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MFF 3A: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

MFF3A–WBT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

Draw and describe a physical arrangement for which the equation below could apply.

$$F = \frac{m_o(8.00 \times 10^{-8} C)(640 \text{ m/s})(3A)}{(3.00 \times 10^{-2} m)(2p)}$$

MFF3A–CCT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

Consider the following statements made by three students.

Student I: “When an electric charge moves near a long straight wire that is carrying a current, there is no acceleration if the charge is moving perpendicular to the wire.”

Student II: “When an electric charge moves near a long straight wire that is carrying a current, there is an acceleration when the charge moves perpendicular toward, or away from, or parallel to the wire.”

Student III: “When an electric charge moves near a long straight wire that is carrying a current, there is no acceleration if the charge is moving parallel to the wire.”

Which, if any, of these three students do you believe is correct?

Student I _____ Student II _____ Student III _____ None of them _____

Explain fully why you chose as you did.

MFF3A–CCT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

Consider the following statements made by three students.

Student I: “When an electric charge moves near a long straight wire that is carrying a current, there is no force if the charge is moving perpendicular to the wire.”

Student II: “When an electric charge moves near a long straight wire that is carrying a current, there is a force when the charge moves perpendicular toward, or away from, or parallel to the wire.”

Student III: “When an electric charge moves near a long straight wire that is carrying a current, there is no force if the charge is moving parallel to the wire.”

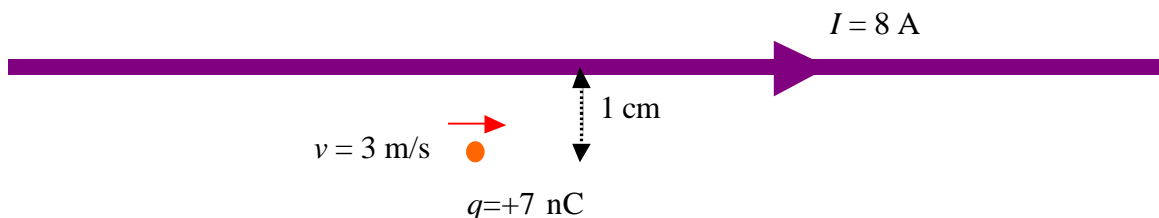
Which, if any, of these three students do you believe is correct?

Student I _____ Student II _____ Student III _____ None of them _____

Explain fully why you chose as you did.

MFF3A–WWT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of +7 nC is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A. The charge has a mass of 6×10^{-6} kg, and it is moving initially at 3 m/s parallel to the wire.

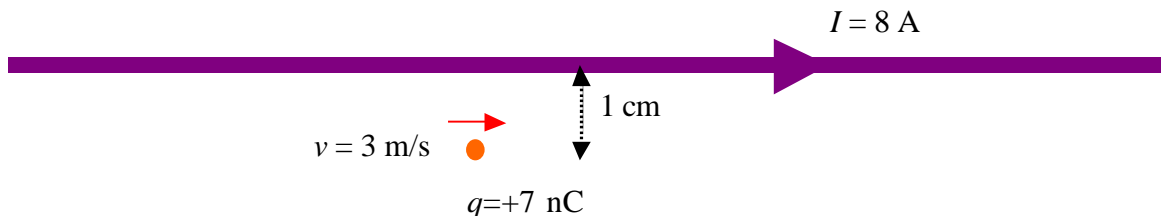


"The force on the charged particle by the magnetic field is zero because the velocity is parallel to the current in the wire."

What, if anything, is wrong with the above statement about this situation? If something is wrong, explain the error and how to correct it. If the statement is valid as it stands, explain why it is valid.

MFF3A–WWT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7\text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6}\text{ kg}$, and it is moving initially at 3 m/s parallel to the wire.

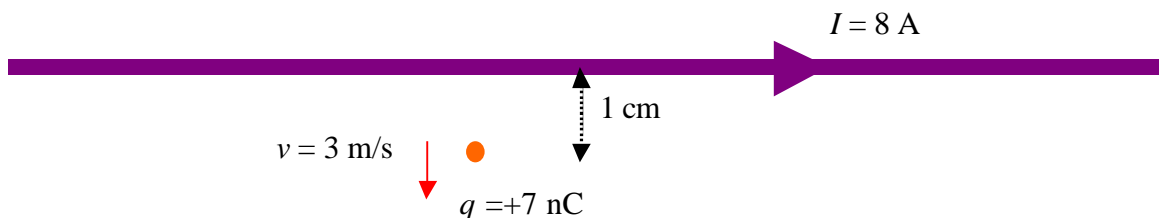


"The force on the charged particle by the magnetic field is initially toward the wire because the velocity is perpendicular to the magnetic field produced by the wire."

What, if anything, is wrong with the above statement about this situation? If something is wrong, explain the error and how to correct it. If the statement is valid as it stands, explain why it is valid.

MFF3A–TT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6} \text{ kg}$, and it is moving initially at 3 m/s away from the wire.

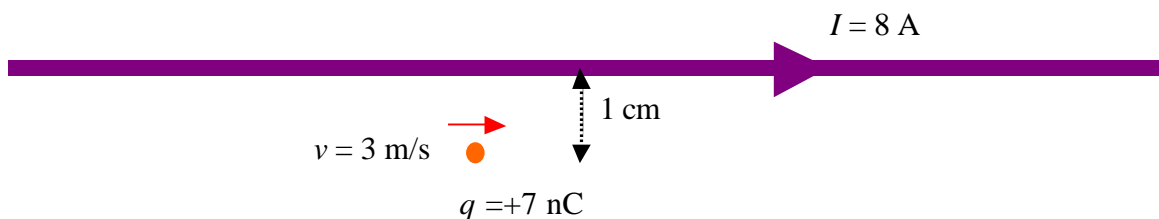


There is at least one error in the statement below. Identify the error(s) and explain how to correct it.

"The force exerted on the charged particle by the magnetic field is zero because the velocity is parallel to the magnetic field produced by the wire."

MFF3A–TT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7\text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6}\text{ kg}$, and it is moving initially at 3 m/s parallel to the wire.

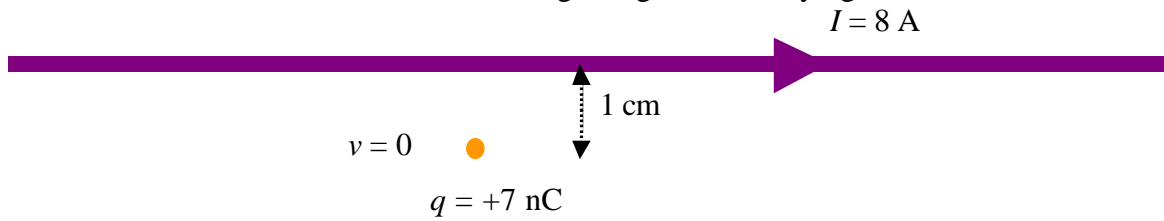


There is at least one error in the statement below. Identify the error(s) and explain how to correct it (them).

"The force exerted on the charged particle by the magnetic field is zero because the velocity is parallel to the magnetic field produced by the wire."

MFF3A–PET1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

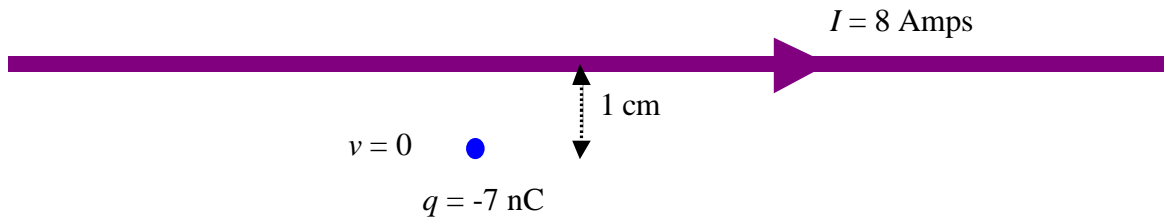
As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located at rest a distance of 1 cm from a long straight wire carrying a current of 8 A .



What will happen to the positively charged particle when it is released? Explain fully.

MFF3A–PET2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

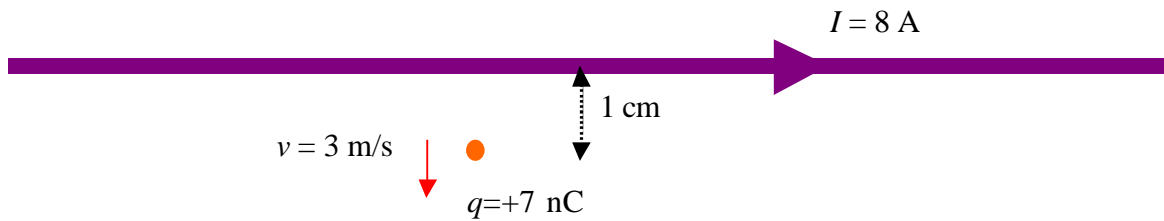
As shown in the figure below, a particle with a net electric charge of -7 nC is initially located at rest a distance of 1 cm from a long straight wire carrying a current of 8 amps .



What will happen to the negatively charged particle when it is released? Explain fully.

MFF3A–PET3: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

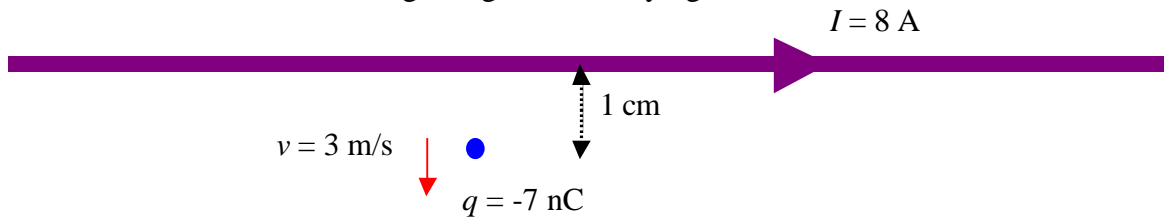
As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A .



What will happen to the charged particle when it is released moving at 3 m/s away from the wire as shown? Explain fully.

MFF3A–PET4 CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

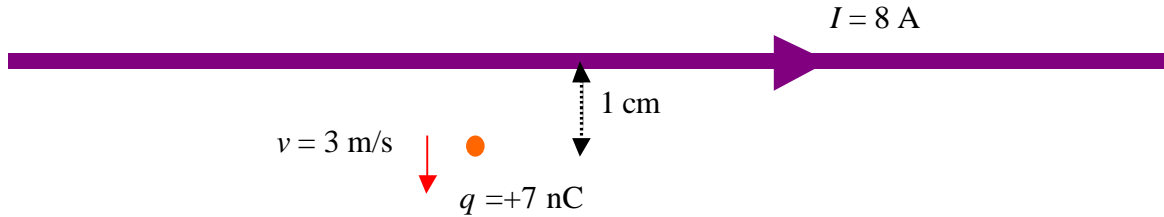
As shown in the figure below, a particle with a net electric charge of -7 nC is initially located at a distance of 1 cm from a long straight wire carrying a current of 8 A .



What will happen to the charged particle when it is released moving at 3 m/s away from the wire as shown? Explain fully.

MFF3A–M/MCT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of +7 nC is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A. The charge has a mass of 6×10^{-6} kg, and it is moving initially at 3 m/s away from the wire.



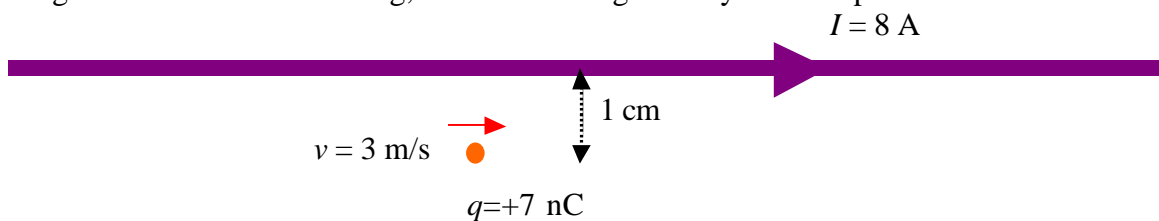
Given below is a calculation for the magnetic field (magnitude) at this point.

$$B = \frac{mv}{Qr} = \frac{(6 \times 10^{-6} \text{ kg})(3 \text{ m/s})}{(7 \times 10^{-9} \text{ C})(1 \times 10^{-2} \text{ m})}$$

Is this calculation meaningful (i.e., it tells us something legitimate about this situation) or is it meaningless (i.e., the value calculated is either nonsense, or it tells us nothing legitimate about this situation)?

MFF3A–M/MCT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of +7 nC is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A. The charge has a mass of 6×10^{-6} kg, and it is moving initially at 3 m/s parallel to the wire.



Given below is a calculation for the magnetic field (magnitude) at this point.

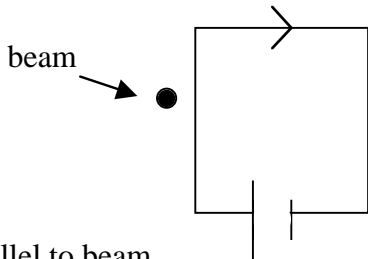
$$B = \frac{mv}{Qr} = \frac{(6 \times 10^{-6} \text{ kg})(3 \text{ m/s})}{(7 \times 10^{-9} \text{ C})(1 \times 10^{-2} \text{ m})}$$

Is this calculation meaningful (i.e., it tells us something legitimate about this situation) or is it meaningless (i.e., the value calculated is either nonsense, or it tells us nothing legitimate about this situation)?

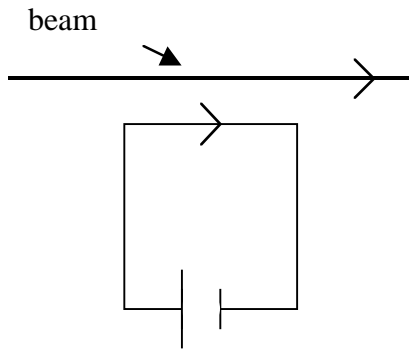
MFF3A–CODT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

Set up a demonstration oscilloscope with the beam of the electrons coming out toward the class. Then demonstrate and discuss the effect on the beam by the North and South pole of a bar magnet. Demonstrate and discuss the magnetic field around a wire that is carrying a current (use DC power supply and magna probes). Then hook up a rectangular wire to a DC power supply (don't turn it on), and align the rectangular loop such that the beam is parallel and perpendicular to the plane of the loop (see Figures below). Ask the students whether there will be any deflection in either orientation (or both orientations) when a DC current is supplied by the power supply.

Perpendicular to beam

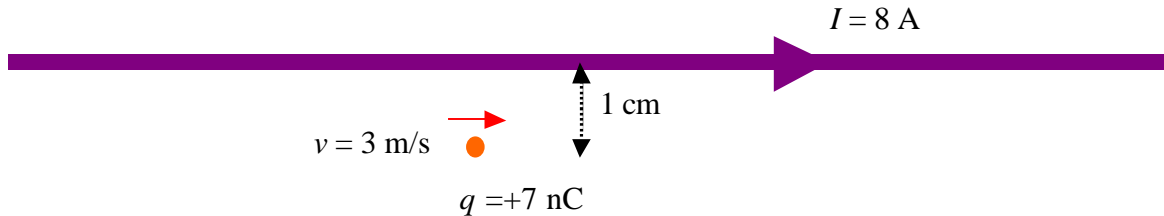


Parallel to beam



MFF3A–QRT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6} \text{ kg}$, and it is moving initially at 3 m/s parallel to the wire.



If we double the charge on the particle, what will happen to the initial acceleration?

If we change the charge on the particle to negative, what will happen to the initial acceleration?

If we double the initial distance away from the wire, what will happen to the initial acceleration?

If we double the mass of the particle, what will happen to the initial acceleration?

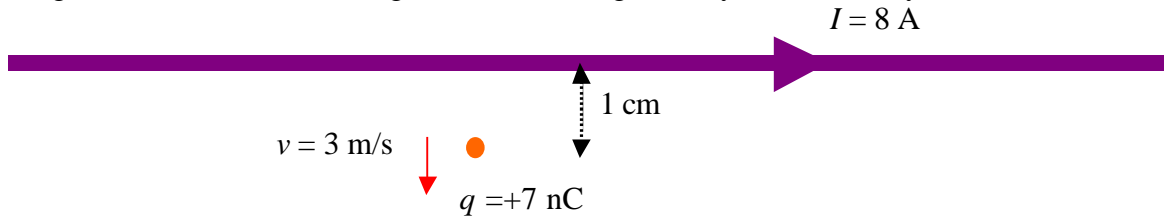
If we double the velocity of the particle, what will happen to the initial acceleration?

If we reduce the magnitude of the current, what will happen to the initial acceleration?

If we reverse the direction of the current, what will happen to the initial acceleration?

MFF3A–QRT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6} \text{ kg}$, and it is moving initially at 3 m/s away from the wire.



If we double the charge on the particle, what will happen to the initial acceleration?

If we change the charge on the particle to negative, what will happen to the initial acceleration?

If we double the initial distance away from the wire, what will happen to the initial acceleration?

If we double the mass of the particle, what will happen to the initial acceleration?

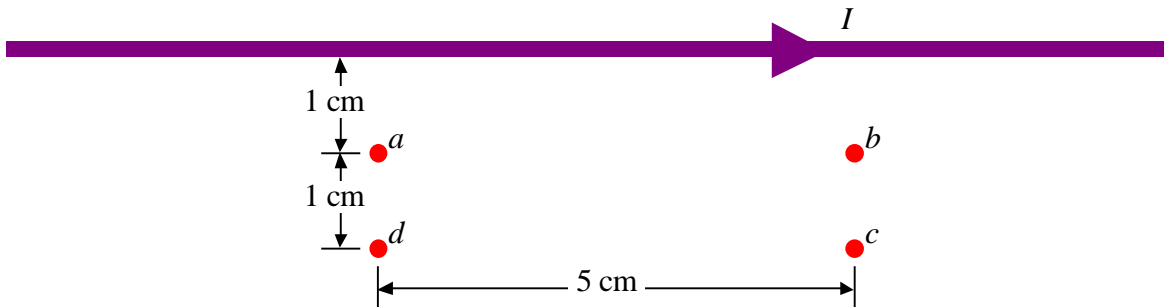
If we double the velocity of the particle, what will happen to the initial acceleration?

If we reduce the magnitude of the current, what will happen to the initial acceleration?

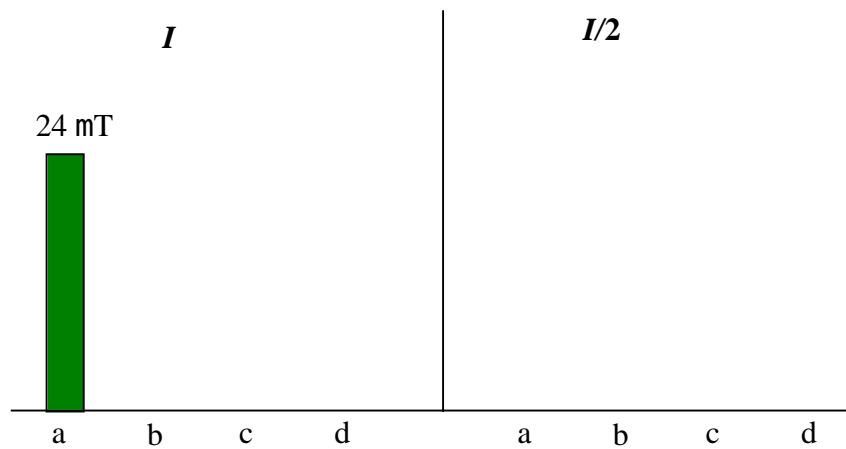
If we reverse the direction of the current, what will happen to the initial acceleration?

MFF3A–BCT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a long straight wire is carrying a current. The magnetic field has a magnitude of 24 mT at point *a*.



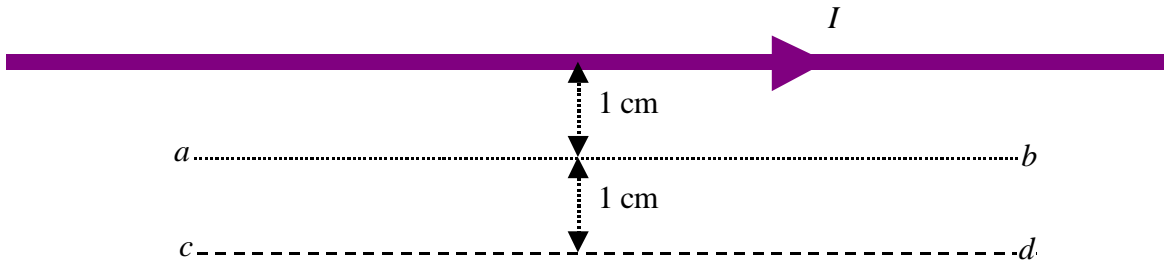
Draw a bar chart (and label the height of each column) of the magnitude of the magnetic field at the points *a*, *b*, *c*, and *d* at this initial current and then when the current is reduced to half its initial value.



Explain the reasoning behind your bar chart:

MFF3A–CRT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a long straight wire is carrying a current. The magnetic field at point *a* has a magnitude of 24 mT.



Draw and label a graph of the magnitude of the magnetic field along the dotted line from *a* to *b* (as a dotted line on this graph) and also draw the magnitude of the magnetic field along the dashed line from *c* to *d*.

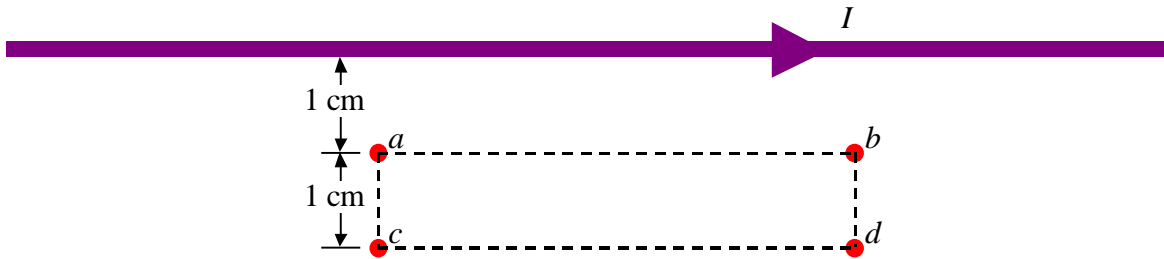


Redraw these graphs if the current is reduced to half its value.

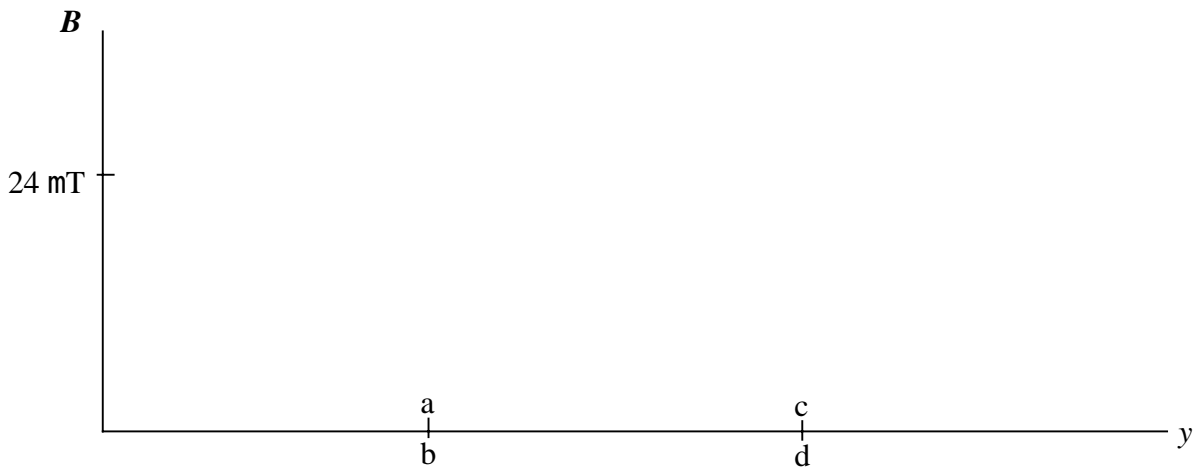


MFF3A–CRT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

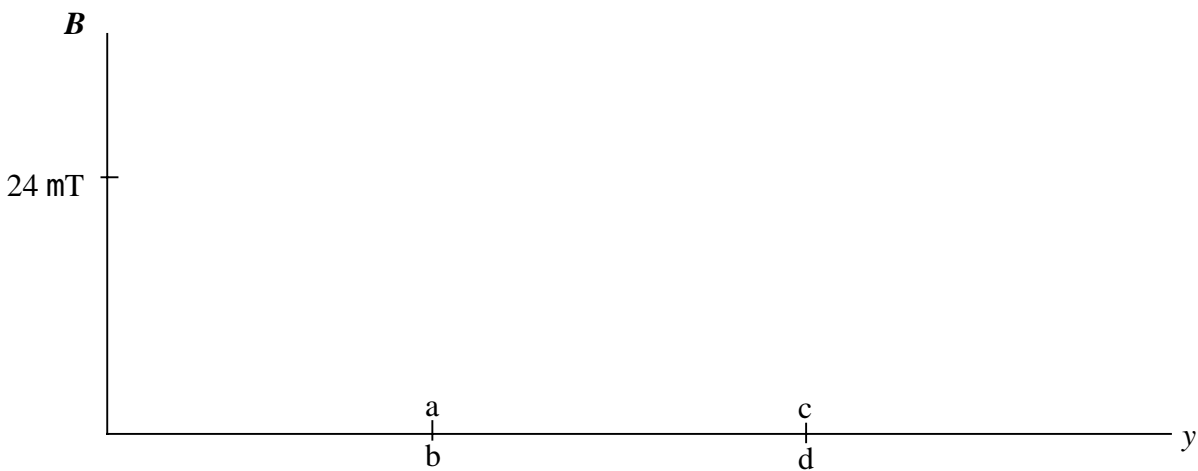
As shown in the figure below, a long straight wire is carrying a current. The magnetic field at point a has a magnitude of 24 mT.



Draw and label a graph of the magnitude of the magnetic field along the dotted line from a to c (as a dotted line on this graph) and also draw the magnitude of the magnetic field along the dashed line from b to d .

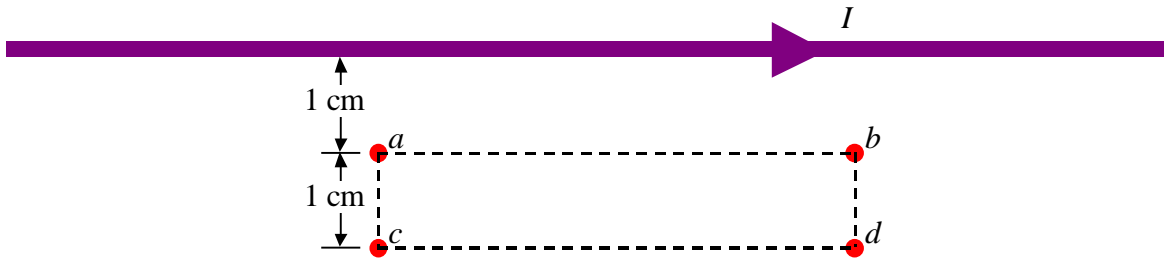


Redraw these graphs if the current is reduced to half its value.

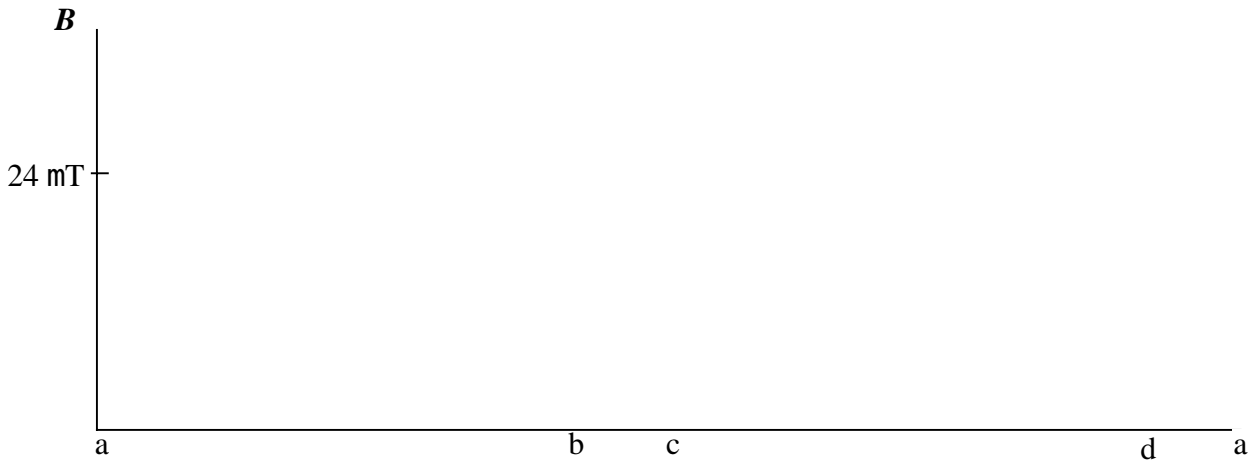


MFF3A–CRT3: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

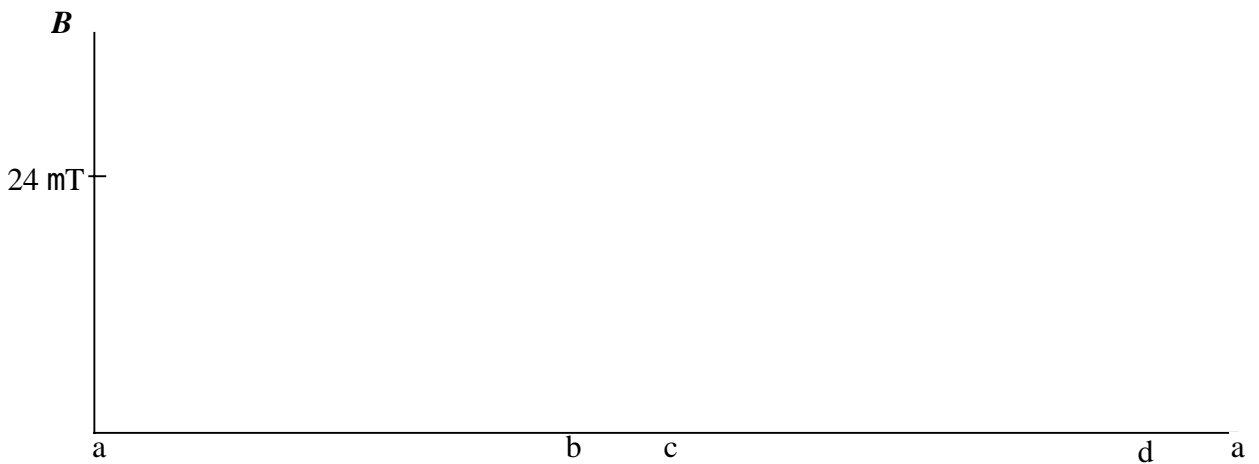
As shown in the figure below, a long straight wire is carrying a current. The magnetic field at point a has a magnitude of 24 mT.



Draw and label a graph of the magnitude of the magnetic field along the dashed line path from a to b to c to d and back to a .

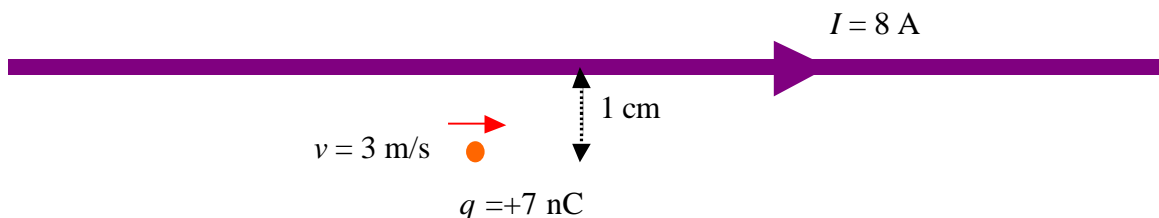


Redraw this graph if the current is reduced to half its value.



MFF3A–LMCT1: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6} \text{ kg}$, and it is moving initially at 3 m/s parallel to the wire.



Descriptions of a number of changes in this situation are presented below. How does each change affect the initial acceleration of the charged particle, if at all?

The possible answers are:

- A. This change would not affect the initial acceleration.
- B. This change would increase the magnitude of the initial acceleration but not affect its direction.
- C. This change would decrease the magnitude of the initial acceleration but not affect its direction.
- D. This change would alter the direction of the initial acceleration but would not affect its magnitude.
- E. This change would alter both the magnitude and direction of the initial acceleration.

Each change below refers to the original situation stated above:

The charge on the particle is doubled. _____

The mass of the particle is doubled. _____

The initial velocity of the particle is doubled. _____

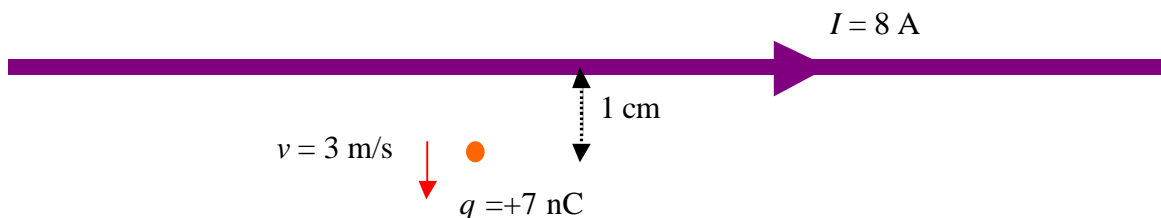
The wire is moved farther away from the charged particle. _____

The direction of the current in the wire is reversed. _____

The current is reversed and the wire is moved farther away from the particle. _____

MFF3A–LMCT2: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a particle with a net electric charge of $+7\text{ nC}$ is initially located a distance of 1 cm from a long straight wire that is carrying a current of 8 A . The charge has a mass of $6 \times 10^{-6}\text{ kg}$, and it is moving initially at 3 m/s away from the wire.



Descriptions of a number of changes in this situation are presented below. How does each change affect the initial acceleration of the charged particle, if at all?

The possible answers are:

- A. This change would not affect the initial acceleration.
- B. This change would increase the magnitude of the initial acceleration but not affect its direction.
- C. This change would decrease the magnitude of the initial acceleration but not affect its direction.
- D. This change would alter the direction of the initial acceleration but would not affect its magnitude.
- E. This change would alter both the magnitude and direction of the initial acceleration.

Each change below refers to the original situation stated above:

The current in the wire is doubled. _____

The charge on the particle is doubled. _____

The mass of the particle is doubled. _____

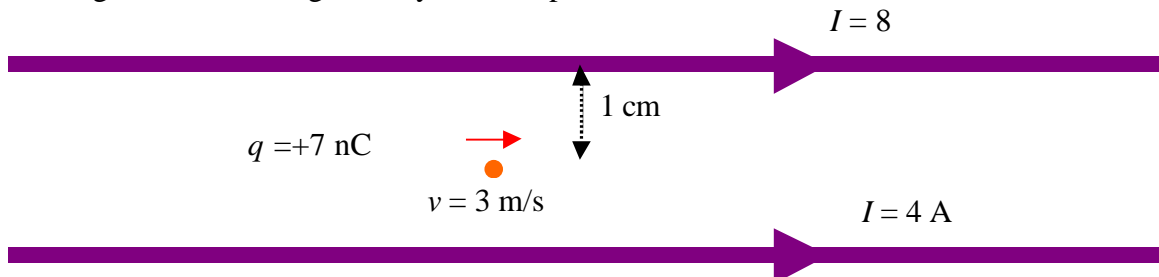
The initial velocity of the particle is doubled. _____

The wire is moved farther away from the charged particle. _____

The direction of the current in the wire is reversed. _____

MFF3A–LMCT3: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRES

As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located midway between two long straight parallel wires that are carrying currents of 4 A and 8 A . The particle is initially at a distance of 1 cm from each wire. The charge has a mass of $6 \times 10^{-6} \text{ kg}$ and it is moving initially at 3 m/s parallel to the wires.



Descriptions of a number of changes in this situation are presented below. How does each change affect the initial acceleration of the charged particle, if at all, after it is made?

The possible answers are:

- A. This change would not affect the initial acceleration.
- B. This change would increase the magnitude of the initial acceleration but not affect its direction.
- C. This change would decrease the magnitude of the initial acceleration but not affect its direction.
- D. This change would alter the direction of the initial acceleration but not affect its magnitude.
- E. This change would alter both the magnitude and direction of the initial acceleration.

Each change below refers to the original situation stated above:

The current in both wires is doubled. _____

The direction of the current in the lower wire is reversed. _____

The charge on the particle is doubled and the mass is doubled. _____

The charge on the particle is changed to negative. _____

The mass of the particle is doubled. _____

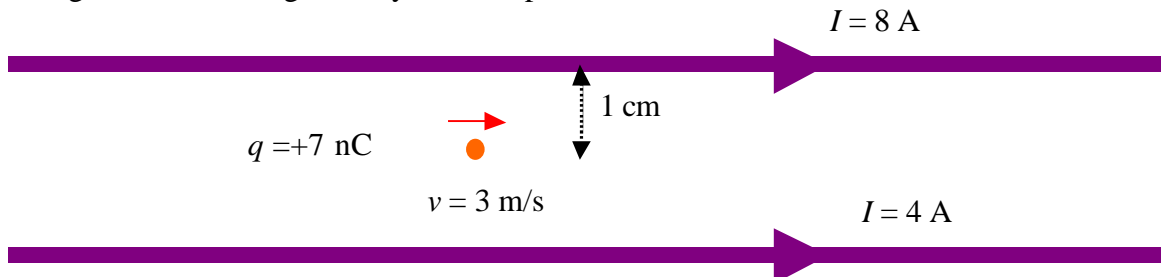
The initial velocity of the particle is doubled. _____

The wires are both moved farther away from the charged particle. _____

The current in the lower wire is changed to 10 A . _____

MFF3A–LMCT4: CHARGED PARTICLE AND STRAIGHT CURRENT-CARRYING WIRES

As shown in the figure below, a particle with a net electric charge of $+7 \text{ nC}$ is initially located midway between two long straight parallel wires that carrying currents of 4A and 8A . The particle is initially at a distance of 1 cm from each wire. The charge has a mass of $6 \times 10^{-6} \text{ kg}$ and it is moving initially at 3 m/s parallel to the wires.



Descriptions of a number of changes in this situation are presented below. How does each change affect, if it does, the initial force on the charged particle after it is made?

The possible answers are:

- A. This change would not affect the initial force on the charged particle.
- B. This change would increase the magnitude of the initial force on the charged particle, but not affect its direction.
- C. This change would decrease the magnitude of the initial force on the charged particle but not affect its direction.
- D. This change would alter the direction of the initial force on the charged particle but would not affect its magnitude.
- E. This change would alter both the magnitude and direction of the initial force on the particle.

Each change below refers to the original situation stated above:

- The current in both wires is doubled.** _____
- The direction of the current in the lower wire is reversed.** _____
- The charge on the particle is doubled and the mass is doubled.** _____
- The charge on the particle is changed to negative.** _____
- The mass of the particle is doubled.** _____
- The initial velocity of the particle is doubled.** _____
- The wires are both moved farther away from the charged particle.** _____
- The current in the lower wire changed to 10 A .** _____