Please check the examination details below before entering your candidate information

Candidate Name	Class	Section

BLOOM Physics Olympiad (BPhO)

Question Paper 2024-25

Class 12

Total Questions **50 + 5** (Tie-Breaking Section)

Total Time Allotted : 60 minutes

Total Marks : 60

Instructions

1. There are **50 Multiple Choice Questions** in this booklet having 4 options out of which **ONLY ONE** is correct.
2. There are two sections in the Question Paper; Section A having 40 Questions carrying 1 Mark each & Section B having 10 Higher Difficulty Order Questions carrying 2 Marks each.
3. All questions are compulsory. There is **NO negative** marking for incorrect answers.
4. Total time allotted to complete the paper is 60 minutes.
5. Please fill in your details in the space provided on this page before attempting the paper.

OMR Sheet Instructions

1. Before starting the paper, fill in all the details in the OMR Sheet.
2. Additional 10 minutes will be provided to fill up the OMR sheet, before the start of the exam.
3. Use HB Pencil to darken the circle of the correct Option in OMR sheet. The correct way to darken the circle in OMR sheet is shown below.

4. Use black or blue ball point pen/HB pencil to fill the information in the OMR sheet. Partially filled OMR sheet will not be checked.
5. Return the OMR sheet to the invigilator after the exam.

CODE#211

P12

BLOOM CAP

Founded by | arihant

Section A (1 Mark)

1. Two identical thin rings, each of radius 10 cm carrying charges 10 C and 5 C are co-axially placed at a distance 10 cm apart. The work done in moving a charge q from the centre of the first ring to that of the second is

(a) $\frac{q}{8\pi\varepsilon_0}\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$ (b) $\frac{q}{8\pi\varepsilon_0}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

(c) $\frac{q}{4\pi\varepsilon_0}\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$ (d) $\frac{q}{4\pi\varepsilon_0}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

2. A charged particle with a specific charge (charge/mass ratio) α is released from the origin at time $t = 0$ with an initial velocity $\mathbf{v} = v_0(\hat{\mathbf{i}} + \hat{\mathbf{j}})$ in a uniform magnetic field $\mathbf{B} = B_0\hat{\mathbf{i}}$. Coordinates of the particle at time $t = \frac{\pi}{B_0\alpha}$ are

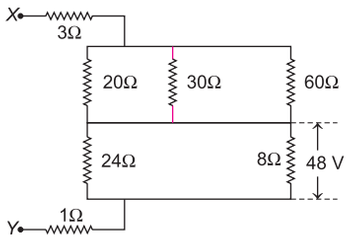
(a) $\left(\frac{v_0}{2B_0\alpha}, \frac{\sqrt{2}v_0}{\alpha B_0}, \frac{-v_0}{B_0\alpha}\right)$ (b) $\left(\frac{-v_0}{2B_0\alpha}, 0, 0\right)$

(c) $\left(0, \frac{2v_0}{B_0\alpha}, \frac{v_0\pi}{2B_0\alpha}\right)$ (d) $\left(\frac{v_0\pi}{B_0\alpha}, 0, \frac{-2v_0}{B_0\alpha}\right)$

3. An α-particle moves in a circular path with a radius of 0.45 m in a magnetic field of strength $B = 1.2\ \text{Wb/m}^2$ at a speed of $2.6\times 10^7\ \text{m/s}$. The period of revolution of the α-particle is

(a) 1.1×10^{-6} s (b) 1.1×10^{-8} s
(c) 1.1×10^{-5} s (d) 1.1×10^{-7} s

4. The potential difference across $8\,\Omega$ resistance is 48 V as shown in the figure. The value of potential difference across X and Y points will be



(a) 128 V (b) 80 V
(c) 160 V (d) 62 V

5. A telescope has an objective lens with a focal length of 50 cm and eyepiece with a focal length of 5 cm. The least distance for clear vision is 25 cm. The telescope is adjusted to clearly view an object 200 cm away. The distance between the objective lens and the eyepiece is

(a) 75 cm (b) 60 cm
(c) 71 cm (d) 74 cm

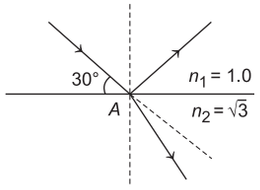
6. The ratio of intensities of consecutive maxima in the diffraction pattern due to a single slit is

(a) 1 : 4 : 9 (b) 1 : 2 : 3
(c) $1:\frac{1}{\pi^2}:\frac{9}{\pi^2}$ (d) $1:\frac{4}{9\pi^2}:\frac{4}{25\pi^2}$

7. A vibration magnetometer placed in magnetic meridian has a small magnet. The magnet executes oscillations with a time period of 2 s in the earth's horizontal magnetic field of 24 μT. When a horizontal field of 18 μT is produced opposite to the earth's field by placing a current-carrying wire, the new time period of the magnet will be

(a) 1 s (b) 2 s (c) 3 s (d) 4 s

8. A beam of monochromatic light reflects and refracts at point A, as shown in the diagram. Find the angle of refraction at point A.



(a) 60° (b) 45° (c) 30° (d) 15°

9. The instantaneous values of alternating current and voltage in a circuit are given as

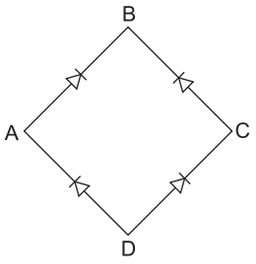
$$i = \frac{1}{\sqrt{2}}\sin(100\,\pi t)\ \text{ampere}$$

$$e = \frac{1}{\sqrt{2}}\sin\left(100\pi t + \frac{\pi}{3}\right)\ \text{volt}$$

The average power (in watt) consumed in the circuit is

(a) $\frac{1}{4}$ (b) $\frac{\sqrt{3}}{4}$
(c) $\frac{1}{2}$ (d) $\frac{1}{8}$

10. In the diagram, the input is across the terminals A and C and the output is across the terminals B and D. Then, the output is

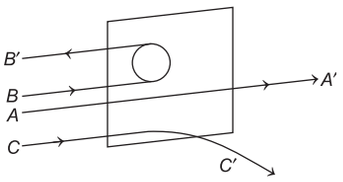


(a) zero
(b) same as input
(c) full wave rectified
(d) half-wave rectified

11. Two charges $+6\mu C$ and $+15\mu C$ are placed along the X-axis at $x = 0$ and $x = 2$ m, respectively. A negative charge is placed between them such that the resultant force on it is zero. The negative charge is placed at

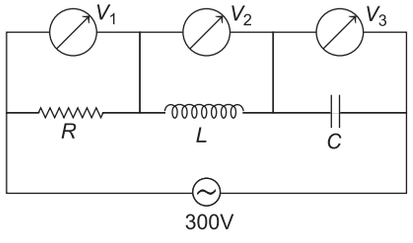
(a) $x = 0.775$ m
(b) $x = 1.2$ m
(c) $x = 0.5$ m
(d) Position depends on the amount of charge

12. A beam of rapidly moving α-particles is directed at a thin film of gold. The parts A', B' and C' of the transmitted and reflected beams correspond to the incident parts A, B and C of the original beam. Based on the given diagram, the number of α-particles in each corresponding part is



(a) B' will be maximum and in C' minimum
(b) A' will be maximum and in B' minimum
(c) A' will be minimum and in B' maximum
(d) C' will be minimum and in B' maximum

13. The figure shows an L-C-R circuit connected to a 300 V AC supply. The circuit components have values such that $R = X_L = X_C = 10\Omega$. Three AC voltmeters V_1, V_2 and V_3 are connected across the resistor, inductor and capacitor, respectively as shown in the figure.



Which option correctly represents the readings of these voltmeters?
(a) $V_1 = 100$ V, $V_2 = 100$ V, $V_3 = 100$ V
(b) $V_1 = 150$ V, $V_2 = 0$, $V_3 = 150$ V
(c) $V_1 = 300$ V, $V_2 = 100$ V, $V_3 = 100$ V
(d) $V_1 = 300$ V, $V_2 = 300$ V, $V_3 = 300$ V

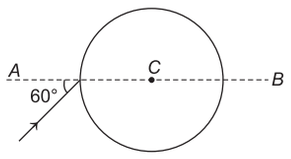
14. An unstable heavy nucleus at rest breaks into two nuclei which move away with velocity in the ratio of 8 : 27. The ratio of the radii of the nuclei (assumed to be spherical) is

(a) 3 : 2 (b) 2 : 3
(c) 4 : 9 (d) 8 : 27

15. A simple L-R circuit is connected to a battery at time $t = 0$. At what time does the energy stored in the inductor reach half of its maximum value?

(a) $\frac{R}{L}\ln\left[\frac{\sqrt{2}}{\sqrt{2}-1}\right]$ (b) $\frac{L}{R}\ln\left[\frac{\sqrt{2}-1}{\sqrt{2}}\right]$
(c) $\frac{L}{R}\ln\left[\frac{\sqrt{2}}{\sqrt{2}-1}\right]$ (d) $\frac{R}{L}\ln\left[\frac{\sqrt{2}-1}{\sqrt{2}}\right]$

16. A ray of light strikes a transparent sphere with its centre at point C, as shown in the figure. The ray exits the sphere parallel to the line AB
The refractive index of the sphere is



(a) $\sqrt{2}$ (b) $\sqrt{3}$ (c) $\frac{3}{2}$ (d) $\frac{1}{2}$

17. When light of wavelength λ is incident on photosensitive surface, the stopping potential is V. When light of wavelength 3λ is incident on same surface, the stopping potential is $\frac{V}{6}$.

Threshold wavelength for the surface is
(a) 2λ (b) 3λ (c) 4λ (d) 5λ

18. If the suspension thread has no torsion, then the time period of a magnet executing simple harmonic motion (SHM) is
(Symbols have their usual meanings)

(a) $T = 2\pi\sqrt{\frac{MB}{I}}$ (b) $T = \frac{1}{2\pi}\sqrt{\frac{I}{MB}}$
(c) $T = 2\pi\sqrt{\frac{I}{MB}}$ (d) $T = \frac{1}{2\pi}\sqrt{\frac{I}{MB}}$

19. A photoelectric threshold for a certain metal is 3800 Å. The maximum energy of the ejected photoelectrons by the radiation of 2000 Å is (Take, $h = 6.62 \times 10^{-34}$ J-s)

(a) 1.86 eV (b) 2.76 eV
(c) 3.26 eV (d) 5.76 eV

20. An AC generator of 220 V having internal resistance $r = 10\,\Omega$ and external resistance $R = 100\,\Omega$. What is the power developed in the external circuit?

(a) 484 W (b) 400 W
(c) 441 W (d) 369 W

21. If m is mass of electron, v is its velocity, r is the radius of stationary circular orbit around a nucleus with charge Ze, then from Bohr's first postulate, the kinetic energy $K = \frac{1}{2}mv^2$ of the electron in CGS system is equal to

(a) $\frac{1}{2}\frac{Ze^2}{r}$ (b) $\frac{1}{2}\frac{Ze^2}{r^2}$ (c) $\frac{Ze^2}{r}$ (d) $\frac{Ze}{r^2}$

22. A transformer having efficiency of 90% is working on 200 V and 3 kW power supply. If the current in the secondary coil is 6 A, then voltage across the secondary coil and the current in the primary coil respectively, are

(a) 300 V, 15 A (b) 450 V, 15 A
(c) 450 V, 13.5 A (d) 600 V, 15 A

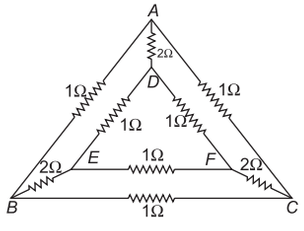
23. If the wavelength of the first line of the Balmer series of hydrogen is 6561 Å, then wavelength of the second line of the series should be

(a) 1312 Å (b) 3280 Å
(c) 4860 Å (d) 2187 Å

24. A pencil of length L is placed in contact with the objective of astronomical telescope. If the telescope is in normal adjustment and the length of image formed by eyepiece is l, then the magnification of telescope is

(a) $\frac{L}{l}$ (b) $\frac{L}{l} + 1$ (c) $\frac{L}{l} - 1$ (d) $\frac{L+l}{L-l}$

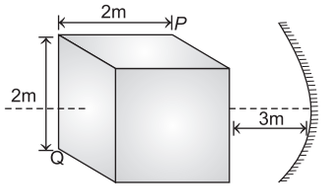
25. The network of nine conductors connect six points A, B, C, D, E and F as shown in figure. The figure denotes resistance in ohms.



Find the equivalent resistance between A and D.

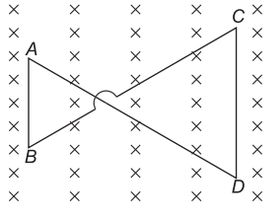
(a) 4 Ω (b) 1 Ω (c) 5 Ω (d) 6 Ω

26. A cube is placed in front of a concave mirror of focal length 1m with its face P at distance of 3 m and face Q at a distance 5 m from the mirror as shown in the figure. The distance between the images of face P and Q and height of images of P and Q are



(a) 1 m, 0.5 m, 0.25 m (b) 0.5 m, 1 m, 0.25 m
(c) 0.5 m, 0.25 m, 1 m (d) 0.25 m, 1 m, 0.5 m

27. A conducting wire frame is placed in a magnetic field which is directed into the plane of paper (figure). The magnetic field is increasing at a constant rate.



The directions of induced currents in wires AB and CD respectively are

(a) B to A and D to C (b) A to B and C to D
(c) A to B and D to C (d) B to A and C to D

28. Stationary nucleus ^{238}U decays by a emission generating a total kinetic energy T.

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$$

What is the kinetic energy of the α-particle?

(a) Slightly less than $\frac{T}{2}$ (b) $\frac{T}{2}$
(c) Slightly less than T (d) Slightly greater than T

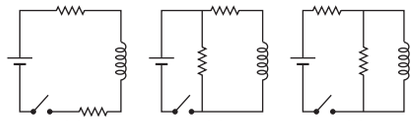
29. A light ray with a certain frequency (ν) and wavelength (λ) enters a liquid with a refractive index of $\frac{3}{2}$. Then the ray propagates through the liquid with

(a) frequency (ν) and wavelength $\left(\frac{2}{3}\lambda\right)$
(b) frequency (ν) and wavelength $\left(\frac{3}{2}\lambda\right)$
(c) frequency $\left(\frac{3}{2}\nu\right)$ and wavelength (λ)
(d) frequency (ν) and wavelength (λ)

30. A bar magnet of magnetic moment 6.0 Am^2 is placed in a uniform magnetic induction field of 4×10^{-5} T. If each pole of the magnet experiences a force of 8×10^{-4} N, the then length of the magnet is

(a) 0.5 m (b) 0.3 m (c) 0.2 m (d) 0.1 m

31. The figure represents three circuits, each comprising identical batteries, inductors, and resistors. Determine the sequence of the circuits based on the current flowing through the battery.



(i) Immediately after the switch is closed.

(ii) After a significant period of time has passed. Listing them from the highest to lowest current.

(a) (i) $i_2 > i_3 > i_1 (i_1 = 0)$ (ii) $i_2 > i_3 > i_1$

(b) (i) $i_2 < i_3 < i_1$ $(i_1 \neq 0)$ (ii) $i_2 > i_3 > i_1$

(c) (i) $i_2 > i_3 = i_1 (i_1 = 0)$ (ii) $i_2 > i_3 > i_1$

(d) (i) $i_2 = i_3 > i_1 (i_1 \neq 0)$ (ii) $i_2 > i_3 > i_1$

32. The radiowave of 20 cm emitted by hydrogen in interstellar space is due to the interaction called the hyperfine interaction in atomic hydrogen. The energy of the emitted wave is nearly

(a) 10^{-17} J (b) 1 J

(c) 10×10^{-25} J (d) 10^{-24} J

33. A point source of electromagnetic radiation has an average power output of 600 W. The maximum value of electric field at a distance 2.0 m from the source is

(a) 64.7 V/m (b) 57.8 V/m

(c) 96.78 V/m (d) 54.77 V/m

34. A concave lens made up of glass with a refractive index of 1.5 has equal radii of curvature (R) for both surfaces. If the lens is immersed in a medium with a refractive index of 1.75, then how will it behave?

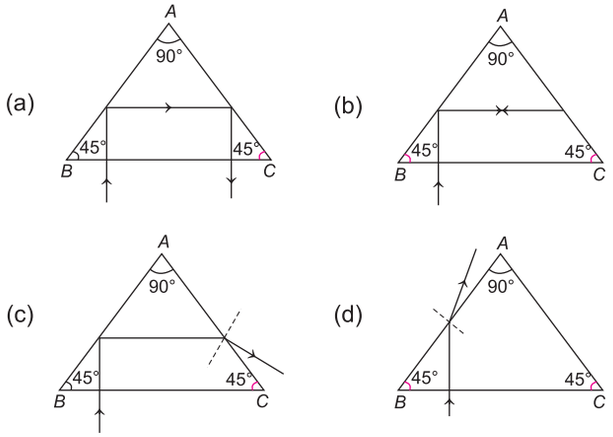
(a) Convergent lens of focal length 3.5 R

(b) Convergent lens of focal length 3.0 R

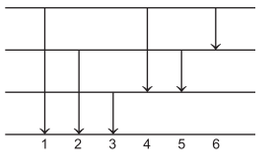
(c) Divergent lens of focal length 3.5 R

(d) Divergent lens of focal length 3.0 R

35. The refractive index of a material of a prism of angles 45° - 45° - 90° is 1.5. The path of the ray of light incident normally on the hypotenuse side is shown in



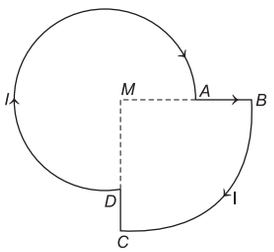
36. The figure shows the energy level diagram of an atom and identifies the origins of six spectral lines in emission (for example, line 5 results of a transition from level B to A). Which of these spectral lines would also appear in the absorption spectrum?



(a) 1, 4, 6 (b) 4, 5, 6

(c) 1, 2, 3 (d) 1, 2, 3, 4, 5, 6

37. A current I flows through the loop shown in the figure. The current's direction and the loop's shape are indicated in the diagram. The loop consists of segments MA and MB such that $MA = R$ and $MB = 2R$, with $\angle DMA = 90°$. The magnetic field at the centre of the loop is $\frac{\mu_0 I}{R}$ times of



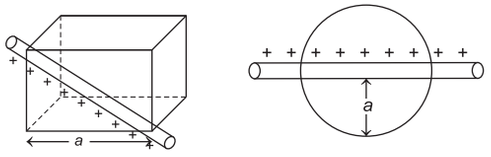
(a) $\frac{5}{16}$ but out of the plane of paper

(b) $\frac{5}{16}$ but into the plane of paper

(c) $\frac{7}{16}$ but out of the plane of the paper

(d) $\frac{7}{16}$ but into the plane of the paper

38. A linear charge with a linear charge density λ passes diagonally through a cube and then passes diametrically through a sphere as shown in figure. What is the ratio of the electric flux emerging from the cube to that from the sphere?

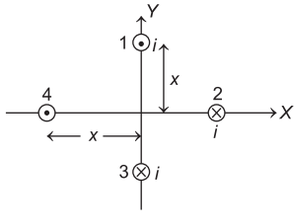


(a) $\frac{1}{2}$ (b) $\frac{2}{\sqrt{3}}$ (c) $\frac{\sqrt{3}}{2}$ (d) 1

39. A particle of mass m and charge q is initially at rest in a uniform electric field E. After being released, it moves through a distance y, then kinetic energy gained by the particle is

(a) $\frac{1}{2}qEy^2$ (b) qEy^2 (c) qE^2y (d) qEy

40. What will be the net magnetic field at origin due to four infinitely long wires, each producing a magnetic field of magnitude B at the origin?



(a) $4B$ (b) $\sqrt{2}B$ (c) $2\sqrt{2}B$ (d) Zero

Section B (2 Marks)

Directions Read the following case study and answer the questions 41-44 based on this case.

A plano-convex lens with a refractive index of 1.5 is placed on a flat glass surface with a refractive index of 1.6. The radius of curvature of the convex side of the lens is 20 cm. A monochromatic light source of wavelength 600 nm is directed vertically downward onto the lens system.

Circular interference fringes are observed due to the air gap between the lens and the glass surface known as Newton's ring.

41. What is the radius of the 5th dark ring observed in this set up?

(a) 0.17 mm (b) 0.34 mm
(c) 0.45 mm (d) 0.55 mm

42. If the refractive index of the lens is increased to 1.6, what happens to the number of observed fringes?

(a) Increases (b) Decreases
(c) Remains unchanged (d) All fringes disappear

43. How would the pattern change, if the experiment were conducted underwater? (refractive index of water is 1.33)

(a) Rings becomes wider
(b) Rings becomes narrower
(c) Number of rings decreases
(d) Central spot changes from dark to bright

44. If the air between the lens and the glass plate is replaced with a liquid of refractive index 1.4, what happens to the central spot?

(a) It remains dark
(b) It becomes bright
(c) It becomes partially bright
(d) It disappears

45. **Assertion (A)** In a Young's double slit experiment, the fringe width decreases, if the separation between the slits is increased.
Reason (R) The fringe width in a Young's double slit experiment is directly proportional to the distance between the slits and inversely proportional to the distance between the slits and the screen.
In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

46. **Assertion (A)** Electromagnetic waves are transverse in nature, and the electric and magnetic fields are perpendicular to each other and to the direction of wave propagation.

Reason (R) In electromagnetic waves, the oscillating electric and magnetic field produced by accelerated charges and they vary sinusoidally with space and time.
In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

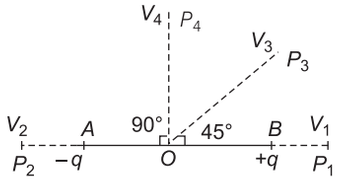
47. **Statement I** Critical angle of light passing from glass to air is minimum for violet colour.
Statement II The wavelength of blue light is greater than the light of other colours.
In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both Statement I and Statement II are incorrect.
(b) Statement I is correct and Statement II is incorrect.
(c) Statement I is incorrect and Statement II is correct.
(d) Both Statement I and Statement II are correct.

48. **Statement I** In nuclear fission, a heavy nucleus splits into two or more lighter nuclei, releasing a large amount of energy.
Statement II The energy released in nuclear fission is due to conversion of kinetic energy into mass.
In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both Statement I and Statement II are incorrect.
(b) Statement I is correct and Statement II is incorrect.
(c) Statement I is incorrect and Statement II is correct.
(d) Both Statement I and Statement II are correct.

49. Match the Column I (potential) with Column II (value) for electric potential at different points, P_1, P_2, P_3 and P_4 as shown in the figure with respect to an electric dipole.



Each points P_1, P_2, P_3 and P_4 are at equal distance r from mid-point O of the dipole.
Match the Column I with Column II and select the correct answer from the codes given below.

	Column I		Column II
A.	V_1	1.	0
B.	V_2	2.	$\frac{p}{4\sqrt{2}\pi\varepsilon_0 r^2}$
C.	V_3	3.	$\frac{-p}{4\pi\varepsilon_0 r^2}$
D.	V_4	4.	$\frac{p}{4\pi\varepsilon_0 r^2}$

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	2	1	(b)	1	2	3	4
(c)	4	3	2	1	(d)	4	3	1	2

50. A charged particle with some initial velocity is projected in a region, where non-zero electric and magnetic fields are present.
Match the Column I with Column II and select the correct answer from the codes given below.

	Column I		Column II
A.	$\mathbf{E} = 0, \mathbf{B} \neq 0$ and initial velocity is at any angle with $\mathbf{B}(\theta \neq 90°)$	1.	Straight line
B.	$\mathbf{E} = 0, \mathbf{B} \neq 0$ and initial velocity is perpendicular to $\mathbf{B}$	2.	Helical path with uniform pitch
C.	$\mathbf{E} \neq 0, \mathbf{B} \neq 0, \mathbf{E} \parallel \mathbf{B}$ and initial velocity is $\perp$ to both	3.	Circular
D.	$\mathbf{E} \neq 0, \mathbf{B} \neq 0, \mathbf{E}$ is perpendicular to $\mathbf{B}$ and $\mathbf{v}$ perpendicular to both $\mathbf{E}$ and $\mathbf{B}$	4.	Helical path with non-uniform pitch

Codes

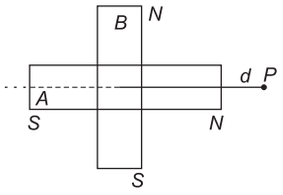
	A	B	C	D		A	B	C	D
(a)	2	3	4	1	(b)	1	3	4	2
(c)	2	3	1	4	(d)	4	1	2	3

Tie-Breaking Section

Instructions

1. This section consists of 5 questions.
2. The score achieved in this section will not be included in the total marks.
3. If overall marks of two or more students are same, winner will be decided based on the score in this section.
4. Participation in this section is optional, and students may choose to attempt it or not.

1. The magnetic induction at P, for the arrangement shown in the figure.

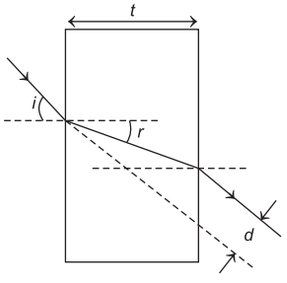


When two similar short magnets of magnetic moment M are joined at the middle, so that they are mutually perpendicular will be

(a) $\frac{\mu_0}{4\pi}\frac{M\sqrt{3}}{d^3}$ (b) $\frac{\mu_0}{4\pi}\frac{3M}{d^3}$

(c) $\frac{\mu_0 M\sqrt{5}}{4\pi\, d^3}$ (d) $\frac{\mu_0 2M}{4\pi\, d^3}$

2. A ray of light is incident on a thick slab of glass (thickness t) as shown in figure.

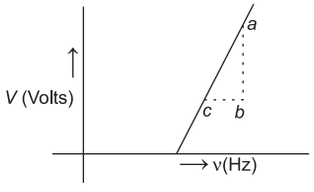


The emergent ray is parallel to the incident ray but displaced sideways by a distance d. If the angles are small, then d is

(a) $t\left(1-\frac{i}{r}\right)$ (b) $rt\left(1-\frac{i}{r}\right)$

(c) $it\left(1-\frac{r}{t}\right)$ (d) $t\left(1-\frac{r}{i}\right)$

3. In a photoelectric experiment, the graph of frequency ν of incident light (in Hz) and stopping potential V (in volts) is shown below. From figure, the value of the Planck's constant is (e is the elementary charge)



(a) $e\frac{ab}{cb}$ (b) $e\frac{cb}{ab}$ (c) $e\frac{ac}{bc}$ (d) $e\frac{ac}{ab}$

4. Light of wavelength 500 nm is incident on a metal with work function 2.28 eV.
The de-Broglie wavelength of the emitted electron is

(a) $\geq 2.8\times10^{-9}$ m (b) $\leq 2.8\times10^{-12}$ m

(c) $< 2.8\times10^{-10}$ m (d) $< 2.8\times10^{-9}$ m

5. A 2.0 cm tall object is placed 15 cm in front of a concave mirror of focal length 10 cm. What is the size and nature of the image?

(a) 4 cm, Real (b) 4 cm, Virtual

(c) 1.0 cm, Real (d) None of the above