Magnetostatics JEST & TIFR

https://snboseplc.com/magnetostatics-jest-tifr/

Q.No:1 JEST-2012

A magnetic field $\vec{B} = B_0(\hat{i}+2\hat{j}-4\hat{k})$ exists at a point. If a test charge moving with a velocity, $\vec{v} = v_0(3\hat{i}-\hat{j}+2\hat{k})$ experiences no force at a certain point, the electric field at that point in SI units is

1. $\vec{E} = -v_0B_0(3\hat{i}-2\hat{j}-4\hat{k})$
2. $\vec{E} = -v_0B_0(\hat{i}+\hat{j}+7\hat{k})$
3. $\vec{E} = v_0B_0(14\hat{j}+7\hat{k})$
4. $\vec{E} = -v_0B_0(14\hat{j}+7\hat{k})$

Q.No:2 JEST-2013

A thin uniform ring carrying charge Q and mass M rotates about its axis. What is the gyromagnetic ratio (defined as ratio of magnetic dipole moment to the angular momentum) of this ring?

1. $Q/(2\pi M)$
2. Q/M
3. $Q/(2M)$
4. $Q/(\pi M)$

Q.No:3 JEST-2014

A system of two circular co-axial coils carrying equal currents I along same direction having equal radius R and separated by a distance R (as shown in the figure below). The magnitude of magnetic field at the midpoint P is given by

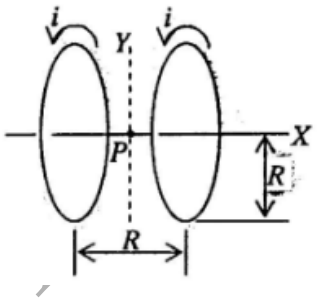


Figure 1: Two co-axial coils separated by distance R.

1. $\frac{\mu_0 I}{2\sqrt{2}R}$
2. $\frac{4\mu_0 I}{5\sqrt{5}R}$
3. $\frac{8\mu_0 I}{5\sqrt{5}R}$
4. 0

Q.No:4 JEST-2015

A charged particle is released at time $t = 0$, from the origin in the presence of uniform static electric and magnetic fields given by $E = E_0\hat{y}$ and $B = B_0\hat{z}$ respectively. Which of the following statements is true for $t > 0$?

1. The particle moves along the x-axis.
2. The particle moves in a circular orbit.
3. The particle moves in the (x, y) plane.
4. The particle moves in the (y, z) plane.

Q.No:5 JEST-2016

The strength of magnetic field at the center of a regular hexagon with sides of length a carrying a steady current I is:

1. $\frac{\mu_0 I}{\sqrt{3}\pi a}$
2. $\frac{\sqrt{6}\mu_0 I}{\pi a}$
3. $\frac{3\mu_0 I}{\pi a}$
4. $\frac{\sqrt{3}\mu_0 I}{\pi a}$

Q.No:6 JEST-2016

A spherical shell of radius R carries a constant surface charge density σ and is rotating about one of its diameters with an angular velocity ω. The magnitude of the magnetic moment of the shell is:

1. $4\pi\sigma\omega R^4$
2. $4\pi\sigma\omega R^4/3$
3. $4\pi\sigma\omega R^4/15$
4. $4\pi\sigma\omega R^4/9$

Q.No:7 JEST-2018

An apparatus is made from two concentric conducting cylinders of radii a and b respectively, where $a < b$. The inner cylinder is grounded and the outer cylinder is at a positive potential V. The space between the cylinders has a uniform magnetic field H directed along the axis of the cylinders. Electrons leave the inner cylinder with zero speed and travel towards the outer cylinder. What is the threshold value of V below which the electrons cannot reach the outer cylinder?

1. $\frac{eH^2(b^2-a^2)}{8mc^2}$
2. $\frac{eH^2(b^2-a^2)^2}{8mc^2b^2}$
3. $\frac{eH^2(b^2-a^2)^2}{8mc^2a^2}$
4. $\frac{eH^2b\sqrt{(b^2-a^2)}}{8mc^2}$

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Q.No:8 JEST-2019

A wire with uniform line charge density λ per unit length carries a current I as shown in the figure. Take the permittivity and permeability of the medium to be $\varepsilon_0 = \mu_0 = 1$. A particle of charge q is at a distance r and is traveling along a trajectory parallel to the wire. What is the speed of the charge?

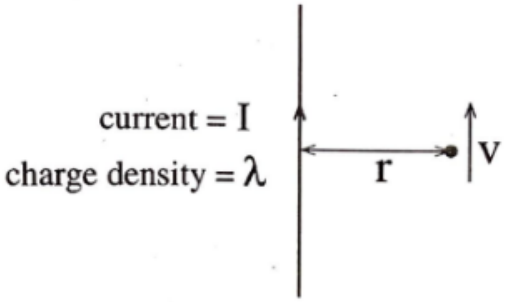


Figure 2: Wire with line charge density λ and current I.

1. $\frac{\lambda}{I}$
2. $\frac{\lambda}{2I}$
3. $\frac{\lambda}{3I}$
4. $\frac{4\lambda}{I}$

Q.No:9 JEST-2020

Consider three infinitely long, straight, and coplanar wires which are placed parallel to each other. The distance between the adjacent wires is d. Each wire carries a current I in the same direction. Consider points on either side of the middle wire where the magnetic field vanishes. What is the distance of these points from the middle wire?

1. $\frac{2d}{3}$
2. $\frac{2d}{\sqrt{3}}$
3. $\frac{d}{3}$
4. $\frac{d}{\sqrt{3}}$

Q.No:10 JEST-2021

A circular ring of radius R with total charge Q_{ring} has uniform linear charge density. It rotates about an axis passing through its centre and perpendicular to its plane with a constant angular speed ω. The magnetic field at the centre is found to be $\mathbf{B}_0$. Another thin circular disk of the same radius R has a constant surface charge density with a total charge Q_{disk}. This disk too rotates about the same axis as the ring with the same constant angular speed ω. The magnetic field at the centre in this case is found to be $10^{-3}\mathbf{B}_0$. What is the value of $Q_{\text{ring}}/Q_{\text{disk}}$?

Q.No:11 JEST-2022

An electron of kinetic energy 100 MeV moving in a region of uniform magnetic field penetrates a layer of lead. In the process it loses half of its kinetic energy. The radius of curvature of the path has changed by a factor

Q.No:12 JEST-2023

Two identical magnetic dipoles of length ℓ, which are free to rotate, are kept fixed at a distance d ($d \gg \ell$). In their minimum energy configuration, they will orient themselves

1. anti-parallel to each other and perpendicular to the line joining them
2. parallel to each other and aligned to the line joining them
3. anti-parallel to each other and aligned to the line joining them
4. parallel to each other and perpendicular to the line joining them

Q.No:13 JEST-2023

Two semi-infinite wires are placed on the x-axis, one from $-\infty$ to $-d$, and the other from d to ∞. Both wires carry a steady current I in the same direction. The magnitude of the magnetic field at a distance d away from the center of this gap in the y-z plane (ignore the charge accumulation) is:

1. $\frac{\mu_0 I}{\pi d}\sqrt{2}$
2. $\frac{\mu_0 I}{2\pi d}\left(1 - \frac{1}{\sqrt{2}}\right)$
3. $\frac{\mu_0 I}{\pi d}\frac{1}{\sqrt{2}}$
4. $\frac{\mu_0 I}{\pi d}\frac{1}{2}$

Q.No:14 JEST-2024

A magnetic vector potential is given as $\vec{A} = 6\hat{i} + yz^2\hat{j} + (3y + z)\hat{k}$. Find the corresponding outgoing magnetic flux through the five faces (excluding the shaded one) of a unit cube with one corner at the origin, as shown in the figure.

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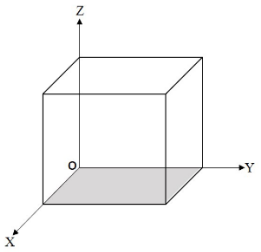


Figure 3: Unit cube with one corner at the origin.

Q.No:15 JEST-2025

A circular loop of radius a, carrying a current I in an anticlockwise direction (when seen downwards from the positive Z-axis), is placed on the XY-plane centered at the origin. What is the magnetic field on the XY-plane at $r \gg a$?

1. $\frac{\mu_0 I a^2}{4r^3}\hat{r}$
2. 0
3. $\frac{\mu_0 I a^2}{4\pi r^3}$ in the positive Z-direction
4. $\frac{\mu_0 I a^2}{4r^3}$ in the negative Z-direction

Q.No:16 JEST-2026

The vector $\vec{B}$ is defined as

$$\vec{B} = B_1 f(x)\left[\sin(ay)\,\hat{i} + \cos(ay)\,\hat{j}\right] + 2B_0 a^2 xy\,\hat{k},$$

where a, B_1 and B_0 are constants with appropriate dimensions. For which of the following forms of the function $f(x)$ will $\vec{B}$ be a valid magnetic field?

1. e^{ax}
2. $\ln(ax)$
3. $\sin(ax)$
4. ax

TIFR Questions

Q.No:1 TIFR-2012

Consider three identical infinite straight wires A, B and C arranged in parallel on a plane as shown in the figure.

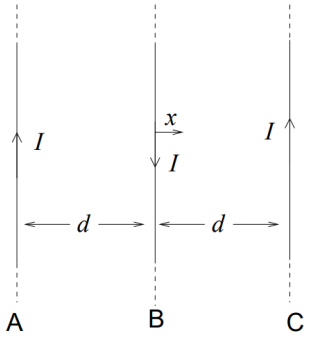


Figure 4: Three parallel wires A, B, C.

The wires carry equal currents I with directions as shown in the figure and have mass per unit length m. If the wires A and C are held fixed and the wire B is displaced by a small distance x from its position, then it (B) will execute simple harmonic motion with a time period

1. $2\pi\sqrt{\frac{m}{\pi\mu_0}}\left(\frac{d}{I}\right)$
2. $2\pi\sqrt{\frac{2\pi m}{\mu_0}}\left(\frac{d}{I}\right)$
3. $2\pi\sqrt{\frac{m}{2\pi\mu_0}}\left(\frac{d}{I}\right)$
4. $2\pi\sqrt{\frac{m}{\mu_0}}\left(\frac{d}{I}\right)$

Q.No:2 TIFR-2014

A short solenoid with n turns per unit length has diameter D and length $L = 8D/15$, as shown in the figure, and it carries a constant current I.

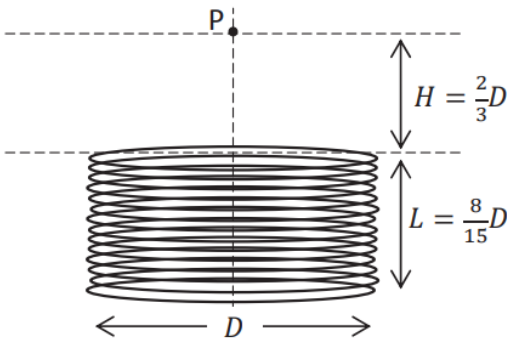


Figure 5: Short solenoid of diameter D and length L.

The magnetic field B at a point P on the axis of the solenoid at a distance $H = 2D/3$ from its near end (see figure) is

[use $\int dx\,(1+x^2)^{-3/2} = x(1+x^2)^{-1/2}$]

1. $\frac{4}{65}\mu_0 nI$

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2. $\frac{4}{13}\mu_0 nI$
3. $\frac{24}{15}\mu_0 nI$
4. $\frac{112}{65}\mu_0 nI$

Q.No:3 TIFR-2015

Two semi-infinite solenoids placed next to each other are separated by a small gap of width W as shown in the figure.

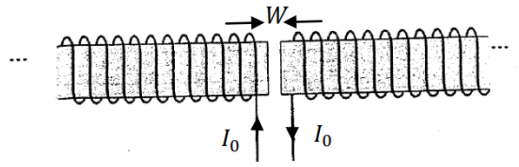


Figure 6: Two semi-infinite solenoids separated by a gap W.

The current I_0 in the solenoids flows in the direction as shown. If the solenoids have a circular cross-section of radius R and are filled with a magnetic material of permeability μ ($\mu > \mu_0$), then the magnetic energy densities u_i inside the solenoid and u_g in the gap are best related by

1. $u_g > u_i$
2. $u_g < u_i$
3. $u_g = c\,u_i$
4. $u_g > c\,u_i$

Q.No:4 TIFR-2016

A circular loop of fine wire of radius R carrying a current I is placed in a uniform magnetic field B perpendicular to the plane of the loop. If the breaking tension of the wire is T_b, the wire will break when the magnetic field exceeds

1. T_b/IR
2. $T_b/2\pi IR$
3. $\mu_0 T_b/2\pi IR$
4. $\mu_0 T_b/4\pi IR$

Q.No:5 TIFR-2016

In an ionization experiment conducted in the laboratory, different singly-charged positive ions are produced and accelerated simultaneously using a uniform electric field along the x-axis. If we need to determine the masses of various ions produced, which of the following methods will NOT work

1. Detect them at a fixed distance from the interaction point along x-axis and measure their time of arrival.
2. Apply a uniform magnetic field along y-axis and measure the deviation.
3. Apply a uniform electric field along y-axis and measure the deviation.
4. Apply a uniform electric field along y-axis and a (variable) uniform magnetic field along z-axis simultaneously and note the zero deviation.

Q.No:6 TIFR-2019

Consider three straight, coplanar, parallel wires of infinite length where the distance between adjacent wires is d. Each wire carries a current I in the same direction. The perpendicular distance from the middle wire (on either side) where the magnetic field vanishes is

1. $d/\sqrt{3}$
2. $2d/3$
3. $d/3$
4. $2d/\sqrt{3}$

Q.No:7 TIFR-2020

Four students were asked to write down possible forms for the magnetic vector potential $\vec{A}(\vec{x})$ corresponding to a uniform magnetic field of magnitude B along the positive z direction. Three returned correct answers and one returned an incorrect answer. Their answers are reproduced below. Which was the incorrect answer?

1. $Bx\hat{j}$
2. $-By\hat{i}$
3. $\frac{1}{2}(Bx\hat{i} - By\hat{j})$
4. $\frac{1}{2}(-By\hat{i} + Bx\hat{j})$

Q.No:8 TIFR-2020

The magnetic vector potential $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$ is defined in a region R of space by

$$A_x = 5\cos(\pi y), \qquad A_y = 2 + \sin(\pi x), \qquad A_z = 0$$

in an appropriate unit.

If L be a square loop of wire in the x-y plane, with its corners at

$$(0,0), \quad (0,0.25), \quad (0.25,0.25), \quad (0.25,0)$$

in an appropriate unit and it lies entirely in the region R, the numerical value of the flux of the above magnetic field (in the same units) passing through L is

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1. 0.543
2. 3.31
3. -0.75
4. zero

Q.No:9 TIFR-2022

An electromagnet is made by winding N turns of wire around a wooden cylinder of diameter d and passing a current I through it. When the current flows, a magnetic field of magnitude B is produced at a perpendicular distance z_0 from the axis of the cylinder, where $z_0 \gg d$.

If the number of turns N, the diameter of the wooden cylinder d and the current I are all doubled, then the magnitude of the magnetic field will be $B/2$ at a distance $z =$

1. $3.2\, z_0$
2. $0.5\, z_0$
3. $4.8\, z_0$
4. $2.4\, z_0$

Q.No:10 TIFR-2022

Two co-axial solenoids A and B, one placed completely inside the other, have the following parameters:

Solenoid	No of turns	Length	Diameter
A	1000	50 cm	2 cm
B	2000	50 cm	4 cm

Figure 7: Co-axial solenoids A and B.

The mutual inductance between the solenoids is

1. 1.58 mH
2. 125.7 mH
3. 395.0 mH
4. 12.57 mH

Q.No:11 TIFR-2024

A mass spectrometer consists of a parallel plate capacitor with plates A and B that accelerates ions through an electric potential V, which is followed by a box carrying a uniform magnetic field B of magnitude 0.2 Tesla (coming out of the page as shown).

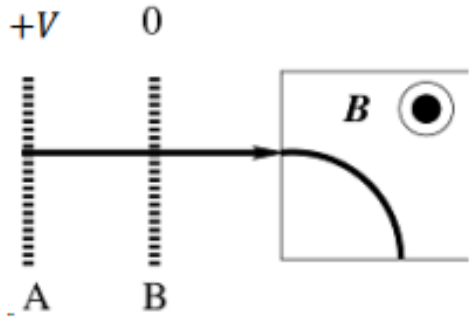


Figure 8: Mass spectrometer setup.

This setup is used to separate two isotopes of Uranium:

1. ^{235}U (mass $= 3.93 \times 10^{-25}$ kg)
2. ^{238}U (mass $= 3.98 \times 10^{-25}$ kg)

Singly charged ions (charge $+e$) of the two isotopes are created at the plate A and pass without energy loss through plate B into the box. In order to separate the isotopes, their radii of curvature in the box must differ by 2 mm. What is the approximate V through which the ions must be accelerated in order to achieve this?

1. 800 Volts
2. 8000 Volts
3. 80 Volts
4. 8 Volts

Q.No:12 TIFR-2025

An experimental set-up needs to be kept in an environment with zero magnetic field by minimizing the Earth's magnetic field. This can be achieved by:

1. Keeping the setup in a place completely covered with a sheet of metal of very high magnetic permeability
2. Keeping the setup in a place completely covered with a sheet of metal of very high permittivity
3. Keeping the setup at the centre of the interior of a long solenoid
4. Keeping the setup in a place completely covered with a sheet of an insulating material

Q.No:13 TIFR-2025

A negative electric charge $-q$ moves in a (classical) circular orbit at a non-relativistic speed v around a positive charge. The magnetic field at the centre of the circular orbit due to the negative charge is found to be B_1. Now, consider another situation where a negative charge $-2q$

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moves in a circular orbit at the same speed v around the same positive charge. The magnetic field at the centre of the circular orbit in this case is B_2. What is the ratio B_2/B_1?

1. 1/2
2. 1
3. 2
4. 4

Q.No:14 TIFR-2025

There is a uniform electric field $E\hat{x}$ between two parallel plates of a capacitor (parallel to the xz-plane). The plates are placed in a uniform magnetic field $B\hat{z}$ which fills the entire region (inside and outside the capacitor). Charged particles enter the capacitor through a small aperture A. They exit from a small aperture A' at the other end, if they do not deviate from a straight line path. There is a detector plate D in the xz-plane passing through A'. D detects where the particles impinge. What is the displacement vector $\vec{r}$ between the impact point S and the aperture A' for a particle with mass m and charge q? (This device is a simple version of a mass spectrometer.)

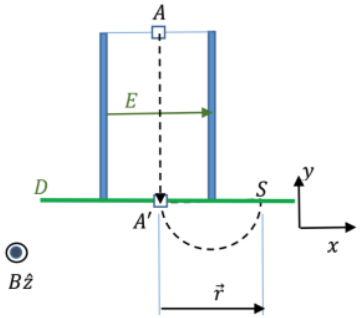


Figure 9: Capacitor with crossed E and B fields and detector plate D.

1. $-\frac{2mE}{qB^2}\hat{x}$
2. $-\frac{mE}{qB^2}\hat{x}$
3. $-\frac{mE}{2qB^2}\hat{x}$
4. $\frac{mE}{qB^2}\hat{x}$

Question No.	Entrance with year	
1	JEST-2012	Option (d)
2	JEST-2013	Option (c)
3	JEST-2014	Option (c)
4	JEST-2015	Option (c)
5	JEST-2016	Option (D)
6	JEST-2016	Option (B)
7	JEST-2018	Option (B)
8	JEST-2019	Option (A)
9	JEST-2020	Option (D)
10	JEST-2021	2000
11	JEST-2022	0.50
12	JEST-2023	Option (b)
13	JEST-2023	Option (b)
14	JEST-2024	0
15	JEST-2025	Option (d)
16	JEST-2026	Option (a)
1	TIFR-2012	Option (c)
2	TIFR-2014	Option (a)
3	TIFR-2015	Option (a)
4	TIFR-2016	Option (a)
5	TIFR-2016	Option (c)
6	TIFR-2019	Option (a)
7	TIFR-2020	Option (a)
8	TIFR-2020	Option (a)
9	TIFR-2022	Option (a)
10	TIFR-2022	Option (a)
11	TIFR-2024	Option (a)
12	TIFR-2025	Option (a)
13	TIFR-2025	No options are correct
14	TIFR-2025	Option (a)

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