# TAGORE INTERNATIONAL SCHOOL
# EAST OF KAILASH, NEW DELHI

## MID TERM EXAMINATION (2024 - 2025)
## CLASS XII
## PHYSICS
## SET II

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**Date: 18.9.24**
**No. of pages: 12**

**Duration: 3 hrs.**
**Max. Marks: 70**

**General Instructions:**

1. All questions are compulsory. There are 33 questions in all.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. **Section A** contains sixteen questions, twelve multiple choice questions and four assertion reasoning questions of 1 mark each, **Section B** has five questions of two mark each, **Section C** contains seven questions of 3 marks each, **Section D** contains two case study-based questions of 4 marks each and **Section E** contains three long answer questions of 5 marks each.
4. There is no overall choice. However, an internal choice has been provided in sections B, C and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

You may use the following values of physical constants wherever necessary.

$c = 3 \times 10^{8}$ m/s
$h = 6.6 \times 10^{-34}$ Js
$e = 1.6 \times 10^{-19}$ C
Mass of electron= $9.1 \times 10^{-31}$ kg
Mass of neutron = $1.675 \times 10^{-27}$ kg
Mass of proton = $1.673 \times 10^{-27}$ kg
$\mu_0 = 4\pi \times 10^{-7}$ T m A
$\varepsilon_0 = 8.854 \times 10^{-12}$ C $^2N^{-1}m^{-2}$

### SECTION A

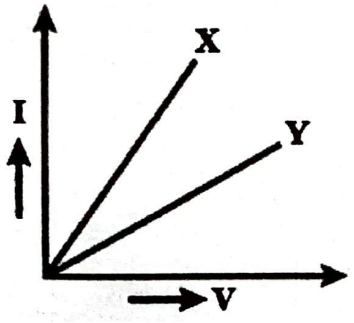
1. An electric dipole of length 2 cm is placed at an angle of 60° with an electric field $4 \times 10^{5}$ N/C. If the dipole experiences a torque of $8\sqrt{3}$ Nm, the magnitude of either of the charge of the dipole is (1mark)
   (a) 4 μC
   (b) 7 μC
   (c) 8 mC
   (d) 2 mC

2. A battery supplies 0.5 A current through a 12 Ω resistor and 0.25 A current through a 25 Ω resistor when connected one by one. The internal resistance of the battery is (1mark)
   (a) 2 Ω
   (b) 1.2 Ω
   (c) 1 Ω
   (d) 0.5 Ω

3. Resistances 10 Ω and R Ω are connected in the two gaps of a meter bridge. The null point is obtained at 60 cm on the meter scale from the zero end. The resistance that must be connected in series to R so that the null point is at the mid-point of the wire is (1mark)

(a) 10 Ω
(b) 10/3 Ω
(c) 10/4 Ω
(d) 3/10 Ω

4. The voltage current variation of two metallic wires X and Y at a constant temperature are shown below. If the wires have same length and same diameter, infer which is most suitable for making (i) standard resistance (ii) connecting wires, respectively. (1mark)




(a) Material X for standard resistance and Y for connecting wires.
(b) Material Y for standard resistance and X for connecting wires.
(c) Material X for both standard resistance and connecting wires.
(d) Material Y for both standard resistance and connecting wires.

5. A freely suspended magnetic dipole is aligned along the magnetic meridian. Four points A, B, C and D are located at equal distances from the center of the magnetic dipole towards the north, east, south, and west of the dipole respectively. Read the statements given below carefully. (1mark)

i. Direction of the magnetic field due to the dipole is same at A and C.
ii. Direction of the magnetic field due to the dipole is same at A and D.
iii. Direction of the magnetic field due to the dipole is opposite at B and D.
iv. Direction of the magnetic field due to the dipole is opposite at C and D.
v. Direction of the magnetic field due to the dipole is same at B and D.
vi. Direction of the magnetic field due to the dipole is opposite at A and C.

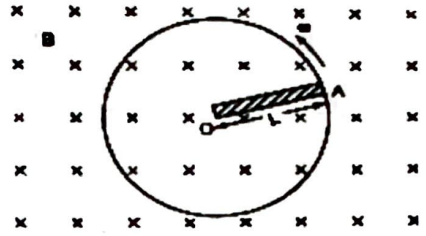
Select the correct option.

(a) Statements (iii) & (vi) are correct
(b) Statements (iv) & (v) are correct
(c) Statements (i), (ii) & (iii) are correct
(d) Statements (i), (iv) & (v) are correct

6. A constant current is flowing through a solenoid. An iron rod is inserted in the solenoid along its axis. Which of the following quantities will **not** increase? (1mark)

(a) The magnetic field at the centre.
(b) The magnetic flux linked with the solenoid.
(c) The rate of heating.
(d) The self-inductance of the solenoid.

7. A metallic rod of length 'L' is rotated with angular frequency 'ω' with one end hinged at the center and the other end at the circumference of a circular metallic ring of radius 'L' about an axis passing through its center and perpendicular to the plane of the ring. (1mark)




The correct equation for induced emf between the center and the metallic ring is

(a) $BL\,\omega^2$
(b) $\frac{1}{2} BL\,\omega^2$
(c) $BL^2\,\omega$
(d) $\frac{1}{2} BL^2\,\omega$

8. Two coils have a mutual inductance of 0.005 H. The current changes in the first coil according to the equation $I = I_0 \sin \omega t$, where $I_0 = 10$ A and $\omega = 100\,\pi$ rad / s. The maximum value of the emf induced in the second coil is (1mark)

(a) $2\,\pi$ V
(b) $5\,\pi$ V
(c) $\pi$ V
(d) $4\,\pi$ V

9. In the wave picture of light, the intensity I of light is related to the amplitude A of the wave as: (1mark)

(a) $I \alpha A^{1/2}$
(b) $I \alpha A$
(c) $I \alpha A^2$
(d) $I \alpha 1/A^2$

10. In an interference experiment, third bright fringe is obtained at a point on the screen with a light of 700 nm. What should be the wavelength of the light source in order to obtain the fifth bright fringe at the same point? (1mark)

(a) 420 nm
(b) 750 nm
(c) 630 nm
(d) 500 nm

11. In the Young's double-slit experiment, the screen is moved away from the plane of the slits. What will be its effect on the following? (1mark)
(i) Angular separation of the fringes.
(ii) Fringe-width

Choose the correct option:

(a) Both (i) and (ii) remain constant
(b) (i) remains constant, but (ii) decreases
(c) (i) remains constant, but (ii) increases
(d) Both (i) and (ii) increase.

12. The electromagnetic waves used to purify water are (1mark)
    (a) infrared rays
    (b) ultraviolet rays
    (c) X rays
    (d) gamma rays

The following questions (Q Nos 13 to 16) consist of two statements each, printed as **Assertion and Reason.** While answering these questions you are required to choose any one of the following responses.

a. If both Assertion and Reason are true and Reason is the correct explanation of the Assertion.
b. If both Assertion and Reason are true but Reason is not the correct explanation of the Assertion.
c. If Assertion is true but Reason is false.
d. If both Assertion and Reason are false.
e. If Assertion is false but Reason is true.

13. **Assertion (A):** For a Gaussian surface through which the net flux is zero, the net charge inside the surface is zero. (1mark)
**Reason (R):** The number of field lines entering is equal to the number of lines exiting the surface.

14. **Assertion (A):** Without disconnecting the battery, when the plates of the capacitor, of capacitance C, are separated apart to a larger distance of separation, the charge stored on the plates will increase. (1mark)
**Reason (R):** The capacitance of the capacitor will increase, when distance between the plates is increased.

15. **Assertion (A):** Greater average power is consumed by the resistor-only ac circuit than by the resistor–inductor (RL) series combination in the same ac circuit. (1mark)
**Reason (R):** For the same ac circuit, the R-L reactance is less than resistance offered to the current flow.

16. **Assertion (A):** The energy of a charged particle moving in a magnetic field does not change. (1mark)
**Reason (R):** It is because the work done by the magnetic force on the charge moving in a magnetic field is zero.

## SECTION B

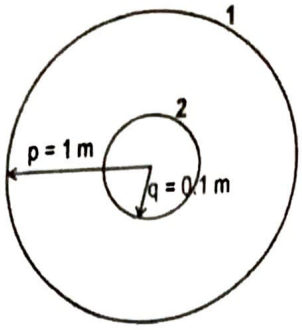
17. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area $1.0 \times 10^{-7}$ m$^2$ carrying current of 1.5 A. Assume the density of conduction electrons to be $9 \times 10^{28}$ m$^{-3}$. (2 marks)

18. A horizontal straight wire 10 m long extending from east to west is falling with a speed of 5 m/s, at right angles to the horizontal component of the earth's magnetic field, $0.30 \times 10^{-4}$ Wb m$^{-2}$. (1+1= 2 marks)
(a) What is the instantaneous value of the induced emf in the wire?
(b) What is the direction of the emf?

**OR**

(2 marks)

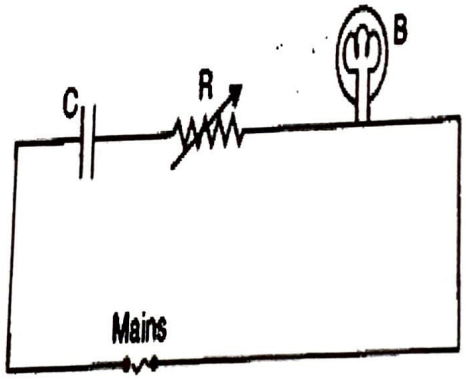
Given two coplanar and concentric loops 1 and 2 as shown.




A time varying voltage (3 + 2t) V is applied to the larger loop 1. If the resistance of the loop is $R_1 = 10\ \Omega$ and $R_2 = 1\ \Omega$, then determine the current induced in the smaller loop.

19. An a.c voltage $V = V_0 \sin \omega t$ is applied to a series combination of a resistor R and an element X. The instantaneous current in the circuit is $I = I_0 \sin (\omega t + \pi/4)$. (0.5+1.5= 2 marks)
(a) Identify the element X.
(b) How is the reactance of the element X related to R? Support your answer with necessary calculation.

20. A capacitor C, a variable resistor R and a bulb B are connected in series to the a.c mains as shown in the figure below. The bulb glows with some brightness. Predict the change in the brightness of the bulb when (1+1= 2 marks)
(a) a dielectric slab is introduced between the plates of the capacitor, keeping R constant.
(b) the resistance R is increased keeping the same capacitance.



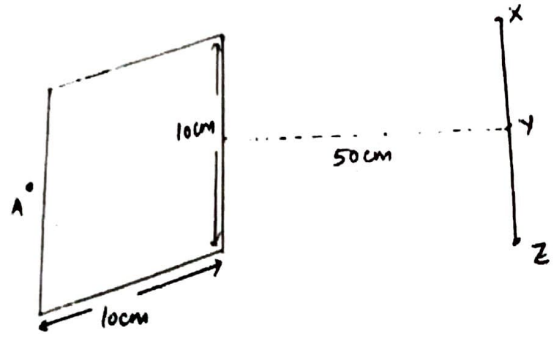

21. State Huygens Principles of wave theory of light. (2 marks)

**OR**

What is the shape of the wavefront in each of the following cases: (1+1= 2 marks)
(a) Light diverging from a point source.
(b) Light emerging out of a convex lens when a point source is placed at its focus.
Draw diagrams to depict the same in each case.

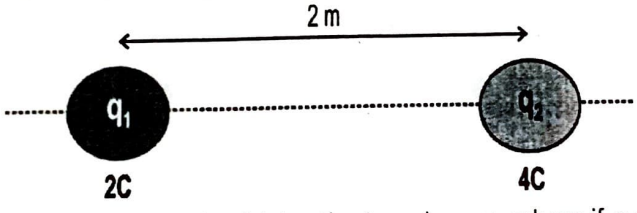
## SECTION C

22. Given a uniformly charged plane sheet of surface charge density $\sigma = 2 \times 10^{17}\ C/m^2$ (1.5x2= 3 marks)
(a) Find the electric field intensity at a point A, 5 mm away from the sheet on the left side.
(b) A straight line with three points X, Y & Z placed 50 cm away from the charged sheet on the right side. At which of these points, the field due to the sheet remains the same as that of point A and why?



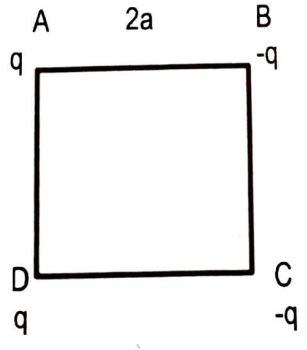

**OR**

Two positive charges $q_1$ and $q_2$ lie along a straight line separated by 2 m as shown below. (2+1= 3 marks)




(a) Find a location along the straight line joining the two charges, where if a positive charge $q_3$ is placed, it experiences a zero-resultant force.
(b) Will the resultant force on $q_3$ placed at the location of part (a) still be zero, if it is negatively charged? Explain.

23. Four electric charges q, -q, -q and q are placed at the vertices A, B, C and D of a square of side 2a as shown in the figure. (1.5x2= 3marks)




(a) Calculate the electrostatic potential energy of the arrangement.
(b) Calculate the electric potential at point P mid-way between the charges +q and +q.

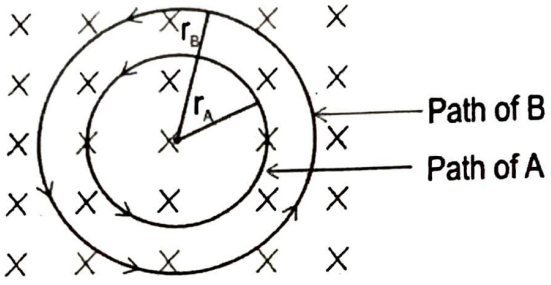
**OR**

(a) Three charges –q, Q and –q are placed at equal distances on a straight line. If the potential energy of the system of these charges is zero, then infer the ratio Q:q.

(b) A proton is released from rest in a uniform electric field. Infer how does the electric potential energy of the proton change in this scenario. Justify your answer.

24. Account for the following: (1x3 = 3marks)
(a) Drift velocity of free electrons in a conductor decreases with rise in temperature.
(b) When Nichrome and Copper wires of the same length and radius are connected in series and then current is passed through them, Nichrome gets more heated.
(c) Constantan and Manganin are most preferred materials for making standard resistance.

25 Two charges A and B, each having a velocity of v, traverse circular paths in a uniform magnetic field as shown below. (2+1= 3 marks)




(a) Compare the charge-to-mass ratio of the two particles A and B. Show the necessary mathematical calculations.
(b) Which of the two particles is likely to be a proton if the other is an alpha particle? Give reason.

26 With the help of neat diagram, illustrate how the magnetic field lines will modify themselves when (1x3 = 3 marks)
(i) a diamagnetic
(ii) a paramagnetic and
(iii) a ferromagnetic material, have been placed in the field.
Further relate the behavior of magnetic field lines to their relative magnetic permeability.

27 (a) Name the parts of the electromagnetic spectrum which are (1.5x2 = 3 marks)
(i) also known as 'heat waves'
(ii) absorbed by ozone layer in the atmosphere
(iii) used in radar communication

(b)The diagrams below show the electric and magnetic field components of an electromagnetic wave at a certain time and location.

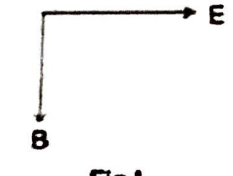


Fig I

Fig II

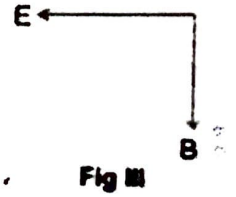


Fig III

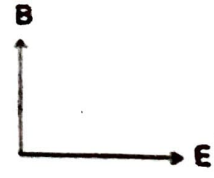


Fig IV

Which of these electromagnetic waves are travelling towards you? Justify your answer.

28 How does the interference fringes in a Young's double-slit experiment get affected due to each of the following operations? Give reason for your answer in each case. (1x3 = 3 marks)

(a) Width of the slits are doubled.

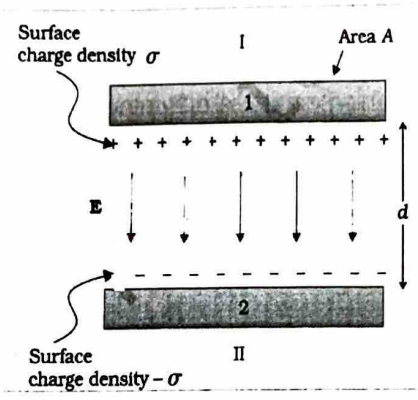
(b) The (monochromatic) source is replaced by another (monochromatic) source of longer wavelength.

(c) Separation between the slits is increased.

## SECTION D

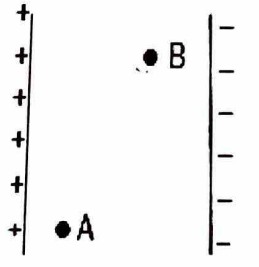
29. **Read the passage given below and answer the questions that follow:** (1x4=4 marks)

A parallel plate capacitor consists of two large plane parallel conducting plates separated by a small distance.




We first take the intervening medium between the plates to be vacuum. Let A be the area of each plate and d the separation between them. Plate 1 has surface charge density σ = Q/A and plate 2 has a surface charge density –σ. The direction of electric field is from the positive to the negative plate. Thus, the electric field is localized between the two plates and is uniform throughout. (Source: NCERT Textbook of Physics, Part 1, Class XII)

(i) Two protons A and B are placed between the plates of a parallel plate capacitor charged to a potential difference V as shown in the figure.




Which of the following statements is true?

I. Both the protons experience the same force.

II. Potential energy of A is greater than potential energy of B.

III. Both A and B have the same potential energy.

IV. A experiences more force than B.

Choose the correct option:

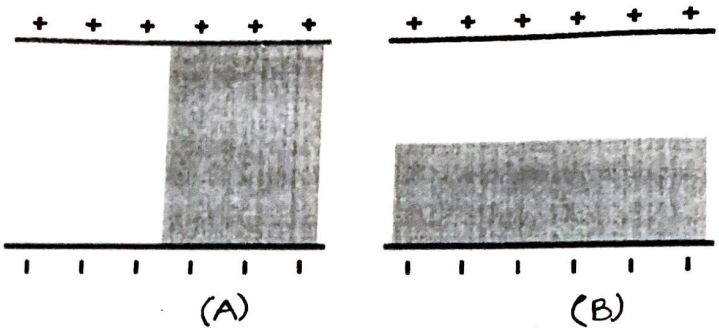
(a) Statements I and III are true.

(b) Statements II, III and IV are true.

(c) Statements I, III and IV are true.

(d) Statements I and II are true.

(ii) The capacitance of a parallel capacitor without any dielectric between the plates is C. It is half filled with a dielectric medium of K = 4 as shown in fig (A) and then as in fig(B).




The new capacitance in fig (A) and (B) are respectively:
(a) 5/2 C in A and 8/5 C in B
(b) 8/5 C in A and 5/2 C in B
(c) 5/8 C in A and 5 C in B
(d) 5 C in A and 5/8 C in B

(iii) The total polarization of a material is the
(a) product of all types of polarization
(b) sum of all types of polarization
(c) orientation directions of the dipoles
(d) total dipole moments in the material

(iv) A parallel plate capacitor C with a dielectric in between the plates is charged to a potential V by connecting it to battery. The capacitor is then isolated. If the dielectric is withdrawn from the capacitor, then
(I) the stored energy of the capacitor increases.
(II) charge on the capacitor increases.
(III) voltage of the capacitor increases
(IV) the capacitance increases.

The correct options are
(a) only I
(b) (I) and (IV)
(c) (I) and (III)
(d) (II) and (IV)

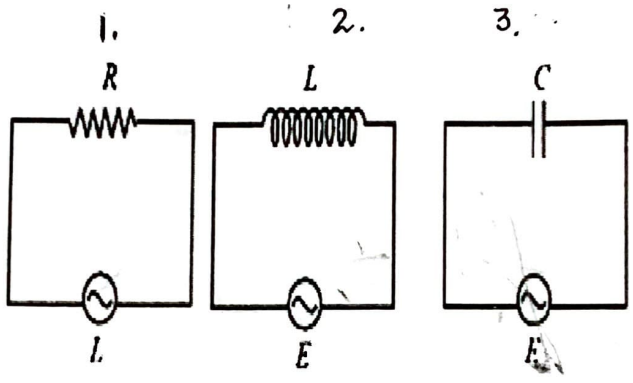
30. **Read the passage given below and answer the questions that follow:** (1x4=4 marks)

The electric mains supply in our homes and offices is a voltage that varies like a sine function with time. Such a voltage is called alternating voltage (a.c voltage) and the current driven by it in a circuit is called the alternating current (a.c current). Today, most of the electrical devices we use require ac voltage. This is mainly because most of the electrical energy sold by power companies is transmitted and distributed as alternating current. The main reason for preferring use of a.c voltage over d.c voltage is that a.c voltages can be easily and efficiently converted from one voltage to the other by means of transformers. Further, electrical energy can also be transmitted economically over long distances. AC voltages can be applied across a resistor, an inductor, and a capacitor, with each reacting to a.c in a particular way. The phase relation between the current and voltage through each of these components is represented by phasor diagrams. (Source: NCERT Textbook of Physics, Part 1, Class XII)

(i) A 5 Ω resistor, a 5 mH inductor and a 5 μF capacitor, joined in series resonate with an a.c. source of frequency $\omega_0$. If only the resistance is changed to 10 Ω, the circuit resonates at a frequency $\omega_1$. If only the inductor is changed to 20 mH, the circuit resonates at a frequency $\omega_2$. Which is the option that gives the ratio $\omega_1/\omega_2$ correctly from the following?

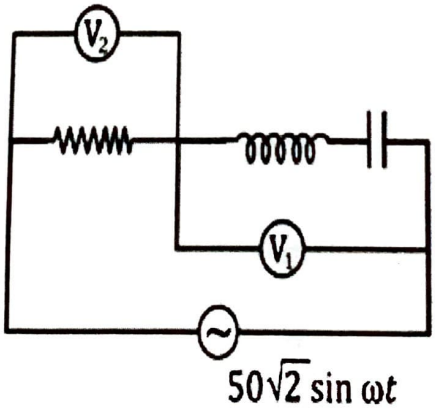
(a) 0.5
(b) 1
(c) 2
(d) 4

(ii) Three electrical circuits 1, 2 and 3 having a.c. sources of variable frequency are shown in figure below. Initially the currents flowing in each of these is same. If the frequency of the applied a.c. sources is increased, how will the current flowing in these circuits be affected?



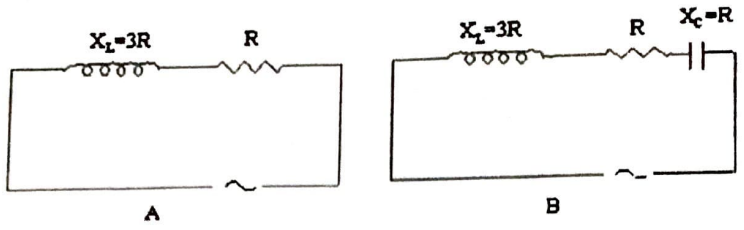

(a) Circuit 1- increases, Circuit 2 – remains same, Circuit 3- decreases.
(b) Circuit 1- decreases, Circuit 2 – remains same, Circuit 3- increases.
(c) Circuit 1- increases, Circuit 2 – decreases, Circuit 3- remains same.
(d) Circuit 1- remains same, Circuit 2 – decreases, Circuit 3 – increases.

(iii) If the reading of the voltmeter $V_1$ is 40 V, then the reading of voltmeter $V_2$ is




(a) 30 V
(b) 58 V
(c) 29 V
(d) 15 V

(iv) Given below are two electrical circuits A and B. Evaluate the ratio of the power factor of circuit B to that of circuit A.




(a) 1/2
(b) $\sqrt{2}$
(c) 4
(d) 2

## SECTION E

31. (a) Using Gauss theorem, deduce an expression for the electric field intensity due to an infinitely long straight wire of linear charge density λ. (3+2=5 marks)

(b) Two-point charges $q_A = 3\ \mu C$ and $q_B = -3\ \mu C$ are located 20 cm apart in vacuum.
(i) What is the electric field at the midpoint O of the line AB joining the two charges?
(ii) If a negative test charge of magnitude $1.5 \times 10^{-9}$ C is placed at this point, what is the force experienced by the test charge?

**OR**

(a) Derive an expression for the electric field intensity due to an electric dipole at an axial point.

(b) A system has two charges $q_A = 2.5 \times 10^{-7}$ C and $q_B = -2.5 \times 10^{-7}$ C located at points A: (0, 0, –15 cm) and B: (0,0, +15 cm), respectively.
(i) Calculate the electric dipole moment of the system.
(ii) If the dipole is placed in an external electric field of magnitude $10^4$ (**-j**) N/C, such that the angle between the dipole moment and the field is 60°, how much work needs to done in order to align it in stable equilibrium position?

32. (a) A circular coil of 20 turns and radius 10 cm is placed in uniform magnetic field of 0.10 T normal to the plane of the coil. If the current in the coil is 5 A, what is the (3+2=5 marks)
(i) total torque on the coil
(ii) total force on the coil
(iii) average force on each electron in the coil due to the magnetic field? (Given $n = 10^{29}\ m^{-3}$ and area = $10^{-5}\ m^2$)

(b) Account for the following:
(i) An ammeter has low resistance and high current carrying capacity.
(ii) When a square and a circular shaped loop of same area and carrying the same current are suspended in a magnetic field, they experience equal torque.

**OR**

(a) A straight horizontal conducting rod of length 0.45 m and mass 60 g is suspended by two vertical wires at its ends. A current of 5.0 A is set up in the rod through the wires.

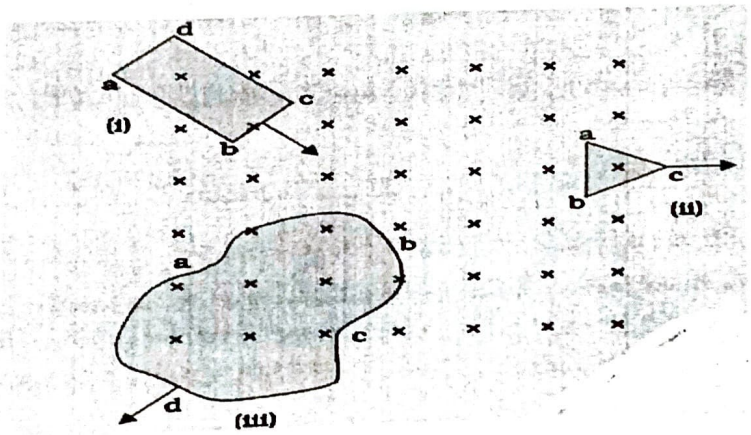
(i) What magnetic field should be set up normal to the conductor in order that the tension in the wires is zero?
(ii) What will be the total tension in the wires if the direction of current is reversed keeping the magnetic field same as before? (Ignore the mass of the wires) ($g = 9.8\ ms^{-2}$)

(b) Account for the following:
(i) A small current carrying coil held in a uniform magnetic field orients itself such that plane of the coil is perpendicular to the direction of magnetic field.
(ii) Pole pieces of the magnet in a moving coil galvanometer are made concave.

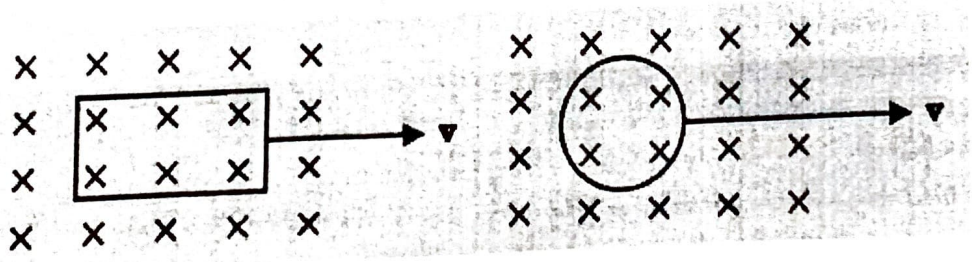
33. (a) A closed loop is held stationary in a magnetic field between the north and the south poles of two permanent magnets held fixed. Can current be generated in the loop by using very strong magnets? (1+2+2=5 marks)
(b) A square loop of a single turn is placed with its plane perpendicular to a uniform magnetic field. The magnetic flux through the square loop is 0.002 Wb. If the square loop is now reshaped into a circular loop, calculate the flux through the circular loop.
(c) A circular ring of 50 turns and diameter 0.2 m is placed in a uniform magnetic field of 0.4 T. The ring is rotated about its diameter at a frequency of 60 Hz. Calculate the maximum induced emf in the ring.

**OR**

(a) Figure below shows planar loops of different shapes moving out of or into a region of a magnetic field which is directed normal to the plane of the loop away from the reader. Infer the direction of induced current in each loop. Justify your answer in each case. (3+2=5 marks)




(b) A rectangular loop and a circular loop are moving out of a uniform magnetic field region to a field-free region with a constant velocity v as shown in the figure below. In which loop do you expect the induced emf to be constant during the passage out of the field region? The field is normal to the loops. Justify your answer.



THE END