(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) Use of Statistical Tables permitted
        (4) Figures to the right indicate full marks.

1   a)   Solve the equation $7\cosh x + 8\sinh x = 1$, for real values of x.   **5**

b)   Find α, β, γ when $A = \begin{bmatrix} 0 & 2\beta & \gamma \\ \alpha & \beta & -\gamma \\ \alpha & -\beta & \gamma \end{bmatrix}$ is orthogonal.   **5**

c)   If $u = 3(ax + by + cz)^2 - \left(x^2 + y^2 + z^2\right)$ and $a^2 + b^2 + c^2 = 1$ **5**

show that $\dfrac{\partial^2 u}{\partial x^2} + \dfrac{\partial^2 u}{\partial y^2} + \dfrac{\partial^2 u}{\partial z^2} = 0$

d)   Find n$^{\text{th}}$ derivative of $y = \dfrac{x}{x^2 + a^2}$ **5**

2   a)   *If* $\cos \alpha + 2\cos \beta + 3\cos \gamma = \sin \alpha + 2\sin \beta + 3\sin \gamma = 0$ *then prove*   **6**
that $\sin 3\alpha + 8\sin 3\beta + 27\sin 3\gamma = 18\sin(\alpha + \beta + \gamma)$

b)   If $v = \left(x^2 - y^2\right) f(xy)$, show that $\dfrac{\partial^2 v}{\partial x^2} + \dfrac{\partial^2 v}{\partial y^2} = \left(x^4 - y^4\right) f''(xy)$ **6**

c)   If $y = e^{m\cos^{-1} x}$, then prove that   **8**
$\left(1 - x^2\right) y_{n+2} - (2n+1) x\, y_{n+1} - \left(n^2 + m^2\right) y_n = 0$. Find $y_n(0)$

3   a)   Prove that $\sinh^{-1}(\tan x) = \log\left[\tan\left(\dfrac{\pi}{4} + \dfrac{x}{2}\right)\right]$ **6**

b)   Verify Euler's theorem for $u = \left(\dfrac{x^2 + y^2}{x + y}\right)$ **6**

c)   Examine the consistency of the system of equations   **8**
$2x - y - z = 2, \quad x + 2y + z = 2, \quad 4x - 7y - 5z = 2$ and solve then
if found consistent.

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4 a) Find the real values of λ for which the system has non-zero solutions. **6**

$$x + 2y + 3z = \lambda x, \quad 3x + y + 2z = \lambda y, \quad 2x + 3y + z = \lambda z$$

b) Find the product of all the values of $\left(\dfrac{1}{2} - i\dfrac{\sqrt{3}}{2}\right)^{3/4}$ **6**

c) If $u = \sin^{-1}\left[\left(x^2 + y^2\right)^{\frac{1}{5}}\right]$ then show that **8**

$$x^2 \frac{\partial^2 u}{\partial x^2} + 2xy \frac{\partial^2 u}{\partial x \partial y} + y^2 \frac{\partial^2 u}{\partial y^2} = \frac{2}{25} \tan u \left(2 \tan^2 u - 3\right)$$

5 a) Using De Moivre's theorem, express $\dfrac{\sin 7\theta}{\sin \theta}$ in powers of $\sin \theta$ **6**

b) If $xyz = 8$ find the values of x,y,z for which $u = \dfrac{5xyz}{x + 2y + 4z}$ is maximum. **6**

c) Considering only principle value, if $\left(1 + i \tan \alpha\right)^{(1+i\tan\beta)}$ is real prove that its **8** value is $\sec \alpha^{\sec^2 \beta}$

6 a) Reduce to normal form and find its rank $A = \begin{bmatrix} 3 & 2 & 5 & 7 & 12 \\ 1 & 1 & 2 & 3 & 5 \\ 3 & 3 & 6 & 9 & 15 \end{bmatrix}$ **6**

b) Find the extreme value of $u = x^3 + xy^2 + 21x - 2y^2 - 12x^2$ **6**

c) Show that $\tan^{-1}\left(\dfrac{x + iy}{x - iy}\right) = \dfrac{\pi}{4} + \dfrac{i}{2}\log\left(\dfrac{x + y}{x - y}\right)$ **8**

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(2 Hours)   **Total Marks – 60**

N.B : (1) Question No.1 is compulsory.
       (2) Attempt any three questions from Q.no 2 to Q.no 6.
       (3) Assume suitable data and symbol if required.
       (4) Figures to the right indicate full marks.

Q1)   Attempt any **FIVE** from the following.

a)   Draw the following with reference to cubic unit cell   3
       (002), (101) and (111).

b)   Calculate the conductivity of a Ge specimen if the donor impurity added to Ge is 1.2×10^{23} 3
        atoms/m^3.Given mobility of electron is 3800 cm^2/V-sec.

c)   What is principle of solar cell? Write its advantages and disadvantages?   3

d)   Draw and explain Fermi level diagram of p-n junction diode.   3

e)   An electron has a speed of 400 m/sec with uncertainty of 0.01%. Find the accuracy in its position.   3

f)   Define superconductivity, critical temperature and critical magnetic field.   3

g)   The Bragg angle corresponding to the first order reflection from (1 1 1) planes of a crystal is 30^0.   3
        Wavelength of X-ray is 1.75 A^0. Determine interplanar spacing and lattice constant of the crystal.

Q2)a)   Derive the conditions for the maxima and minima due to interference of light in a wedge shaped   8
        film.

b)   Derive Bragg's equation for x ray diffraction in crystals. If X-rays of wavelength 1.549A^0 is reflected   7
        from a crystal with interplanar spacing 4.255A^0, calculate the smallest glancing angle and the highest
        order of reflection that can be observed.

Q3)a)   Derive Schrodinger Time Independent Wave Equation. Find the lowest energy of a neutron within a   8
        nucleus of dimension 10^{-14} m. given mass of a neutron 1.67×10^{-27} kg.

b)   Draw and explain the energy band diagram for a p-n junction in forward and reverse biased mode.   7

Q4)a)   Define drift current, diffusion current and mobility of charge carriers and state its S.I units.   5

b)   Describe in detail the concept of anti-reflecting film with a proper ray diagram.   5

c)   Explain phase velocity of a wave and group velocity of matter waves.   5

Q5)a)   Explain formation of Newton's rings with experimental arrangement? Also give characteristics of   5
        Newton's rings.

b)   Define Fermi level and explain it in detail for conductors.   5

c)   Explain de-Broglie hypothesis of matter waves and deduce the expression for wavelength.   5

Q6)a)   What are type- I and type-II superconductors?   5

b)   Find the thickness of the soap film which appear yellow (wavelength 5896 A^0) in reflection when it   5
        is illuminated by white light at an angle of 45^0.Given refractive index of the film is 1.33.

c)   The minimum energy possible for a particle trapped in a 1-d box is 3.2×10^{-18} J. What are the next   5
        three energies in eV the particle can have?

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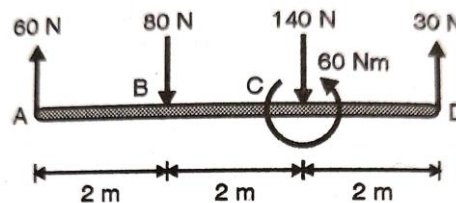**Time: 3 Hrs** **Max. Marks: 80**

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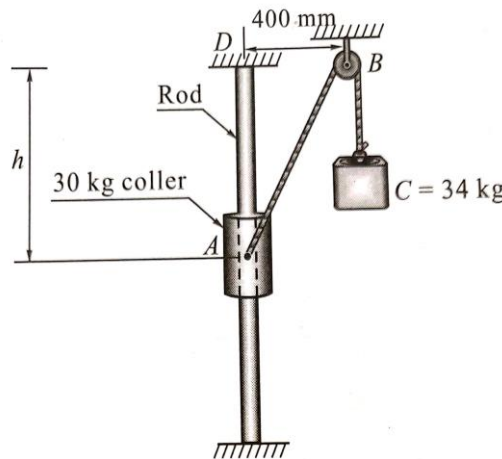(3) Assume suitable data if necessary and mention the same clearly.
(4) Take g = 9.81 m/s^2, unless otherwise specified.

Q1. **Solve any Four-**

a) Replace the given force system in two parallel components at B & D. **05**

b) The 30 kg collar may slide on frictionless vertical rod and is connected to a 34 kg counterweight. Find the value of h for which the system is in equilibrium. **05**

c) A block rests on a rough inclined plane making an angle of 30^0 with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, Find the mass of the block (in kg). **05**

d) A force acts at the origin in the direction defined by the angles $\theta_y = 65^0$ & $\theta_z = 40^0$. Knowing that the x-component of the force is 750 N. Determine (i) the other components. (ii) Magnitude of the force & (iii) the value of θx. **05**

e) Explain the following with example- **05**
   i) General Plane motion.
   ii) Instantaneous centre of rotation.

f) If x = 1- t and y = t^2 where x and y are in meters and t is in second, determine the acceleration of the particle at t= 3 sec. **05**

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Q 2   Two spheres A and B of weight   **07**
A)   1000 N and 750 N respectively are kept as shown in figure. Determine the reactions at all contact points 1, 2, 3 and 4. Radius of A is 400 mm and radius of B is 300 mm
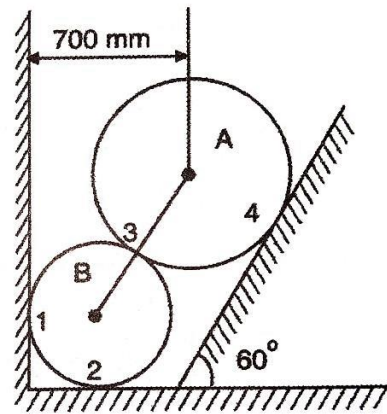
B)   Find the centroid of the shaded areas shown in the fig.   **07**
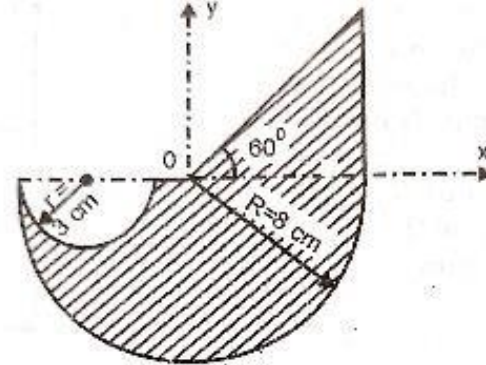
C)   A particle starts from rest from origin and its acceleration is given by   **06**
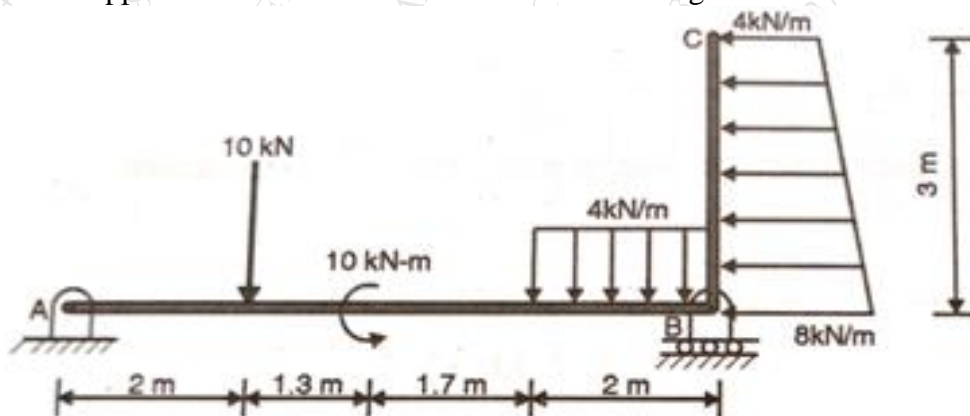
$$a = \frac{k}{(x+4)^2}$$

Knowing that v = 4 m/s when x = 8 m. Find value of k, Also calculate the velocity when displacement is 10 m.

Q 3   Find the support reactions of beam loaded as shown in fig.   **07**
A)

B)   A uniform ladder rests with one end against a smooth vertical wall and other end   **07**
on the ground, whose coefficient of friction is 0.5. If the inclination of ladder to the ground is 50^0, find the position of a man (whose weight is same as ladder) from the bottom of the ladder when the ladder is at the verge of slipping. The length of ladder is 8 m.

C)   A particle moves in x-y plane with acceleration components $a_x = -3 m/s^2$ and   **06**
$a_y = -16t$ m/s². If its initial velocity is $V_0 = 50$ m/s directed at $35°$ to the x-axis, compute the radius of curvature of the path at t = 2 sec. Also calculate the velocity at t = 5 Sec.

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Q 4. A dam is subjected to three forces, 50 kN on the upstream face AB, 30 kN force on the downstream inclined face and its own weight of 120 kN as shown in figure. Determine the single force and locate its point of intersection with the base AD assuming all the forces to lie in a single plane.
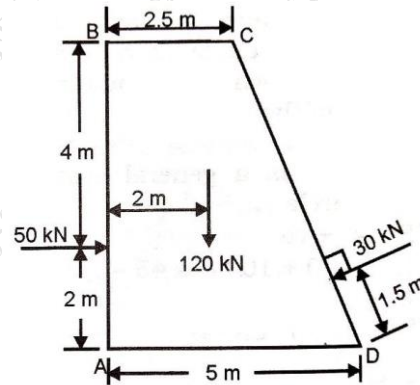
07

B) A boy throws a ball so that it may clear a wall 3.6 m high. The boy is at a distance of 4.8 m from the wall. The ball was found to hit the ground at a distance of 3.6 m on the other side of the wall, Find the least velocity with which the ball can be thrown, and the corresponding angle of projection.
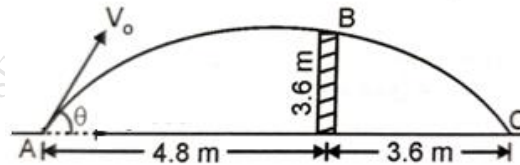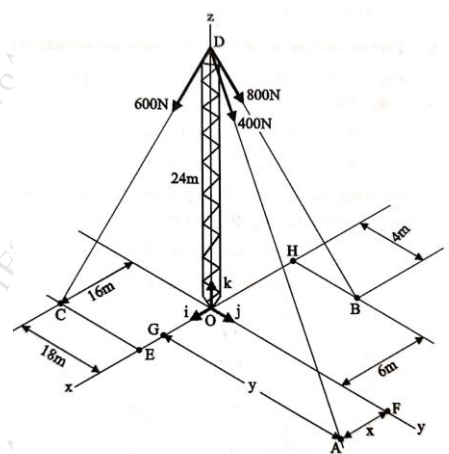
07

C) For the mechanism shown in figure, the angular velocity of bar AB is 3 rad/s clockwise. Using instantaneous center of rotation, calculate the angular velocity of bar BC and the velocity of slider C for this position
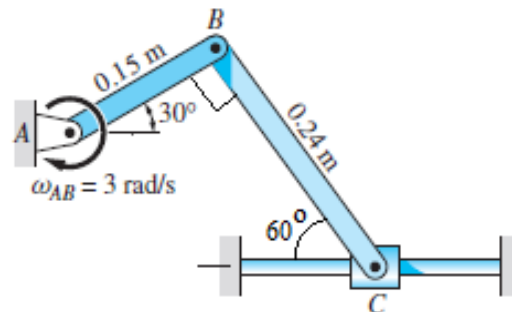
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Q 5. A tower is held in position by three cables. Determine position (x, y) for the cable DA so that the resultant force exerted is directed from D to O.
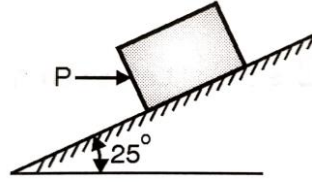
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B) Fig shows a-t curve for a particle moving along x axis what is speed & distance covered by the particle after 50 sec? Find also the maximum speed & the time at which the speed is attain by the particle, also plot v-t & x-t curve.
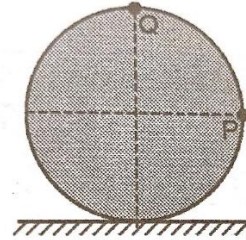
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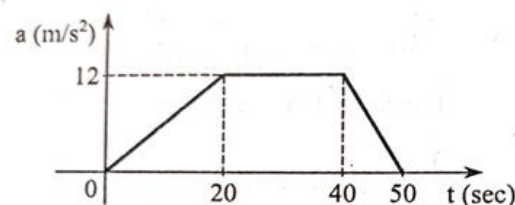
Q 6.
A) A block of weight 800 N is acted upon by a horizontal force P as shown in figure, if $\mu_s = 0.35$ & $\mu k = 0.25$, determine the value of P for impending motion up the plane.   **05**
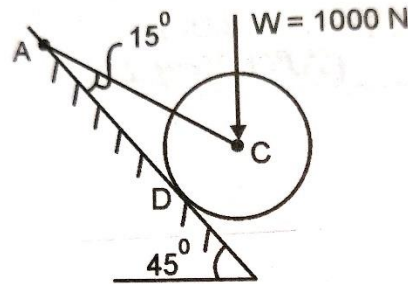
B) A wheel of radius 0.75 m rolls without slipping on a horizontal surface. Determine the velocities of point P and Q shown in figure, when the velocity of centre of the wheel is 10 m/s towards right.   **05**

C) `A wheel of weight W = 1000 N rest on a smooth incline plane. It is kept from rolling down the plane by a string AC. Find the tension in the string and reaction at the point of contact D.   **05**

D) A train starting from rest accelerates uniformly for 3 minutes, runs at constant speed for next 5 minutes and then come to rest in next 2 min. If it covers a total distance of 9 km, draw V- t diagram and find the acceleration and retardation in m/s^2 **05**

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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)**

    a)   Calculate the temporary and permanent hardness of water sample having the following impurities in ppm: $Ca(HCO_3)_2$= 29.5, $CaSO_4$= 13, $Mg(HCO_3)_2$= 7.3, NaCl = 49.

    b)   Explain the term Viscoelasticity.

    c)   State Huckel's rule of aromaticity.

    d)   Give difference between bonding and antibonding orbitals.

    e)   Define the terms: phase, component, and degree of freedom.

    f)   Discuss the effect of temperature on polymers.

    g)   Write a note on Reverse Osmosis.

Q.2) a)   Explain the reduced phase rule. Draw and explain phase diagram of Pb-Ag   **(6)**
          system.

    b)   Explain Electrodialysis with the help of principle, process, and diagram.   **(5)**
       Also give its advantages.

    c)   Give Preparation, Properties and uses of PMMA.   **(4)**

Q.3) a)   Draw the Molecular Orbital diagram of O_2 molecule. Give its electronic   **(6)**
          configuration. Calculate its bond order and identify its magnetic behaviour.

    b)   i) Define the terms BOD and COD.   **(2)**

       ii) 6 ml of waste water sample was refluxed with 25 ml of $K_2Cr_2O_7$ and   **(3)**
       after refluxing the excess unreacted dichromate required 20 ml of 0.1N
       FAS solution. A blank of 10 ml of distilled water on refluxing with 25 ml
       of $K_2Cr_2O_7$ solution required 35 ml of 0.1N FAS solution. Calculate COD
       of waste water sample in ppm.

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

Number of polymer (N_i)	1	3	2	1	2
Molecular weight of each polymer (M_i)	200	100	300	500	400

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Q.4) a) Explain Gibbs phase rule with the help of its mathematical expression. **(6)** Write advantages and limitations of phase rule.

b) Write resonance structure of benzene. Give limitations of Kekule's **(5)** structure of benzene.

c) Explain intrinsic and doped conducting polymers with appropriate **(4)** examples.

Q.5) a) Define fabrication of plastics. Explain injection moulding process with **(6)** neatly labelled diagram. Give its advantages.

b) What are atomic orbitals? Explain the shapes of p-orbitals and **(5)** d-orbitals with their diagrams.

c) 0.5g of $CaCO_3$ was dissolved in HCl and diluted to 500 ml with distilled **(4)** water. 50 ml of this solution required 45 ml of EDTA solution for titration. 50 ml of hard water sample required 15 ml of EDTA solution for titration. 50 ml of same water sample on boiling and filtering requires 10 ml of EDTA solution. Calculate the total and permanent hardness in ppm.

Q.6) a) Explain the ion-exchange method for softening of water giving the **(6)** following details: Principle, diagram, process and Reactions.

b) i) Explain the term eutectic point. **(1)**

ii) Calculate the mass of eutectic when 1 kg an alloy of Cd and Bi **(4)** contains 25% Cd and eutectic mixture contains 40% of Cd.

c) i) Give the Molecular Orbital diagram of carbon monoxide **(2)** (CO) molecule.

ii) Discuss the role of fillers in compounding of plastics. **(2)**

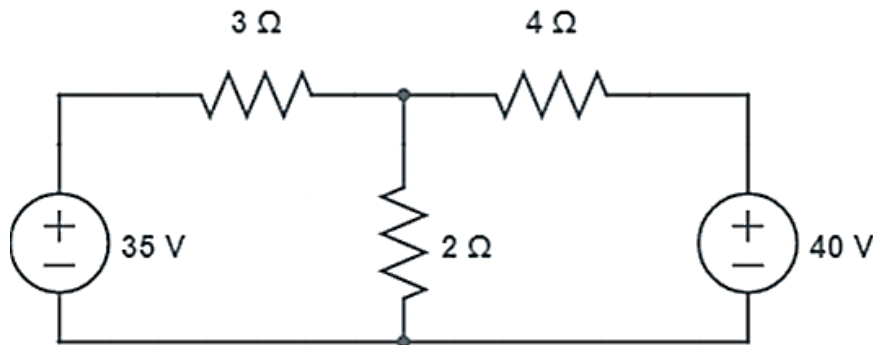****************

(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**

(i) Find current through 3Ω resistor by mesh analysis.   **05**

(ii) Compare star and delta connection in three phase circuits.   **05**

(iii) State Superposition theorem. What is its application?   **05**

(iv) A balanced 3-Φ, star-connected load consists of three coils each consisting of R=6Ω and X_L=8Ω. Determine the phase impedance, phase voltage, phase current, line current and load power factor when the load is connected across 400 V, 50 Hz supply.   **05**
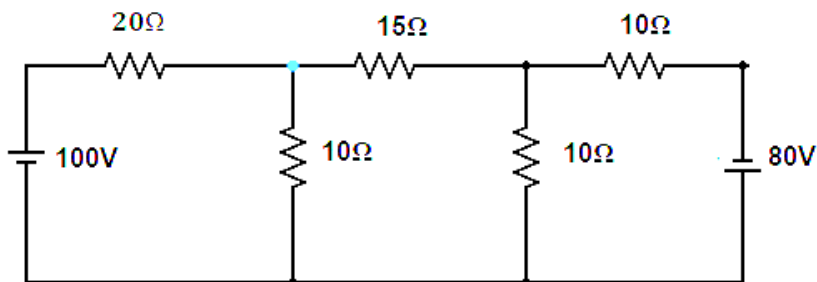
v) Derive the EMF equation of a DC machine.   **05**

II. A) An alternating current of frequency 50Hz has a maximum value of 12A. Find the following: (i) Angular frequency in radians/sec;(ii) Equation of instantaneous value of current;(iii) Value of current after 5msec; (iv) RMS value of current and (v) Time taken to reach 9.6A for the first time.   **10**

B) Find the current through 15Ω through nodal analysis?   **10**

III. A) Prove the relation between phase voltage and line voltage in a three-phase star connected system with neat phasor diagrams.   **10**

B) A resistor of 25Ω is connected in series with a pure inductor. The series combination when connected across a 230V, 50Hz supply, draws a current of 5A which lags behind the supply voltage by 60⁰. Calculate (i)impedance of the circuit; (ii) reactance; (iii)inductor value; (iv)voltage drop across inductor; and (v) active power.   **10**

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IV. A) Three similar coils each having a resistance of 5Ω and an inductance of 0.02H are connected in star to a 440V,50Hz,3φ supply. Calculate (a) reactance and impedance of the coil b) phase voltage (c)phase current & line current (d) power factor (e)active & reactive power. **10**

B) State the working of a three-phase induction motor? What are the two types of rotor? **10**

V. A) Two wattmeters that are connected to measure power in a three-phase system using the two-wattmeter method, indicate 1250W and 250W respectively. Find the total power supplied and the power factor of the circuit. When i) both the readings are positive ii) when the latter reading is obtained by reversing the connections of the pressure coil. **10**

B) Derive the formula for resonant frequency of a series resonant circuit? State any five conditions of series resonance. **10**

VI. A) Find Thevenin's and Norton's equivalent circuit across A & B. **10**
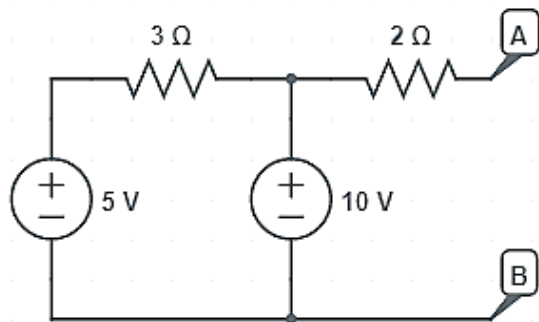
B) State and prove maximum power transfer theorem. Find the value of resistor (RL) that will transfer maximum power in the circuit given. **10**