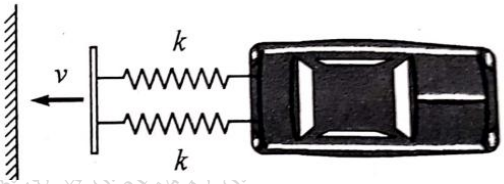
c. In the reciprocating engine mechanism shown in Fig. the crank OA of length 200mm rotates at 100rad/sec. determine the angular velocity of the connecting rod AB and the velocity of the piston at B. [6]



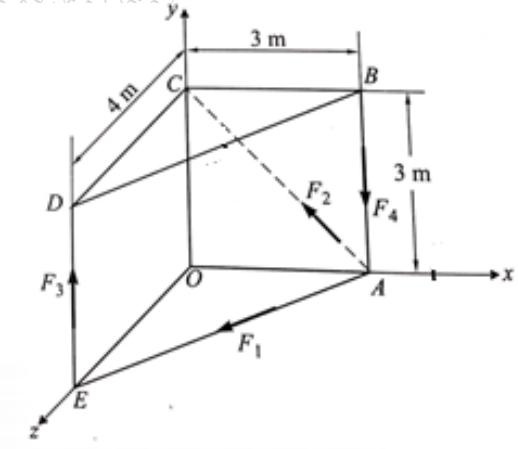
Q.5 a. Find the support reaction at A and force P if reaction at B is 60 kN for the beam loaded as shown in Figure below. [8]



b. A 1200Kg car has a light bumper supported horizontally by two springs of stiffness 15kN/m. Determine the initial speed of impact with the fixed wall that causes 0.2 m compression. Neglect friction. [6]



c. Determine the resultant force of the force system shown in figure where F_1=150N, F_2 = 120 N, F_3 = 200 N and F_4 = 220 N. [6]



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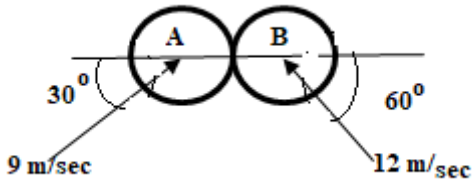
Q.6 a. Two bodies A and B are connected by a thread and move along a rough horizontal plane (μ=0.3) under the action of 400 N force applied to the body as shown in Fig.12. Determine the acceleration of the two bodies and the tension in the thread using D'Alembert's principle. [8]

b. Train A starts with a uniform acceleration of 0.5 m/s^2 and attains a speed of 90 km/hr which subsequently remains constant. One minute after it starts, another train B starts on a parallel track with a uniform acceleration of 0.9 m/s^2 and attains a speed of 120 km/hr. How much time does train B take to overtake train A. [6]

c. The magnitude and direction of the velocities of two identical spheres having frictionless surfaces are shown in Figure below. Assuming coefficient of restitution as 0.90, determine the magnitude and direction of the velocity of each sphere after the impact. Also find the loss in Kinetic energy. [6]



3hrs **80marks**

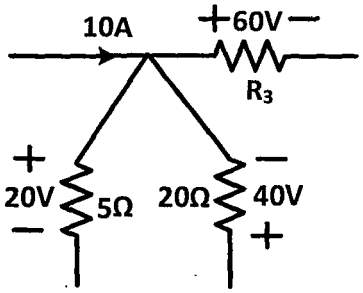
N. B:(1) Question No.1 is compulsory.

(2) Answer any THREE from the remaining five questions.

(3) Assume suitable data if required and state the assumption.

Q1. Answer any five.

(i) Find value of R_3 in the figure given below by applying Kirchhoff's laws. 4



(ii) Briefly describe the operation of any one type of stepper motor. 4

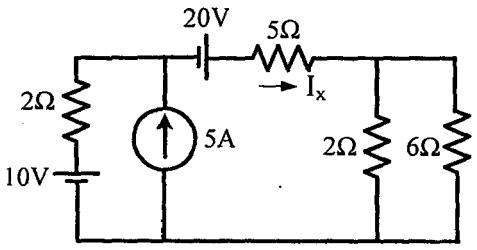
(iii) Two pure circuits elements in a series connection have the following current and applied voltage: v(t) = 150 sin (500t+10°) V, i(t) = 13.42 sin (500t-53.4°) A. Find the supply frequency (in Hz) and the value of circuit elements. 4

(iv) A three-phase, three-wire, 100V system supplies a balanced delta-connected load with per phase impedance of $20\angle 45°$ ohms. Determine the line current drawn and active power taken by the load. 4

(v) Draw the phasor diagram of a single phase non ideal transformer feeding a resistive load. 4

vi) Single phase induction motor is not self-starting. State True or False and Justify your answer. 4

Q2. **(A)** Find the current through 5Ω (I_x) using Superposition theorem **without using source transformation.** 10



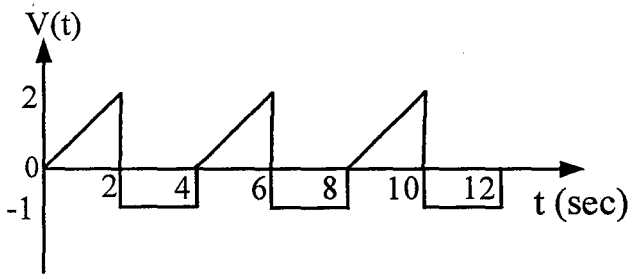
(B) State and prove Maximum Power Transfer theorem. 05

(C) Plot the variation of current, impedance, resistance, inductive reactance and capacitive reactance when supply frequency is varied in R-L-C series circuit. 05

Q3. **(A)** The Open Circuit (OC) and Short Circuit (SC) tests on a 5 KVA, 200/400 V, 50 Hz, single phase transformer gave the following results. **OC:** 200 V, 1 A, 100 W (lv side), **SC:** 15 V, 10 A, 85 W (hv side). Draw the equivalent circuit referred to primary and put all values. 10

(B) Derive the EMF equation of a dc motor. 05

(C) Find the Root Mean Square (RMS) value of the following waveform. 05

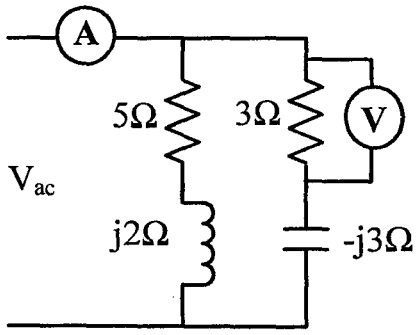


Q4. **(A)** With neat circuit diagram and phasor diagram, prove that by two watt meter method active power and reactive power of a three phase load can be measured. 10

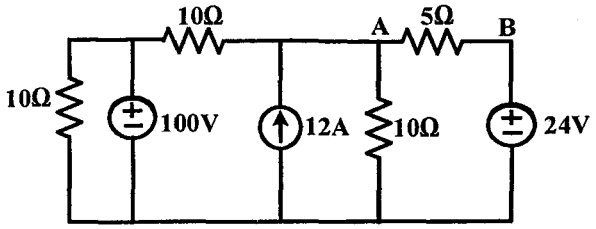
(B) A sinusoidal voltage v(t)=200sinωt is applied to a series *R-L-C* circuit with R = 20 Ω, L=100 mH, and C =10 μF. Find (i) the resonant frequency, (ii) RMS value of current at resonance (iii) Quality factor of the circuit, (iv) voltage across the inductor at resonant frequency and (v) phasor diagram at resonance. 10

Q5. **(A)** Derive the transformation formula to convert a delta network of resistors to an equivalent star network and star network of resistors to an equivalent delta network. 10

(B) In the parallel circuit, voltmeter across 3 Ω resistor reads 45 V. What is the indication on the ammeter? Also find the input power factor. 10



Q6. **(A)** Find current through 5Ω from A to B using Thevenin's theorem. 10



(B) A 20 KVA Transformer has iron loss of 450W and full load copper loss of 900W. Assume power factor of load as 0.8 lagging. Find full load and half load efficiency of the transformer. 05

(C) Briefly explain the principle of operation of three phase Induction motor. What are the types of three phase Induction motor? 05

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