

[This question paper contains 2 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5786

J

Unique Paper Code : 2222011201

Name of the Paper : Mathematical Physics II

Name of the Course : B.Sc. (H) Physics (UGCF) – DSC-4

Semester : II

Duration : 2 Hours

Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Four** questions in all.
3. Question number **1** is compulsory. Attempt any **three** questions from the rest.
4. **All** questions carry equal marks.
5. Use of calculator not allowed.
6. Some useful formulae are given at the end.

1. Attempt **all** questions. **All** questions carry equal marks. (3×5=15)

(a) Represent the vector $\vec{A} = z\hat{i} - 2x\hat{j} + y\hat{k}$ in cylindrical coordinates.

(b) What is the period of following functions :

(i) $\tan(x)$ (ii) $\cos(nx)$, $n \in \mathbb{I}$

(c) Evaluate (i) $\int [P_4(x)]^2 dx$ (ii) $\int P_1(x)P_4(x)dx$

(d) Determine whether or not it is possible to solve the following differential equation using Frobenius method about $x = 0$:

$$x(1-x)\frac{d^2y}{dx^2} + (1-x)\frac{dy}{dx} - y = 0$$

(e) Evaluate the following integral using Gamma function

$$\int_0^\infty x^3 e^{-2x} dx$$

2. Consider the following function :

$$f(x) = \begin{cases} 0 & \text{for } -5 < x < 0 \\ 3 & \text{for } 0 < x < 5 \end{cases}$$

(a) Plot the above function $f(x)$.

(b) Find the Fourier Series expansion of the above function. (5,10)

P.T.O.

3. (a) Using Gamma and Beta functions prove :

$$\int \frac{x^2}{\sqrt{2-x}} dx = \frac{64\sqrt{z}}{15}$$

- (b) Prove that for the Orthogonal Curvilinear Coordinates (u_1, u_2, u_3)

$$\vec{\nabla}F = \frac{\hat{e}_1}{h_1} \frac{\partial F}{\partial u_1} + \frac{\hat{e}_2}{h_2} \frac{\partial F}{\partial u_2} + \frac{\hat{e}_3}{h_3} \frac{\partial F}{\partial u_3}$$

where F is a scalar field, h_i are scale factors and $\hat{e}_i$ represents unit vector in the increasing i direction. Further derive the expression of the gradient of F in spherical coordinate system. (5,10)

4. Consider the Differential Equation : (5,10)

$$2x^2y''(x) + 3xy'(x) - (x^2 + 1)y(x) = 0$$

- (a) Identify and name the nature of all the real singularities (both finite and infinite) of above differential equation.
- (b) Solve the above differential equation around $x = 0$ by Frobenius Method.
5. (a) Expand the function $f(x) = 7x^4 - 3x + 1$ in terms of Legendre Polynomials in the interval $[-1, 1]$.
- (b) Starting from Generating function of Legendre Polynomials derive the following recurrence relation of Legendre Polynomials

$$P_n(x) = P'_{n+1}(x) - 2xP'_n(x) + P'_{n-1}(x) \quad (10,5)$$

Some useful formulae :

Legendre Polynomials :

$$P_0(x) = 1, P_1(x) = x, P_2(x) = \frac{1}{2}(3x^2 - 1)$$

$$P_3(x) = \frac{1}{2}(5x^3 - 3x), P_4(x) = \frac{1}{8}(35x^4 - 30x^2 + 3)$$

Generating Function of Legendre Polynomials :

$$g(x, t) = \frac{1}{\sqrt{1 - 2xt + t^2}} = \sum_{n=0}^{\infty} P_n(x)t^n$$

[This question paper contains 4 printed pages.]

June 2025

Sr. No. of Question Paper : 5806

Unique Paper Code : 2222011202

Name of the Paper : Electricity and Magnetism

Name of the Course : B.Sc. Hons. (Physics) NEP: UGCF-2022

Semester : II

Duration : 3 Hours

Maximum Marks : 90



Your Roll No.....

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Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all, including Question No. 1 which is compulsory.
3. **All** questions carry equal marks.

1. Answer **any 6** of the following : (6×3=18)

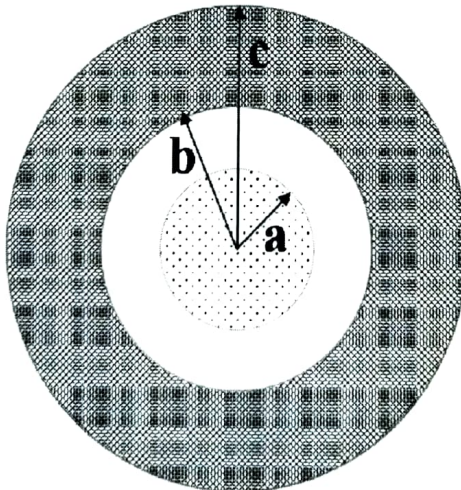
- (a) Find V_{ab} in an electric field $\vec{E} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ N/C where $\vec{r}_a = \hat{i} - 2\hat{j} + \hat{k}$ m and $\vec{r}_b = 2\hat{i} + \hat{j} - 2\hat{k}$ m.
- (b) State the Second uniqueness theorem.
- (c) What is the work required to bring a charge q from infinity to a distance d above a grounded conducting plane?
- (d) At the boundary of two dielectric materials, material 1 has $\epsilon_1 = 2\epsilon_0$, and material 2 has $\epsilon_2 = 4\epsilon_0$. If $e_1^\perp = 6$ V/m, what is $\epsilon_2^\perp$, assuming no free surface charge?
- (e) A solenoid of length 0.5 m and 1000 turns per meter carries a current of 2 A. Find the magnetic field inside the solenoid.

P.T.O.

- (f) A material placed in a field $H = 800 \text{ A/m}$ shows a $M = -0.08 \text{ A/m}$. Find its magnetic susceptibility χ_m . What type of material is it?
- (g) A cylindrical conductor of uniform cross section, has a voltage drop of 2.0 V along its 100 m length and a current density of $5.0 \times 10^5 \text{ A/m}^2$. What is the conductivity of the material in the conductor?
2. (a) A half-infinite line has linear charge density λ . Find the electric field at a point that is “even” with the end, a distance l from it, as shown in Figure. (8)



- (b) Prove that electrostatic field is negative of gradient of electrostatic potential. (2)
- (c) State Ampere's law. The coaxial line shown in Figure below carries the same current i up the inside conductor of radius a and down the outer conductor of inner radius b & outer radius c .



Find the magnetic field at all distances r from the center of the conductor. (8)

3. (a) Let a charge q be distributed over a sphere of radius R with a constant volume charge density ρ , and thus for $r > R$ the charge density is zero. Applying the Laplace's or Poisson equations, find the electrostatic potential inside $r < R$ and outside $r > R$ the sphere. (8)
- (b) For the above system, find the electrostatic field on the surface of the sphere. (2)
- (c) What do you understand by magnetization and magnetic polarization of the material? Derive expressions for differential and integral form of Ampere's law in the presence of magnetized materials. (8)
4. (a) A point charge q is situated a distance a from the centre of a grounded conducting sphere of radius R . Applying the method of images, find the electrostatic potential at any point outside the sphere. (8)
- (b) The electric field in a region is given by $\vec{E} = x\hat{i}$. Find the total flux passing through a cube bounded by the surfaces, $x = 1$, $x = 2$, $y = 0$, $y = 1$, $z = 0$ and $z = 1$. (2)
- (c) Write down the four fundamental Maxwell equations in the differential form along with their explanations. Also, comment on their significance. (8)
5. (a) A sphere of radius R carries a polarization $\vec{P}(\vec{r}) = k\vec{r}$, where k is a constant and $\vec{r}$ is the vector from the center. (a) Calculate the bound charges σ_b and ρ_b . (b) Find the field inside and outside the sphere. (8)
- (b) Show that the potential is constant inside an enclosure completely surrounded by conducting material, provided there is no charge within the enclosure. (2)
- (c) A tightly wound cylindrical coil of wire, of radius a and n turns per unit length, is usually called a solenoid. Use Biot Savart law to find the magnetic field at the point on its axis if the wire carries a current I . Consider the turns to be essentially circular and solenoid to be infinite in both directions. (8)

6. (a) Find the magnetic field $\vec{B}$ and hence the vector potential $\vec{A}$ at a distance r from a long straight wire carrying a current I . (8)
- (b) A point charge q is located d distance above an infinite grounded conducting plane. Find the direction of the electric field at the point P directly above the charge, at a height $2d$ from the plane. (2)
- (c) State the Gauss Law in integral and differential form. Suppose the electric field in some region is found to be $\vec{E} = kr^3\hat{r}$, in spherical coordinates (k is some constant). (a) Find the charge density ρ . (b) Find the total charge contained in a sphere of radius R , centered at the origin. (8)

[This question paper contains 4 printed pages.]

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June 2025
Your Roll No.....

Sr. No. of Question Paper : 5826

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Unique Paper Code : 2222011203

Name of the Paper : Electrical Circuits Analysis

Name of the Course : B.Sc. (Hons.) Physics- NEP: UGCF-2022

Semester : II

Duration : 2 Hours

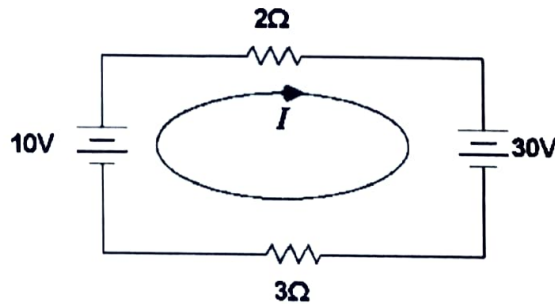
Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. All questions carry equal marks.
3. Ques. No. 1 is compulsory and attempt any **three** from the remaining **four** questions.
4. Use of non-programmable scientific calculator is allowed.

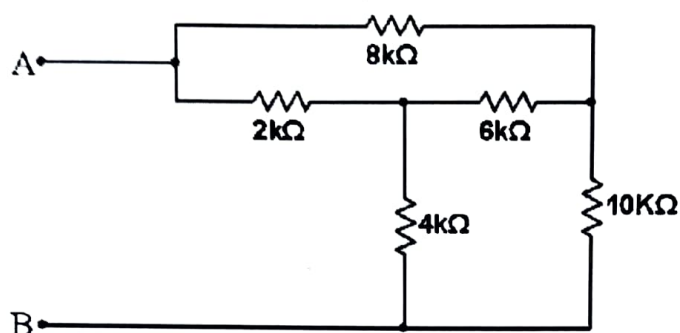
1. Attempt any **five** of the following : (5×3=15)

- (a) For the given circuit determine the power dissipated in the resistors :

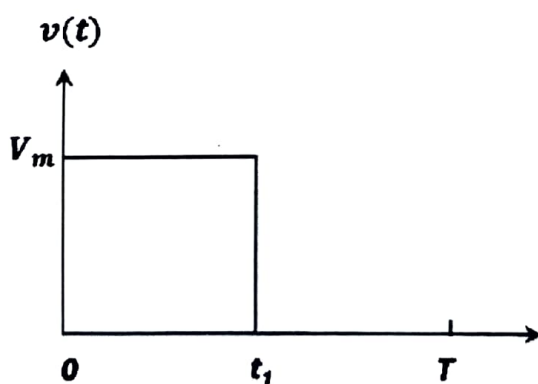


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- (b) Find the equivalent resistance of the following circuit using Star-Delta transformations:

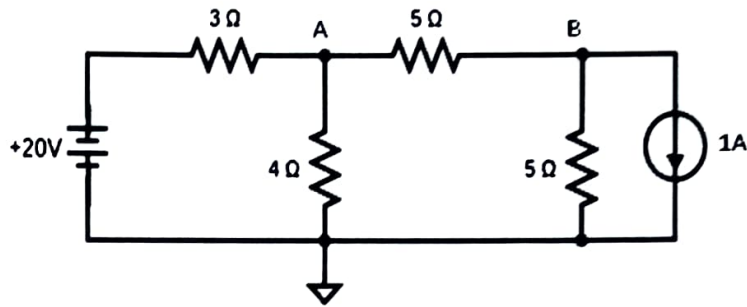


- (c) Define inductive reactance. Write its S.I. units. Plot a graph showing variation of resistance and inductive reactance with change in the frequency of the ac source.
- (d) Prove that an ideal capacitor does not dissipate power in an ac circuit.
- (e) Find the form factor for the periodic wave shown below with time period T :



- (f) A series RC circuit with $R = 5 \text{ k}\Omega$ and $C = 20 \text{ }\mu\text{F}$ has a constant voltage source of 100 V applied at $t = 0$. Obtain the value of voltage across the capacitor and the resistor for $t > 0$ if there is no initial charge on the capacitor.

2. (a) Calculate the direction and magnitude of the current through the $5\ \Omega$ resistor between points A and B in the given circuit by Nodal analysis method. (7)

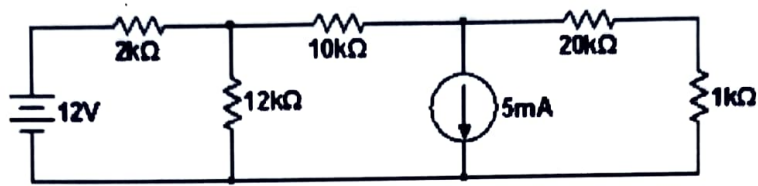


- (b) A coil with a self-inductance of 2.4 H and resistance $12\ \Omega$ is suddenly switched across a 120 V DC supply of negligible internal resistance. Determine the time constant of the coil, the instantaneous value of the current after 0.1 second, the final steady value of the current and the time taken for the current to reach 5 A . (8)
3. (a) In a parallel LCR circuit, the inductance of 0.1 H having a Quality factor of 5 is in parallel with a capacitor. Determine the value of capacitance and coil resistance at resonant frequency of 500 Hz . (7)
- (b) In a series RL circuit containing pure resistance and pure inductance, the current and the voltage are expressed as :

$$i(t) = 5\sin(314t + 2\pi/3) \text{ and } v(t) = 15 \sin(314t + 5\pi/6)$$

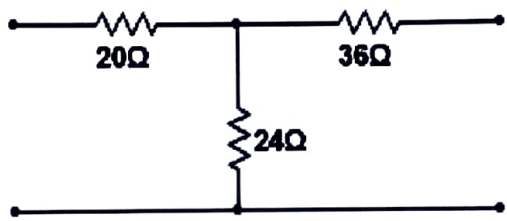
Determine the values of impedance, resistance, inductance and average power drawn by the circuit. (8)

4. (a) Find the Norton equivalent circuit for the given circuit and calculate the load voltage across $1\text{ k}\Omega$ resistance. (7)



(b) Explain Millman's and Tellegen's theorem for the ac circuits. (8)

5. (a) Find the Y-parameters for the following T-network : (7)



(b) According to Maximum Power Transfer theorem, what should be the value of load resistance R_L to obtain maximum power from the 12 V battery shown in the following circuit? What is the value of this power? (8)

