

Duration: 3 hours

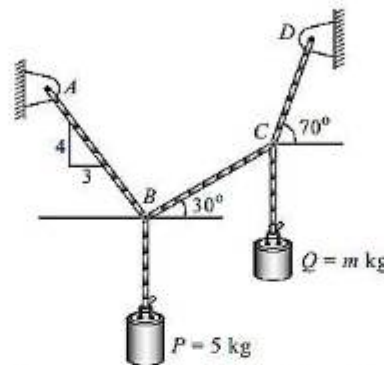
Total: 80 Marks

Note :

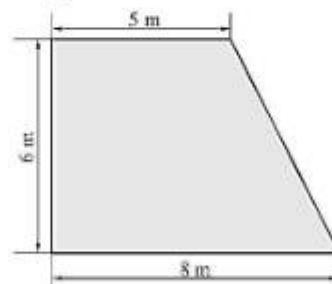
- Question No.1 is compulsory.
- Solve ANY THREE questions from the remaining five questions.
- Figure to the right indicates full marks.
- Assume suitable data wherever required, but justify the same.
- Take $g = 9.81 \text{ m/s}^2$.

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

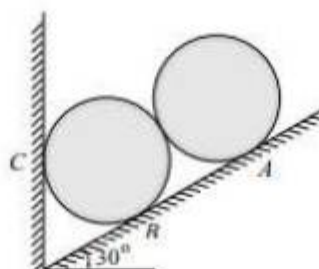
- a) Determine the mass m for the equilibrium of the 5 kg block as shown in the figure.



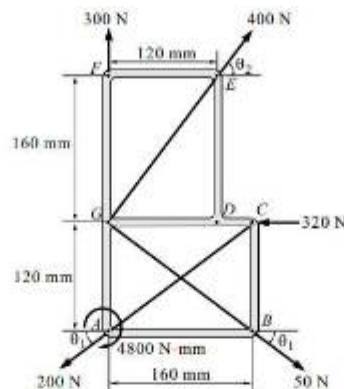
- b) Define the Varignon's theorem and write the significance of Varignon's theorem.
- c) Acceleration of a particle moving along a straight line is represented by the relation $a = t^3 - 2t^2 + 7$. At $t = 1$ second, velocity of the particle is 3.58 m/s and displacement is 9.39 m. Determine the velocity and displacement at $t = 2$ seconds.
- d) State the properties of Instantaneous Centre of Rotation .
- e) Determine the centroid of the given area.



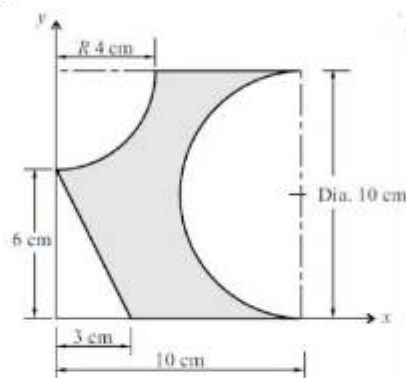
Q. 2 a) Two identical rollers of mass 50kg are supported as shown in figure. To maintain the equilibrium, Determine the support reactions assuming all smooth surfaces. **8**



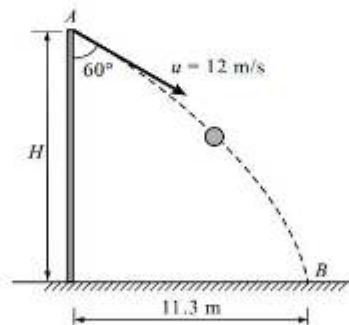
- b) Calculate the resultant of the given force system and locate it with respect to the point of action of 200 N force. 6



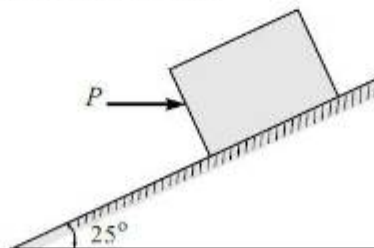
- c) Determine the "x" and "y" coordinates of the Centroid for the shaded area shown. 6



- 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

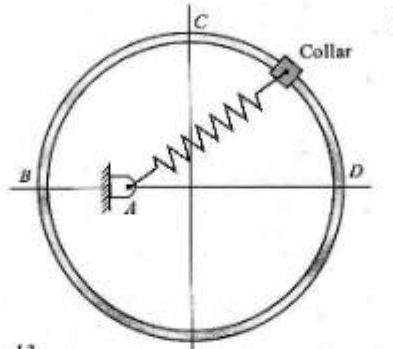


- b) A block of 800 N is placed on an inclined surface. Determine the force P required to prevent the sliding of the block down the plane if the coefficient of friction between the block and surface is 0.35. 6

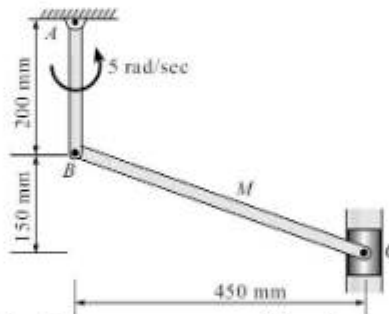


- c) A point moving along a path $y=x^2/3$ with a constant speed of 8m/s. What are the x and y components of its velocity when $x=3\text{m}$? Also, find the radius of curvature and acceleration. 6

- Q4 a) A collar of mass 1kg is attached to spring and slides without friction along a circular rod which lies in a horizontal plane. The spring is undeformed when the collar is at B knowing that the collar is passing through point D with a speed of 1.8 m/s Determine the speed of collar when it passes through point C and B. Take stiffness of the spring, $k=250\text{N/m}$, Radius of the circular path $=300\text{mm}$ and distance $OA=125\text{mm}$. 8

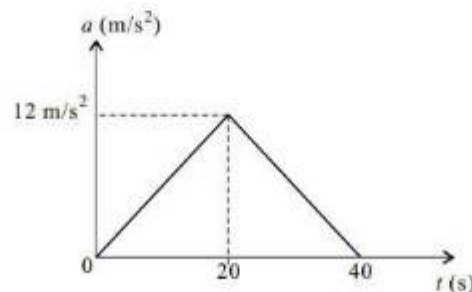


- b) At the instant shown, locate the ICR and determine the angular velocity of rod BC and the velocity of the piston C. 6

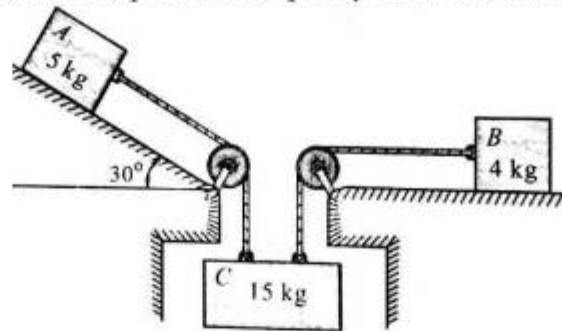


- c) A ball is thrown vertically down on a smooth horizontal floor with a velocity of 10 m/s from which it bounces to a height of 3 m. If the coefficient of restitution is 0.7. Find the maximum height it can reach after hitting the ground. 6

- Q5. a) A car moves along a straight road such that its acceleration time motion is described by the graph shown in fig. construct v-t and s-t graphs and determine the maximum speed and maximum distance covered. 8

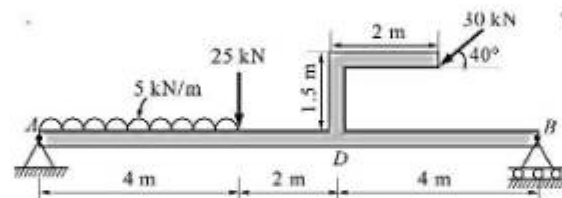


- b) The system shown in fig. is released from rest. What is the height lost by bodies A, B and C in 2 sec. Take coefficient of kinetic friction at rubbing surfaces as 0.4. Find tension in each rope. Assume pulleys to be frictionless. 6

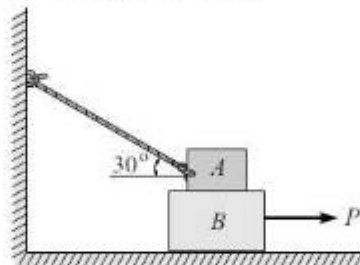


- c) A force $F = 100 \text{ N}$ acts at a point A $(-2, 3, 5) \text{ m}$ has its line of action passing through point B $(10, 3, 4) \text{ m}$. Calculate moment of the force about the origin. 6

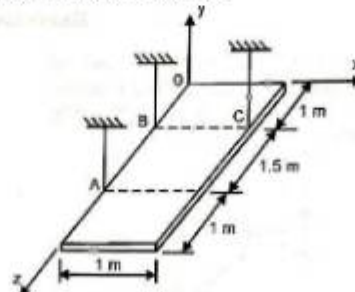
- Q6 a) A beam is loaded and supported as shown in figure. Find the support reactions at support A and B. 8



- b) Block A weighs 40 kN and the block B weighs 60 kN. The coefficient of friction between A and B is 0.3 and between B and the floor is 0.25. Determine the value of "P" for holding the system in equilibrium. 6



- c) A rectangular plate weighing 500 N is suspended in the horizontal plane using three cables. Find the tension in each cable. 6



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Time: 2 Hours

Marks: 60

Note the following instructions.

1. **Question 1** is compulsory. Attempt **any three** questions out of remaining questions.
2. Draw neat diagrams and write chemical reactions wherever necessary.
3. Assume data, if missing, with justification.
4. Atomic Weight: H=1, C=12, O=16, Ca=40, S=32

Q.1. Attempt any five.

- a. Draw orbital diagrams for p_x , p_y and p_z orbitals. 3M
- b. A 30 ml of wastewater refluxed with potassium dichromate solution and after refluxing excess unreacted dichromate required 15 ml 0.1 N FAS solution. If blank titration is 20 ml, calculate COD value of wastewater. 3M
- c. Write merit of Gibb's phase rule. 3M
- d. Draw molecular orbital picture of benzene. 3M
- e. A hard water sample contains following impurities (in mg/L)
 $\text{Ca}(\text{HCO}_3)_2 = 4.86$; $\text{CaSO}_4 = 13.6$ Calculate temporary, permanent and total hardness of the given sample of water. 3M
- f. Define glass transition temperature. Discuss any two factors affecting glass transition temperature. 3M
- g. Differentiate between bonding and antibonding molecular orbitals. 3M

Q.2.a. i) Define Gibb's phase rule and explain the following terms with suitable example:

- A) Phase B) Component C) Degree of freedom 6M
- b. Define moulding of Plastic. Explain injection moulding with the help of neat diagram. 5M
- c. An alloy of tin and lead contains 25% lead. Find the mass of eutectic in 1 kg of solid alloy if the eutectic contains 62 % of tin. Calculate the mass of tin separated out. 4M

Q.3.a. Draw the diagram for ion exchange process and explain the process with suitable reactions. 6M

- b. 1.0 g of CaCO_3 was dissolved in dilute HCl and diluted to 1000 ml with distilled water. 100 ml of this solution required 28 ml of EDTA solution. 100 ml of hard water sample required 33 ml of EDTA. After boiling, cooling and filtering 100 ml of this water sample required 10 ml of EDTA solution Calculate each type of hardness of water. 5M
- c. Explain n-doped conducting and p-doped conducting polymer with suitable examples. 4M

- Q 4.a Write preparation, properties and uses of Kevlar. 6M
- b. i) Differentiate thermoplastic and thermosetting polymers. 3M
- ii) Define BOD and COD. 2M
- c. Be₂ molecule does not exist. Explain the reason with the help of molecular orbital diagram. 4M

Q 5.a Draw the molecular orbital structure of O₂ molecule and answer the following:

- a) Electronic configuration of molecule 6M
- b) Bond order of O₂ molecule.
- c) Comment on its magnetism
- b. i) If a polymer sample has following population: 5M
- 5 molecules of molecular mass = 10000
- 2 molecules of molecular mass = 20000

Calculate Number- average and Weight- average molecular weight of the polymer.

- c. Explain Reverse Osmosis method and mention its applications. 4M

Q 6.a Draw the phase diagram of one component system. Calculate degree of freedom for areas, curves, and triple point. 6M

- b. Explain Electro dialysis process with the help of diagram. 5M
- c. Discuss the role of following compounds in compounding of plastic: 4M
- I. Plasticizers II. Stabilizers

Time: 3 hrs

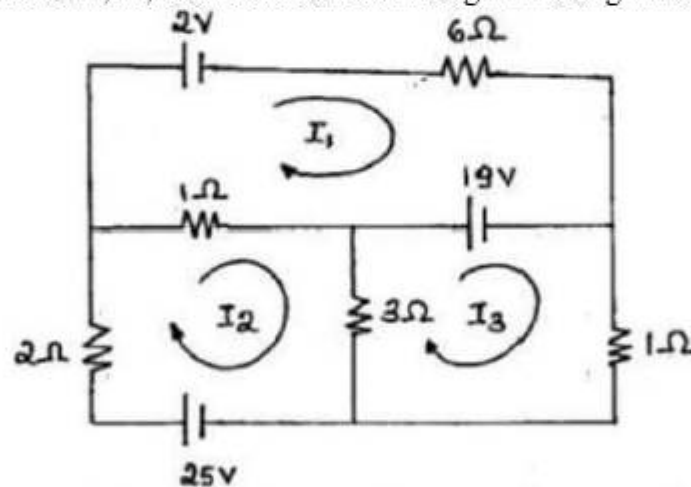
Marks: 80

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

1. Answer any four

- a) Draw a neat diagram of two wattmeter method of power measurement in three phase circuits for resistive load and state any two advantages. 05
- b) Derive the emf equation of a single-phase transformer. 05
- c) State and prove Maximum Power Transfer theorem. 05
- d) A balanced 3- Φ , star-connected load consists of three coils each consisting of $R=6\Omega$ and $X_L=8\Omega$. 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
- e) Derive the EMF equation of a DC machine. 05

2. A) Find the currents I_1 , I_2 , I_3 and the current through 1Ω using mesh analysis? 10

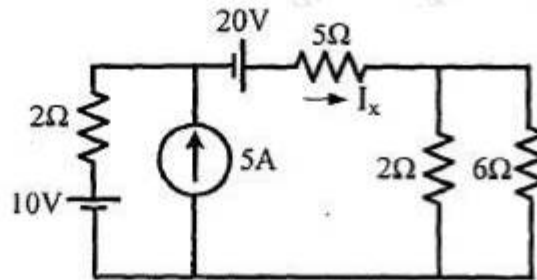


- B) A circuit consists of a pure resistor and a coil in series. Power dissipated in the resistor and in the coil are 1000W and 250W respectively. The voltage drops across the resistor and the coil are 200V and 300V respectively. Determine value of resistance, resistance and reactance of a coil, combined resistance and impedance of the coil and supply voltage. 10

3. A) An alternating voltage is represented by $v(t)=141.4 \sin (377t)$ V. Find 10
 - (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.

B) Find the current through 5Ω (I_x) using Superposition theorem without using source transformation.

10



4.A) State the working of a three-phase induction motor? What are the two types of rotor?

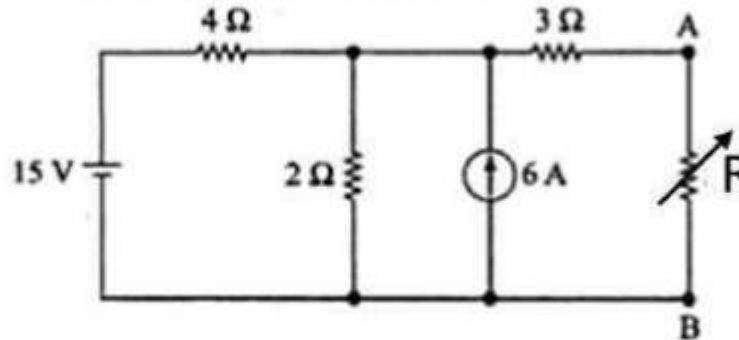
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B) Prove the relation between phase voltage and line voltage in a three-phase star connected system with neat phasor diagrams.

10

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

10



B) Derive the formula for resonant frequency of a series resonant circuit? Compare Series and Parallel Resonance circuit.

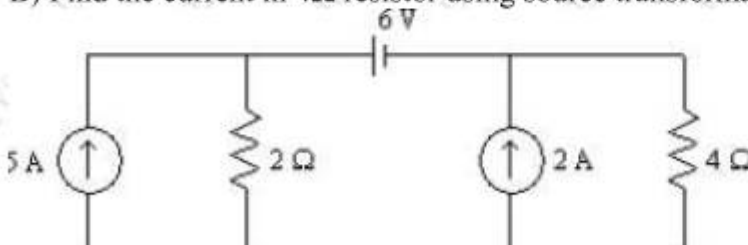
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6. A) A series RLC circuit has values $R = 10$ ohms, $L = 10$ mH, and $C = 10$ micro F. It is connected to a 200 V variable frequency supply. Find the resonant frequency? At resonance find, i) current drawn, ii) power consumed, iii) power factor and iv) Quality factor.

10

B) Find the current in 4Ω resistor using source transformation.

10



Time: 1 ½ Hours

Marks: 45

N.B.

1. Q.1. is compulsory.
2. Attempt any two out of the remaining four questions.
3. Figures to the right indicate full marks.
4. Answers to the sub questions should be grouped together.
5. Assume suitable data wherever necessary.

Q1 Answer the following questions (15)

- a** Explain Verbal Communication Method. 5
- b** You ordered a cellphone from Click & Buy online shopping portal. On opening the parcel, you noticed that the cell phone was damaged. Write a complaint cum claim letter to the Customer Relations Manager. 5
- c** Write a set of instruction for making an UPI payment. 5

Q.2. Answer any three of the following questions (15)

- a** Write antonyms of the following words 5

Word	Synonym
Abundant	
Arrive	
Borrow	
Conceal	
Enter	

- b** Write one sentence summary of the following extracts: 5

1. World Book Day, celebrated on April 23rd, is an international event organized by UNESCO to promote reading, publishing, and the love of literature. The date was chosen to honour the memory of great literary figures. The day encourages people of all ages to discover the joy of reading and to appreciate the value of books as tools for education, empathy, and cultural exchange. Schools, libraries, and bookstores worldwide host activities that inspire reading habits, especially among children and young adults.
2. Information literacy is the ability to identify, locate, evaluate, and effectively use information for problem-solving, decision-making, and learning. In today's digital age, where vast amounts of information are readily accessible, being information literate means not just finding data but also critically analyzing sources for credibility, relevance, and bias. It empowers individuals to navigate misinformation, engage in informed discussions, and become responsible digital citizens. Information literacy is a vital skill in education, the workplace, and everyday life.
3. Values and ethics are fundamental principles that guide human behavior and decision-making. Values refer to the personal and societal beliefs that define what is important and worthwhile, such as honesty, respect, and compassion. Ethics, on the other hand, are the rules or standards that govern conduct within a particular context, such as professional or social settings. Together, they shape moral judgment, promote integrity, and foster trust in relationships and institutions. Upholding strong values and ethical practices is essential for building a just and responsible society.

- c** Identify types of communication barriers in the following communication situations 5

1. As the workers doubted the manager's intentions, they couldn't talk to him frankly.
2. A sudden power outage prevented a scheduled virtual class.
3. Saavi's illegible handwriting failed to convey her message to the readers.
4. Rama was not able to speak properly due to throat infection.
5. The audience in the back couldn't hear properly due to faulty PA system.

- d** Explain the Grapevine Communication Network. 5

Q.3 Answer any three of the following questions (15)

- a Punctuate the following sentences 5
1. You may seat wherevr you laik
 2. i had seen a movi yesterdays
 3. i believe on him
 4. sahu did not understood what you say
 5. its amazing
- b Write a short paragraph on 'Responsible Use of Social Media'. 5
- c Do as Directed: 5
1. The correct option should be clicked (Rewrite as an imperative sentence).
 2. Actual fact. (Identify the redundant word).
 3. End result (identify the redundant phrase).
 4. Yours Faithfully, (Rewrite the complimentary close in open punctuation style)
 5. Give an example of cliché
- d Describe a Scientific Calculator 5

Q.4 Answer any three of the following questions (15)

- a Apply the SMART goal-setting method and write your academic goals for next semester. 5
- b Your teacher has assigned a group project report writing activity as part of the term work. You are allowed to select your topic and group members. Write your group project actions/events as per the five stages of team building. 5
- c Explain the structural parts of a formal letter. 5
- d Match the Column 'A' with Column 'B' 5

Column- A	Column -B
Note	Direct exposure to sunlight will affect the process outcome
Caution	Password is case insensitive
Warning	Damaged to equipment/improper results
Danger	Instruction Writing
Action Verbs	Highly Inflammable

Q.5. Answer any three of the following Questions (15)

- a Write meaning of the following idioms: 5

Idioms	Meaning
Strike a blow	
Game over	
All comers	
Ahead of your its time	
Under the weather	

- b Give Diagrammatic representation and explanation of the Complete Block style. 5
- c Write an email to your class teacher for requesting a two days leave. 5
- d Read the following Paragraph and answer the questions given there below: 5
- India, with its large and youthful population, holds immense potential for economic growth. However, a significant challenge the country faces is the skills gap — the mismatch between the skills possessed by the workforce and those required by employers. While millions of students graduate each year, many lack the practical, technical, and soft skills needed for modern jobs. Rapid technological advancement and changing industry demands have widened this gap further. Despite efforts by the government and private sector to provide skill development programs, the reach and effectiveness of these initiatives vary. Bridging the skills gap is crucial not only for reducing unemployment but also for boosting productivity and driving inclusive growth.

1. What is the main issue discussed in the passage? 1
 - A) Unemployment in rural India
 - B) The mismatch between workforce skills and job requirements
 - C) High dropout rates in schools
 - D) The rise of online education platforms
2. Why is the skills gap a problem for India? 1
 - A) It leads to overpopulation
 - B) It causes students to study abroad
 - C) It limits employment and economic development
 - D) It increases government spending on education
3. What kinds of skills are often lacking in Indian graduates? 1
 - A) Physical and athletic skills
 - B) Only academic knowledge
 - C) Practical, technical, and soft skills
 - D) Language translation skills
4. How has technology affected the skills gap? 1
 - A) It has closed the gap completely
 - B) It has made manual labor jobs more popular
 - C) It has widened the gap by changing industry needs
 - D) It has replaced the need for education
5. What does the passage say about current skill development programs? 1
 - A) They are not needed anymore
 - B) They are effective in every part of the country
 - C) Their reach and effectiveness vary
 - D) They are run only by international organizations

(2 Hours)

Max Marks:60

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

(2) Attempt any **THREE** questions from the remaining **FIVE** questions.

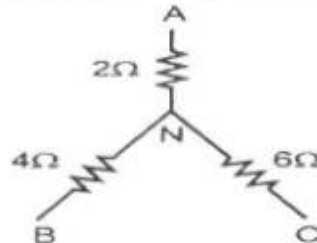
(3) Assume suitable data if necessary and mention the same clearly.

(4) Figures on the right indicate the marks.

MARKS

Q1 (a) Convert the star circuit into its equivalent delta circuit

(3)



(b) Write down the relation between line current and phase current, line voltage and phase voltage, power in balanced three phase delta connected balanced load.

(3)

(c) Explain the concept of back emf in a DC motor.

(3)

(d) What are the losses in a single-phase transformer?

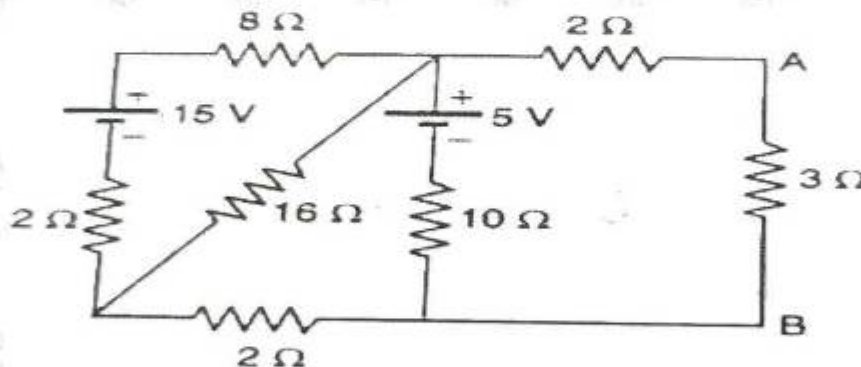
(3)

(e) Draw and explain the construction diagram of LED and enlist the applications.

(3)

Q2 (a) Using Norton's theorem, calculate the current through $3\ \Omega$ resistor across the terminals A and B in the given circuit.

(10)



(b) Explain the working principle of three phase induction motor and mention its types.

(5)

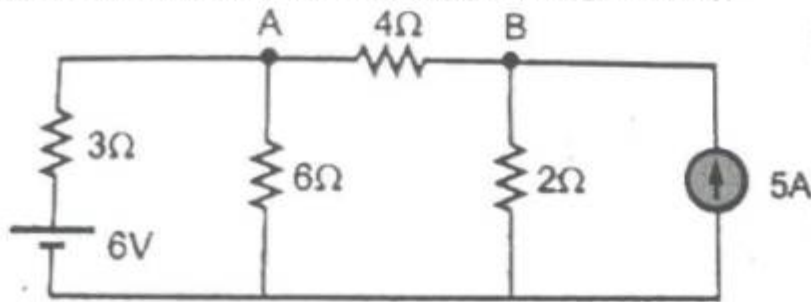
Q3 (a) An inductive coil having inductance of 0.04H and resistance $25\ \Omega$ has been connected in series with another inductive coil of inductance 0.2H and resistance $15\ \Omega$. The whole circuit is powered with 230V , 50Hz mains. Calculate the power dissipation in each coil and total power factor

(10)

(b) Explain the application of Zener diode as a voltage regulator.

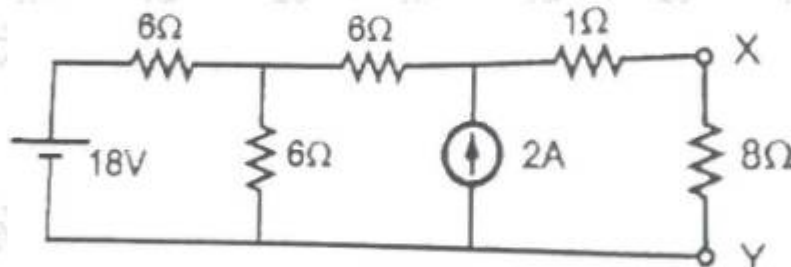
(5)

- Q4 (a) Find the current through 4Ω resistance using Nodal analysis (5)



- (b) With the help of a neat circuit diagram explain the operation of a BJT as a switch. (5)
- (c) What is the necessary condition for resonance in a series circuit? Derive an expression for resonance frequency. (5)
- Q5 (a) Explain the working principle of single phase transformer and derive the EMF equation. (6)
- (b) Explain the working principle of Brushless DC Motor. (4)
- (c) A balanced 3- ϕ , star connected load consist of three coils each consisting of $R = 6\Omega$ and $X_L = 8\Omega$. Determine the 1) Phase impedance 2) Phase voltage 3) Phase current 4) Line current 5) Power factor when connected across 400V, 50 Hz supply. (5)

- Q6 (a) Using source transformation find the current flowing the 8Ω resistance (6)



- (b) A coil having a resistance of 10Ω and an inductance of 40mH is connected to a 200V , 50Hz supply. Calculate the impedance of the coil, current, power factor and power consumed. (4)
- (c) Differentiate between BJT and FET. (5)

Time: 1 1/2 hour

Maximum marks : 45

NB:

- 1) Question No.1 is Compulsory
- 2) Attempt any two questions from the remaining four questions
- 3) Draw neat diagrams and write chemical equations wherever necessary.
- 4) Figures to the right indicate full marks.

- Q. 1 Attempt any **five** of the following: (15)
- a) What are advantages of gaseous fuels over solid and liquid fuels?
 - b) Distinguish between galvanizing and tinning.
 - c) Why are alloys preferred over pure metals in many applications?
 - d) Explain viscoelasticity property of polymer.
 - e) Define Matrix phase and dispersed phase of composites.
 - f) What is supercritical CO₂, and how does it differ from liquid and gaseous CO₂.
 - g) 1 gm. of coal sample was used for determination of nitrogen. The ammonia evolved was passed into 50ml of 0.1 N H₂SO₄, the excess acid required 42 ml. of 0.1N NaOH for neutralization Calculate % of N.
- Q.2 a) How do following factors affects the rate of corrosion i) P^H medium ii) Purity of metal iii) Area of anode and cathode. (6)
- b) Explain the determination of sulphur present in coal sample and write its significance. (5)
- c) Write an informative note on biodiesel. (4)
- Q.3 a) In a polymer sample 30% molecules have a molecular mass 20,000, 40% have molecular mass 30,000 and the 30% have 60,000. Calculate the weight average, number average molecular weight and polydispersity of polymer sample. (6)
- b) What is condensed phase rule equation? Write merits and limitation of phase rule. (5)
- c) Write a short note on sandwich panel of structural composite write its applications. (4)
- Q.4 a) Give the definitions and significance of following properties of polymer. Tensile strength, insulation resistance and refractive index. (6)
- b) Explain synthesis of Adipic acid by traditional and green pathway. Also write the principle of green chemistry involved in this reaction. (5)
- c) A sample of coal has the following composition C = 84 %, O = 8.4 %, H = 5.5 %, S = 1.5%, N = 0.6 %, Calculate the higher and lower calorific values of coal. (4)
- Q.5 a) How material selection and proper design of equipments can prevent corrosion. Explain with the help of diagram and designing principles. (6)
- b) Explain fiber reinforced composite and write its applications and limitations. (5)
- c) An alloy of Cd and Bi contain 25% of Cd Find the mass of eutectic in 1kg of solid Alloy, if the eutectic contains 40 % of Cd. (4)

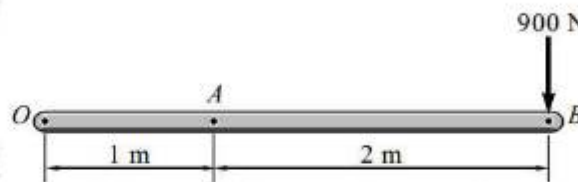
Time: 2 Hrs

Max. Marks: 60

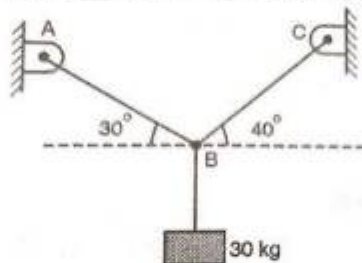
- N. B. (1) Question No.1 is compulsory.
 (2) Attempt any 3 questions from remaining five questions.
 (3) Assume suitable data if necessary and mention the same clearly.
 (4) Take $g = 9.81 \text{ m/s}^2$.

Q1. Solve any Five

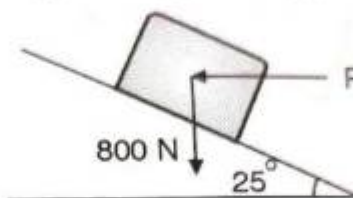
- a) Resolve the force $F = 900 \text{ N}$ acting at B as shown in Fig. into parallel components at O and A. (03)



- b) Determine the tensions in the cords AB and BC for equilibrium of 30 kg block. (03)

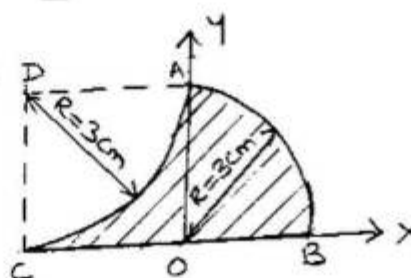


- c) A support block is acted upon by two forces as shown in fig. Knowing that the coefficient of friction between the block & the incline are $\mu_s = 0.35$, $\mu_k = 0.25$. Determine the force P required to prevent it from slipping down. (03)



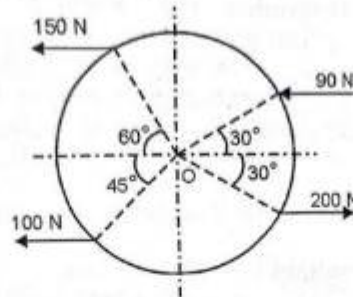
- d) A force of magnitude 50 kN is acting at point A(2,3,4) m towards point B(6,-2,-3) m. Find the components of this force along X, Y and Z axis. (03)
 e) The acceleration of a particle in rectilinear motion is given by $a = 100 - 3X^2 \text{ m/s}^2$. Knowing that at $t = 0$, $v = 0$ and $x = 0$ find the velocity of the particle at $x = 8 \text{ m}$. (03)
 f) Explain with neat sketch 1) Direct central Impact 2) Oblique central Impact. (03)

- Q 2 Find the coordinate of the centroid for the shaded part of the lamina with respect to given reference axis. (07)

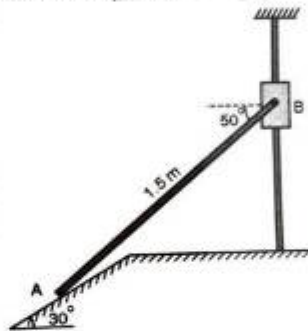


- B) The position vector of a particle which moves in the X-Y plane is given by
 $\vec{r} = (3t^3 - 4t^2)\mathbf{i} + (0.5t^4)\mathbf{j} \text{ m}$ Calculate Velocity and acceleration at $t = 4 \text{ Sec}$ (08)

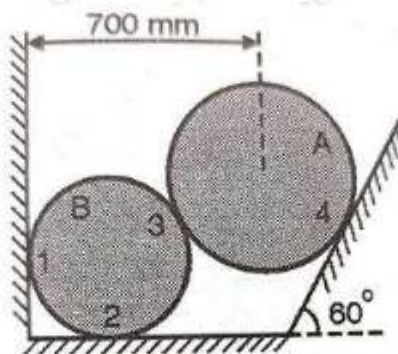
- Q 3 Determine the resultant of the following force system as shown in figure. Also locate its
 A) position w. r. t. O. Radius of circle is 2 m. (07)



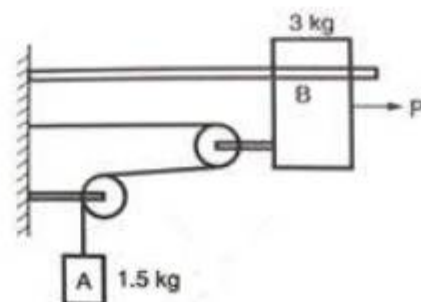
- B) Collar B moves up with constant velocity of $V_B = 2 \text{ m/s}$. Rod AB is pinned at B. Find the angular velocity of rod AB and velocity of A. (08)



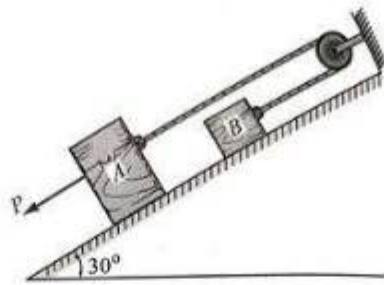
- Q 4. Two spheres A and B weight 1000 N and 750 N. Determine the reaction at all contact points
 A) 1, 2, 3 and 4. $r_A = 400 \text{ mm}$, $r_B = 300 \text{ mm}$ (07)



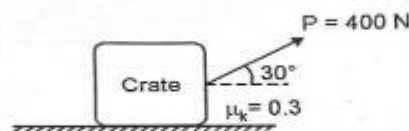
- B) The system shown in figure is initially at rest. Neglecting friction determine the force 'P' required if the velocity of the collar B is 5 m/s after 2 sec and corresponding tension in the cable. (08)



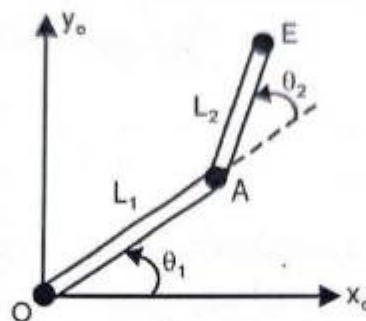
- Q 5. Determine the force P to cause the motion to impend. Take masses of the block A & B as 8 kg & 4 kg respectively and the coefficient of sliding friction as 0.3. The force P and the rope are parallel to the inclined plane. Assume frictionless pulley. (07)



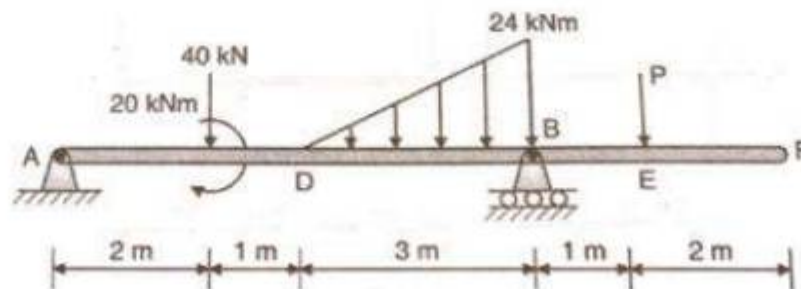
- B) A 50 kg crate shown in fig, rest on horizontal plane for which the coefficient of kinetic friction is $\mu = 0.3$. If the crate does not tip over when it is subjected to a 400 N force, determine the velocity of the crate in 8 sec starting from rest using impulse momentum principle. (08)



- Q 6. A planar elbow manipulator is shown. Write the D H parameters and hence locate the position and orientation of the end E of the manipulator. Given $L_1 = L_2 = 250$ mm and $\theta_1 = \theta_2 = 30^\circ$ (07)



- B) For the beam loaded as shown in figure, Calculate the support reactions at A and B. (08)



(Time: 3 hours)

Max.Marks:80

NB: (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) Prove that $\tanh^{-1}(\sin\theta) = \cosh^{-1}(\sec\theta)$ 5
- b) Prove that the matrix $A = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & 1+i \\ 1-i & -1 \end{bmatrix}$ is unitary. 5
- c) Find the nth derivative of $\cos 5x \cdot \cos 3x \cdot \cos x$. 5
- d) Prove that $\log \sec x = \frac{x^2}{2} + \frac{x^4}{12} + \dots$ 5
- 2 a) Find all values of $(1+i)^{\frac{1}{3}}$ and show that the continued product is $1+i$ 6
Find non-singular matrices P&Q such that PAQ is in normal form where
- b) $A = \begin{bmatrix} 2 & -2 & 3 \\ 3 & -1 & 2 \\ 1 & 2 & -1 \end{bmatrix}$ 6
- c) Find the maximum & minimum values of $f(x, y) = x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$. 8
- 3 a) If $u = f\left(\frac{y-x}{xy}, \frac{z-x}{zx}\right)$ then prove that $x^2 \frac{\partial u}{\partial x} + y^2 \frac{\partial u}{\partial y} + z^2 \frac{\partial u}{\partial z} = 0$. 6
- b) Test the consistency and solve if consistent $x + y + z = 3$, $x + 2y + 3z = 4$, $x + 4y + 9z = 6$. 6
- c) If $y = e^{\tan^{-1}x}$ then prove that 8
 $(1+x^2)y_{n+2} + ((2n+2)-1)xy_{n+1} + (n^2+n)y_n = 0$
- 4 a) If $z = x^2 \tan^{-1}\left(\frac{y}{x}\right) - y^2 \tan^{-1}\left(\frac{x}{y}\right)$ then prove that $\frac{\partial^2 z}{\partial x \partial y} = \frac{x^2 - y^2}{x^2 + y^2}$ 6
Investigate for what values of λ & μ the equations
- b) $2x + 3y + 5z = 9$, $7x + 3y - 2z = 8$, $2x + 3y + \lambda z = \mu$ have (i) no solution 6
(ii) a unique solution (iii) an infinite solutions.
- c) Prove that $\log \tan\left(\frac{\pi}{4} + \frac{ix}{2}\right) = \frac{1}{2} \log(1) + i \tan^{-1}(\sinh x)$ 8

- 5 a) Find $\tanh x$ if $5 \sinh x - \cosh x = 5$ 6
- b) If $u = \sin^{-1} \left(\frac{x+y}{x^2+y^2} \right)$ then prove that 6
- $$x^2 \frac{\partial^2 u}{\partial x^2} + 2xy \frac{\partial^2 u}{\partial x \partial y} + y^2 \frac{\partial^2 u}{\partial y^2} = \frac{\sin u}{4} \left[\frac{1-2\cos^2 u}{\cos^3 u} \right]$$
- c) Using Newton Raphson method, find approximate root of $x^3 - 2x - 5 = 0$ (correct up to three places of decimals.) 8
- 6 a) Prove that $\tan 5\theta = \frac{\tan \theta - 10 \tan^3 \theta + \tan^5 \theta}{1 - 10 \tan^2 \theta + 5 \tan^4 \theta}$ 6
- b) If $z = x^2 y + y^2, x = \log t, y = e^t$, find $\frac{dz}{dt}$ at $t = 1$ 6
- c) Solve the following systems of equations by Gauss-seidel method 8
- $$20x + y - 2z = 17, 3x + 20y - z = -18, 2x - 3y + 20z = 25$$

Duration: 1.5 hours

[MaxMarks: 45]

N.B.:

1. Question No. 1 is compulsory.
2. Attempt any two questions from Q.2 to Q.5.
3. Assume suitable data wherever required.
4. Figures to the right indicate marks.

- 1 Attempt any FIVE [15]
 - (a) What is metastable state? What is the role of metastable state in LASER?
 - (b) Define the terms: Critical angle, Acceptance angle and Attenuation.
 - (c) What is antireflection coating? What should be the refractive index and minimum thickness of the coating?
 - (d) Show that the divergence of the curl of a vector is zero.
 - (e) Calculate the wavelength of de-Broglie waves associated with mass 1 kg moving with a speed of 10^3 m/sec.
 - (f) Explain the de Broglie hypothesis of matter waves.
 - (g) Write Fermi-Dirac distribution function and explain the terms in it.
- 2 (a) What is resonant cavity? Explain its use in the generation of Laser beams. [05]
 - (b) Derive an expression for numerical aperture of a step index optical fibre. Give its physical significance. [05]
 - (c) In Newton's rings experiment the diameter of 5th ring was 0.336 cm and the diameter of 15th ring was 0.590 cm. Find the radius of curvature of plano convex lens if the wavelength of light used is 5890 Å. [05]
- 3 (a) Determine the curl of these vector fields. [05]
 - (1) $\vec{A} = \hat{a}_x (2x^2 + y^2) + \hat{a}_y (xy - y^2)$
 - (2) $\vec{A} = yz \hat{a}_x + 4xy \hat{a}_y + y \hat{a}_z$
 - (b) Derive Schrodinger's Time Independent wave equation for matter waves. [05]
 - (c) Explain mobility of electrons. The resistivity of Cu is 1.72×10^{-8} ohm-m. Calculate the mobility of electrons in Cu given that number of electrons per unit volume is $10.41 \times 10^{28} \text{ m}^{-3}$. [05]
- 4 (a) Derive an expression for Fermi level for an intrinsic semiconductor. [05]
 - (b) Obtain the condition for maxima and minima of the light reflected from a thin transparent film of uniform thickness. [05]
 - (c) An electron has a speed of 400 m/sec with uncertainty of 0.01%. Find the accuracy in its position. [05]
- 5 (a) The refractive indices of core and cladding materials of a step index fibre are 1.48 and 1.45 respectively. Calculate (1) Numerical Aperture, (2) acceptance angle, (3) the critical angle at the core cladding interface, (4) fractional refractive indices change. [05]
 - (b) State Ampere's Circuital law. Derive Maxwell's fourth equation in differential form. [05]
 - (c) With a neat energy level diagram, describe the construction and working of He-Ne Laser. [05]

Question 1 is compulsory.

Attempt any 3 from questions 2 to 6.

A Scientific Calculator is allowed to use.

**Applied Mathematics-I
Revised Course (NEP-2020)
(June 2025)**

**Marks-60
Duration-02 Hours**

1. Attempt any Five questions. (Compulsory Problem)

- | | | |
|-----|---|---|
| (a) | Prove that $\sqrt{1 + \operatorname{cosec}(\theta/2)} = (1 - e^{i\theta})^{-1/2} + (1 - e^{-i\theta})^{-1/2}$. | 3 |
| (b) | Find n^{th} derivative of $\frac{2}{(x-1)(x-2)(x-3)}$. | 3 |
| (c) | If $5 \sinh x - \cosh x = 5$, find $\tanh x$. | 3 |
| (d) | Show that the matrix $A = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & 1+i \\ 1-i & -1 \end{bmatrix}$ is unitary and hence find A^{-1} . | 3 |
| (e) | If $u = 2(ax + by)^2 - k(x^2 + y^2)$ and $a^2 + b^2 = k$, find $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$. | 3 |
| (f) | Using Newton-Raphson Method, find the real root of $x^3 - 2x - 5 = 0$ correct to three decimal places. | 3 |
- 2.**
- | | | |
|-----|---|---|
| (a) | If $\tan[\log(x + iy)] = a + ib$, prove that
$\tan[\log(x^2 + y^2)] = \frac{2a}{1 - a^2 - b^2} \text{ when } a^2 + b^2 \neq 1.$ | 4 |
| (b) | Examine the function $f(x, y) = y^2 + 4xy + 3x^2 + x^3$ for extreme values. | 5 |
| (c) | 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 |
- 3.**
- | | | |
|-----|---|---|
| (a) | Reduce the following matrix to normal form and find the rank of matrix $A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & -1 \\ 3 & 1 & 1 \end{bmatrix}$. | 4 |
| (b) | Solve $x^6 + 1 = 0$. | 5 |
| (c) | Apply Gauss-Seidel iteration method to solve the following linear equations up to the three iterations.
$20x + y - 2z = 17, 3x + 20y - z = -18, 2x - 3y + 20z = 25.$ | 6 |
- 4.**
- | | | |
|-----|--|---|
| (a) | Expand $\sin^5 \theta \cos^3 \theta$ in a series of sines of multiples of θ . | 4 |
| (b) | Investigate for what values of λ and μ the equations $x + y + z = 6, x + 2y + 3z = 10, x + 2y + \lambda z = \mu$ will have (i) No Solution (ii) Unique Solution (iii) Infinitely Many Solutions. | 5 |
| (c) | If $y = a \cos(\log x) + b \sin(\log x)$, prove that
$x^2 y_{n+2} + (2n + 1)x y_{n+1} + (n^2 + 1)y_n = 0$ | 6 |
- 5.**
- | | | |
|-----|---|---|
| (a) | If $\cos \alpha + \cos \beta + \cos \gamma = 0, \sin \alpha + \sin \beta + \sin \gamma = 0$, prove that
i) $\cos 3\alpha + \cos 3\beta + \cos 3\gamma = 3\cos(\alpha + \beta + \gamma)$
ii) $\sin 3\alpha + \sin 3\beta + \sin 3\gamma = 3\sin(\alpha + \beta + \gamma)$ | 4 |
| (b) | If $\alpha + i\beta = \tanh\left(x + i\frac{\ln}{4}\right)$, prove that $\alpha^2 + \beta^2 = 1$. | 5 |
| (c) | If $u = \sin^{-1}\left(\frac{x+y}{\sqrt{x}+\sqrt{y}}\right)$, prove that $x^2 \frac{\partial^2 u}{\partial x^2} + 2xy \frac{\partial^2 u}{\partial x \partial y} + y^2 \frac{\partial^2 u}{\partial y^2} = -\frac{\sin u \cos 2u}{4 \cos^3 u}$. | 6 |
- 6.**
- | | | |
|-----|---|---|
| (a) | Find all the roots of $\left(\frac{1}{2} + i\frac{\sqrt{3}}{2}\right)^{3/4}$, hence find the continued product of the roots. | 4 |
| (b) | Show that the minimum value of $u = xy + a^3\left(\frac{1}{x} + \frac{1}{y}\right)$ is $3a^2$. | 5 |
| (c) | Find non-singular matrices P & Q such that PAQ is in normal form & hence find rank of the matrix A and obtain A^{-1} . | 6 |

$$A = \begin{bmatrix} 1 & 2 & -2 \\ -1 & 3 & 0 \\ 0 & -2 & 1 \end{bmatrix}$$