विद्या सर्वार्थि साधिका

ANANDALAYA

MIDTERM EXAMINATION

Class : XII

Subject: Physics M.M: 70

Date : 26/09/2019 Time: 3 Hours

General Instructions:

1. All questions are compulsory. There are 37 questions in all.
2. This question paper has four sections: Section A, Section B, Section C and Section D.
3. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
4. There is no overall choice. However, internal choices have been provided in three questions of one mark, two questions of two marks, three questions of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.
5. You may use the following values of physical constants wherever necessary.

$c = 3 \times 10^8 ms^{-1}$
$h = 6.63 \times 10^{-34} Js$
$e = 1.6 \times 10^{-19}\ C$
$\mu_0 = 4 \times 10^{-7}\ TmA^{-1}$
$\varepsilon_0 = 8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\ m^2 C^{-2}$
$m_e = 9.1 \times 10^{-31} kg$
Mass of neutron = $1.675 \times 10^{-27} kg$
Mass of proton = $1.673 \times 10^{-27}\ kg$
Avagadro's No = $6.023 \times 10^{23} gram\ mole^{-1}$
Boltzmann constant = $1.38 \times 10^{-23} JK^{-1}$
g = 10 m/s^2

SECTION A

Answer the questions from 1 to 7 by choosing the correct option:

1. 1 bohr magneton is equal to (1)
   (a) $1.6 \times 10^{-19} Am^2$ (b) 9.27×10^{-24} Am^2
   (c) $9.27 \times 10^{-19} Am^2$ (d) None of the above

2. If the ratio between vertical component of earth's magnetic field and the resultant magnetic field at a place is $\frac{1}{\sqrt{2}}$, what is the value of angle of dip at this place? (1)
   (a) 45° (b) 30° (c) 90° (d) 0°

3. The relative permittivity of a medium is 9 and its relative permeability is close to unity. What is the speed of electromagnetic waves in the medium if the speed of light in vacuum is 'c'? (1)
   (a) $\frac{c}{3}$ (b) $\frac{c}{2}$ (c) c (d) 3c

4. Which of the following statement about electric field lines is true: (1)
   (a) Electric field lines forms closed loop.
   (b) Electric field lines can cross each other.
   (c) Electric field lines start from positive charge and end at negative charge.
   (d) In a charge free region the electric field lines are discontinuous.

5. Two charges 100 μC each are placed 1 m apart in a medium of relative permittivity 4. What is the electrostatic force acting between the two charges?
   (a) 90 N (b) 2.25 N (c) 2.25×10^{13}N (d) 22.5 N

   OR

   A charged object is held in earth's gravitational field using a uniform electric field of 100 V/m. The mass of the object and the acceleration due to gravity at the place are 5 g and 10 m/s^2 respectively. Find the charge on the object.
   (a) 5×10^{-6}C (b) 5×10^{-4}C (c) 2×10^3 C (d) 5 μC

6. The following table gives the length, area of cross section of three manganin wires and the potential differences across their ends. (1)
Arrange the wires in increasing order according to the current densities (J_A, J_B and J_C) in them.

Wire	Length	Area of cross section	Potential difference
A	L	A	V
B	L	2A	2V
C	2L	A	3V

(a) $J_A < J_c < J_B$ (b) $J_A < J_B < J_C$
(c) $J_C < J_B < J_A$ (d) $J_B < J_C < J_A$

7. Which one of the following materials is chosen for making resistance box? (1)
(a) Copper (b) Manganin
(c) Mercury (d) Silicon

8. The susceptibility of a material is -0.000023. What is the nature of this magnetic material? (1)

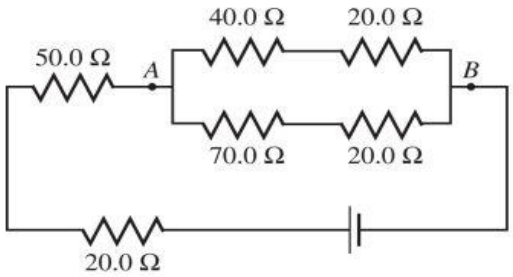
9. Fill in the blank. (1)
Maxwell's modified ampere circuital states that the line integral of magnetic field along the boundary of a closed path is equal to _____

10. A Gaussian surface encloses a dipole of dipole moment 2 μC-m. What is the electric flux passing through the Gaussian surface? (1)

OR

Two conducting spheres of same radius (R) – one solid and the other hollow – are each charged to the same amount of charge. The electric fields at a distance (r < R), in each case are E_1 and E_2. Which one of the electric fields would be greater?

11. The voltage across the 40 Ω resistor is 4 V. What is the current flowing through 70 Ω resistor? (1)



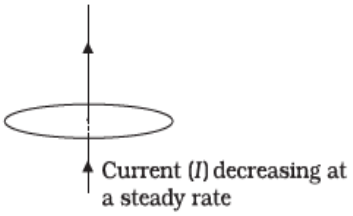
12. In what direction a magnetic compass placed above a wire carrying current in north – south direction is deflected? (1)

OR

A charge entering a uniform magnetic field B with a velocity v, starts moving in a circular path. What is the angle between the direction of B and v?

13. A proton and a deuteron having same momentum are in turn allowed to pass through a magnetic field $\vec{B}$, acting normal to the direction of motion of the particles. Calculate the ratio of radii of the circular paths described by them. (1)

14. Predict the direction of induced current in the circular loop described by the figure. (1)

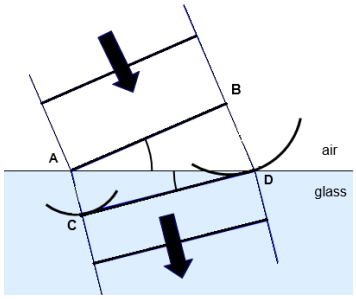


15. Two coils have mutual inductance of 1.5 henry.The current in the primary circuit is raised by 5A in one millisecond after closing the circuit, then the induced emf in secondary coil is _____ volt. (Fill in the blank.) (1)

16. A point charge 2 μC is placed at the origin. What is the electric field due to this charge at a point (0, 0, 4m)? (1)

17. A light ray travelling in medium 1 (refractive index = n_1) strikes the surface of medium 2 (refractive index = n_2) and undergoes a total internal reflection. Which of the two media is denser? (1)

18. The magnification of the image formed by a spherical mirror is always positive. What is the nature of the spherical mirror? (1)

19. 

In the diagram shown beside the light ray passing from air to glass. AB and CD are incident and refracted wave fronts. The time taken by the ray to travel the distance BD and that to travel AC are t_a and t_g respectively. The speeds of light in air and in glass are v_a and v_g respectively. Then the value of $\frac{t_a}{t_g}$ = _____. (Fill in the blank) (1)

20. State true or false: "Resolving power of the telescope decreases when the aperture size of the objective is increased". (1)

SECTION B

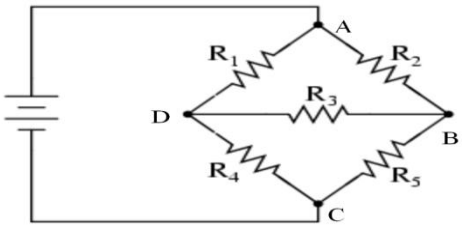
21. State Coulomb's law in electrostatics and define one coulomb of charge. (2)

OR

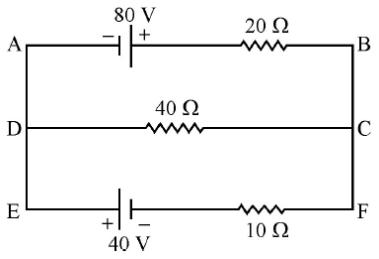
What is an equipotential surface? Give one example.

22. An electric dipole with dipole moment 4×10^{-9} C m is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^4 NC^{-1}. Calculate the magnitude of the torque acting on the dipole. (2)

23. In the circuit shown, the values of R_1 = 33 Ω, R_2 = 11 Ω, R_3 = 10 Ω, R_4 = 12 Ω and R_5 = 4 Ω. The current flowing through the R_3 is zero. What is the equivalent resistance of the circuit? (2)



24. Using Kirchhoff's rules, calculate the current through the 40 Ω resistor in the given circuit. (2)



25. There are two ac circuits A and B. Circuit A with only a resistance and an ac source 200 V, 50 Hz. Circuit B with only an inductor and the ac source 200V, 50 Hz. (2)
(a) What is the phase relation between the current and voltage in each circuit?
(b) What is the power factor in each case?

26. Using Ampere circuital law, derive the expression for the magnetic field due to an infinitely long conductor carrying a current I at a distance r from the conductor. (2)

OR

Using Biot-Savart law, derive the expression for the magnetic field at the centre of a current (I) carrying circular coil of N turns.

27. Distinguish between diamagnetic and paramagnetic substances. Give two differences. (2)

SECTION C

28. State, using a proper diagram, the condition when unpolarised light incident on the boundary between two transparent media produces polarised light. Explain briefly. Hence show that the angle of incidence θ_p is related to the refractive index n by the relation $n = \tan\theta_p$. (3)

29. The magnetic field in a plane electromagnetic wave is given by (3)
$B_y = 2 \times 10^{-7} \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ T
(a) What is the wavelength and frequency of the wave?
(b) Write an expression for the electric field.

OR

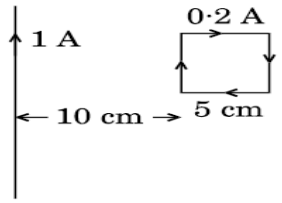
A parallel plate capacitor made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with an angular frequency of 300 rad s^{-1}.
(a) What is the rms value of the conduction current?
(b) Determine the amplitude of B at a point 3.0 cm from the axis between the plates.

30. (a) Derive an expression for the electric field E due to a dipole of length '2a' at a point 'r' distant from the centre of the dipole on the axial line. (3)
(b) If this dipole were kept in a uniform external electric field E_0, diagrammatically represent the position of the dipole in stable and unstable equilibrium.

31. Two identical circular coils, P and Q each of radius R, carrying currents 1 A and 3 A respectively, are placed concentrically and perpendicular to each other lying in the XY and YZ planes. Find the magnitude and direction of the net magnetic field at the centre of the coils. (3)
Also find the net dipole moment due to the two coils.

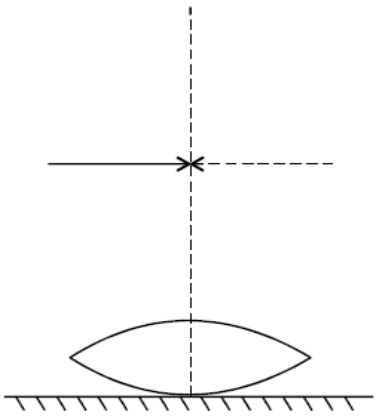
OR

A square loop of sides 5 cm carrying a current of 0·2 A in the clockwise direction is placed at a distance of 10 cm from an infinitely long wire carrying a current of 1A as shown.
Calculate (i) the resultant magnetic force, and
(ii) the torque, if any, acting on the loop.



32. An inductor is connected to an ac source of 200 V and the current through the inductor is found to be $2\sqrt{2}$ A. When a resistor is connected in series with the inductor the current becomes 2 A. Find (i) the reactance offered by the inductor and (ii) the resistance of the resistor. (3)

33. A symmetric biconvex lens of radius of curvature R and made of glass of refractive index 1·5, is placed on a layer of liquid placed on top of a plane mirror as shown in the figure. An optical needle with its tip on the principal axis of the lens is moved along the axis until its real, inverted image coincides with the needle itself. The distance of the needle from the lens is measured to be x. On removing the liquid layer and repeating the experiment, the distance is found to be y. Obtain the expression for the refractive index of the liquid in terms of x and y. (3)



33. An aeroplane is flying horizontally from west to east with a velocity of 900 km/hour. Calculate the potential difference developed between the ends of its wings having a span of 20 m. The horizontal component of the Earth's magnetic field is 5×10^{-4} T and the angle of dip is 30°. (3)

OR

A device X is connected across an ac source of voltage $V = V_0 \sin \omega t$. The current through X is given as $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$.

(a) Identify the device X and write the expression for its reactance.
(b) How does the reactance of the device X vary with frequency of the ac? Show this variation graphically.
(c) Draw the phasor diagram for the device X.

SECTION D

35. (a) Draw a labelled ray diagram of compound microscope, when final image forms at the least distance of distinct vision. (5)
(b) Why is its objective of short focal length and of short aperture, compared to its eyepiece? Explain.
(c) The focal length of the objective is 4 cm while that of eyepiece is 10 cm. The object is placed at a distance of 6 cm from the objective lens.
(i) Calculate the magnifying power of the compound microscope, if its final image is formed at the near point.
(ii) Also calculate length of the compound microscope.

OR

(a) With the help of a labelled ray diagram, explain the construction and working of a Cassegrain reflecting telescope.
(b) An amateur astronomer wishes to estimate roughly the size of the Sun using his crude telescope consisting of an objective lens of focal length 200 cm and an eyepiece of focal length 10 cm. By adjusting the distance of the eyepiece from the objective, he obtains an image of the Sun on a screen 40 cm behind the eyepiece. The diameter of the Sun's image is measured to be 6·0 cm. Estimate the Sun's size, given that the average Earth-Sun distance is 1.5×10^{11} m.

36. (a) Define a wavefront. Using Huygen's principle, verify the laws of reflection at a plane surface. (5)
(b) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band? Explain.
(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the obstacle. Explain why.

OR

(a) What is the condition in terms of phase difference to obtain constructive interference between the two coherent sources?
(b) In a Young's double slit experiment, the distance between the slits is d and the distance between the slits and the screen is D. The wavelength of the light used is λ. Obtain the expression for the position of constructive interference.
(c) What kind of fringes do you expect to observe if white light is used instead of monochromatic light?

37. (a) Use Gauss law to find electric field due to uniformly charged infinite plane sheet. What is the direction of the field for positive and negative charge densities? (5)
(b) Find the ratio of potential differences that must be applied across the parallel and series combinations of two capacitors C_1 and C_2 with their capacitance in the ratio 1:2 so that the energy stored in the two cases becomes the same.

OR

(a) If two similar large plates, each of area A having surface charge densities +σ and - σ are separated by a distance d in air, find the expressions for
(i) Field at points between the two plates and at points on the outer side of the plates. Specify the direction of the field in each case.
(ii) The potential difference between the two plates.
(iii)The capacitance of the capacitor so found.
(b) Two metallic spheres of radii R and 2R are charged so that so that both of them have the same charge density (σ). If they are connected to each other with a connecting wire, in which direction will the charge flow and why?