

ISC 2026 EXAMINATION
Sample Question Paper - 3
Physics

Time Allowed: 3 hours and 15 minutes

Maximum Marks: 70

General Instructions:

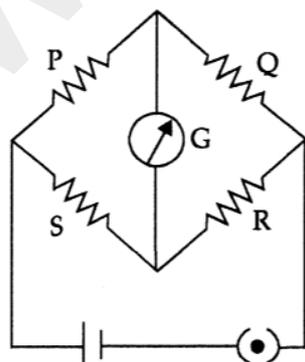
- You are allowed an additional 15 minutes for only reading the question paper.
- You must NOT start writing during reading time.
- This question paper has 20 questions.
- The paper has four sections: A, B, C and D. Internal choices have been provided in two questions each in Sections B, C and D.
- Section A consists of one question having fourteen sub-parts of one mark each.
- Section B consists of seven questions of two marks each.
- Section C consists of nine questions of three marks each.
- Section D consists of three questions of five marks each.
- Answer all questions.
- The intended marks for questions are given in brackets [].
- A list of useful constants and relations is given at the end of this paper.
- A simple scientific calculator without a programmable memory may be used for calculations.

Section A

1. **Answer the following questions:** **[14]**

(a) **In questions (i) to (vii) below, choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:**

- i. In the Wheatstone bridge circuit shown below, $P = 10\Omega$, $Q = 20\Omega$, $R = 200\Omega$ and $S = 100\Omega$, emf of the battery being 2 V. The current flowing through the galvanometer is **[1]**



- a) 1 A b) 3 A
- c) 0 d) 2 A
- ii. If a diamagnetic solution is poured into a U-tube and one arm of this U-tube is placed between poles of a strong magnet, with the meniscus in line with the field, then the level of solution will **[1]**

- in carrying a charge of $400 \mu\text{C}$ from one point to the another?
- v. Mention any one postulate of Bohr's theory of hydrogen atom. [1]
- vi. State one assumption made in deriving the formula $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ for refraction at a spherical interface. [1]
- vii. Draw a plot of potential energy between a pair of nucleons as a function of their separation. Mark the regions where potential energy is [1]
- (i) positive and
(ii) negative.

Section B

2. A circular coil of 16 turns and radius of 10 cm carrying a current of 0.75 A, rests with its plane normal to an external field of magnitude 5.0×10^{-2} T. The coil is free to turn about an axis in its plane perpendicular to the field direction. When the coil is turned slightly and released, it oscillates about its stable equilibrium with a frequency of 2.0 s^{-1} . What is the moment of inertia of the coil about its axis of rotation? [2]

OR

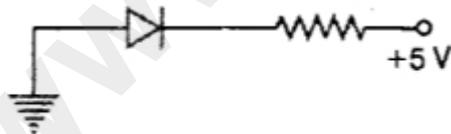
A short bar magnet has a magnetic moment of 0.48 J/T. Give the direction and magnitude of the magnetic field produced by the magnet at a distance of 10 cm from the centre of the magnet on

- i. the axis,
ii. the equatorial lines (normal bisector) of the magnet.
3. Calculate the displacement current between the square plates of side 1 cm of a capacitor, if electric field between the plates is changing at the rate of $3 \times 10^6 \text{ Vm}^{-1} \text{ s}^{-1}$. [2]
4. i. The peak voltage of an AC supply is 300 V. What is its rms voltage? [2]
ii. The rms value of current in an AC circuit is 10 A. What is the peak current?

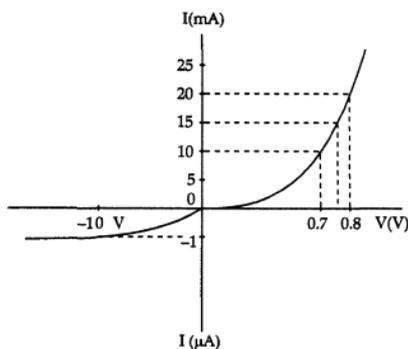
OR

An alternating voltage given by $E = 140 \sin 314t$ is connected across a pure resistor of 50Ω . Find

- i. the frequency of the source.
ii. the rms current through the resistor.
5. i. In the following diagram, is the junction diode forward biased or reverse biased? [2]



- ii. Draw the circuit diagram of a full wave rectifier and state how it works?
6. Two concentric circular wire loops of radii 20 cm and 30 cm are located in an XY-plane, each carries a clockwise current of 7 A. [2]
- i. Find the magnitude of the net magnetic dipole moment of the system.
ii. Repeat for reversed current in the inner loop.
7. Automobile ignition failure occurs in damp weather. Explain, why. [2]
8. The characteristic curve of a silicon diode is shown in the Figure below: [2]



Calculate the resistance of the diode at:

- i. $I = 15 \text{ mA}$ and
- ii. $V = -10 \text{ V}$

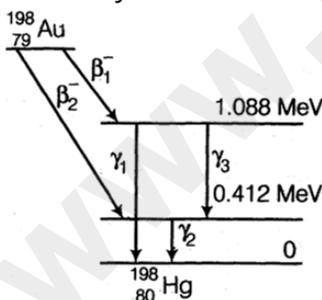
Section C

9. Plot a labelled graph of (V_s) , where V_s is stopping potential of photoelectrons versus frequency ν of incident radiation. How will you use this graph to determine the value of Planck's constant? Explain. [3]
10. Define self inductance. Obtain the expression for the self inductance of a solenoid, explaining steps with the help of a diagram. [3]

OR

A metallic ring of mass m and radius l is falling under gravity in a region having a magnetic field. If z is the vertical direction, the z -component of magnetic field is $B_z = B_0(1 + \lambda z)$. If R is the resistance of the ring and if the ring falls with a velocity v , find the energy lost in the resistance. If the ring has reached a constant velocity, use the conservation of energy to determine v in terms of m , B , λ and acceleration due to gravity g .

11. Two charges $5 \times 10^{-8} \text{ C}$ and $-3 \times 10^{-8} \text{ C}$ are located 16 cm apart. At what point (s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero. [3]
12. Obtain the maximum kinetic energy of β -particles, and the radiation frequencies of γ -decays in the decay scheme shown. You are given that [3]



$$m(^{198}\text{Au}) = 197.968233 \text{ u}$$

$$m(^{198}\text{Hg}) = 197.966760 \text{ u}$$

OR

A nuclide 1 is said to be the mirror isobar of nuclide 2, if $Z_1 = N_2$ and $Z_2 = N_1$.

- i. What nuclide is a mirror isobar of $^{23}_{11}\text{Na}$?
 - ii. Which nuclide out of the two mirror isobars have greater binding energy and why?
13. i. A mobile phone lies along the principal axis of a concave mirror. Show with the help of a suitable diagram the formation of its image. Explain, why magnification is not uniform? [3]

ii. Suppose the lower half of the concave mirror's reflecting surface is covered with an opaque material. What effect this will have on the image of the object? Explain.

14. The atomic mass of uranium ${}_{92}^{238}\text{U}$ is 238.0508 u while that of thorium ${}_{90}^{234}\text{Th}$ is 234.0436 u and that of helium ${}_{2}^4\text{He}$ is 4.0026 u, alpha decay converts ${}_{92}^{238}\text{U}$ into ${}_{90}^{234}\text{Th}$ as shown
- $${}_{92}^{238}\text{U} \longrightarrow {}_{90}^{234}\text{Th} + {}_{2}^4\text{He} + \text{energy}$$

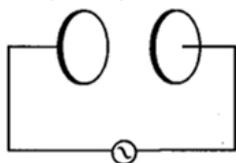
Determine the energy released in this reaction.

15. Which type of combination of cells is used in the following three cases. [3]
- If the external resistance is much larger than the total internal resistance?
 - If the external resistance is much smaller than the total internal resistance?
 - If the external resistance is equal to the total internal resistance?

16. An observer to the left of a solenoid of N turns each of cross-section area A observes that a steady current I in it flows in the clockwise direction. Depict the magnetic field lines due to the solenoid specifying its polarity and show that it acts as a bar magnet of magnetic moment $m = NIA$. [3]



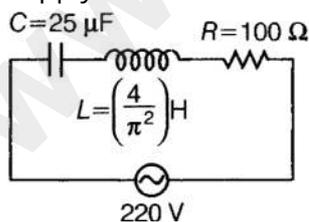
17. A parallel plate capacitor (shown in the figure) made of circular plates each of radius $R = 6.0$ cm has a capacitance $C = 100$ pF. The capacitor is connected to a 230 V AC supply with angular frequency of 300 rad/s. [3]



- What is the rms value of the conduction current?
- Is the conduction current equal to the displacement current?
- Determine the amplitude of \mathbf{B} at a point 3.0 cm from the axis between the plates.

Section D

18. i. Figure below shows a capacitor C , an inductor L and a resistor R connected in series to an AC supply of 220 V. [5]

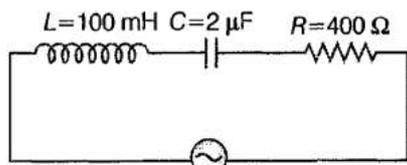


Calculate

- the resonant frequency of the given L-C-R circuit.
 - current flowing through the circuit.
 - average power consumed by the circuit.
- ii. In a series L-C-R circuit, what is the phase difference between V_L and V_C , where V_L is the potential difference across the inductor and V_C is the potential difference across the capacitor?

OR

- i. Find the value of the phase difference between the current and the voltage in the series L-C-R circuit shown below. Which one leads in phase, current or voltage?



- ii. Without making any other change, find the value of the additional capacitor C' , to be connected in parallel with the capacitor C , in order to make the power factor of the circuit unity.
19. Light waves from coherent sources arrive at two points on a screen with path difference of 0 and $\lambda/2$. Find the ratio of intensities at the points. [5]

OR

In Young's double slit experiment using monochromatic light L_1 of wavelength 700 nm , 10th bright fringe was obtained at a certain point P on a screen.

Which bright fringe will be obtained at the same point P , if monochromatic light of wavelength 500 nm is used in place of L_1 . (No other alterations were made in the experimental set up.)

20. i. A magnetic field that varies in magnitude from point to point but has a constant direction (East to West) is set up in a chamber. A charged particle enters the chamber and travels undeflected along a straight path with constant speed. What can you say about the initial velocity of the particle? [5]
- ii. A charged particle enters an environment of a strong and non-uniform magnetic field varying from point to point both in magnitude and direction, and comes out of it following a complicated trajectory. Would its final speed equal to the initial speed, if it suffered no collisions with the environment?
- iii. An electron travelling West to East enters a chamber having a uniform electrostatic field in North to South direction. Specify the direction in which a uniform magnetic field should be set up to prevent the electron from deflecting its straight line path.

Solution

Section A

1. Answer the following questions:

(a) In questions (i) to (vii) below, choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:

i. (c) 0

Explanation:

$$P = 10 \Omega, Q = 20 \Omega, R = 200 \Omega,$$

$$S = 100 \Omega, E = 2V$$

$$\frac{P}{S} = \frac{Q}{R} \text{ or, } \frac{10}{100} = \frac{20}{200}$$

$$\text{So, } \frac{1}{10} = \frac{1}{10}$$

It means bridge is balanced.

So, current through galvanometer is 0 A.

ii. (c) fall

Explanation:

A diamagnetic liquid moves from stronger parts of magnetic field to weaker parts. Therefore, the meniscus of the level of solution will fall.

iii. (a) X rays

Explanation:

In X-Ray crystallography X-ray is used to determine the atomic and molecular structure of a crystal.

iv. (c) a capacitor will tend to become SHORT.

Explanation:

$$X_C = 1/2\pi fC$$

So, as f increases, X_C becomes smaller and smaller. For very high value of f, X_C will be too small which may be considered as SHORT.

v. (a) Almost empty conduction band and almost filled up valence band with a very narrow forbidden band between them.

Explanation:

Pure semiconductor at 0K. It should be 0 K. K is for Kelvin. Should be written in bold, behaves like an insulator. So, it has almost empty conduction band and almost filled up valence band. Forbidden band is less than 3eV.

vi. (a) directly proportional to angle of deflection.

Explanation:

$$\theta = \frac{niAB}{C}$$

vii. (c) $\epsilon_w = 81\epsilon_0$

Explanation:

$$\text{Relative permittivity} = K = \frac{\epsilon_w}{\epsilon_0}$$

$$\text{Or, } 81 = \frac{\epsilon_w}{\epsilon_0}$$

$$\therefore \epsilon_w = 81\epsilon_0$$

(b) Answer the following questions briefly:

i. For first minima, $\sin\theta_1 = 1 \times \lambda/a = \lambda/a$

ii. Given, $\nu_0 = 5 \times 10^{14}$ Hz

$$\text{Work function, } W_0 = h\nu_0$$

$$W_0 = 6.6 \times 10^{-34} \times 5 \times 10^{14}$$

$$= 3.3 \times 10^{-19} \text{ J}$$

$$W_0 = \frac{3.3 \times 10^{-19}}{1.6 \times 10^{-19}} \text{ eV}$$

$$W_0 = 2.0625 \text{ eV.}$$

- iii. i. As $\phi = MI$, with the increase in the distance between the coils, the magnetic flux linked with the secondary coil decreases and hence, the mutual inductance of the two coils will decrease with the increase of separation between them.
 ii. Mutual inductance of two coils can be found out by $M = \mu_0 N_1 N_2 A l$, i.e. $M \propto A_1, N_2$, so with the increase in number of turns, mutual inductance increases.

iv. Given, ΔV and $q = 400 \mu\text{C} = 400 \times 10^{-6} \text{ C}$

We know that,

$$\text{Electrostatic potential difference} = \frac{\text{Work done}}{\text{Charge}}$$

$$\Rightarrow \Delta V = \frac{W}{q}$$

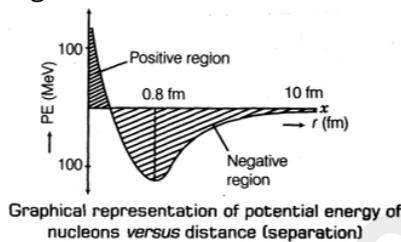
$$\Rightarrow 20 = \frac{W}{400 \times 10^{-6}}$$

$$\therefore W = 20 \times 400 \times 10^{-6} = 8 \times 10^{-3} \text{ J}$$

- v. Electron can revolve only in those orbits in which their angular momentum is an integral multiple of $\frac{h}{2\pi}$, where h is Planck's constant.

$$\text{i.e., } mvr = \frac{nh}{2\pi}$$

- vi. The assumption is that we concerned the rays to be paraxial (rays close to principal axis) only.
 vii. The graph between the potential energy of a pair of nucleons as a function of their separation is given below



- (i) For distance less than 0.8 fm, negative PE decreases to zero and then becomes positive.
 (ii) For distances larger than 0.8 fm, negative PE goes on decreasing.

Section B

2. Given, number of turns of circular coil, $n = 16$

Radius of circular coil, $r = 10 \text{ cm} = 0.1 \text{ m}$

Current, $I = 0.75 \text{ A}$, frequency, $f = 2\text{s}^{-1}$

Magnetic field, $B = 5.0 \times 10^{-2} \text{ T}$

Magnetic moment of the coil, $M = nIA = 16 \times 0.75 \times \pi(0.1)^2$

$$= 16 \times 0.75 \times 3.14 \times (0.1)^2 = 0.377 \text{ J/T}$$

$$\text{Frequency of oscillation of the coil, } f = \frac{1}{2\pi} \sqrt{\frac{M \times B}{I}}$$

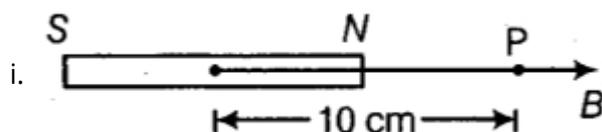
where, I = moment of inertia of the coil.

Squaring on both sides, we get

$$f^2 = \frac{1}{4\pi^2} \cdot \frac{MB}{I} \Rightarrow I = \frac{MB}{4\pi^2 f^2}$$

$$= \frac{0.377 \times 5 \times 10^{-2}}{4 \times 3.14 \times 3.14 \times 2 \times 2} = 1.2 \times 10^{-4} \text{ Kg-m}^2.$$

OR

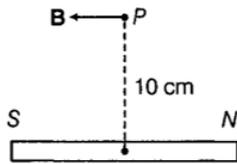


On axis,

$$B = \frac{\mu_0 M 2}{4\pi d^3} = \frac{10^{-7} \times 2 \times 0.48}{0.1^3} = 0.96 \times 10^4 \text{ T}$$

Direction is away from magnet on the axis on the North-side and towards the magnet on the axis on the South-side

ii.



On the equatorial line of the magnet

$$B = \frac{\mu_0 M}{4\pi d^3} = 0.48 \times 10^{-4} T \text{ along N-S direction.}$$

Direction at equatorial line is same as direction from north pole to south pole.

3. We know that, $L_d = \epsilon_0 A \frac{dE}{dt}$

where, $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

Area, $A = 1 \text{ cm}^2 = 10^{-4} \text{ m}^2$

$\therefore \frac{dE}{dt} = 3 \times 10^6 \text{ Vm}^{-1} \text{ s}^{-1}$

$\therefore I_d = 8.85 \times 10^{-12} \times 10^{-4} \times 3 \times 10^6 = 2.7 \times 10^{-9} \text{ A}$

4. i. $E_{\text{rms}} = \frac{E_0}{\sqrt{2}} = \frac{300}{\sqrt{2}} = 212.1 \text{ V}$ [$\because E_0 = \text{peak voltage}$]

ii. $I_{\text{rms}} = 10 \text{ A}$

$\Rightarrow I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$ [$\because I_0 = \text{peak current}$]

$\Rightarrow I_0 = \sqrt{2} I_{\text{rms}} = 10 \times \sqrt{2} = 14.14 \text{ A}$

OR

i. As given, $E = 140 \sin 314t$

On comparing with $E = E_0 \sin \omega t$, we have

$\omega = 314, E_0 = 140 \text{ V}$

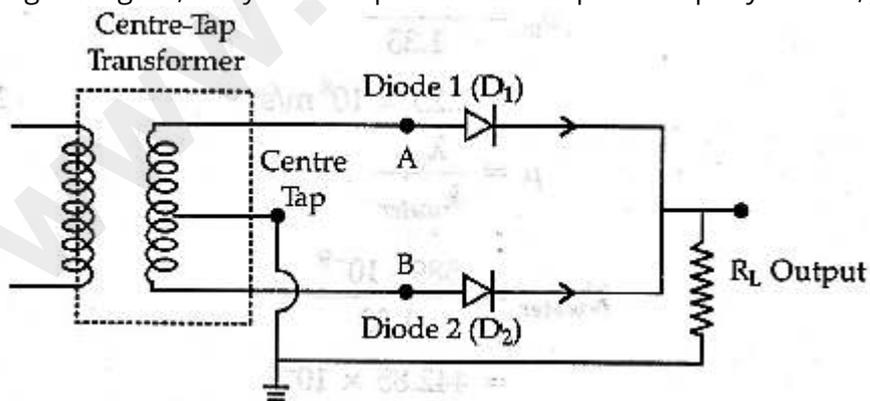
$\therefore \omega = 2\pi v \Rightarrow v = \frac{\omega}{2\pi} = \frac{314}{2 \times 3.14} = 50 \text{ Hz}$

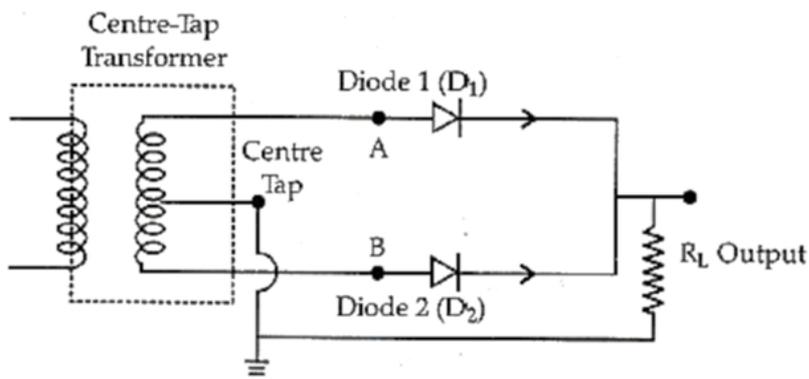
ii. $E_0 = 140 \text{ V}$

$E_{\text{rms}} = \frac{E_0}{\sqrt{2}} = \frac{140}{\sqrt{2}} = 99.29 \text{ V}$

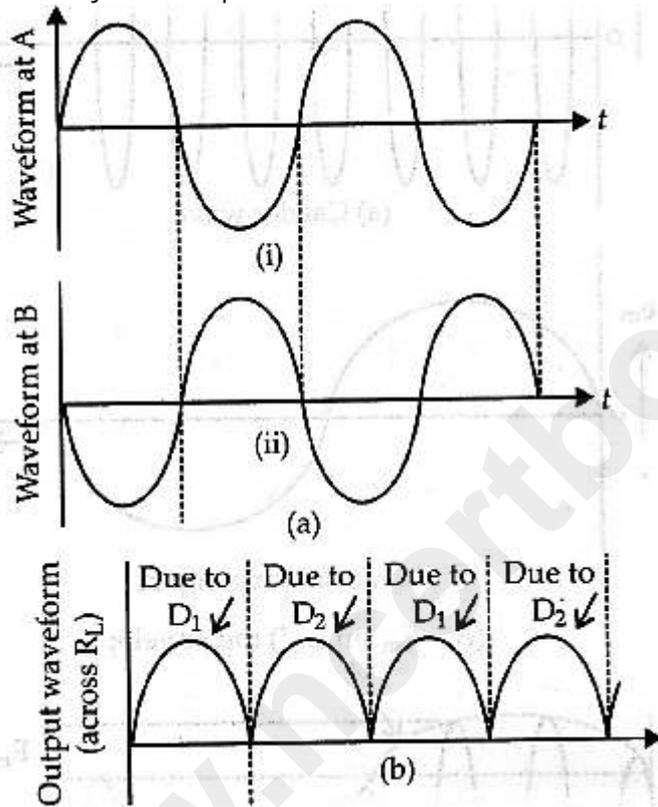
$\therefore I_{\text{rms}} = \frac{E_{\text{rms}}}{R} = \frac{99.29}{50} = 1.98 \text{ A}$

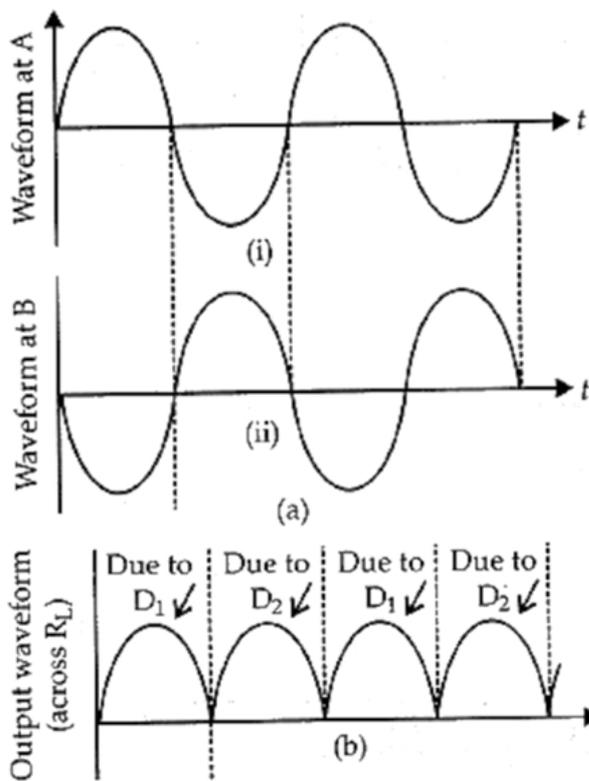
5. i. In given figure, n-crystals are positive as compared to p-crystals so, junction diode is reverse biased.



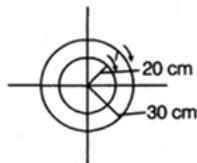


- ii. For a positive half cycle of input ac, one of the two diodes gets forward biased and conducts and output current is obtained across the load R_L . For a negative half cycle of input ac, the other diode gets forward biased and thus output current is obtained due to it. Therefore, output is obtained for both the cycles of input ac.





6. i. $M_1 = N_1 I_1 A_1 \otimes$
 $M_2 = N_2 I_2 A_2 \otimes$
 $\therefore M = M_1 + M_2 = 286 \text{ A} - \text{m}^2$
 ii. $M = |M_1 - M_2| = 1.10 \text{ A} - \text{m}^2$

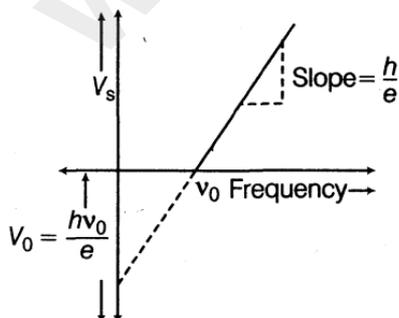


7. The insulating porcelain of the spark plugs accumulates a film of dirt. The surface dirt is hygroscopic and picks up moisture from the air. Therefore, in humid weather, the insulating porcelain of the plugs becomes quasi-conductor. This allows an appreciable proportion of the spark to leak across the surface of the plug instead of discharging across the gap.

8. i. Resistance = $\frac{0.75 \text{ V}}{15 \text{ mA}} = 50 \Omega$
 ii. Resistance = $\frac{-10 \text{ V}}{-1 \times 10^{-6} \text{ A}} = 10^7 \Omega$

Section C

9. Graph for V_s and v is as follows



Determination of Planck's constant

As from the graph it is clear that slope of the graph is given by

$$\text{Slope} = \frac{h}{e}$$

where, h = Planck's constant

and e = charge on an electron

Now, from Einstein's photoelectric equation,

$$K_{\max} = hv - \phi$$

$$\Rightarrow eV_0 = hv - \phi$$

$$\Rightarrow V_0 = \left(\frac{h}{e}\right)v - \frac{\phi}{e}$$

Comparing this equation with

$$y = mx + c,$$

$$\text{Slope of } (V_0, v) \text{ graph} = \frac{h}{e}$$

So, Planck's constant h = slope (V_0, v) graph.

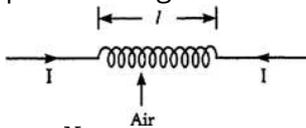
10. Self inductance of a coil is equal to the total magnetic flux linked with the coil, when unit current passes through it.

Also, self-inductance of a coil is equal to the emf induced in the coil, when rate of change of current in coil is 1 A/s.

The SI unit of self-inductance is henry (H).

$$1 \text{ H} = 1\text{V}\cdot\text{s}/\text{A}$$

Let the radius of air cored solenoid be r and l , respectively such that $r \ll l$ and having n turns per unit length.



$$n = \frac{N}{l} \dots(i)$$

where, N = total number of turns.

If I current flows through the coil, then magnetic field is given by

$$B = \mu_0 n I$$

where, n = number of turns per unit length

\therefore Magnetic flux linked with each turn,

$$\phi = BA = \mu_0 n I A$$

\therefore Total magnetic flux linked with solenoid,

$$N\phi = (\mu_0 n I A) N$$

$$\text{But } N\phi = LI$$

where, L is coefficient of self-induction.

$$(\mu_0 n I A) = LI \Rightarrow L = \mu_0 n A N$$

$$= \mu_0 \left(\frac{N}{l}\right) A N = \frac{\mu_0 A N^2}{l}$$

This is the required expression.

OR

$$\text{Rate of change of flux} = \frac{d\phi}{dt} = (\pi l^2 \lambda) B_0 \lambda \frac{dz}{dt}$$

$$= IR$$

$$I = (\pi l^2 \lambda) B_0 \frac{v}{R}$$

$$\text{Energy lost per second} = I^2 R = (\pi l^2 \lambda)^2 B_0^2 \frac{v^2}{R}$$

$$\text{Rate of change in P.E.} = mg \frac{dz}{dt} = mgv$$

$$mgv = (\pi l^2 \lambda)^2 B_0^2 \frac{v^2}{R}$$

$$v = \frac{mgR}{(\pi l^2 \lambda)^2 B_0^2}$$

11. Consider a point P on the line joining the two charges, as shown in the given figure.



r = Distance of point P from charge q_1

Let the electric potential (V) at point P be zero.

Potential at point P is the sum of potentials caused by charges q_1 and q_2 respectively.

$$V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1}{r} + \frac{1}{4\pi\epsilon_0} \cdot \frac{q_2}{(d-r)} \dots(i)$$

For $V = 0$, equation (i) reduces to

$$0 = \frac{1}{4\pi\epsilon_0} = \frac{q_1}{r} + \frac{1}{4\pi\epsilon_0} \cdot \frac{q_2}{(d-r)}$$

$$\frac{1}{4\pi\epsilon_0} \cdot \frac{q_1}{r} = -\frac{1}{4\pi\epsilon_0} \cdot \frac{q_2}{(d-r)}$$

$$\frac{q_1}{r} = -\frac{q_2}{(d-r)}$$

$$\frac{5 \times 10^{-8}}{r} = -\frac{(-3 \times 10^{-8})}{(0.16-r)}$$

$$5(0.16 - r) = 3r$$

$$0.8 = 8r$$

$$r = 0.1\text{m} = 10\text{ cm}$$

Therefore, the potential is zero at a distance of 10 cm from the positive charge between the charges.

12. The energy corresponding to γ_1 ,

$$E_1 = 1.088 - 0 = 1.088\text{ MeV}$$

$$= 1.088 \times 1.6 \times 10^{-13}\text{ J}$$

$$\text{Frequency for } \gamma_1, \nu_1 = \frac{E_1}{h} = \frac{1.088 \times 1.6 \times 10^{-13}}{6.63 \times 10^{-34}}$$

$$= 2.63 \times 10^{20}\text{ Hz}$$

The energy corresponding to γ_2 ,

$$E_2 = 0.412 - 0 = 0.412\text{ MeV}$$

$$= 0.412 \times 16 \times 10^{-13}\text{ J}$$

$$\text{Frequency for } \gamma_2, \nu_2 = \frac{E_2}{h} = \frac{0.412 \times 16 \times 10^{-13}}{6.63 \times 10^{-34}}$$

$$= 9.98 \times 10^{19}\text{ Hz}$$

The energy corresponding to γ_3

$$E_3 = 1.088 - 0.412$$

$$= 0.676\text{ MeV}$$

$$= 0.676 \times 1.6 \times 10^{-13}\text{ J}$$

$$\text{Frequency for } \gamma_3, \nu_3 = \frac{E_3}{h} = \frac{0.676 \times 16 \times 10^{-13}}{6.63 \times 10^{-34}}$$

$$\nu_3 = 1.64 \times 10^{20}\text{ Hz}$$

Maximum KE of β_1 ,

$$K_{\max}(\beta_1) = [m({}_{79}^{196}\text{Au}) - \text{Mass of second excited state of } {}_{80}^{198}\text{Hg}] \times 931\text{MeV}$$

$$= 931[197.968233 - 197.966760] - 1.088$$

$$= 1.371 - 1.088 = 0.283\text{ MeV}$$

Maximum KE of β_2

$$K_{\max}(\beta_2) = [m({}_{79}^{198}\text{Au}) - \text{Mass of third excited state of } {}_{150}^{198}\text{Hg}] \times 931\text{ MeV}$$

$$= 931[197.968233 - 197.966760] - 0.412$$

$$= 0.957\text{ MeV}$$

OR

i. According to the question, a nuclide 1 is said to be mirror isobar of nuclide 2, if $Z_1 = N_2$ and $Z_2 = N_1$.

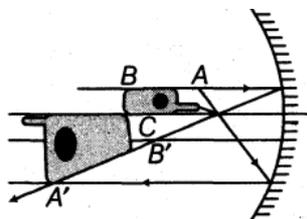
Now, in ${}_{11}^{23}\text{Na}$, $Z_1 = 11$, $N_1 = 23 - 11 = 12$

\therefore Mirror isobar of ${}_{11}^{23}\text{Na}$ is ${}_{12}^{23}\text{Mg}$, for which

$$Z_2 = 12 = N_1 \text{ and } N_2 = 23 - 12 = 11 = Z_1$$

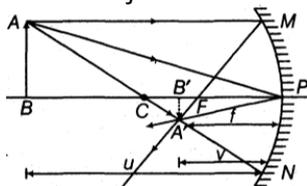
ii. As, ${}_{12}^{23}\text{Mg}$ contains even number of protons (12) against ${}_{11}^{23}\text{Na}$ which has odd number of protons (11), therefore ${}_{11}^{23}\text{Mg}$ has greater binding energy than ${}_{11}^{23}\text{Na}$.

13. i. The ray diagram for the formation of the image of the mobile phone is shown below. The image of the part which is on the plane perpendicular to principal axis will be on the same plane. It will be of the same size, i.e. $B'C = BC$



As the shape of mobile phone is not uniform, thus the magnification produced will also be not uniform. This can be seen in diagram above.

- ii. We may think that the image will now show only half of the object, but considering the laws of reflection to be true for all points of the remaining part of the mirror, the image will be that of the whole object.



However, as the area of the reflecting surface has been reduced, the intensity of the image will be low, i.e. half.

14. The fission reaction is, ${}_{92}^{238}\text{U} \rightarrow {}_{90}^{234}\text{Th} + {}_2^4\text{He} + Q$

So, $\Delta m = m_{\text{U}} - m_{\text{Th}} - m_{\text{He}}$

Mass defect, $\Delta m = 238.0508 - (234.0436 + 4.0026)$
 $= 0.00464 \text{ u}$ [$\because 1 \text{ u} = 931 \text{ MeV}$]

As, $E = \Delta m \times c^2 = 0.0046 \times 931 = 4.28 \text{ MeV}$

where, $c =$ velocity of light.

15. i. Series combination of cells.
 ii. Parallel combination of cells.
 iii. Mixed combination of cells.

16. Since, it is given that the current flows in the clockwise direction for an observer on the left side of the solenoid. It means that the left face of the solenoid acts as South pole and right face acts as North pole. Inside a bar, the magnetic field lines are directed from South to North. ($\frac{1}{2}$) Therefore, the magnetic field lines are directed from left to right in the solenoid.

Magnetic moment of a single current carrying loop is give by, $m' = IA$.

So, magnetic moment of the whole solenoid is give by

$$m = Nm' = N(IA)$$

17. Given, radius of plates, $R = 6 \text{ cm} = 6 \times 10^{-2} \text{ m}$

Capacitance of capacitor,

$$C = 100 \text{ pF} = 100 \times 10^{-12} \text{ F} = 10^{-10} \text{ F}$$

Voltage of capacitor, $V = 230 \text{ V}$

Frequency of capacitor, $\omega = 300 \text{ rad/s}$.

- i. The rms value of current, $I_{\text{rms}} = \frac{V_{\text{rms}}}{X_C}$

$$\therefore X_C = \frac{1}{\omega C} = \frac{1}{300 \times 10^{-10}} = \frac{10^{10}}{300} \Omega$$

$$\therefore I_{\text{rms}} = \frac{230 \times 300}{10^{10}} = 3 \times 23 \times 1000 \times 10^{-10}$$

$$= 69 \times 10^{-7} = 6.9 \times 10^{-6} \text{ A} = 6.9 \mu\text{A}$$

- ii. Yes, the conduction current is equal to displacement current.
 iii. Given, the distance of point from the axis between the plates,

$$r = 3 \text{ cm} = 3 \times 10^{-2} \text{ m}$$

Radius of plates, $R = 6 \text{ cm} = 6 \times 10^{-2} \text{ m}$

The magnetic field at a point between the plates,

$$B = \frac{\mu_0}{2\pi R^2} \cdot r \cdot I_d \Rightarrow B = \frac{\mu_0 r}{2\pi R^2} I \quad [\because I_d = I]$$

If $I = I_0$ is maximum value of current, then

$$I = \sqrt{2} I_{\text{rms}}$$

$$\therefore B = \frac{\mu_0 r}{2\pi R^2} \sqrt{2} I_{\text{rms}}$$

$$= \frac{4\pi \times 10^{-7} \times 0.03 \times \sqrt{2} \times 6.9 \times 10^{-6}}{2\pi \times 0.06 \times 0.06}$$

$$= 1.63 \times 10^{-11} \text{ T}$$

Section D

18. i. Given, $E_{\text{rms}} = 220\text{V}$, $C = 25\mu\text{F} = 25 \times 10^{-6} \text{ F}$,

$$L = \frac{4}{\pi^2} \text{ H}, R = 100\Omega$$

a. Resonant frequency is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.14 \times \sqrt{\frac{4}{\pi^2} \times 25 \times 10^{-6}}}$$

$$= \frac{1}{2 \times 3.14 \times \frac{2}{314} \times 5 \times 10^{-3}} = 50\text{Hz}$$

b. Impedance of the circuit is given by

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \dots(i)$$

$$\text{We know that, } X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$= \frac{1}{2 \times 3.14 \times 50 \times 25 \times 10^{-6}} = 127.3\Omega$$

$$X_L = \omega L = 2\pi f L = 2 \times 3.14 \times \frac{4}{\pi^2} \times 50 = 127.3\Omega$$

Substituting the all values in Eq. (i), we get

$$Z = \sqrt{(100)^2 + (127.3 - 127.3)^2}$$

$$= \sqrt{(100)^2} = 100\Omega$$

$$\text{We know that, } I_{\text{rms}} = \frac{E_{\text{rms}}}{Z} = \frac{220}{100} = 2.2 \text{ A}$$

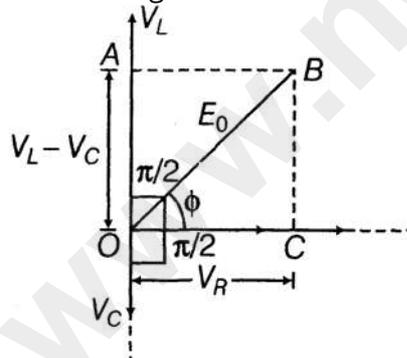
c. Average power consumed by the circuit

$$= E_{\text{rms}} \times I_{\text{rms}} \times \frac{R}{\sqrt{R^2 + (L\omega - \frac{1}{C\omega})^2}}$$

$$\therefore Z = R = 100\Omega$$

$$\text{So, power} = E_{\text{rms}} \times I_{\text{rms}} = 220 \times 2.2 = 484 \text{ W}$$

ii. Phasor diagram of L-C-R circuit is shown below.



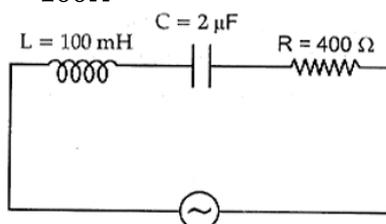
The phase difference across the inductor and phase difference across the capacitor is 180° .

OR

i. $\omega = 1000$

$$X_L = \omega L = 1000 \times 100 \times 10^{-3} \Omega$$

$$= 100\Omega$$



$$V = V_0 \sin(1000t + \phi)$$

$$X_C = \frac{1}{\omega c} = \frac{1}{2 \times 10^{-6} \times 1000}$$

$$= \frac{1000}{2} = 500 \Omega$$

$$\cos \phi = \frac{R}{Z} = \frac{400}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{400}{400\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$\phi = 45^\circ$$

ii. For unit power factor, $\cos \phi = 1$

$$\Rightarrow \frac{R}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C''})^2}} = 1$$

where, C' is the total capacitance.

$$\Rightarrow R^2 + \left(\omega L - \frac{1}{\omega C''}\right)^2 = R^2 \Rightarrow \omega L = \frac{1}{\omega C''}$$

$$\Rightarrow \omega L = 100 = \frac{1}{\omega C''}$$

$$\Rightarrow C'' = \frac{1}{10^5} = 10^{-5} = 10 \mu F$$

Additional capacitance C' required in parallel

$$C' = C'' - C = 10 \mu F - 2 \mu F = 8 \mu F$$

19. As, $I = I_0 \cos^2 \phi$

\therefore Phase difference, $\phi = \frac{2\pi x}{\lambda}$ path difference.

$$\text{So, } I_1 = I_0 \cos^2\left(\frac{2\pi \times 0}{\lambda}\right) = I_0$$

$$\text{and } I_2 = I_0 \cos^2\left(\frac{2\pi}{\lambda} \times \lambda/2\right)$$

$$= I_0 \cos^2(\pi) = I_0$$

$$\therefore \frac{I_1}{I_2} = \frac{1}{1}$$

OR

According to the question, for the same arrangement of YDSE, the ratio of d/D remains constant.

$$y_n = n \frac{D}{d} \lambda$$

Given, $\lambda_1 = 700 \text{ nm}$, $n_1 = 10\text{th}$ bright fringe,

$$\lambda_2 = 500 \text{ nm}, n_2 = ?$$

We know that, $y = n \frac{D\lambda}{d}$

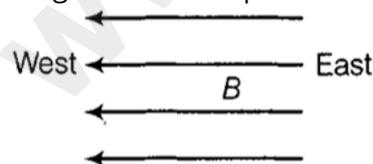
For the same point, x is constant and for same arrangement, then $\frac{d}{D}$ is constant.

$$\Rightarrow n_1 \lambda_1 = n_2 \lambda_2$$

$$\Rightarrow 10 \times 700 = n_2 \times 500$$

$$\text{or } n_2 = \frac{10 \times 700}{500} = 14$$

20. i. The magnetic field is in constant direction from East to West. According to the question, a charged particle travels undeflected along a straight path with constant speed. It is only possible, if the magnetic force experienced by the charged particle is zero.



The magnitude of magnetic force on a moving charged particle in a magnetic field is given by $F = qvB \sin \theta$ (where θ is the angle between v and B). Here $F = 0$, if and only if $\sin \theta = 0$ (as $v \neq 0$, $q \neq 0$, $B \neq 0$). This indicates the angle between the velocity and magnetic field is 0° or 180° . Thus, the charged particle moves parallel or anti-parallel to the magnetic field B .

ii. Yes, the final speed be equal to its initial speed as the magnetic force acting on the charged particle only changes the direction of velocity of charged particle but cannot change the magnitude of velocity of charged particle.

iii. As, the electric field is from North to South, that means the plate in North is positive and in South is negative. Thus, the electrons (negatively charged) attract towards the positive plate that means move towards North. If we want that there should be no deflection in the path of electron, then the

magnetic force should be in South direction.

By $F = -e(v \times B)$, the direction of velocity is West to East, the direction of force is towards South, by using the Fleming's left hand rule, the direction of magnetic field (B) is perpendicularly inwards to the plane of paper.

