Magnetic Field JEE Main PYQ - 2

Total Time: 1 Hour **Total Marks:** 100

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Magnetic Field

1. Given below are two statements: **(+4, -1)**
Statement I: For diamagnetic substance $-1 \leq X < 0$, where X is the magnetic susceptibility.
Statement II: Diamagnetic substances when placed in an external magnetic field, tend to move from stronger to weaker part of the field.
In the light of the above statements, choose the correct answer from the options given below.

a. Both Statement I and Statement II are true.

b. Both Statement I and Statement II are false.

c. Statement I is correct but Statement II is false.

d. Statement I is incorrect but Statement II is true.

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2. The amplitude of magnetic field in an electromagnetic wave propagating along y-axis is 6.0×10^{-7} T. The maximum value of electric field in the electromagnetic wave is **(+4, -1)**

a. 6.0×10^{-7} Vm^{-1}

b. 180 Vm^{-1}

c. 2×10^{15} Vm^{-1}

d. 5×10^{14} Vm^{-1}

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3. A bar magnet is released from rest along the axis of a very long, vertical aluminum tube. After sometime the magnet will : **(+4, -1)**

a. move down with an acceleration equal to g

b. move down with an acceleration grater than g

c. will move with almost constant speed

d. oscillate inside the tube

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4. **Given below are two statements:** **(+4, -1)**
Statement I : The diamagnetic property depends on temperature.
Statement II : The included magnetic dipole moment in a diamagnetic sample is always opposite to the magnetizing field.
In the light of given statement, choose the correct answer from the options given below:

a. Both Statement I and Statement II are true.

b. Both Statement I and Statement II are false.

c. Statement I is correct but Statement II is false.

d. Statement I is incorrect but Statement II is true

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5. The source of time varying magnetic field may be **(+4, -1)**
(A) a permanent magnet
(B) an electric field changing linearly with time
(C) direct current
(D) a decelerating charge particle
(E) an antenna fed with a digital signal
Choose the correct answer from the options given below:

a. (A) only

b. (D) only

c. (C) and (E) only

d. (B) and (D) only

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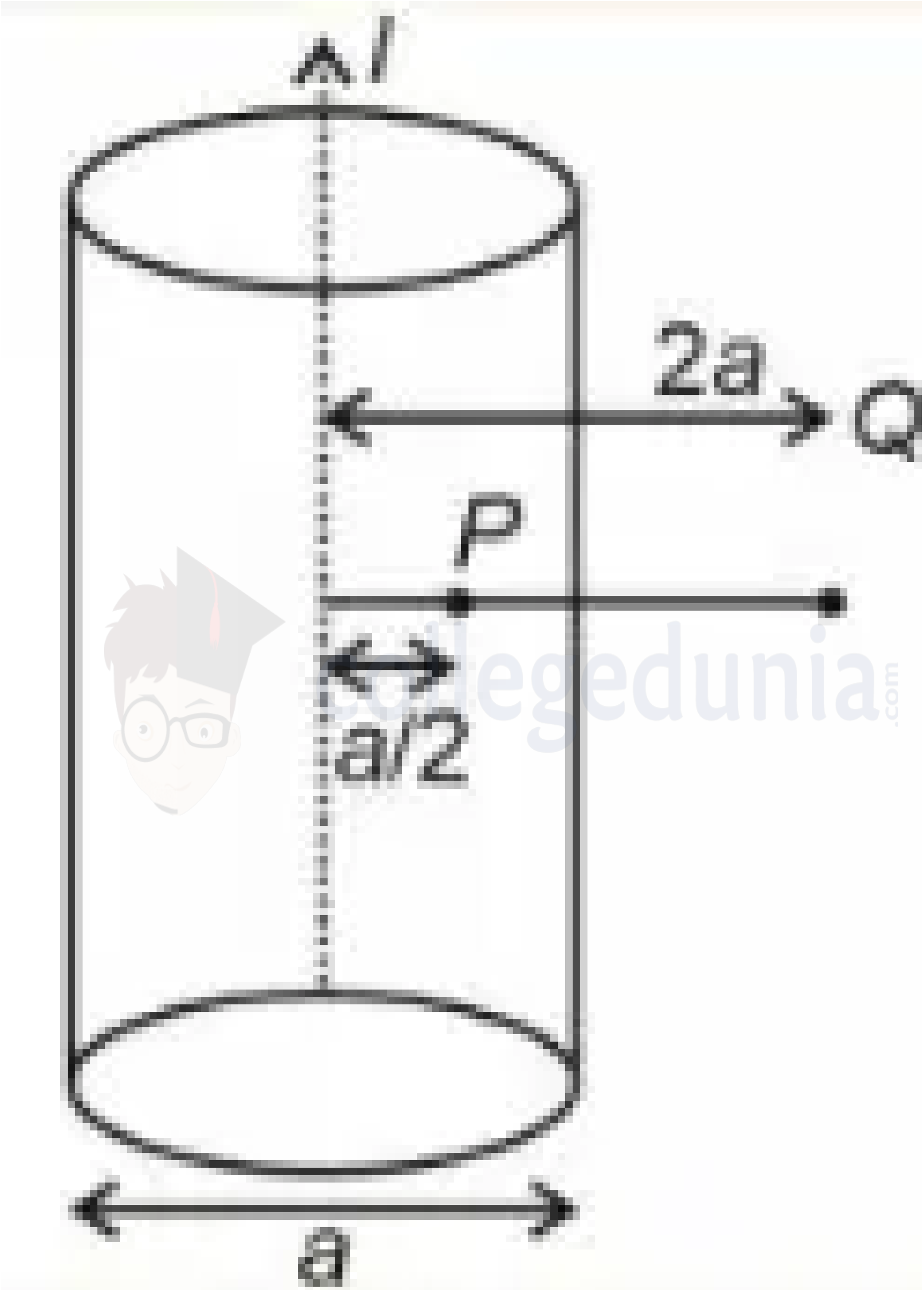
6. Find ratio of magnetic field at point P to that at point Q. Point P is inside the solid cylinder and Q is outside the cylinder. Current is uniform through the crosssection of cylinder. **(+4, -1)**



a. 2:1

b. 1:1

c. 1:2

d. 4:1

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7. A straight wire AB of mass 40 g and length 50 cm is suspended by a pair of flexible leads in uniform magnetic field of magnitude 0.40 T as shown in the figure. The magnitude of the current required in the wire to remove the tension in the supporting leads is (Take g = 10 ms^{-2}). **(+4, -1)**

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8. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R **(+4, -1)**

Assertion (A): A bar magnet dropped through a metallic cylindrical pipe takes more time to come down compared to a non-magnetic bar with same geometry and mass.

Reason (R) : For the magnetic bar, Eddy currents are produced in the metallic pipe which oppose the motion of the magnetic bar.

In the light of the above statement, choose the correct answer from the options given below :

a. Both A and R are true and R is the correct explanation of A

b. A is false but R is true

c. Both A and R are true but R is NOT the correct explanation of A

d. A is true but R is false

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9. A solenoid having 60 turns and length 15 cm produces magnetic field of 2.4 × 10^{-3} T, Find the current in the solenoid (+4, -1)

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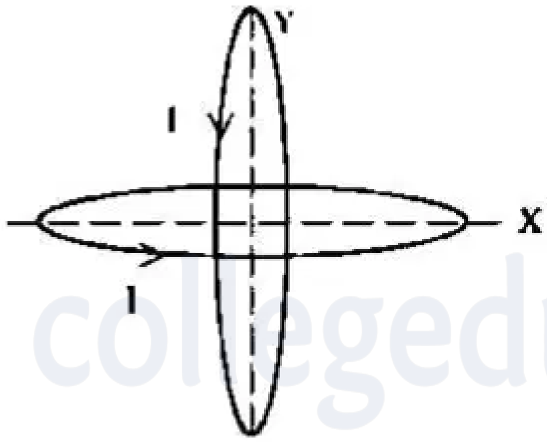
10. Two identical circular wires of radius 20 cm and carrying current $\sqrt{2}$A are placed in perpendicular planes as shown in figure. The net magnetic field at the centre of the circular wires is __________ × 10^{-8} T. (+4, -1)



(Take $\pi = 3.14$)

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11. The magnetic flux through a loop varies with time as $\Phi = 5t^2 - 3t + 5$. If the resistance of loop is 8 , find the current through it at $t = 2\ s$ (+4, -1)

a. $\frac{15}{8}A$

b. $\frac{5}{8}A$

c. $\frac{17}{8}A$

d. $\frac{13}{8}A$

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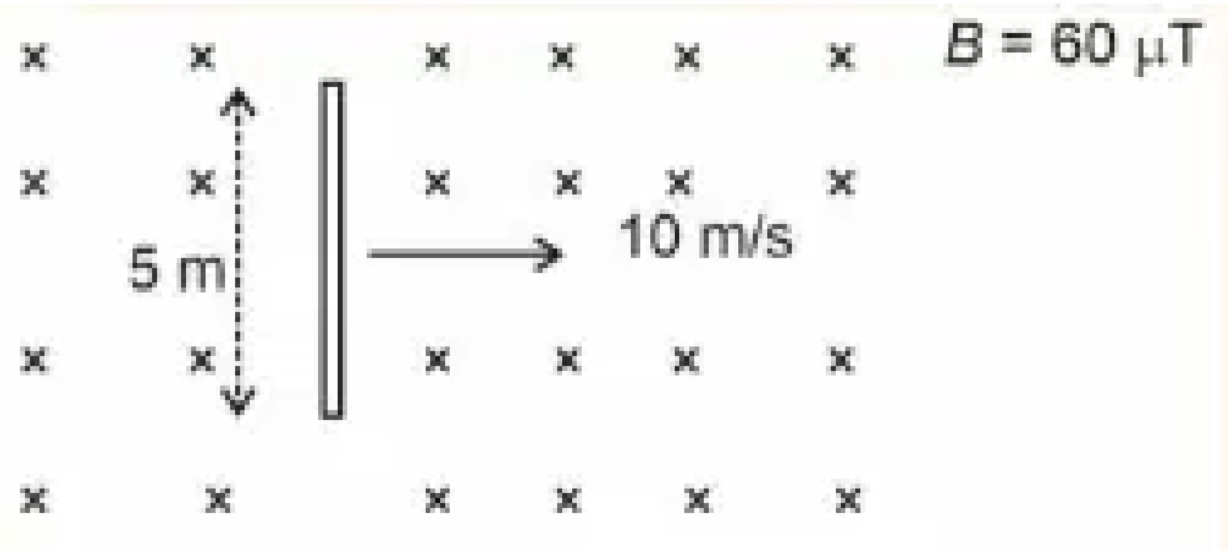
12. Consider a rod moving in a magnetic field as shown: (+4, -1)



The induced emf across the ends of the rod is

a. 3 mV

b. 6 mV

c. 0 V

d. 1 mV

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13. The vertical component of the earth's magnetic field is 6×10^{-5} T at any place where the angle of dip is 37°. The earth's resultant magnetic field at that place will be (Given tan 37° = ¾) **(+4, -1)**

a. $8x10^{-5}$ T

b. $6x10^{-5}$ T

c. $5x10^{-4}$ T

d. $1x10^{-4}$ T

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14. The space inside a straight current carrying solenoid is filled with a magnetic material having magnetic susceptibility equal to 1.2×10^{-5}. What is fractional increase in the magnetic field inside solenoid with respect to air as medium inside the solenoid? **(+4, -1)**

a. 1.2 × 10^{-5}

b. 1.2 × 10^{-3}

c. 1.8 × 10^{-3}

d. 2.4 × 10^{-5}

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15. The electric field in an electromagnetic wave is moving in a free space given as vec $E = E_0\ sin(\omega t - kz)\ i$ The corresponding magnetic field will be: **(+4, -1)**

a. $\frac{E_0}{c}\ sin(\omega t - kz)\hat{j}$

b. $\frac{E_0}{c}\ sin(\omega t - kz)\hat{j}$

c. $\frac{E_0}{c}\ cos(\omega t - kz)\hat{i}$

d. $\frac{E_0}{c}\ sin(\omega t - kz)\hat{i}$

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16. A long wire carrying current $\sqrt{(2)}A$ is placed in a uniform magnetic field of $3 \times 10^{-5}\ T$. If the magnetic field is perpendicular to wire, find magnetic force on the length of wire. **(+4, -1)**

a. $3 \times 10^{-4}\ N$

b. $3\sqrt{(2)} \times 10^{-5} N$

c. $3 \times 10^{-3}\ N$

d. Zero

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17. Two rings of equal radius R arranged perpendicular to each other with common center at C, carrying equal current I. Find magnetic field at C. **(+4, -1)**

a. $\frac{\mu_0 I}{2R}$

b. $\frac{\mu_0 I}{R}$

c. $\sqrt{\frac{2\mu_0 I}{R}}$

d. $\frac{\mu_0 I}{\sqrt{2}R}$

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18. A metallic rod of length 20 cm is placed in North-South direction and is moved at a constant speed of 20 m/s towards East. The horizontal component of the Earth's magnetic field at that place is 4×10^{-3} T and the angle of dip is $45°$. The emf induced in the rod is __________mV. **(+4, -1)**

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19. The magnetic field at the center of current carrying circular loop is B_1. The magnetic field at a distance of √3 times radius of the given circular loop from the center on its axis is B_2. The value of B_1/B_2 will be **(+4, -1)**

a. 9 : 4

b. 12 : √5

c. 8 : 1

d. 5 : √3

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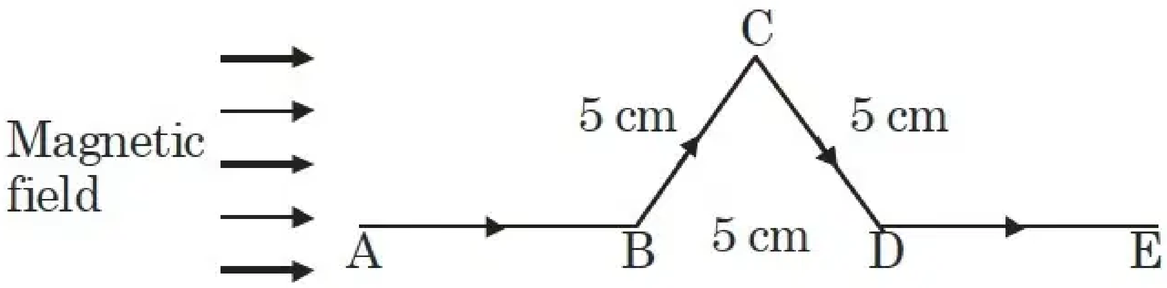
20. A triangular shaped wire carrying 10 A current is placed in a uniform magnetic field of 0.5 T, as shown in figure. The magnetic force on segment CD is (Given BC = CD = BD = 5 cm). **(+4, -1)**



a. 0.126 N

b. 0.312 N

c. 0.216 N

d. 0.245 N

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21. A circular coil of 1000 turns each with area $1\ m^2$ is rotated about its vertical diameter at the rate of one revolution per second in a uniform horizontal magnetic field of $0.07\ T$. The maximum voltage generation will be _____ V. **(+4, -1)**

22. B_X and B_Y are the magnetic field at the centre of two coils X and Y, respectively each carrying equal current. If coil X has 200 turns and 20 cm radius and coil Y has 400 turns and 20 cm radius, the ratio of B_X and B_Y is **(+4, -1)**

a. 1:1

b. 1:2

c. 2:1

d. 4:1

23. At a certain place the angle of dip is 30° and the horizontal component of earth's magnetic field is 0.5 G. The earth's total magnetic field (in G), at that certain place, is **(+4, -1)**

a. $\frac{1}{\sqrt{3}}$

b. $\frac{1}{2}$

c. $\sqrt{3}$

d. 1

24. Two parallel, long wires are kept 0.20 m apart in vacuum, each carrying current of x A in the same direction. If the force of attraction per meter of each wire is 2×10^{-6} N, then the value of x is approximately: **(+4, -1)**

a. 1

b. 2.4

c. 1.4

d. 2

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25. The space inside a straight current carrying solenoid is filled with a magnetic material having magnetic susceptibility equal to 1.2×10^{-5}. What is fractional increase in the magnetic field inside solenoid with respect to air as medium inside the solenoid? **(+4, -1)**

a. 1.2×10^{-5}

b. 1.2×10^{-3}

c. 1.8×10^{-3}

d. 2.4×10^{-5}

Answers

1. Answer: a

Explanation:

Statement I is correct: For diamagnetic substances, the magnetic susceptibility X lies between $-1 \leq X < 0$, as diamagnetic substances are repelled by the magnetic field, and their susceptibility is negative.
Statement II is also correct: Diamagnetic substances move from stronger magnetic fields to weaker magnetic fields due to their negative susceptibility. This is because diamagnetic materials tend to create an opposing magnetic field that repels the external field, thus moving to areas where the magnetic field is weaker.
Therefore, both statements are correct.

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2. Answer: b

Explanation:

In an electromagnetic wave, the amplitude of the electric field E_0 is related to the amplitude of the magnetic field B_0 by the equation:

$$E_0 = cB_0$$

where c is the speed of light $\left(3 \times 10^8 \, \mathrm{m/s}\right)$. Given that the amplitude of the magnetic field is $B_0 = 6.0 \times 10^{-7} \, \mathrm{T}$, we can calculate E_0 as follows:

$$E_0 = (6.0 \times 10^{-7}) \times (3 \times 10^8) = 18 \times 10^1 = 180 \, \mathrm{Vm}^{-1}$$

Thus, the maximum value of the electric field is $180 \, \mathrm{Vm}^{-1}$.

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3. Answer: c

Explanation:

Step 1: Understanding Lenz's Law.
According to Lenz's Law, the induced current in the copper tube due to the motion of

the bar magnet will produce a magnetic field that opposes the motion of the magnet. This means the magnet will experience a resistive force as it falls down the tube.

Step 2: Analyzing the forces.

Initially, when the bar magnet is released, it experiences an acceleration due to gravity (g). However, as the magnet moves, the changing magnetic flux through the conducting tube induces an electromotive force (EMF), which generates a current in the tube. This current creates a magnetic force that opposes the motion of the magnet, according to Lenz's Law.

Step 3: Reaching terminal velocity.

The opposing magnetic force increases as the magnet's velocity increases, and eventually, it balances the downward gravitational force. At this point, the net force on the magnet becomes zero, and the magnet moves with a constant speed, also known as terminal velocity.

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4. **Answer: d**

Explanation:

Step 1: Analyzing the given statements
Statement I: Diamagnetic properties are independent of temperature. Therefore, Statement I is incorrect.
Statement II: In diamagnetic materials, the induced magnetic dipole moment is opposite to the external magnetic field, which makes Statement II true.

Thus, the correct answer is that Statement I is incorrect, and Statement II is true.

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5. **Answer: b**

Explanation:

A time-varying magnetic field can be produced by sources that involve changing electric fields or accelerating charges. Let's analyze each option:

1. **A permanent magnet**: A permanent magnet produces a static (unchanging) magnetic field. Therefore, it does not produce a time-varying magnetic field.

2. **An electric field changing linearly with time**: A changing electric field can induce a magnetic field according to Maxwell's equations. However, if the electric field changes linearly with time (i.e., has a constant rate of change), the induced magnetic field is steady, not varying with time.
3. **Direct current**: Direct current (DC) produces a constant magnetic field. It does not produce a time-varying magnetic field.
4. **A decelerating charge particle**: An accelerating (or decelerating) charge particle produces electromagnetic waves (EMW), which have both time-varying electric and magnetic fields.
5. **An antenna fed with a digital signal**: An antenna fed with a digital signal transmits electromagnetic waves, which consist of time-varying electric and magnetic fields.

Analysis of Options:

- Option (1): (B) and (D) only
  - (B) An electric field changing linearly with time: Produces a steady induced magnetic field.
  - (D) A decelerating charge particle: Produces time-varying magnetic fields.
  - Partial: Only (D) is correct.
- Option (2): (C) and (E) only
  - (C) Direct current: Produces a constant magnetic field.
  - (E) An antenna fed with a digital signal: Produces time-varying magnetic fields.
  - Partial: Only (E) is correct.
- Option (3): (D) only
  - (D) A decelerating charge particle: Correct.
- Option (4): (A) only
  - (A) A permanent magnet: Incorrect.

Conclusion:

Only option (D) results in a time-varying magnetic field. Therefore, the correct answer is (3) (D) only.

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6. **Answer: b**

Explanation:

The Correct answer is option is (B) : 1:1

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7. Answer: 2 - 2

Explanation:

For equilibrium, the magnetic force on the wire must balance its weight:

$$F_{\text{magnetic}} = F_{\text{gravity}}.$$

The magnetic force is given by:

$$F_{\text{magnetic}} = ILB,$$

where I is the current, $L = 50\,\text{cm} = 0.5\,\text{m}$ is the length of the wire, and $B = 0.40\,\text{T}$ is the magnetic field. The gravitational force is:

$$F_{\text{gravity}} = mg,$$

where $m = 40\,\text{g} = 0.040\,\text{kg}$ and $g = 10\,\text{m/s}^2$. Equating the forces:

$$ILB = mg.$$

Solve for I:

$$I = \frac{mg}{LB}.$$

Substitute the values:

$$I = \frac{0.040 \cdot 10}{0.5 \cdot 0.40}.$$

Simplify:

$$I = \frac{0.40}{0.2} = 2\,\text{A}.$$

Thus, the required current in the wire is $\boxed{2\,\text{A}}$.

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8. Answer: a

Explanation:

When a bar magnet is dropped through a metallic cylindrical pipe, the phenomenon can be explained using Lenz's law and the induction of eddy currents:

- The changing magnetic flux due to the falling magnet induces eddy currents in the metallic pipe.
- According to Lenz's law, these eddy currents generate their own magnetic field, which opposes the change in magnetic flux caused by the falling magnet.
- This opposing magnetic field creates an upward force on the magnet, reducing its acceleration and slowing its descent.

Comparison with a Non-Magnetic Bar:

A non-magnetic bar falling through the same pipe would not induce eddy currents because it does not have a magnetic field. The forces acting on the non-magnetic bar would be:

- Gravity, pulling it downward.
- Air resistance, which slightly opposes its motion.

Since there are no additional opposing forces (like those due to eddy currents), the non-magnetic bar falls more quickly than the magnet.

Analysis of Assertion and Reason:

- **Assertion (A):** The bar magnet takes longer to fall through the pipe than a non-magnetic bar of the same geometry and mass.
- **Reason (R):** Eddy currents in the metallic pipe create opposing magnetic fields, which slow down the descent of the magnet.

Both Assertion (A) and Reason (R) are true, and Reason (R) correctly explains Assertion (A).

Final Answer:

Both Assertion (A) and Reason (R) are true, and Reason (R) correctly explains Assertion (A).

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9. **Answer: 100 - 100**

Explanation:

Given:

- Number of turns (N) = 60
- Length of the solenoid (l) = 15 cm = 0.15 m
- Magnetic field (B) = $2.4 \times 10^{-3}\,\text{T}$
- Permeability of free space (μ_0) = \(4\pi \times 10^{-7} \, \text{T·m/A} \)

Step 1: Formula for Magnetic Field in a Solenoid

The magnetic field inside a solenoid is given by the formula:

$B = \mu_0 \cdot n \cdot I$

Where:

- B: Magnetic field
- μ_0: Permeability of free space
- $n = \frac{N}{l}$: Number of turns per unit length
- I: Current in the solenoid

Step 2: Substituting Values

First, calculate the number of turns per unit length:

$$n = \frac{N}{l} = \frac{60}{0.15} = 400\,\text{turns/m}$$

Now substitute into the formula:

$$B = \mu_0 \cdot n \cdot I$$

$$2.4 \times 10^{-3} = (4\pi \times 10^{-7}) \cdot 400 \cdot I$$

Step 3: Solve for Current (I)

Rearranging the formula for I:

$$I = \frac{B}{\mu_0 \cdot n}$$

Substituting the values:

$$I = \frac{2.4 \times 10^{-3}}{(4\pi \times 10^{-7}) \cdot 400}$$

Simplify:

$$I = \frac{2.4 \times 10^{-3}}{1.6 \times 10^{-4}}$$

$$I = 100\,\text{A}$$

Step 4: Final Answer

The current in the solenoid is $\boxed{100\,\text{A}}$.

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10. Answer: 628 - 628

Explanation:

$$\overrightarrow{B_{net}} = \frac{\mu_0 i}{2r}\hat{i} + \frac{\mu_0 i}{2r}\hat{j}$$

$$\Rightarrow B_{\text{net}} = \frac{\mu_0 i}{2r}\sqrt{2} = 4\pi \times 10^{-7} \times \sqrt{2} \times \sqrt{2} \times \frac{1}{2 \times 0.2} = 2 \times 3.14 \times 10^{-6} = 628 \times 10^{-8}\,\text{T}$$

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11. Answer: c

Explanation:

The Correct Option is (C) : $\frac{17}{8}A$

Concepts:

1. Magnetic Field:

The magnetic field is a field created by moving electric charges. It is a force field that exerts a force on materials such as iron when they are placed in its vicinity. Magnetic fields do not require a medium to propagate; they can even propagate in a vacuum. Magnetic field also referred to as a vector field, describes the magnetic influence on moving electric charges, magnetic materials, and electric currents.

A magnetic field can be presented in two ways.

- **Magnetic Field Vector:** The magnetic field is described mathematically as a *vector field*. This vector field can be plotted directly as a set of many vectors drawn on a grid. Each vector points in the direction that a compass would point and has length dependent on the strength of the magnetic force.
- **Magnetic Field Lines:** An alternative way to represent the information contained within a vector field is with the use of *field lines*. Here we dispense with the grid pattern and connect the vectors with smooth lines.

Properties of Magnetic Field Lines

- Magnetic field lines never cross each other
- The density of the field lines indicates the strength of the field
- Magnetic field lines always make closed-loops
- Magnetic field lines always emerge or start from the north pole and terminate at the south pole.

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12. **Answer: a**

Explanation:

The correct option is (A): 3 mV

Concepts:

1. Magnetic Field:

The magnetic field is a field created by moving electric charges. It is a force field that exerts a force on materials such as iron when they are placed in its vicinity. Magnetic fields do not require a medium to propagate; they can even propagate in a vacuum. Magnetic field also referred to as a vector field, describes the magnetic influence on moving electric charges, magnetic materials, and electric currents.

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13. Answer: d

Explanation:

To solve this question, we need to determine the earth's resultant magnetic field at a place where the vertical component is given, and the angle of dip is provided.

Concept: The earth's magnetic field at any place can be resolved into two components:

- Vertical component B_V
- Horizontal component B_H

The angle of dip (δ) is related to these components by the following relations:

- $B_V = B \cdot \sin(\delta)$
- $B_H = B \cdot \cos(\delta)$

Given:

- The vertical component $B_V = 6 \times 10^{-5}\,\mathrm{T}$
- Angle of dip $\delta = 37^\circ$
- $\tan(37^\circ) = \frac{3}{4}$

Let's calculate the earth's resultant magnetic field:

First, use the relation for the vertical component:

$B_V = B \cdot \sin(37^\circ)$

But we know:

$\sin(37^\circ) = \frac{\tan(37^\circ)}{\sqrt{1+\tan^2(37^\circ)}}$

Calculating $\sin(37^\circ)$:

$\tan(37^\circ) = \frac{3}{4}$ therefore:

$\sin(37^\circ) = \frac{\frac{3}{4}}{\sqrt{1+\left(\frac{3}{4}\right)^2}} = \frac{\frac{3}{4}}{\sqrt{1+\frac{9}{16}}} = \frac{\frac{3}{4}}{\sqrt{\frac{25}{16}}} = \frac{\frac{3}{4}}{\frac{5}{4}} = \frac{3}{5}$

Now substitute the values:

$B_V = B \cdot \frac{3}{5}$

$6 \times 10^{-5} = B \cdot \frac{3}{5}$

Solving for B:

$B = \frac{6 \times 10^{-5} \times 5}{3} = \frac{30 \times 10^{-5}}{3} = 1 \times 10^{-4}\ \text{T}$

Therefore, the earth's resultant magnetic field at that place is **1×10^{-4} T**.

Conclusion: The correct answer is:

1×10^{-4} T

Concepts:

1. Horizontal and vertical lines:

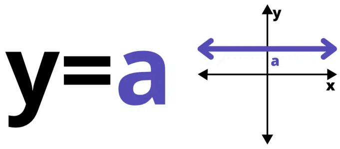
Horizontal Lines:

- A horizontal line is a sleeping line that means "side-to-side".
- These are the lines drawn from left to right or right to left and are parallel to the x-axis.

Equation of the horizontal line:

In all cases, horizontal lines remain parallel to the x-axis. It never intersects the x-axis but only intersects the y-axis. The value of x can change, but y always tends to be constant for horizontal lines.

Equation of a Horizontal Line



Vertical Lines:

- A vertical line is a standing line that means "up-to-down".
- These are the lines drawn up and down and are parallel to the y-axis.

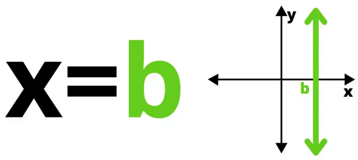
Equation of vertical Lines:

The equation for the vertical line is represented as x=a,

Here, ‘a’ is the point where this line intersects the x-axis.

x is the respective coordinates of any point lying on the line, this represents that the equation is not dependent on y.

Equation of a Vertical Line



⇒ [Horizontal lines and vertical lines] are perpendicular to each other.

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14. Answer: a

Explanation:

To find the fractional increase in the magnetic field inside a solenoid when filled with a magnetic material, we need to understand the effect of magnetic susceptibility on the magnetic field inside the solenoid.

1. **Magnetic Field Inside a Solenoid:**

For a solenoid with air inside, the magnetic field B_0 is given by:

$$B_0 = \mu_0 \cdot n \cdot I$$

where:

- μ_0 = permeability of free space
- n = number of turns per unit length of the solenoid
- I = current through the solenoid

2. **Effect of Magnetic Material:**

When a magnetic material with susceptibility χ_m is inserted inside the solenoid, the permeability becomes:

$$\mu = \mu_0(1 + \chi_m)$$

The new magnetic field B inside the solenoid is:

$$B = \mu \cdot n \cdot I = \mu_0(1 + \chi_m) \cdot n \cdot I$$

3. **Fractional Increase in the Magnetic Field:**

The fractional increase in the magnetic field is given by:

$$\text{Fractional increase} = \frac{B - B_0}{B_0} = \frac{\mu_0(1+\chi_m) - \mu_0}{\mu_0} = \chi_m$$

Given $\chi_m = 1.2 \times 10^{-5}$, the fractional increase in the magnetic field is simply this susceptibility value:

$$\text{Fractional increase} = 1.2 \times 10^{-5}$$

Therefore, the correct answer is the fractional increase is 1.2×10^{-5}.

Concepts:

1. Magnetic Field:

The magnetic field is a field created by moving electric charges. It is a force field that exerts a force on materials such as iron when they are placed in its vicinity. Magnetic fields do not require a medium to propagate; they can even propagate in a vacuum. Magnetic field also referred to as a vector field, describes the magnetic influence on moving electric charges, magnetic materials, and electric currents.

A magnetic field can be presented in two ways.

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Properties of Magnetic Field Lines

- Magnetic field lines never cross each other
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- Magnetic field lines always make closed-loops
- Magnetic field lines always emerge or start from the north pole and terminate at the south pole.

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15. Answer: b

Explanation:

The Correct Option is (B): $\frac{E_0}{c} sin(\omega t - kz)\hat{j}$

Concepts:

1. Magnetic Field:

The magnetic field is a field created by moving electric charges. It is a force field that exerts a force on materials such as iron when they are placed in its vicinity. Magnetic fields do not require a medium to propagate; they can even propagate in a vacuum. Magnetic field also referred to as a vector field, describes the magnetic influence on moving electric charges, magnetic materials, and electric currents.

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16. **Answer: b**

Explanation:

The Correct Option is (B): $3\sqrt{(2)} \times 10^{-5} N$

Concepts:

1. **Magnetic Field:**

The magnetic field is a field created by moving electric charges. It is a force field that exerts a force on materials such as iron when they are placed in its vicinity. Magnetic fields do not require a medium to propagate; they can even propagate in a vacuum. Magnetic field also referred to as a vector field, describes the magnetic influence on moving electric charges, magnetic materials, and electric currents.

A magnetic field can be presented in two ways.

- **Magnetic Field Vector:** The magnetic field is described mathematically as a *vector field*. This vector field can be plotted directly as a set of many vectors drawn on a grid. Each vector points in the direction that a compass would point and has length dependent on the strength of the magnetic force.
- **Magnetic Field Lines:** An alternative way to represent the information contained within a vector field is with the use of *field lines*. Here we dispense with the grid

pattern and connect the vectors with smooth lines.

Properties of Magnetic Field Lines

- Magnetic field lines never cross each other
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17. **Answer: a**

Explanation:

The Correct Option is (D): $\frac{\mu_0 I}{\sqrt{2}R}$

Concepts:

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18. **Answer: 16 - 16**

Explanation:

The emf induced in the rod is $\underline{16}$ mV.

$E \;=\; Blv$

$=4 \times 10^{-3} \times \frac{20}{100} \times 20 \ Volts$

$= 16 \ mV$

Concepts:

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19. **Answer: c**

Explanation:

$$B_1 = \frac{\mu 0 I}{2R}$$
$$B_2 = \frac{\mu 0 I R^2}{2(R^2+3R^2)^{3/2}} = \frac{1}{8}(\frac{\mu 0 I}{2R}) = \frac{B_1}{8} \frac{B_1}{B_2} = \frac{8}{1}$$

Concepts:

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20. **Answer: c**

Explanation:

$$F_m(CD) = BIl_{eff} = 0.5 \times (10) \times (5sin60 \times 10^{-2}) = 0.216N$$

Concepts:

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21. **Answer: 440 - 440**

Explanation:

The maximum voltage generation,
$V_{max} = NAB\omega$
$V_{max} = 1000 \times 1 \times 0.07 \times (2\pi \times 1)$
$V_{max} \cong 440\ V$
So, the answer is $440\ V$.

Concepts:

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22. **Answer: b**

Explanation:

$B = \frac{\mu_0 NI}{2R}$

$\frac{B_x}{B_y} = \frac{N_x R_y}{N_y R_x}$

$\frac{B_x}{B_y} = \frac{200 \times 20}{400 \times 20}$

$\frac{B_x}{B_y} = \frac{1}{2}$

So, the correct option is (B): $1 : 2$

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23. **Answer: a**

Explanation:

The correct option is(A): $\frac{1}{\sqrt{3}}$

B_H = Bcos30°

$\Rightarrow B = \frac{1}{\sqrt{3}}G$

Concepts:

1. **Earth's Magnetic field:**

The Earth's magnetic field stretches millions of kilometers into space and resembles a bar magnet. The earth's magnetic pole is positioned between the Northern Pole and the North Pole's Antarctic magnets. That is why a compass magnet's north pole points north (north and south poles attract).

The Earth's magnetic field extends far and wide, but it is very small in terms of field power. It has a field power of merely 40,000 nT as compared to a refrigerator magnet which has a power of 107 nT.

Theory of Earth's Magnetism

- **The Dynamo Effect:** The outer core of the earth has molten Iron and other heavy elements in liquid form. The inner core solidifies under the influence of gravity. Therefore, the motion of metallic fluids in the outer core of the earth causes an electric current. Thus, the earth gets its own magnetic field lines.
- **Ionization of the Outer Layers:** This theory tells us that the rotation of the earth in its own axis produces strong electric current due to the ionization of the outer layers of earth. This produces magnetism due to the movement of the ions. However, the magnetic field will be very weak. The Dynamo Effect is the more acceptable theory.

Components of Earth's Magnetic Field

These are the components that are responsible for the magnitude and direction of the magnetic field of the earth at a given location:

- Magnetic Declination
- Horizontal Component of Earth's Magnetic Field
- The angle of Dip or Magnetic Inclination

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24. Answer: c

Explanation:

$\frac{dF}{dl} = 2 \times 10^{-6}\ N/m = \frac{\mu_0 i_1 i_2}{2\pi d}$

$2 \times 10^{-6} = \frac{2\times10^{-7}\times x^2}{0.2}$

x= $\sqrt{2}$≃1.4

So, the correct option is (C): 1.4

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25. **Answer: a**

Explanation:

$\vec{B}' = \mu 0(1 - X)ni$ in the material
$\vec{B} = \mu_0 ni$ without material

So, fractional increase is
$\frac{B' - B}{B} = X = 1.2 \times 10^{-5}$

So, the correct option is (A): 1.2×10^{-5}

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