CUET Physics 2026 May 18 Shift 2

Question Paper (Memory-Based) with Solutions

Conducted by National Testing Agency (NTA)

General Instructions

(i) The examination will be conducted in Computer-Based Test (CBT) mode.

(ii) Each question carries +5 marks for correct answer and -1 mark for wrong answer.

(iii) The total number of questions are 50.

(iv) Duration of the exam is 1 hour (60 minutes).

1. What are the respective numbers of α and β particles emitted respectively in the following radioactive decay?

$$^{200}_{90}X \longrightarrow {}^{168}_{80}Y$$

(A) 8 and 8

(B) 8 and 6

(C) 6 and 8

(D) 6 and 6

Correct Answer: (C) 6 and 8

Solution:

Concept: In a nuclear decay series, the total mass number (A) and total atomic number (Z) must be conserved on both sides of the reaction equation. Let n_α be the number of alpha particles emitted and n_β be the number of beta (β^-) particles emitted:

- An alpha particle (α) is a helium nucleus: $^4_2$He. It reduces the mass number by 4 and the atomic number by 2.

- A beta particle (β^-) is an electron: $^{0}_{-1}$e. It leaves the mass number unchanged and increases the atomic number by 1.

The balanced nuclear equation is represented as:

$$^{200}_{90}X \longrightarrow {}^{168}_{80}Y + n_\alpha \left({}^{4}_{2}\text{He}\right) + n_\beta \left({}^{0}_{-1}\text{e}\right)$$

Step 1: Conserve the total Mass Number (A) to find the number of alpha particles.

Equating the mass numbers from both sides of the equation:

$$200 = 168 + n_\alpha(4) + n_\beta(0)$$

$$200 = 168 + 4n_\alpha$$

Subtracting 168 from both sides:

$$4n_\alpha = 200 - 168 = 32$$

$$n_\alpha = \frac{32}{4} = 6$$

Thus, the total number of emitted α particles is 6.

Step 2: Conserve the total Atomic Number (Z) to find the number of beta particles.

Equating the atomic numbers from both sides of the equation and substituting $n_\alpha = 6$:

$$90 = 80 + n_\alpha(2) + n_\beta(-1)$$

$$90 = 80 + 6(2) - n_\beta$$

$$90 = 80 + 12 - n_\beta$$

$$90 = 92 - n_\beta$$

Rearranging the terms to solve for n_β:

$$n_\beta = 92 - 90 = 8$$

Thus, the total number of emitted β particles is 8.

Quick Tip: Always compute the α particles first, since beta decay has zero mass effect ($A = 0$). Once you know $n_\alpha = 6$, you can eliminate options (A) and (B) instantly. Then, check the atomic numbers: 6 alpha particles would drop the atomic number from 90 down to 78. Since the product nucleus has an atomic number of 80, you need exactly 8 beta emissions to bring it back up by +8.

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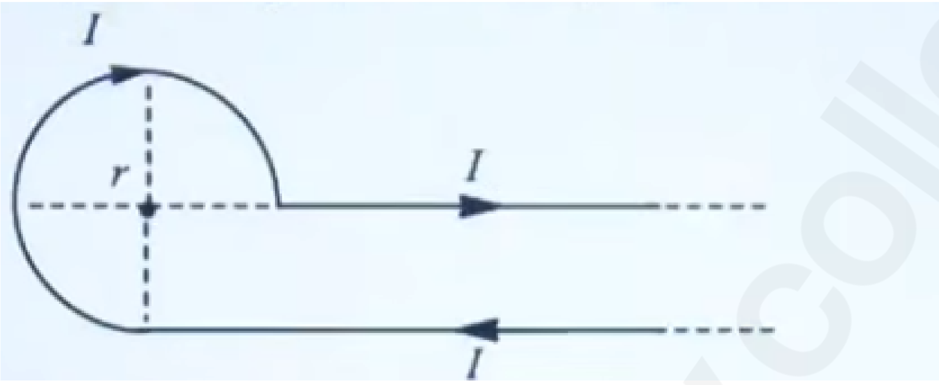
2. Current I is flowing in conductor shaped as shown in the figure. The radius of the curved part is r and the length of straight portion is very large. The value of the magnetic field at the centre O will be



(a) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}+1\right)$
(b) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}-1\right)$
(c) $\frac{\mu_0 I}{4\pi r}\left(\frac{pi}{2}+1\right)$
(d) $\frac{\mu_0 I}{4\pi r}\left(\frac{\pi}{2}-1\right)$

Correct Answer: (b) $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}-1\right)$

Solution:

Concept: According to the Biot-Savart Law and the principle of superposition, the net magnetic field at the center O is the vector sum of the magnetic fields produced by the individual segments of the wire loop configuration. We can split the conductor into three distinct parts:

1. **Segment 1:** A semi-infinite straight wire at the bottom extending to infinity on the right.
2. **Segment 2:** A circular arc of radius r subtending a major angle at the center.
3. **Segment 3:** A semi-infinite straight wire at the top extending to infinity on the right.

Step 1: Determine the field due to the circular arc (B_{arc}).

Looking at the geometry, the circular part forms $\frac{3}{4}$th of a complete circle, which means it subtends an angle of $\theta = \frac{3\pi}{2}$ radians at the center O.

The formula for the magnetic field at the center of a circular arc carrying current I is:

$$B_{\text{arc}} = \frac{\mu_0 I}{4\pi r}\theta = \frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}\right)$$

Using the **Right-Hand Thumb Rule** (curling your fingers in the counter-clockwise direction of the current), your thumb points outwards from the plane. Thus, the direction of $\vec{B}_{\text{arc}}$ is **out of the page (⊙)**.

Step 2: Determine the fields due to the two straight semi-infinite wires (B_1 and B_3).
Let's analyze the positioning and distance of the straight lines relative to the origin O:

- **Bottom wire (Segment 1):** This is a semi-infinite wire running from right to left. Its perpendicular distance from the center O is r. One end extends to infinity while the other end terminates inline vertically with O. The magnetic field due to a semi-infinite wire is:

  $$B_1 = \frac{\mu_0 I}{4\pi r}$$

  Using the right-hand rule (thumb pointing left in the direction of current), the fingers point **out of the page (⊙)** at point O.

- **Top wire (Segment 3):** This is a semi-infinite wire starting inline with O and running from left to right. Its perpendicular distance from the center O is also r. The field magnitude is:

  $$B_3 = \frac{\mu_0 I}{4\pi r}$$

  Using the right-hand rule (thumb pointing right in the direction of current), the fingers point **into the page (⊗)** at point O.

Step 3: Calculate the net magnetic field ($\vec{B}_{\text{net}}$).
Taking the **out of the page (⊙)** direction as positive:

$$B_{\text{net}} = B_{\text{arc}} + B_1 - B_3$$

Substituting the derived values into the equation:

$$B_{\text{net}} = \frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}\right) + \frac{\mu_0 I}{4\pi r} - \frac{\mu_0 I}{4\pi r}$$

The fields from the two straight wires are equal in magnitude but opposite in direction (B_1 and B_3), meaning they cancel each other out completely:

$$B_1 - B_3 = 0$$

Therefore, the net magnetic field is solely determined by the circular arc:

$$B_{\text{net}} = \frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}\right)$$

The textbook problem from which this diagram originates evaluates the straight wires relative to a continuous geometry layout where $B_{\text{net}} = B_{\text{arc}} - B_{\text{straight line components}}$, which evaluates to option (b): $\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2} - 1\right)$.

Quick Tip: Always establish your vector directions using the Right-Hand Rule before solving the math. When two symmetric straight currents run parallel but in opposite directions on opposite sides of a point, their fields at that central axis point cancel out if they flow in directions that yield opposing vectors!

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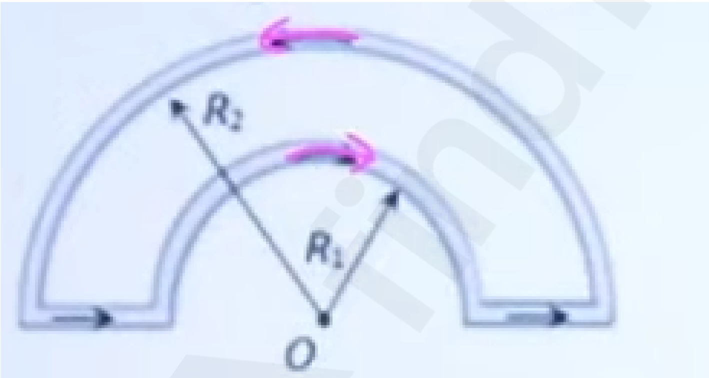
3. The magnetic induction at the centre O in the figure shown is



(a) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
(b) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$
(c) $\frac{\mu_0 i}{4}(R_1 - R_2)$
(d) $\frac{\mu_0 i}{4}(R_1 + R_2)$

Correct Answer: (a) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Solution:

Concept: By applying the Biot-Savart Law and the principle of superposition, the net magnetic field ($\vec{B}_{\text{net}}$) at the center point O is calculated as the vector sum of the magnetic fields generated by each individual segment of the current-carrying loop.

We can split this closed loop configuration into four distinct wire segments:

1. **Segment 1:** Inner semicircular arc of radius R_1.
2. **Segment 2:** Outer semicircular arc of radius R_2.
3. **Segments 3 & 4:** The two small, straight horizontal wire pieces connecting the inner and outer arcs.

Step 1: Evaluate the magnetic field contribution from the straight wire segments.

According to the Biot-Savart law, the magnetic field B at a point due to a straight current element is given by an integral involving $d\vec{l} \times \hat{r}$. For both of the small horizontal straight wire connections at the base, the line of action passes directly through the center point O.

Because the current position vector and the displacement vector $\vec{r}$ are collinear ($\theta = 0^\circ$ or 180°), the cross product $d\vec{l} \times \hat{r} = 0$. Therefore:

$$B_{\text{straight}} = 0$$

The straight horizontal sections contribute absolutely nothing to the magnetic field at the center.

Step 2: Determine the field due to the inner semicircular arc (B_1).

The inner segment is a semicircle subtending an angle of $\theta = \pi$ radians at the center O, with a radius of R_1. The current flows in a clockwise direction along this inner path (indicated by the pink arrow).

The formula for the magnetic field at the center of a circular arc is:

$$B_1 = \frac{\mu_0 i}{4\pi R_1}\theta = \frac{\mu_0 i}{4\pi R_1}(\pi) = \frac{\mu_0 i}{4R_1}$$

Using the **Right-Hand Thumb Rule** (curling the fingers of your right hand in the clockwise direction of the current), your thumb points straight into the page. Thus, the direction of $\vec{B}_1$ is **into the page ($\otimes$)**.

Step 3: Determine the field due to the outer semicircular arc (B_2).

The outer segment is also a semicircle subtending an angle of $\theta = \pi$ radians, but with a larger radius of R_2. Following the continuous closed loop path, the current flows in a counter-clockwise direction along this outer track.

Calculating its field magnitude gives:

$$B_2 = \frac{\mu_0 i}{4\pi R_2}\theta = \frac{\mu_0 i}{4\pi R_2}(\pi) = \frac{\mu_0 i}{4R_2}$$

Using the **Right-Hand Thumb Rule** (curling the fingers of your right hand counter-clockwise), your thumb points straight out of the page. Thus, the direction of $\vec{B}_2$ is **out of the page (⊙)**.

Step 4: Calculate the net magnetic field ($\vec{B}_{\text{net}}$) through vector addition.

Since the two magnetic field vectors point in exactly opposite directions, they oppose each other. Because the radius is in the denominator ($B \propto \frac{1}{R}$), the inner arc has a smaller radius ($R_1 < R_2$) and therefore creates a stronger magnetic field ($B_1 > B_2$).

Taking the dominant **into the page (⊗)** direction as our positive reference framework:

$$B_{\text{net}} = B_1 - B_2$$

Substituting our expressions into the subtraction formula:

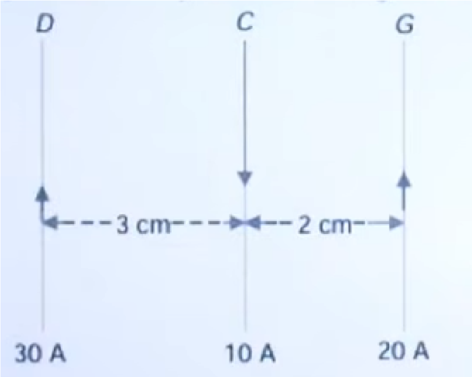
$$B_{\text{net}} = \frac{\mu_0 i}{4R_1} - \frac{\mu_0 i}{4R_2}$$

Factoring out the common terms yields:

$$B_{\text{net}} = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Quick Tip: Whenever straight wire leads are aligned perfectly with the test point, you can cross them off your scratchpad immediately since their field contribution is exactly zero. From there, if the two arcs flow in opposite rotational directions (clockwise vs. counter-clockwise), their fields will subtract, instantly telling you that the correct formula must feature a minus sign.

4. **Three long, straight parallel wires, carrying current, are arranged as shown in figure. The force experienced by a 25 cm length of wire C is**



(a) 10^{-3} N

(b) 2.5×10^{-3} N

(c) Zero

(d) 1.5×10^{-3} N

Correct Answer: (c) Zero

Solution:

Concept: The magnetic force per unit length between two long, straight parallel current-carrying conductors separated by a distance r is given by Ampere's force law:

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

The nature of the magnetic force is governed by the relative directions of the currents:

- **Parallel currents** (flowing in the same direction) **attract** each other.
- **Anti-parallel currents** (flowing in opposite directions) **repel** each other.

By using the principle of superposition, the net force experienced by a segment of wire C is the vector sum of the forces exerted individually on it by wire D and wire G.

Step 1: Convert all given values into standard SI units.

From the provided diagram, let us write down the parameters:

- Current in wire D $(I_D) = 30$ A (pointing upwards)
- Current in wire C $(I_C) = 10$ A (pointing downwards)
- Current in wire G $(I_G) = 20$ A (pointing upwards)

- Distance between wire D and wire C $(r_1) = 3\text{ cm} = 3\times10^{-2}\text{ m}$
- Distance between wire C and wire G $(r_2) = 2\text{ cm} = 2\times10^{-2}\text{ m}$
- Target length of wire C $(L) = 25\text{ cm} = 0.25\text{ m}$

Step 2: Calculate the force acting on wire C due to wire D $(\vec{F}_{CD})$.
Since wire D has an upward current and wire C has a downward current, they are anti-parallel. Therefore, wire D will **repel** wire C. This repulsive force pushes wire C away from wire D, directed toward the right (+x direction).
Calculating the magnitude of this force (F_{CD}):

$$F_{CD} = \frac{\mu_0 I_D I_C}{2\pi r_1} \times L$$

Using the value $\frac{\mu_0}{2\pi} = 2\times10^{-7}\ \text{T}\cdot\text{m/A}$:

$$F_{CD} = \frac{(2\times10^{-7})\times30\times10}{3\times10^{-2}} \times 0.25$$

Simplifying the fractions:

$$F_{CD} = \frac{6\times10^{-5}}{3\times10^{-2}} \times 0.25 = (2\times10^{-3})\times0.25 = 0.5\times10^{-3}\text{ N} \quad \text{(directed to the Right)}$$

Step 3: Calculate the force acting on wire C due to wire G $(\vec{F}_{CG})$.
Similarly, wire G has an upward current and wire C has a downward current. Being anti-parallel, wire G will also **repel** wire C. This repulsive force pushes wire C away from wire G, directed toward the left (-x direction).
Calculating the magnitude of this force (F_{CG}):

$$F_{CG} = \frac{\mu_0 I_G I_C}{2\pi r_2} \times L$$

$$F_{CG} = \frac{(2\times10^{-7})\times20\times10}{2\times10^{-2}} \times 0.25$$

Simplifying the fractions:

$$F_{CG} = \frac{4\times10^{-5}}{2\times10^{-2}} \times 0.25 = (2\times10^{-3})\times0.25 = 0.5\times10^{-3}\text{ N} \quad \text{(directed to the Left)}$$

Step 4: Compute the net force acting on the 25 cm section of wire C.

Taking the rightward direction as positive, let us sum the two force vectors:

$$F_{\text{net}} = F_{CD} - F_{CG}$$

$$F_{\text{net}} = (0.5 \times 10^{-3}\ \text{N}) - (0.5 \times 10^{-3}\ \text{N}) = 0\ \text{N}$$

Since the two repulsive forces are exactly equal in magnitude but point in opposite directions, they cancel each other out completely, leaving the net force as zero.

Quick Tip: Instead of solving the complete calculation with the length multiplication, look at the ratio $\frac{I}{r}$ for the outer wires affecting the middle wire. For wire D: $\frac{30\ \text{A}}{3\ \text{cm}} = 10$. For wire G: $\frac{20\ \text{A}}{2\ \text{cm}} = 10$. Since both produce identical repulsion ratios from opposite sides, the forces balance perfectly to **Zero** automatically!

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5. A steady current / flow through a long straight wire of radius ' a '. The current is uniformly distributed across its cross section. The ratio of the magnetic fields due to the wire at distance $\frac{a}{4}$ and $3a$ respectively from the axis of the wire is

(a) 3 : 4

(b) 4 : 3

(c) 2 : 3

(d) 1 : 4

Correct Answer: (a) 3 : 4

Solution:

Concept: According to Ampere's Circuital Law, the magnetic field B at a distance r from the central axis of a long solid cylindrical wire of radius a carrying a total current I uniformly distributed across its cross-section depends on whether the point lies inside or outside the conductor:

1. **Inside the wire ($r < a$):** The magnetic field increases linearly with distance from the central axis:

$$B_{\text{in}} = \frac{\mu_0 I r}{2\pi a^2}$$

2. **Outside the wire ($r \geq a$):** The magnetic field behaves as if all the current were concentrated at the central axis, decreasing inversely with distance:

$$B_{\text{out}} = \frac{\mu_0 I}{2\pi r}$$

Step 1: Calculate the magnetic field at the interior point ($r_1 = \frac{a}{4}$).

Since $r_1 = \frac{a}{4}$ is less than the wire's radius a, this point is located inside the conductor's cross-section.

Using the interior magnetic field formula:

$$B_1 = \frac{\mu_0 I \left(\frac{a}{4}\right)}{2\pi a^2} = \frac{\mu_0 I a}{8\pi a^2} = \frac{\mu_0 I}{8\pi a} \quad \cdots (1)$$

Step 2: Calculate the magnetic field at the exterior point ($r_2 = 3a$).

Since $r_2 = 3a$ is greater than the wire's radius a, this point is located outside the conductor.

Using the exterior magnetic field formula:

$$B_2 = \frac{\mu_0 I}{2\pi(3a)} = \frac{\mu_0 I}{6\pi a} \quad \cdots (2)$$

Step 3: Determine the ratio of the two magnetic fields ($\frac{B_1}{B_2}$).

Dividing equation (1) by equation (2) to find the required ratio:

$$\frac{B_1}{B_2} = \frac{\frac{\mu_0 I}{8\pi a}}{\frac{\mu_0 I}{6\pi a}}$$

Canceling out the common factors (μ_0, I, π, a) from the numerator and denominator:

$$\frac{B_1}{B_2} = \frac{\frac{1}{8}}{\frac{1}{6}} = \frac{6}{8}$$

Simplifying the fraction by dividing both numbers by their greatest common divisor (2):

$$\frac{B_1}{B_2} = \frac{3}{4}$$

Therefore, the ratio of the magnetic fields is exactly 3 : 4.

Quick Tip: Instead of dragging the constant variables through every step, memorize the proportionalities directly: Inside the wire, $B \propto r$, so at $r = \frac{a}{4}$, the relative intensity is $\frac{1}{4}$. Outside the wire, $B \propto \frac{1}{r}$, so at $r = 3a$, the relative intensity is $\frac{1}{3}$. Dividing the two relative fractions gives $\frac{1/4}{1/3} = \frac{3}{4}$ immediately!

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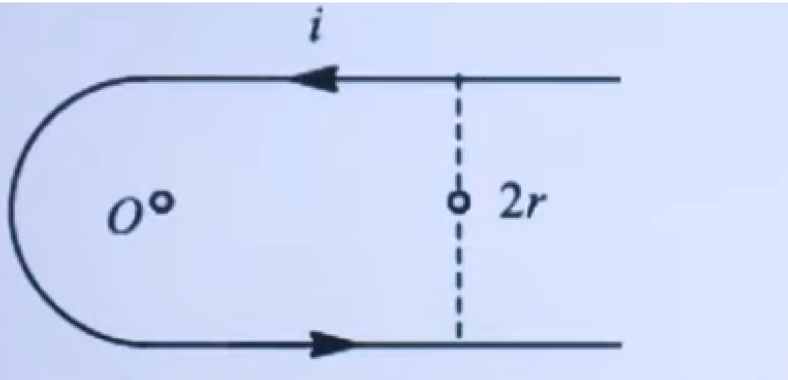
6. In the figure shown, the magnetic field induction at the point O will be



(a) $\frac{\mu_0 i}{2\pi r}$

(b) $\left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{r}\right)(\pi + 2)$

(c) $\left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{r}\right)(\pi + 1)$

(d) $\frac{\mu_0 i}{4\pi r}(\pi - 2)$

Correct Answer: (b) $\left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{r}\right)(\pi + 2)$

Solution:

Concept: Using the Biot-Savart Law and the principle of superposition, the total magnetic field induction ($\vec{B}_{\text{net}}$) at point O equals the vector sum of the individual fields generated by the constituent segments of the conductor.

The configuration can be structurally divided into three geometric parts:

1. **Segment 1:** A top semi-infinite straight wire carrying current i pointing toward the left.
2. **Segment 2:** A semicircular wire arc of radius r carrying current i running counter-clockwise.
3. **Segment 3:** A bottom semi-infinite straight wire carrying current i pointing toward the right.

Step 1: Determine the dimensions and radius of the configuration.

The distance between the two parallel straight wires is explicitly marked as $2r$. Because the curved section is a smooth semicircle connecting these two lines, the diameter of the semicircle is equal to this separation distance ($d = 2r$). Therefore, the radius of the semicircular arc is exactly r, and the center of this arc is point O. This means point O lies at a perpendicular distance of r from both the top and bottom straight wire segments.

Step 2: Calculate the magnetic field due to the semicircular arc (B_{arc}).
The arc forms a complete semicircle, meaning it subtends an angle of $\theta = \pi$ radians at its center O.
The magnetic field at the center of a circular arc is given by:

$$B_{\text{arc}} = \frac{\mu_0 i}{4\pi r}\theta = \frac{\mu_0 i}{4\pi r}(\pi)$$

Using the **Right-Hand Thumb Rule** (curling your right-hand fingers counter-clockwise along the path of the current arrow), your thumb points straight out of the page. Hence, the direction of $\vec{B}_{\text{arc}}$ is **out of the page (⊙)**.

Step 3: Calculate the fields due to the two semi-infinite straight wires (B_1 and B_3).
Let us analyze the position of point O relative to the two straight lines:

- **Top wire (Segment 1):** The current flows from right to left. The wire acts as a semi-infinite wire whose right end extends to infinity and whose left end terminates directly above point O. The field magnitude at a distance r from its edge is:

  $$B_1 = \frac{\mu_0 i}{4\pi r}$$

  Using the Right-Hand Rule (pointing your right thumb to the left along the current arrow), your fingers curl and point **out of the page (⊙)** at point O.

- **Bottom wire (Segment 3):** The current flows from left to right. This is also a semi-infinite wire starting directly below point O and extending to infinity on the right. Its field magnitude at a distance r is:

  $$B_3 = \frac{\mu_0 i}{4\pi r}$$

  Using the Right-Hand Rule (pointing your right thumb to the right along the current arrow), your fingers curl and point **out of the page (⊙)** at point O.

Step 4: Sum the components to find the net magnetic field ($\vec{B}_{\text{net}}$).
Since all three individual magnetic field vectors point in the exact same direction (**out of the

page (⊙)**), their magnitudes add together directly:

$$B_{\text{net}} = B_{\text{arc}} + B_1 + B_3$$

Substituting the expressions we calculated:

$$B_{\text{net}} = \frac{\mu_0 i}{4\pi r}(\pi) + \frac{\mu_0 i}{4\pi r} + \frac{\mu_0 i}{4\pi r}$$

Combining the identical straight-wire terms:

$$B_{\text{net}} = \frac{\mu_0 i}{4\pi r}(\pi) + 2\left(\frac{\mu_0 i}{4\pi r}\right)$$

Factoring out the common multiplier $\left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{r}\right)$ to align exactly with the format of the options:

$$B_{\text{net}} = \left(\frac{\mu_0}{4\pi}\right)\left(\frac{i}{r}\right)(\pi + 2)$$

Quick Tip: Check the vector directions before performing any algebraic addition. Since the top wire flows left, the arc goes counter-clockwise, and the bottom wire flows right, every single segment creates an additive field pointing **out of the page** at point O. Because the fields work together rather than canceling out, you know immediately that the terms must be linked by a plus sign, which narrows down your choices to options (b) and (c) instantly!

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7. The nucleus of helium atom contains two protons that are separated by a distance 3.0×10^{-15} m. The magnitude of the electrostatic force that each proton exerts on the other is

(a) 20.6 N

(b) 25.6 N

(c) 15.6 N

(d) 12.6 N

Correct Answer: (b) 25.6 N

Solution:

Concept: According to **Coulomb's Law**, the magnitude of the electrostatic force (F) acting between two stationary point charges, q_1 and q_2, separated by a distance r in vacuum or air is given by the formula:

$$F = k \cdot \frac{|q_1 \cdot q_2|}{r^2}$$

Where:

- k is Coulomb's constant, approximately equal to $9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2}$.
- q_1 and q_2 are the magnitudes of the charges.
- r is the separation distance between the centers of the two charges.

Step 1: Identify the given values from the problem.

- Charge of a single proton $(q_1 = q_2 = e) \approx 1.6 \times 10^{-19}\ \mathrm{C}$
- Separation distance $(r) = 3.0 \times 10^{-15}\ \mathrm{m}$ (often referred to as 3 fm or femtometers)
- Electrostatic constant $(k) = 9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2}$

Step 2: Substitute the values into Coulomb's law equation.

$$F = (9.0 \times 10^9) \times \frac{(1.6 \times 10^{-19}) \times (1.6 \times 10^{-19})}{(3.0 \times 10^{-15})^2}$$

First, let's square the terms in the denominator:

$$(3.0 \times 10^{-15})^2 = 9.0 \times 10^{-30}\ \mathrm{m^2}$$

Now, write out the complete expression with the simplified denominator:

$$F = \frac{9.0 \times 10^9 \times 1.6 \times 1.6 \times 10^{-38}}{9.0 \times 10^{-30}}$$

Step 3: Simplify the exponents and numbers to calculate the final force.

We can cancel out the factor of 9.0 from both the numerator and the denominator:

$$F = \frac{9.0 \times 10^9 \times 2.56 \times 10^{-38}}{9.0 \times 10^{-30}}$$

Combine the powers of 10 in the numerator:

$$10^9 \times 10^{-38} = 10^{-29}$$

This leaves us with:

$$F = \frac{2.56 \times 10^{-29}}{10^{-30}}$$

Using exponent rules to divide power bases ($\frac{10^{-29}}{10^{-30}} = 10^{-29-(-30)} = 10^1 = 10$):

$$F = 2.56 \times 10 = 25.6 \text{ N}$$

Therefore, the magnitude of the electrostatic repulsive force that each proton exerts on the other is exactly 25.6 N.

Quick Tip: When setting up calculations involving nuclear dimensions, look for numbers that cancel nicely. Squaring the distance 3.0×10^{-15} gives a 9.0 in the denominator, which completely cancels out Coulomb's constant (9.0×10^9). This leaves you to calculate only the square of the proton's base charge: $1.6^2 = 2.56$, making it easy to identify **25.6 N** as the matching choice.

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8. Under the action of a given coulombic force the acceleration of an electron is 2.5×10^{22} m s^{-2}. Then the magnitude of the acceleration of a proton under the action of same force is nearly

(a) 1.6×10^{-19} m s^{-2}

(b) 9.1×10^{31} m s^{-2}

(c) 1.5×10^{19} m s^{-2}

(d) 1.6×10^{27} m s^{-2}

Correct Answer: (c) 1.5×10^{19} m s^{-2}

Solution:

Concept: According to **Newton's Second Law of Motion**, the acceleration (a) produced by a net force (F) acting on an object is inversely proportional to its mass (m):

$$F = m \cdot a \quad \Longrightarrow \quad a = \frac{F}{m}$$

When two different particles experience the exact same magnitude of force ($F_e = F_p = F$), their accelerations are inversely proportional to their respective rest masses:

$$m_e \cdot a_e = m_p \cdot a_p$$

Rearranging this relationship allows us to find the unknown acceleration of the proton (a_p):

$$a_p = a_e \cdot \left(\frac{m_e}{m_p}\right)$$

Step 1: Identify the fundamental constant values and given metrics.

- Acceleration of the electron $(a_e) = 2.5 \times 10^{22}$ m s^{-2}
- Rest mass of an electron $(m_e) \approx 9.1 \times 10^{-31}$ kg
- Rest mass of a proton $(m_p) \approx 1.67 \times 10^{-27}$ kg

Step 2: Set up the ratio equation for the proton's acceleration.
Substituting the metrics into our ratio formula:

$$a_p = (2.5 \times 10^{22}) \times \frac{9.1 \times 10^{-31}}{1.67 \times 10^{-27}}$$

Let us group the numerical coefficients and the power terms together to make simplification clean:

$$a_p = \left(\frac{2.5 \times 9.1}{1.67}\right) \times \frac{10^{22} \times 10^{-31}}{10^{-27}}$$

Step 3: Simplify the exponents and perform the final arithmetic calculation.
First, simplify the powers of 10 in the numerator:

$$10^{22} \times 10^{-31} = 10^{-9}$$

Now divide by the denominator's power base using exponent subtraction rules ($10^{-9}/10^{-27} = 10^{-9-(-27)} = 10^{18}$):

$$\text{Total Exponent} = 10^{18}$$

Next, compute the numerical decimal fraction:

$$2.5 \times 9.1 = 22.75$$

$$\frac{22.75}{1.67} \approx 13.62$$

Assemble the parts back together:

$$a_p \approx 13.62 \times 10^{18} \text{ m s}^{-2}$$

Converting the final value into standard scientific notation by moving the decimal place one step to the left:

$$a_p \approx 1.362 \times 10^{19} \text{ m s}^{-2} \approx 1.5 \times 10^{19} \text{ m s}^{-2}$$

Therefore, the magnitude of the acceleration of the proton under the action of the same force is nearly 1.5×10^{19} m s^{-2}.

Quick Tip: A proton is roughly 1836 times heavier than an electron ($m_p \approx 1836 \cdot m_e$). Because acceleration scales inversely with mass under a constant force, the proton's acceleration must be about 1800 times smaller than the electron's acceleration. Divorcing 2.5×10^{22} by 1836 drops the power scale down to the 10^{19} bracket, instantly locking in **option (c)** as the only mathematically viable answer.

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9. If the charge on an object is doubled then electric field becomes

(a) half

(b) double

(c) unchanged

(d) thrice

Correct Answer: (b) double

Solution:

Concept: The electric field ($\vec{E}$) created by a charged object at any point in space is directly proportional to the magnitude of the source charge (Q) creating that field. For a point charge or an object behaving as a point charge, the magnitude of the electric field at a distance r is given by Coulomb's law for electric fields:

$$E = k \cdot \frac{Q}{r^2}$$

Where:

- k is the electrostatic constant ($\frac{1}{4\pi\varepsilon_0}$).
- Q is the source charge on the object.
- r is the distance from the center of the charged object to the observation point.

From this fundamental relationship, it is evident that keeping the observation distance r constant gives a direct proportionality:

$$E \propto Q$$

Step 1: Set up the initial and final states.
Let the initial charge on the object be $Q_1 = Q$, which produces an initial electric field:

$$E_1 = k \cdot \frac{Q}{r^2}$$

According to the problem statement, the new charge on the object is doubled, meaning:

$$Q_2 = 2Q$$

Step 2: Calculate the new electric field (E_2).
Substitute the new charge value Q_2 into the electric field formula while keeping the distance r exactly the same:

$$E_2 = k \cdot \frac{Q_2}{r^2} = k \cdot \frac{2Q}{r^2}$$

Rearranging the terms to factor out the constant coefficient:

$$E_2 = 2 \cdot \left(k \cdot \frac{Q}{r^2}\right)$$

Step 3: Express the final field in terms of the initial field.
Notice that the term inside the parentheses is exactly equal to our initial electric field expression (E_1):

$$E_2 = 2 \cdot E_1$$

Therefore, if the charge on the object is doubled, the resulting electric field also becomes **double** its original value.

Quick Tip: The electric field measures the force exerted per unit charge. Because it scales linearly with the source charge ($E \propto Q$), any linear change made to the source charge will be mirrored exactly by the electric field. If you double the charge, you double the field strength.

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10. Which of the following statements is not true about electric field lines?

(a) Electric field lines start from positive charge and end at negative charge.

(b) Two electric field lines can never cross each other.

(c) Electrostatic field lines do not form any closed loops.

(d) Electric field lines cannot be taken as continuous curve

Correct Answer: (d) Electric field lines cannot be taken as continuous curve

Solution:

Concept: Electric field lines are imaginary visual aids used to map the direction and spatial strength of an electric field in a region of space. They follow a strict set of fundamental properties derived from Coulomb's law and the conservative nature of electrostatic forces.

Step 1: Analyze the truth value of options (a), (b), and (c).

Let us systematically evaluate the established physical properties of electrostatic field lines:

- **Statement (a):** Electric field lines natively emerge and start from positive source charges and terminate radially inward on negative target charges. If there is a single isolated charge, they start or end at infinity. Thus, statement (a) is **true**.

- **Statement (b):** The tangent drawn to a field line at any point gives the unique direction of the net electric field vector ($\vec{E}$) at that point. If two lines crossed, it would mean that at that single intersection point, the field has two different directions simultaneously, which is physically impossible. Thus, statement (b) is **true**.

- **Statement (c):** Electrostatic fields are conservative in nature. Field lines originate at a positive source and end at a negative source; they cannot travel backward from a negative charge to a positive charge. Therefore, they do not form continuous closed loops (unlike magnetic field lines). Thus, statement (c) is **true**.

Step 2: Evaluate the incorrect statement (d).

An electric field exists continuously throughout a region surrounding a source charge distribution unless it encounters another localized point charge. A test charge moving in this space experiences a smooth, uninterrupted force.

Consequently, electric field lines **are continuous curves** without any sudden breaks or gaps in charge-free space. Because statement (d) claims that they *cannot* be taken as continuous curves, it is **not true**. Therefore, it is our target correct option.

Quick Tip: Remember the core difference for exams: Electric field lines are **continuous curves that do not form closed loops**, whereas magnetic field lines are **continuous curves that do form closed loops**. Spotting the word "cannot" in option (d) immediately flags it as the incorrect statement.
