This print-out should have 18 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Conceptual 16 Q15
001 10.0 points

The magnetic field at the equator points north.

If you throw a positively charged object (for example, a baseball with some electrons removed) to the east, what is the direction of the magnetic force on the object?

1. Toward the east

2. Toward the west

3. Upward **correct**

4. Downward

Explanation:

Use the right-hand rule: point your index finger east and your middle finger north. Your thumb points upward (representing the force on a positively charged object). Or, swing your right-hand fingers from east to north. Your thumb points upward.

Hewitt CP9 24 E27
002 10.0 points

Can an electron at rest in a magnetic field be set into motion by the magnetic field? What if it were at rest in an electric field?

1. It depends on the intensity of the fields, which is not provided in the problem.

2. yes; no

3. no; yes **correct**

4. yes for both

5. None of these

6. no for both

Explanation:

An electron has to move across lines of magnetic field in order to feel a magnetic force, so an electron at rest in a stationary magnetic field will feel no force to set it in motion. However, an electron in an electric field will accelerate regardless of its current state of motion.

Electron in a Magnetic Field 02
003 10.0 points

An electron in a vacuum is first accelerated by a voltage of 68200 V and then enters a region in which there is a uniform magnetic field of 0.101 T at right angles to the direction of the electron's motion.

What is the force on the electron due to the magnetic field?

Correct answer: 2.5064×10^{-12} N.

Explanation:

$$\text{Let :}\quad V = 1.54888 \times 10^{8}\ \text{m/s} \quad \text{and} \quad B = 0.101\ \text{T}\,.$$

The kinetic energy gained after acceleration is $KE = \frac{1}{2} m_e v^2 = q_e V$, so the velocity is

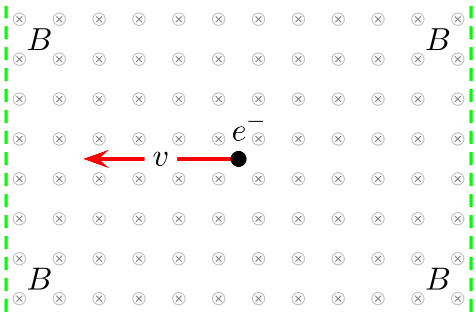
$$\begin{aligned} v &= \sqrt{\frac{2 q_e V}{m}} \\ &= \sqrt{\frac{2(1.60218 \times 10^{-19}\ \text{C})(68200\ \text{V})}{9.10939 \times 10^{-31}\ \text{kg}}} \\ &= 1.54888 \times 10^{8}\ \text{m/s}\,. \end{aligned}$$

Then the force on it is

$$\begin{aligned} f &= q v B \\ &= (1.60218 \times 10^{-19}\ \text{C}) \\ &\quad \times (1.54888 \times 10^{8}\ \text{m/s})(0.101\ \text{T}) \\ &= \boxed{2.5064 \times 10^{-12}\ \text{N}}\,. \end{aligned}$$

AP B 1998 MC 21
004 10.0 points

An electron is in a uniform magnetic field **B** that is directed into the plane of the page, as shown.



When the electron is moving in the plane of the page in the direction indicated by the arrow, the force on the electron is directed

1. toward the top of the page. **correct**

2. toward the right

3. into the page.

4. toward the left

5. toward the bottom of the page.

6. out of the page.

Explanation:
The force on the electron is

$$\vec{F} = q\,\vec{v} \times \vec{B} = -e\,\vec{v} \times \vec{B}.$$

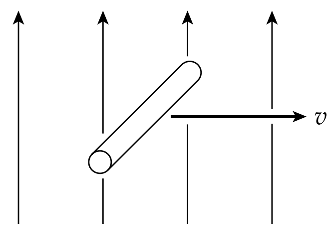
The direction of the force is thus

$$\widehat{F} = -\widehat{v} \times \widehat{B}\,,$$

pointing $\boxed{\text{toward the top of the page}}$, using right hand rule for $\widehat{v} \times \widehat{B}$, and reversing the direction due to the negative charge on the electron.

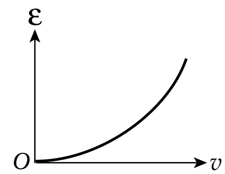
Wire in Magnetic Field 01
005 10.0 points

A wire of constant length is moving in a constant magnetic field, as shown below. The wire and the velocity vector are perpendicular to each other and also perpendicular to the field.

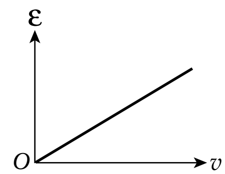


Which graph best represents the potential difference $\mathcal{E}$ between the ends of the wire as a function of the speed v of the wire?

1.

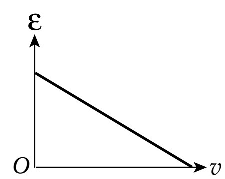


2.

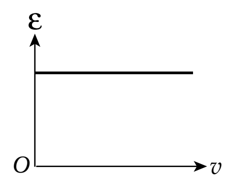


correct

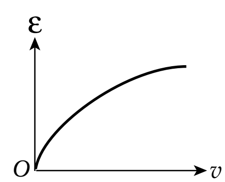
3.



4.



5.



Explanation:
Motional emf $= \mathcal{E} = B l v$. This indicates that the potential difference between the ends of the wire will also increase linearly with the velocity.

Conceptual 17 Q01
006 10.0 points

The figure represents two long, straight, parallel wires extending in a direction perpendicular to the page. The current in the right wire runs into the page and the current in the left runs out of the page.

If the magnitude of the current in each wire is the same, what is the direction of the magnetic field created by these wires at locations a, b and c? (b is midway between the wires.)

1. down, down, up

2. up, down, up

3. down, up, down **correct**

4. up, zero, down

5. down, zero, up

6. up, up, down

Explanation:

By the right-hand rule the right wire has a clockwise field and the left wire a counter-clockwise field.

Force on a Wire Segment
007 10.0 points

A segment of wire carries a current of 66 A along the x axis from $x = -6$ m to $x = 0$ and then along the z axis from $z = 0$ to $z = 4.1$ m. In this region of space, the magnetic field is equal to 72 mT in the positive z direction.

What is the magnitude of the force on this segment of wire?

Correct answer: 28.512 N.

Explanation:

$$\begin{aligned}\text{Let}: \quad I &= 66 \text{ A}\,,\\ B &= 72 \text{ mT} = 0.072 \text{ T}\,,\\ L_x &= -6 \text{ m}\,, \quad \text{and}\\ L_z &= 4.1 \text{ m}\,.\end{aligned}$$

Basic Concept: Magnetic Force on a Current:

$$\vec{F} = I\,\vec{L} \times \vec{B}$$

Solution: We have to add up the forces that the magnetic field produces on each segment of wire.

For the segment along the z-axis:

$$\begin{aligned}\vec{F}_{z-seg} &= I\,\vec{L} \times \vec{B}\\ &= I\,L_z\,B\,(\hat{k} \times \hat{k})\\ &= 0\,.\end{aligned}$$

Therefore, only the segment of wire along the x-axis contributes to the force. This force is

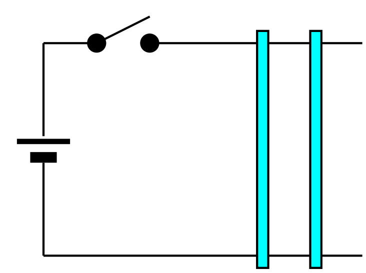
$$\begin{aligned}\vec{F}_{x-seg} &= I\,\vec{L} \times \vec{B}\\ &= I\,L_x\,B\,(\hat{\imath} \times \hat{k})\\ &= I\,L_x\,B\,(-\hat{\jmath})\,.\end{aligned}$$

Therefore the magnitude of this force is

$$F = (66 \text{ A}) \times (-6 \text{ m}) \times (0.072 \text{ T}) = 28.512 \text{ N}.$$

Parallel Sections of Wires
008 10.0 points

Two identical parallel sections of wire are connected parallel to a battery as shown. The two sections of wire are free to move.



When the switch is closed, the wires

1. will accelerate away from each other.

2. will heat up, and remain motionless.

3. will accelerate towards each other. **correct**

Explanation:

The currents in both rods move downward, so they are parallel currents that attract, causing them to accelerate toward one another.

Electron Gun
009 10.0 points

The accelerating voltage that is applied to an electron gun is 56 kV, and the horizontal distance from the gun to a viewing screen is 0.28 m.

What is the deflection caused by the vertical component of the Earth's magnetic field of strength 4×10^{-5} T, assuming that any change in the horizontal component of the beam velocity is negligible. The elemental charge is 1.60218×10^{-19} C and the electron's mass is 9.10939×10^{-31} kg.

Correct answer: 0.00196493 m.

Explanation:

$$\text{Let : } \quad q_e = 1.60218 \times 10^{-19} \text{ C}, \quad d = 0.28 \text{ m}, \quad B = 4 \times 10^{-5} \text{ T}, \quad V = 56 \text{ kV} = 56000 \text{ V}, \quad \text{and} \quad m_e = 9.10939 \times 10^{-31} \text{ kg}.$$

The velocity v can be obtained from energy conservation

$$K = U$$
$$\frac{1}{2} m_e v^2 = q_e V$$

$$\begin{aligned} v &= \sqrt{\frac{2 q_e V}{m_e}} \\ &= \sqrt{\frac{2 (1.60218 \times 10^{-19} \text{ C}) (56000 \text{ V})}{9.10939 \times 10^{-31} \text{ kg}}} \\ &= 1.40352 \times 10^8 \text{ m/s}. \end{aligned}$$

From Newton's second law,

$$\begin{aligned} m_e a &= q_e v B \\ a &= q_e \frac{v B}{m_e} \\ &= (1.60218 \times 10^{-19} \text{ C}) \\ &\quad \times \frac{(1.40352 \times 10^8 \text{ m/s}) (4 \times 10^{-5} \text{ T})}{9.10939 \times 10^{-31} \text{ kg}} \\ &= 9.87418 \times 10^{14} \text{ m/s}^2. \end{aligned}$$

The time is

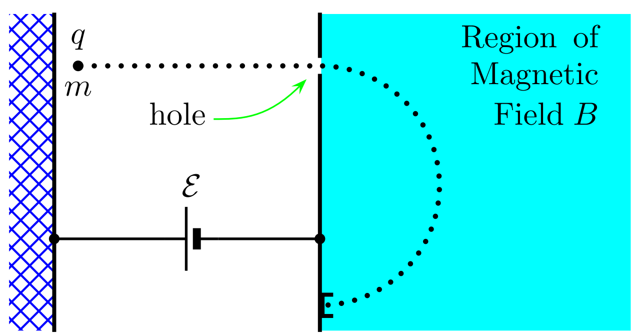
$$\begin{aligned} t = \frac{d}{v} &= \frac{0.28 \text{ m}}{1.40352 \times 10^8 \text{ m/s}} \\ &= 1.99498 \times 10^{-9} \text{ s}, \end{aligned}$$

so the deflection is

$$\begin{aligned} x = \frac{1}{2} a t^2 &= \frac{1}{2} (9.87418 \times 10^{14} \text{ m/s}^2) \\ &\quad \times (1.99498 \times 10^{-9} \text{ s})^2 \\ &= \boxed{0.00196493 \text{ m}}. \end{aligned}$$

AP B 1993 FR 3 v1
010 (part 1 of 2) 10.0 points

A particle of mass 1.1122×10^{-25} kg and charge of 4.8×10^{-19} C is accelerated from rest in the plane of the page through a potential difference of 190 V between two parallel plates as shown. The particle is injected through a hole in the right-hand plate into a region of space containing a uniform magnetic field of magnitude 0.197 T. The particle curves in a semicircular path and strikes a detector.



Which way does the magnetic field point?

1. toward the lower left corner of the page

2. to the left

3. toward the bottom of the page

4. toward the lower right corner of the page

5. toward the top of the page

6. into the page

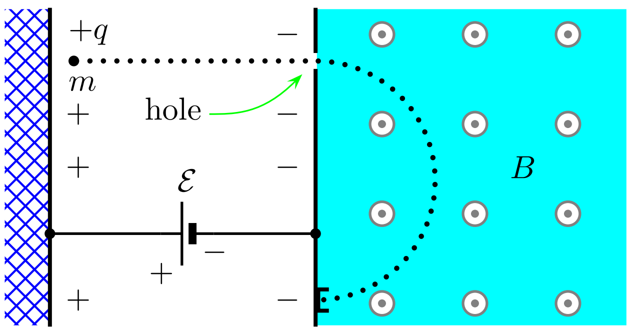
7. toward the upper left corner of the page

8. out of the page **correct**

9. toward the upper right corner of the page

10. to the right

Explanation:



Because the particle curves down, the direction of $\vec{v} \times \vec{B}$ points down. By the right-hand rule, $\vec{B}$ must $\boxed{\text{point out of the page}}$.

011 (part 2 of 2) 10.0 points

What is the magnitude of the force exerted on the charged particle as it enters the region of the magnetic field $\vec{B}$?

Correct answer: 3.82938×10^{-15} N.

Explanation:

$$\begin{aligned} \text{Let :} \quad m &= 1.1122 \times 10^{-25}\ \text{kg}\,, \\ V &= 190\ \text{V}\,, \quad \text{and} \\ |q| &= 4.8 \times 10^{-19}\ \text{C}\,. \end{aligned}$$

First, we can find the velocity of the particle by considering the change in kinetic energy of the particle. The change in kinetic energy of the charged particle is equal to the work done on it by the potential difference thus:

$$\frac{1}{2}\, m\, v^2 = q\, V$$

$$\begin{aligned} v &= \sqrt{\frac{2\, q\, V}{m}} \\ &= \sqrt{\frac{2\,(4.8 \times 10^{-19}\ \text{C})\,(190\ \text{V})}{(1.1122 \times 10^{-25}\ \text{kg})}} \\ &= \boxed{40496.8\ \text{m/s}}\,. \end{aligned}$$

$$\text{Let :} \quad B = 0.197\ \text{T}\,.$$

Then the force on the particle is given by the Lorentz force law

$$\begin{aligned} \vec{F} &= q\, \vec{v} \times \vec{B} \\ \|\vec{F}\| &= q\, v\, B \\ &= (4.8 \times 10^{-19}\ \text{C})\,(40496.8\ \text{m/s})\,(0.197\ \text{T}) \\ &= \boxed{3.82938 \times 10^{-15}\ \text{N}}\,. \end{aligned}$$

EarthAndCompass

012 10.0 points

Why does a compass point to the Earth's North Pole?

1. The north pole of the compass is attracted to the Earth's North Pole due to like-magnetic pole attracting

2. The north pole of the compass is attracted to the Earth's magnetic south pole which happens to be near the Earth's North Pole **correct**

3. The arrow of a compass contains an electric charge which is attracted to the electric charge at the Earth's North Pole

4. The north pole of the compass is really a south magnetic pole and is attracted to the Earth's North Pole

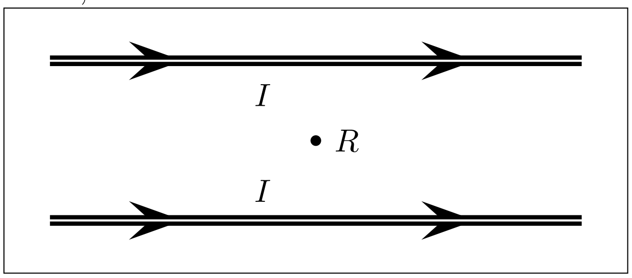
Explanation:

The arrow on a compass is a magnetic north pole. A magnetic north pole will be attracted to a magnetic south pole. This means that the arrow has to be attracted to a magnetic south pole. Therefore, since the compass points to the Earth's North Pole, the Earth's North Pole is actually a magnetic south pole.

MagFieldBetweenTwoWires

013 10.0 points

Consider two straight wires each carrying current I, as shown.



What is the direction of the magnetic field at point R (midpoint between the two wires) caused by the two current carrying wires?

1. Towards the bottom wire

2. To the left

3. Out of the page

4. Towards the top wire

5. There is no magnetic field **correct**

6. To the right

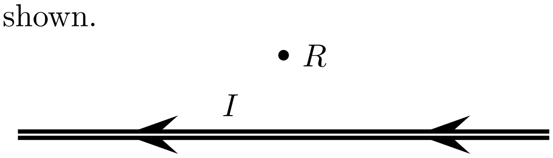
7. Into the page

Explanation:

Use the right-hand rule to determine the direction of the magnetic field surrounding a long, straight wire carring a current (thumb). We find that the magnetic field points Out of the page at point R (fingers) due to the bottom wire and points Into the page for the top wire. The two together are equal and opposite so they add to zero and thus, there is no magnetic field at point R.

AP B 1993 MC 18
014 10.0 points

Consider a straight wire carrying current I, as shown.



What is the direction of the magnetic field at point R caused by the current I in the wire?

1. Toward the wire

2. To the right

3. Into the page **correct**

4. Out of the page

5. Away from the wire

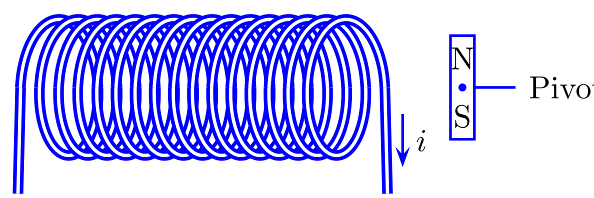
6. To the left

Explanation:

Use the right-hand rule to determine the direction of the magnetic field surrounding a long, straight wire carring a current (thumb). We find that the magnetic field points Into the page at point R (fingers).

Conceptual 17 Q03
015 10.0 points

An electric current runs through a coil of wire as shown. A permanent magnet is located to the right of the coil. The magnet is free to rotate.



What will happen to the magnet if its original orientation is as shown in the figure, with the current coming in on the front side of the solenoid, and then looping around the back?

1. Unable to determine

2. rotate counterclockwise **correct**

3. rotate clockwise

4. remain still

Explanation:

The magnetic field inside the coil points to the left, so the right side of the coil is a S pole. This will attract the N pole of the bar magnet, causing it to rotate counterclockwise.

Electromagnetism 11
016 10.0 points

A long coil of wire with many loops is called a

1. solenoid. **correct**

2. generator.

3. transformer.

4. motor.

5. galvanometer.

Explanation:

AP B 1993 MC 41
017 10.0 points

A copper wire of constant length ℓ is moving in a constant magnetic field, as shown.

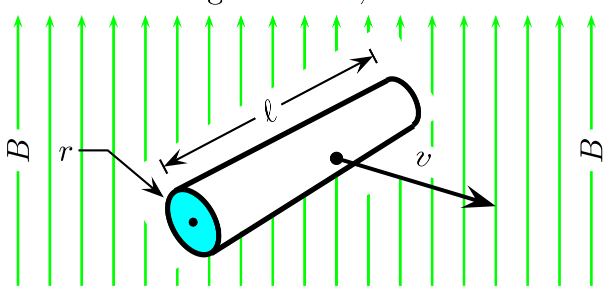
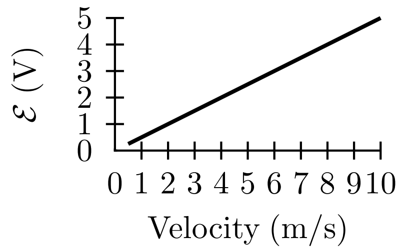


Figure: The wire and the velocity vector $\vec{v}$ are perpendicular (in the horizontal plane) to each other and are both perpendicular to the magnetic field $\vec{B}$ (vertical).

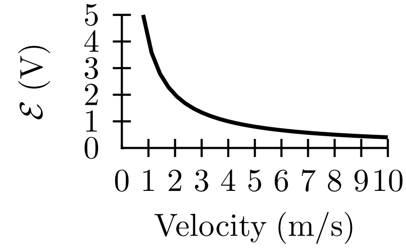
Which of the following graphs best represents the magnitude of the *emf* $\mathcal{E}$ between the ends of the wire as a function of the speed v of the wire?

1.

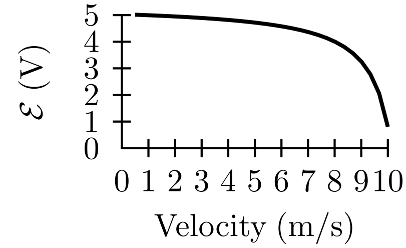


correct

2.



3.



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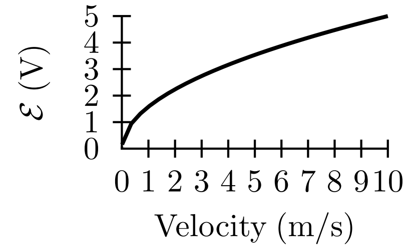

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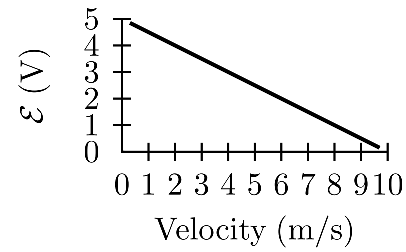

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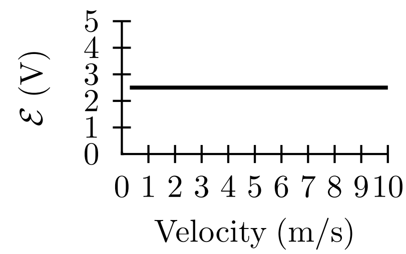

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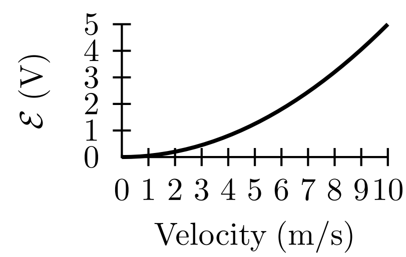


Explanation:

As the conductor moves with velocity v, the charge carriers experience a magnetic force F_{mag}. This force leads to a separation of charge carriers of opposite sign. This in turn creates an electric field E_H that leads to an electric force F_E opposing the magnetic force. In equilibrium these two forces balance out. Hence

$$F_E = F_{mag}$$
$$q\,E_H = q\,v\,B\,;$$

with $E_H\,\ell = \mathcal{E}$ one gets

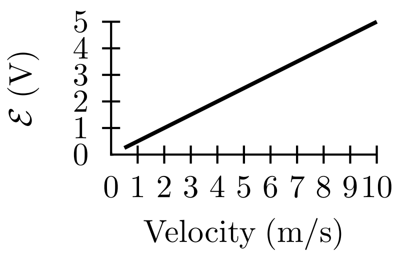
$$\mathcal{E} = E_H\,\ell = v\,B\,\ell\,, \quad \text{or}$$
$$\mathcal{E} \propto v\,,$$

since B and ℓ are constants.

Alternative Solution: From Faraday's law,

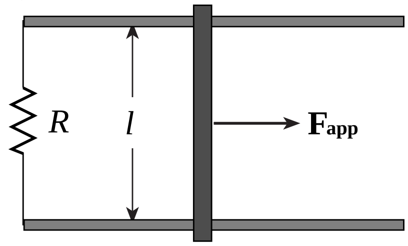
$$\mathcal{E} = B\,\ell\,v \implies \mathcal{E} \propto v\,,$$

since B and ℓ are constants. Thus the correct graph is



Bar in a Field 01
018 10.0 points

Consider the arrangement shown. Assume that $R = 4.03\ \Omega$, $\ell = 1.08$ m, and a uniform 1.06 T magnetic field is directed into the page.



At what speed should the bar be moved to produce a current of 0.483 A in the resistor?

Correct answer: 1.70029 m/s.

Explanation:

$$\text{Let}: \quad R = 4.03\ \Omega\,,$$
$$\ell = 1.08\ \text{m}\,,$$
$$B = 1.06\ \text{T}\,, \quad \text{and}$$
$$I = 0.483\ \text{A}\,.$$

The *emf* inside the loop can be calculated using Ohm's Law

$$\mathcal{E} = I\,R$$

and the motional *emf* is

$$\mathcal{E} = B\,\ell\,v\,,$$

so the velocity of the bar is

$$v = \frac{\mathcal{E}}{B\,\ell} = \frac{I\,R}{B\,\ell} = \frac{(0.483\ \text{A})(4.03\ \Omega)}{(1.06\ \text{T})(1.08\ \text{m})} = \boxed{1.70029\ \text{m/s}}$$