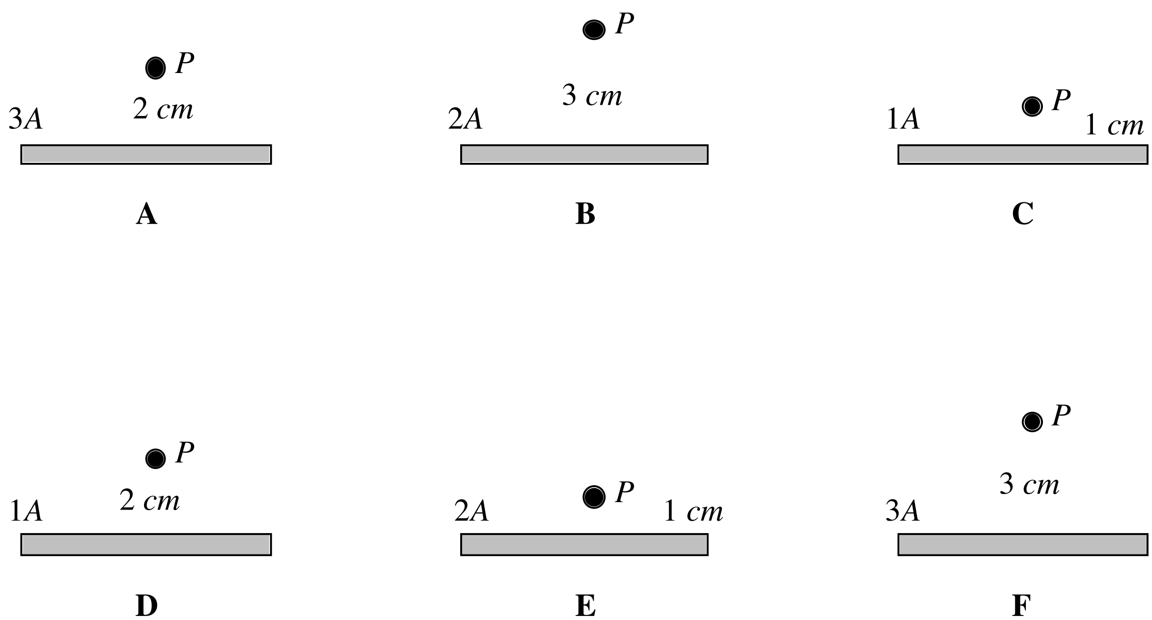
MFF 6A: STRAIGHT CURRENT-CARRYING WIRE

MFF6A-RT1: STRAIGHT CURRENT-CARRYING WIRE

The figures below show identical current-carrying, long straight wires. The current in the wire is given. Also given is a point in space, P, and its distance from the wire.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic field at point P.



Greatest 1 ___*E*___ 2 ___*A*___ 3 ___*CF*___ 4 _______ 5 ___*B*___ 6 ___*D*___ Least

Or, the field is the same for all six situations. _______

Or, the ranking for the fields cannot be determined. _______

Please carefully explain your reasoning.

Based on $B = \mu_o I/2\pi r$. Thus, $B \propto I/r$.

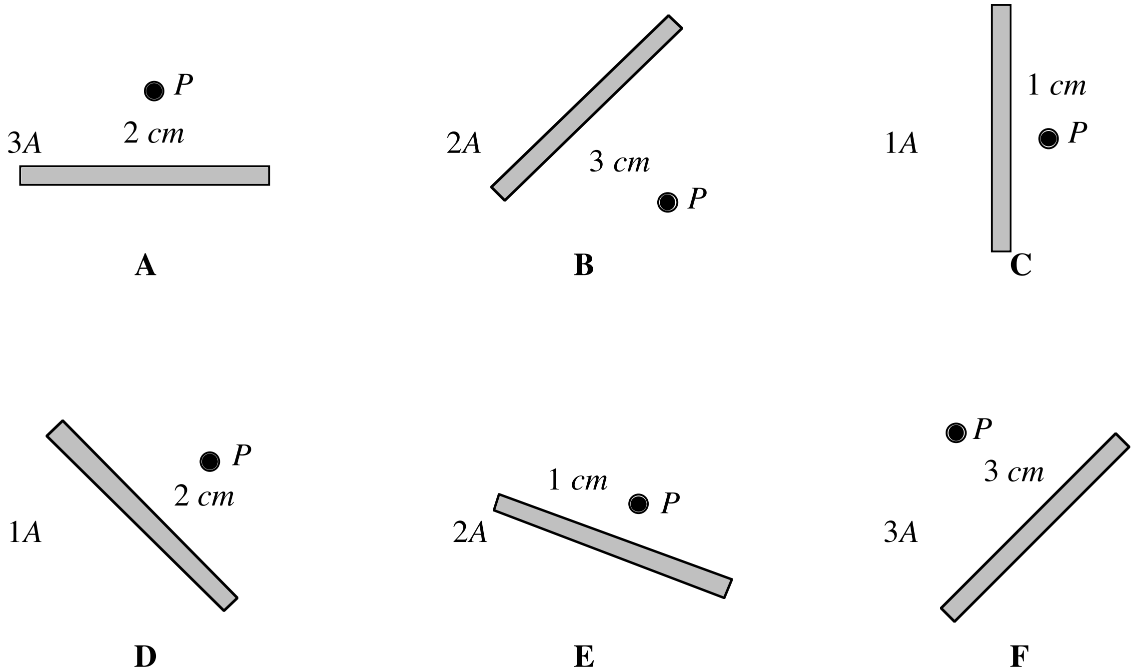
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	**10**

MFF6a-RT2: Straight Current-Carrying Wire

The figures below show current-carrying, long straight wires. The current in the wire is given. Also given is a point in space, P, and its distance from the wire.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic field at point P.



Greatest 1 ___*E*___ 2 ___*A*___ 3 ___*CF*___ 4 ______ 5 ___*B*___ 6 ___*D*___ Least

Or, the field is the same for all six situations. ______

Or, the ranking for the fields cannot be determined. ______

Please carefully explain your reasoning.

Based on $B = \mu_o I / 2\pi r$. Thus, $B \propto I/r$.

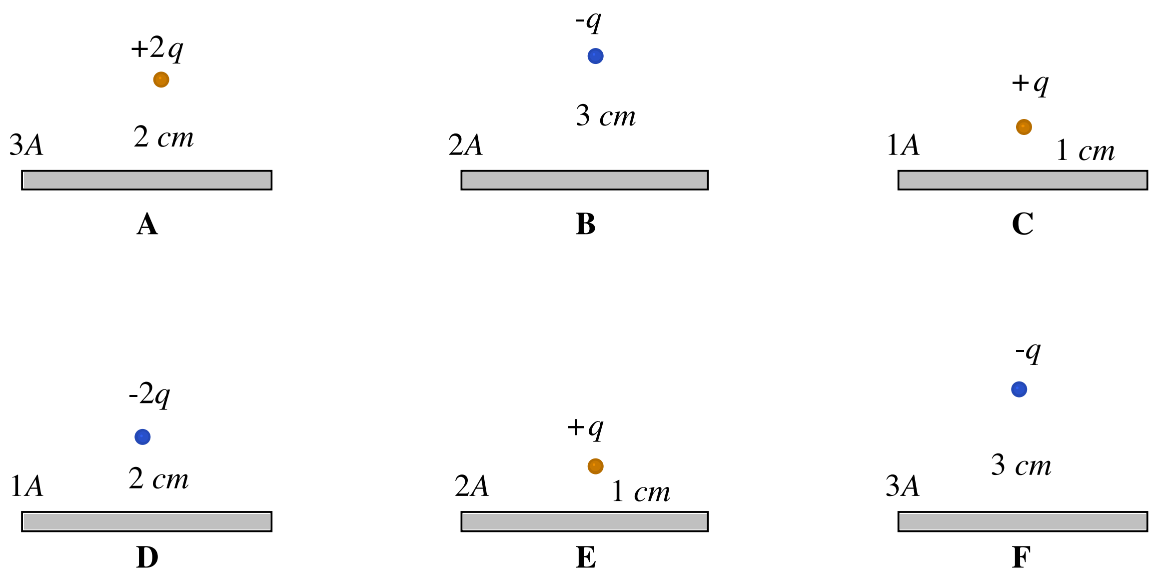
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	**10**

MFF6A-RT3: Straight Current-Carrying Wire

The figures below show current-carrying, long straight wires. The current in the wire is given. Also shown are various charges at rest at specific distances from the wire.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic field on these charges.



Greatest 1 ___*E*___ 2 ___*A*___ 3 ___*CF*___ 4 ______ 5 ___*B*___ 6 ___*D*___ Least

Or, the field is the same for all six situations. ______

Or, the ranking for the fields cannot be determined. ______

Please carefully explain your reasoning.

Based on $B = \mu_o I / 2\pi r$. Thus, $B \propto I/r$. Q has nothing to do with the B magnitude.

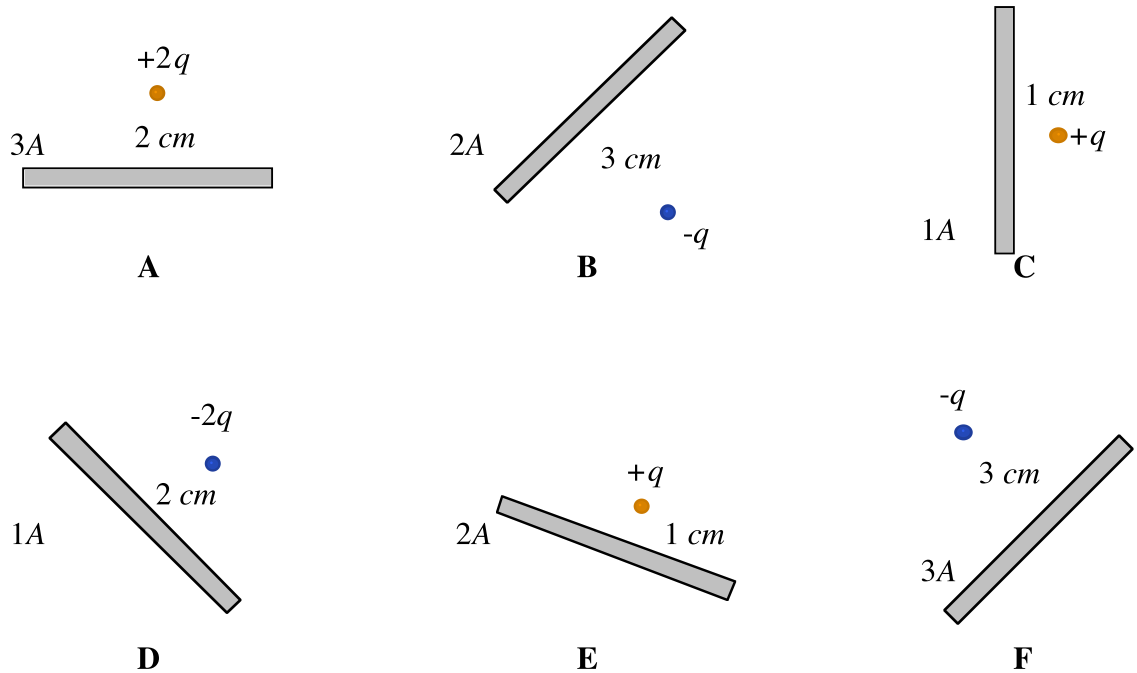
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

MFF6A-RT4: STRAIGHT CURRENT-CARRYING WIRE

The figures below show current-carrying, long straight wires. The current in the wire is given. Also shown are various charges at rest at specific distances from the wire.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic field on these charges.



Greatest 1 ___*E*___ 2 ___*A*___ 3 ___*CF*___ 4 ______ 5 ___*B*___ 6 ___*D*___ Least

Or, the field is the same for all six situations. ______

Or, the ranking for the fields cannot be determined. ______

Please carefully explain your reasoning.

Based on $B = \mu_o I / 2\pi r$. Thus, $B \propto I/r$. Q has nothing to do with the B magnitude.

How sure were you of your ranking? (circle one)

Basically Guessed   Sure   Very Sure

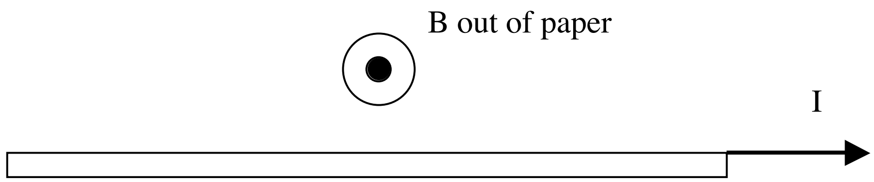
1 2 3 4 5 6 7 8 9 10

MFF6A-WBT1: STRAIGHT CURRENT-CARRYING WIRE

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

$$1\times10^{-5}\,T=\frac{\left(4\pi\times10^{-7}\,m\cdot T/A\right)(2.50A)}{2\pi(0.05m)}$$

A long, straight wire is conducting current toward the east (right) of strength 2.50 A. At a point .05 m away from the wire (and above it in the diagram), the magnetic field strength is 1×10^{-5} T.

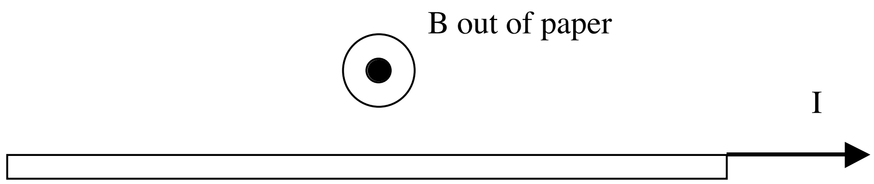


MFF6a-WBT2: Straight Current-Carrying Wire

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

$$0.133m = \frac{\left(4\pi \times 10^{-7} m \cdot T/A\right)\left(10A\right)}{2\pi\left(1.50 \cdot 10^{-5} T\right)}$$

A long, straight wire is conducting current toward the east (right) of strength 10 A. At a point .133 m away from the wire (and above it in the diagram), the magnetic field strength is 1.50 x 10^{-5} T. You are solving for the perpendicular distance from the wire.

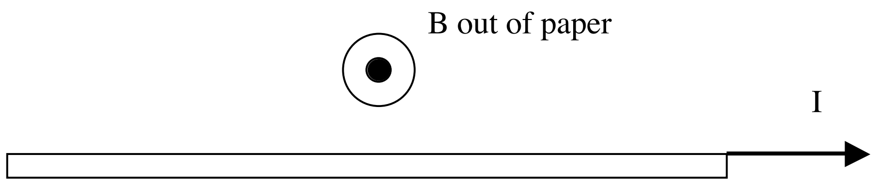


MFF6A-WBT3: STRAIGHT CURRENT-CARRYING WIRE

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

$$7.50\,A = \frac{2\pi(.05m)(3.00\times10^{-5}T)}{4\pi\times10^{-7}\,m\cdot T/A}$$

A long, straight wire is conducting current toward the east (right) of strength 7.5 A. At a point .05 m away from the wire (and above it in the diagram), the magnetic field strength is 3.00 x 10^{-5} T. You are solving for the current in the wire to obtain this magnetic field strength.



MFF6A-CCT1: STRAIGHT CURRENT-CARRYING WIRE

Consider the following statements made by three students.

Student I: "For a long, straight wire to create a magnetic field, it only needs to have current flowing in the wire."

Student II: "For a long, straight wire to create a magnetic field, it will create a magnetic field if it has a net charge."

Student III: "A long, straight wire cannot create a magnetic field by itself."

Which, if any, of these three students do you believe is correct? Explain fully why you chose as you did.

Student I is correct. Since $B = \mu_o I / 2\pi r$, then any current-carrying, straight wire will create a magnetic field around the wire.

MFF6A-CCT2: STRAIGHT CURRENT-CARRYING WIRE

Consider the following statements made by three students.

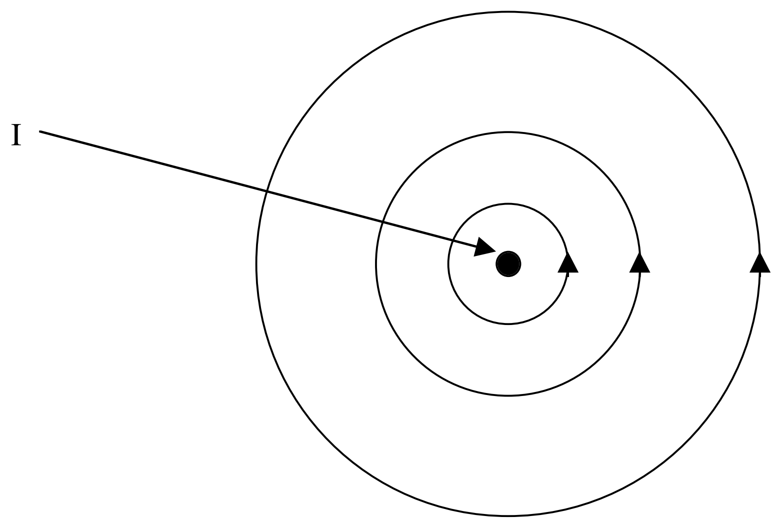
Student I: "For a current-carrying long, straight wire, the magnetic field generated looks like the magnetic field generated around a bar magnet."

Student II: "For a current-carrying long, straight wire, the magnetic field generated looks like circular loops around the wire with the wire as the center of the loops."

Student III: "For a current-carrying long, straight wire, the magnetic field generated looks like straight lines sticking out of the wire."

Which, if any, of these three students do you believe is correct? Explain fully why you chose as you did.

Student II is correct. The magnetic field around a long, straight current-carrying wire are concentric circles of decreasing strength the further you are from the wire.

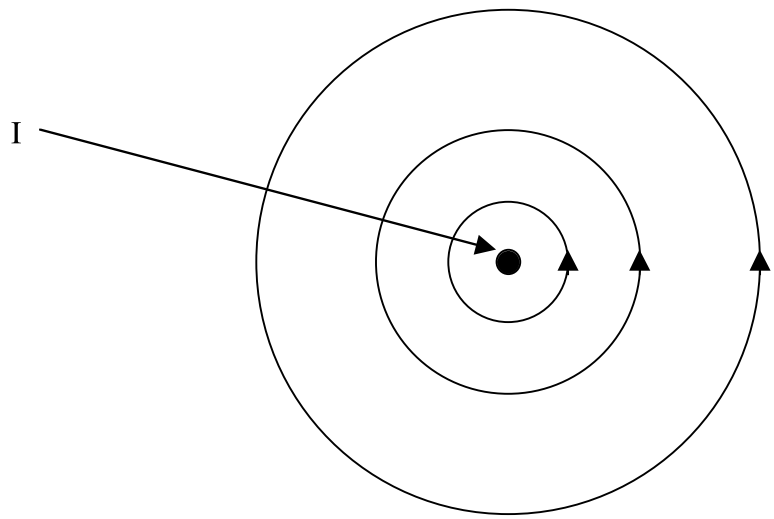


MFF6A-WWT1: STRAIGHT CURRENT-CARRYING WIRE

"A long, straight wire is conducting current whose direction is pointing out of the paper towards you. The magnetic field generated by this wire may be represented by concentric circular loops (with the wire being the center of the circle) evenly separated from 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 legitimate as it stands explain why it is valid.

The statement is correct if the field strength as you go from the wire is decreasing as 1 / r.

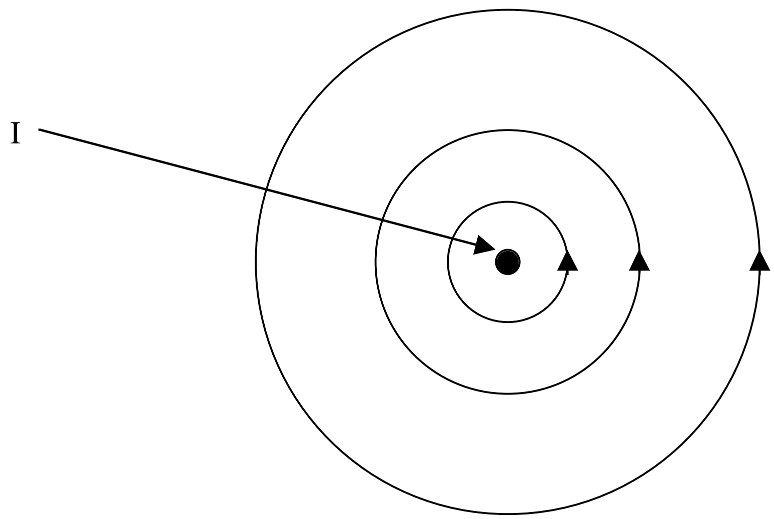


MFF6A-WWT2: STRAIGHT CURRENT-CARRYING WIRE

"A long, straight wire is conducting current whose direction is pointing out of the paper towards you. The magnetic field generated by this wire may be represented by concentric circular loops (with the wire being the center of the circle) in the clockwise direction."

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 legitimate as it stands explain why it is valid.

The direction of the magnetic field around the long, straight wire pointed out of the page towards you should be counter-clockwise.

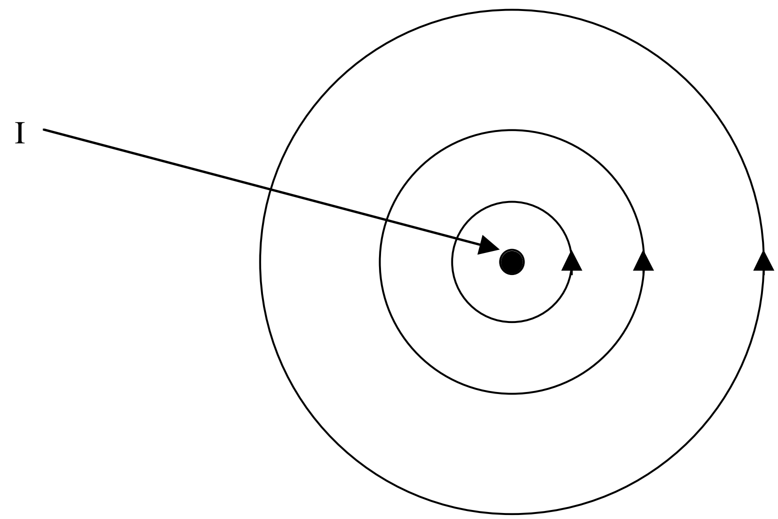


MFF6A-WWT3: STRAIGHT CURRENT-CARRYING WIRE

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

"A long, straight wire is conducting current whose direction is pointing out of the paper towards you. The magnetic field generated by this wire is into the paper to the right of the wire and out of the paper to the left of the wire."

No, the student is incorrect. The magnetic field generated by the long, straight current-carrying wire are concentric circles (with the wire as the center).

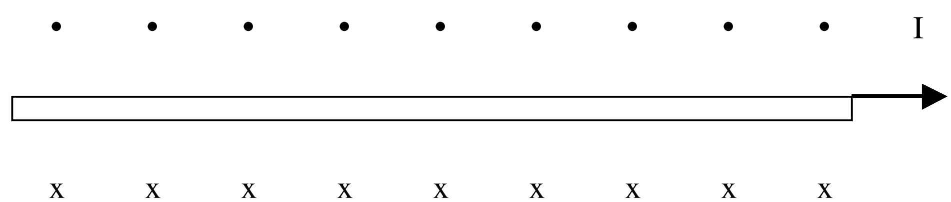


MFF6a-TT1: Straight Current-Carrying Wire

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

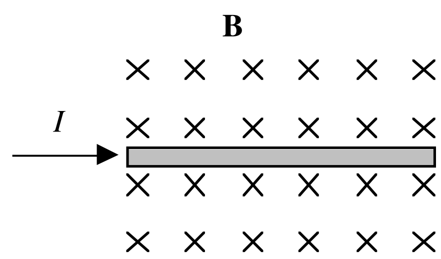
"A current-carrying long, straight wire is conducting current in the + x-direction. The direction of the magnetic field generated must be out of the x-y plane everywhere in the region of the wire."

No, the student is partially correct. The long, straight current-carrying wire pointing in the + x-direction will generated a magnetic field that will be out of the x-y plane above (towards the top of the page) the wire and into the x-y plane below (towards the bottom of the page) the wire.



MFF6A-TT2: STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a current-carrying long, straight wire is conducting current to the right. The magnetic field generated by the current in the wire is uniform and into the paper.

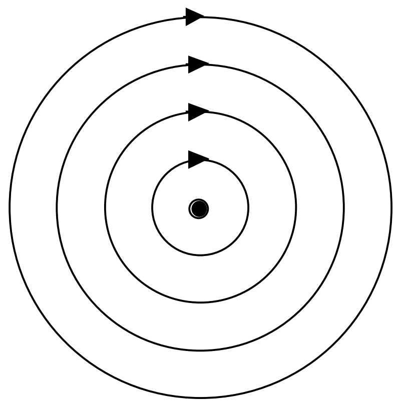


There is at least one error in the diagram and/or statement above. Identify the error(s) and explain how to correct it (them).

The magnetic field direction below the wire is correct, but the field above the wire should be coming out of the page towards you. The field strength both above and below the wire should be decreasing as you move further away from the wire.

MFF6a-TT3: Straight Current-Carrying Wire

As shown in the figure below, a current-carrying long straight wire is conducting current out of the paper (indicated by the •). Concentric circles in the clockwise direction indicate the magnetic field generated by this current-carrying wire.



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

The direction of the magnetic field around the current-carrying wire should be in the counter-clockwise direction (not clockwise).

MFF6A-LMCT1: STRAIGHT CURRENT-CARRYING WIRE

As shown in the figure below, a current-carrying long, straight wire is conducting current to the right. Point P is located above the wire as shown.

A number of changes in this situation will be described below. For each change, you are to identify how the change will affect, if it will, the magnetic field generated by the current-carrying wire at point P.

The possible answers are:

A. this change will only alter the direction of the magnetic field generated by the wire.
B. this change will only increase the magnitude of the magnetic field generated by the wire.
C. this change will only decrease the magnitude of the magnetic field generated by the wire.
D. this change will alter both the magnitude and direction of the magnetic field generated by the wire.
E. this change will not affect the magnetic field generated by the wire.

Each change below refers to the original situation stated above:

The current in the wire is replaced by a larger current.	___*B*____
The direction of the current in the wire is reversed.	___*A*____
The current in the wire is reduced to zero.	___*C*____
The current in the wire is replaced by a smaller current.	___*C*____
Point P is placed closer to the current-carrying wire.	___*B*____
Point P is placed further away from the current-carrying wire.	___*C*____
Point P is placed the same distance below the wire.	___A____

MFF6A-PET1 : STRAIGHT CURRENT-CARRYING WIRE

A current-carrying long, straight wire is initially conducting current towards the east. The current is reversed.

What will happen to the magnetic field generated by the current-carrying wire? Explain fully.

The magnitude of the generated magnetic field will be the same, but the direction will be opposite to what it was originally. In other words, the direction of the magnetic field above the wire (towards the top of the page) will be into the page and the magnetic field below the wire (towards the bottom of the page) will be out of the page.

MFF6a-PET2: Straight Current-Carrying Wire

A current-carrying long, straight wire is conducting current out of the paper. The current direction is reversed.

What will happen to the magnetic field generated by the current-carrying wire? Explain fully.

The magnitude of the magnetic field will remain the same, but the direction will change. The magnetic field will now be clockwise around the current-carrying wire.

MFF6a-M/MCT1: Straight Current-Carrying Wire

The figure below shows a long, straight wire conducting a 10 A current. Point P is 0.05 m from the wire.

Given below is a student's calculation for the magnetic field generated by the current-carrying, long straight wire.

$$\vec{\mathbf{B}} = \frac{(4\pi \bullet 10^{-7}\,\mathrm{m}\cdot\mathrm{T}/\mathrm{A})(10\mathrm{A})}{2\pi(.05\mathrm{m})}\hat{\mathbf{k}}$$

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)?

The calculation is meaningful.

MFF6a-QRT1: Straight Current-Carrying Wire

The figure below shows a current-carrying long, straight wire.

What is the direction of the magnetic field due to the current-carrying wire at point P?

The direction of the magnetic field is out of the paper.

What would happen to the direction of the magnetic field at point P if the current in the wire was reversed?

The direction of the magnetic field would reverse (it would be into the paper).

What would happen to the magnetic field at point P if the current in the wire was increased?

The magnitude of the magnetic field would increase.

What would happen to the magnetic field at point P if the current in the wire was decreased?

The magnitude of the magnetic field would decrease.

What would happen to the magnetic field at P if point P was moved farther away from the wire?

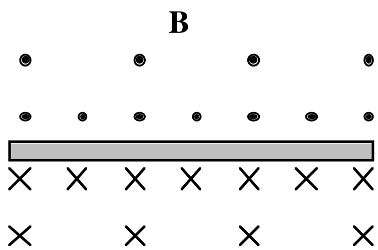
The magnitude of the magnetic field would decrease.

What would happen to the magnetic field at P if point P was moved closer to the wire?

The magnitude of the magnetic field would increase.

MFF6a-QRT2: Straight Current-Carrying Wire

The figure below shows the magnetic field due to a current-carrying long, straight wire.



What is the direction of the current in the wire?

The current is towards the right.

If we reversed the direction of the current, what would happen to the direction of the magnetic field generated by the wire?

The directions would also reverse – the magnetic field above the wire would be into the page and the magnetic field below the wire would be out of the page.

If we increase the current flowing in the wire, what will happen to the strength of the generated magnetic field?

The magnitude of the magnetic field would increase.

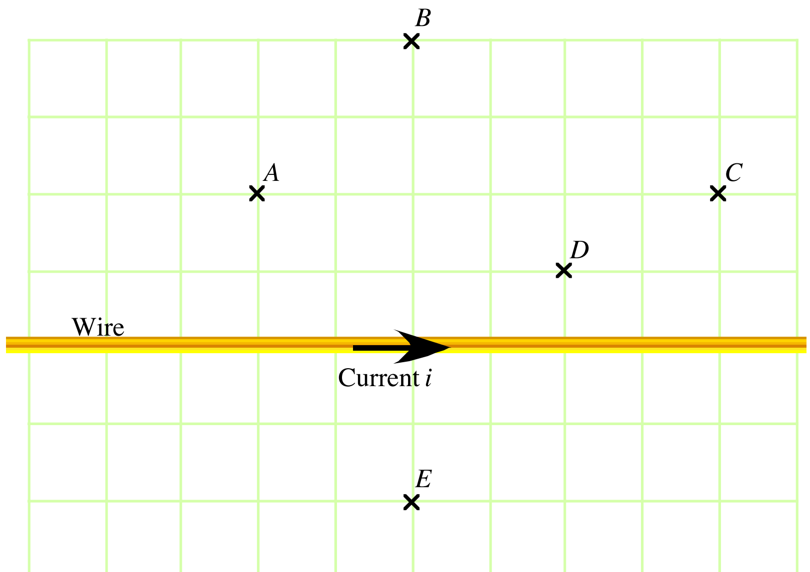
Describe the strength of the magnetic field as a function of the distance from the wire.

The magnitude of the magnetic field would decrease.

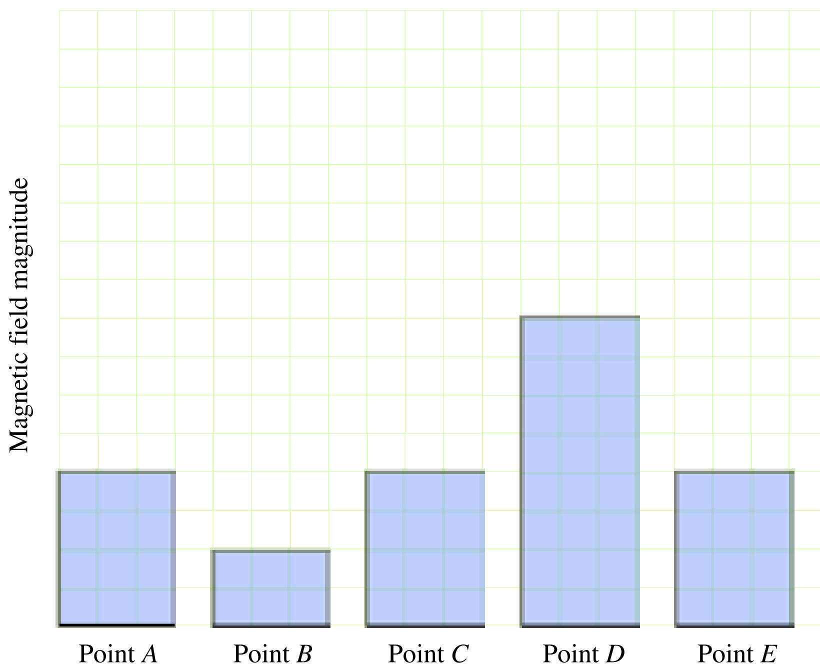
MFF6A-BCT1: Straight Current-Carrying Wire

The figure below shows a current-carrying long, straight wire conducting current in the +x-direction. Point P is located at a perpendicular distance r away from the wire.

The figure below shows a current-carrying long, straight wire conducting current in the +x-direction.



Represent on the bar chart below, the magnitude of the magnetic field at the various points shown in the diagram above given the magnitude at point A.



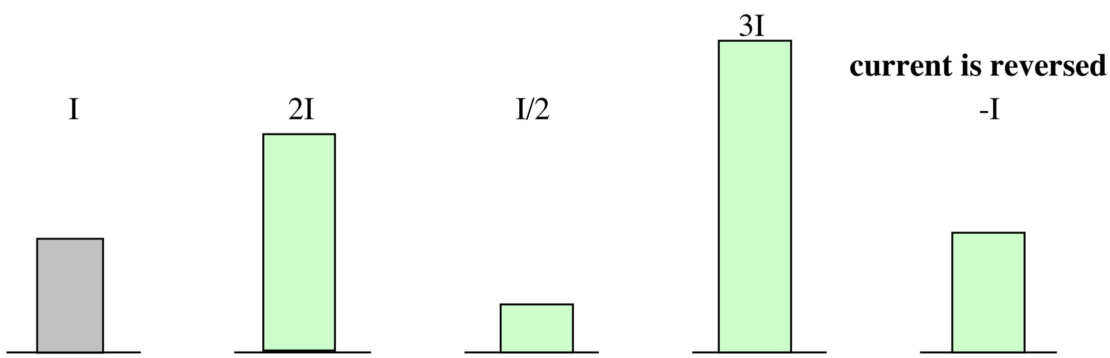
Explain the reasoning behind your bar charts:

The size of the bars on the bar chart is based on the equation $B = \mu_o I / 2\pi r$.

MFF6a-BCT2: Straight Current-Carrying Wire

The figure below shows a current-carrying long, straight wire conducting current in the +x-direction. Point P is located a distance r away from the wire.

Represent these situations with a bar chart of the magnitude of the magnetic field at point P if the current in the wire can change. The current in the wire is indicated above each bar chart, and the bar chart for P in the figure is given.



Explain the reasoning behind your bar charts:

The size of the bars on the bar chart is based on the equation $B = \mu_o I / 2\pi r$.

MFF6A-CRT1: STRAIGHT CURRENT-CARRYING WIRE

The equation below represents the magnetic field at a particular point due to a current-carrying long, straight wire.

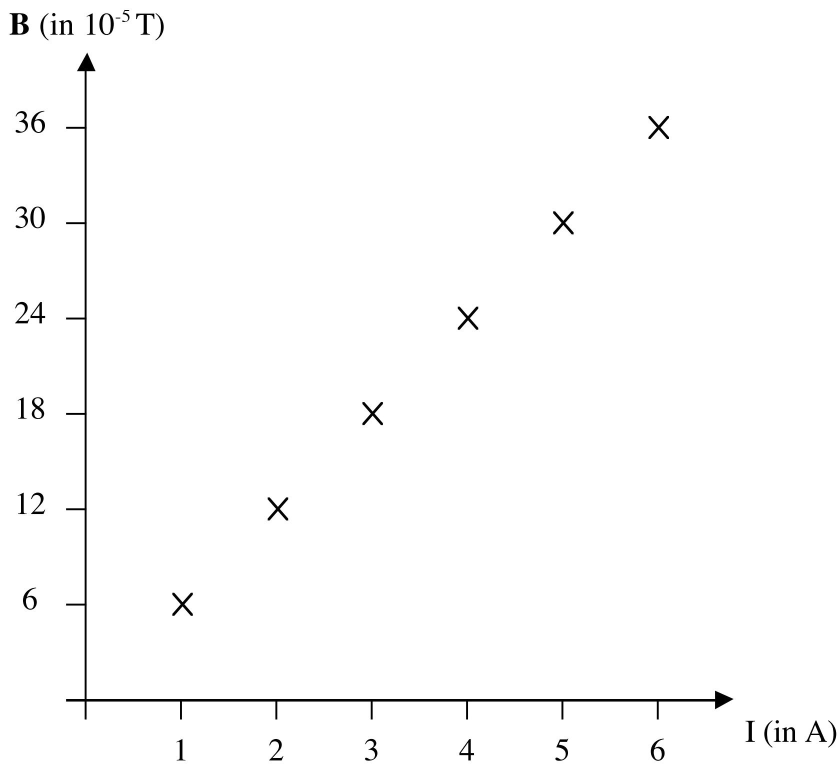
$$1 \times 10^{-5} T = \frac{(4\pi \times 10^{-7} m \cdot T / A)(2.50 A)}{2\pi(0.05 m)}$$

Draw an appropriate diagram of the current-carrying wire and magnetic field represented by this equation.

Based on the magnetic field generated by a long, straight, current-carrying wire. The current in the wire is 2.50 A and the point is .05 m away from the wire. The magnitude of the magnetic field at this point would be 1.00 x 10^{-5} T.

MFF6A-CRT2: STRAIGHT CURRENT-CARRYING WIRE

Shown below is the graph of the magnetic field due to a current in a long straight wire. The magnetic field is measured at some point P.



Setup an appropriate equation that would give the distance r that point P is from the current-carrying straight wire.

Using $B = \mu_o I/2\pi r$

$B = (6\ T/A)\ I \quad (T)$