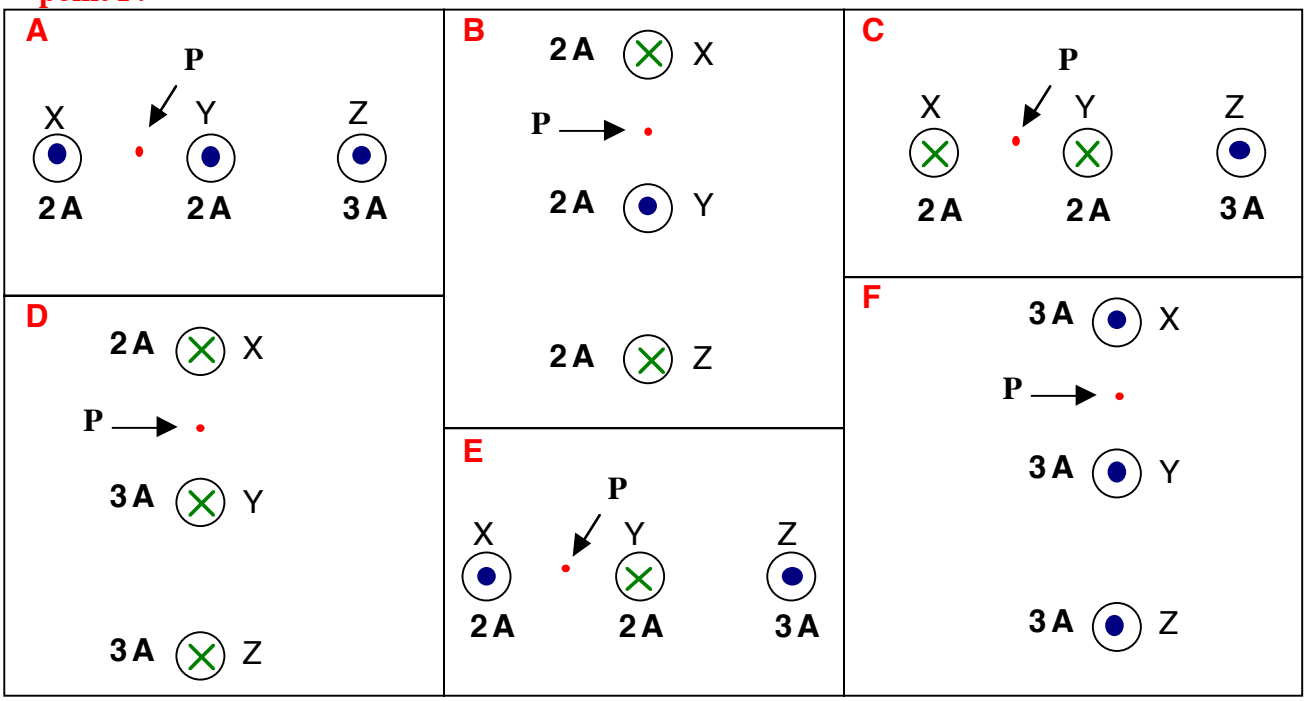
MFF 8B: THREE PARALLEL CURRENT-CARRYING WIRES I

MFF8B—RT1: THREE PARALLEL CURRENT-CARRYING WIRES I

Shown below are six situations where three long straight wires are parallel to each other carrying currents either into, or out of, the page. The distance between wires X and Y is the same as the distance between wires Y and Z. The magnitudes of the currents in each wire, as well as their directions, are given in each figure. In each situation, a point P is identified, and is halfway between the two wires adjacent to it.

Rank these situations, from greatest to least, on the strength of the total magnetic field at point P.



Greatest 1 ___*B*__ 2 __*E*___ 3 __*D*__ 4 *ACF*__ 5 _____ 6 _____ Least

OR, The total magnetic field at P has the same strength for ALL 6 of these situations. _____

OR, the total magnetic field is zero at P for all 6 of these situations. _____

Carefully explain your reasoning.

Divide the current in each wire by the distance between the wire and point P. We also took into account the directions of the fields. Add the three magnetic fields to get the net magnetic field.

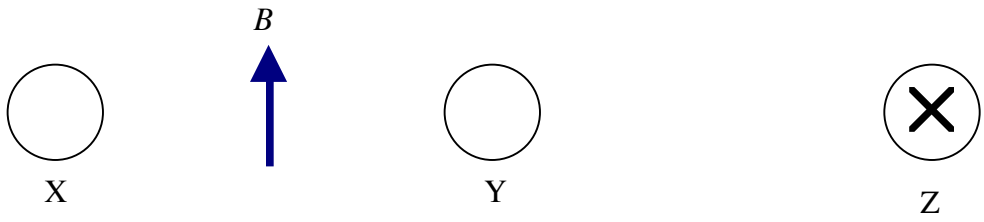
How sure were you of your ranking? (circle one)

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

MFF8B—WBT1: THREE PARALLEL CURRENT-CARRYING WIRES I

The arrow in the figure below represents the magnitude and direction of the total magnetic field at that point. Wire Z at the far right is carrying a current down into the page. All three wires are carrying the same current.

For the situation shown below, what can we determine about the direction(s) of the currents in wires X and Y?

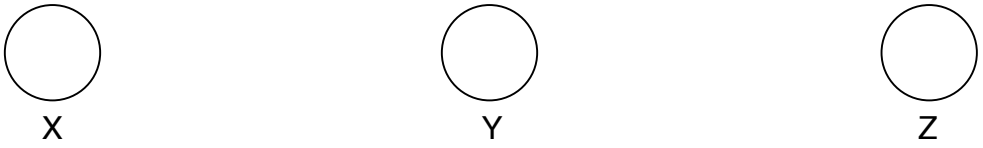


Carefully explain your reasoning.

We can determine that the current in X is not down at the same time as the current in Y is up since that would result in a net field pointing toward the bottom of the page. Beyond that we cannot say anything for sure because we do not have any comparison to determine how strong the field that is represented by the arrow actually is.

MFF8B—CCT1: THREE PARALLEL CURRENT-CARRYING WIRES I

Given below are statements made by three students about the situation shown. All three wires have the same non-zero magnitude of current.



With which, if any, of the following students do you agree and why?

Student A: "For this configuration, the total field midway between wires X and Y only will be zero if all 3 currents are in the same direction."

Student B: "For this configuration, the total field midway between wires X and Y only will be zero if the center current is opposite the other two."

Student C: "For this configuration, the total field midway between wires X and Y will never be zero."

Carefully explain your reasoning.

Student C is correct. The fields at that point due to the currents in wires X and Y will be equal but the field due to wire Z's current will be smaller. Consequently, there is no way to get the three fields to sum to zero vectorially at the point midway between wires X and Y.

MFF8B—WWT1: THREE PARALLEL CURRENT-CARRYING WIRES I

What, if anything, is wrong with the following situation? If something is wrong, identify it and explain how to correct it. If nothing is wrong, explain why the situation works as it does.

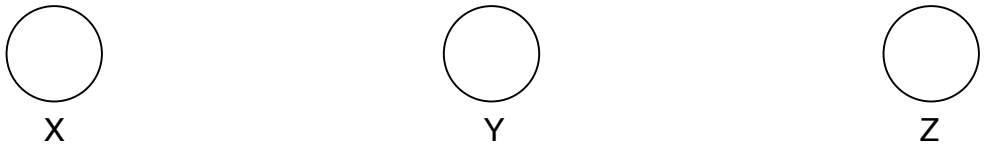
For three long straight parallel wires lying on a table and carrying equal magnitude electric currents, it is not possible for the total magnetic field between the wires to be zero at any point.

This is not valid. One case for which there will be a point where the field is zero would be if the direction of the current in one of the outside wires is the same as that in the center wire and the other outside wire has a current in the opposite direction. In this case there will be a point between the two wires that have currents in the same direction where the net field will be zero. This point will be closer to the central wire than to the outside wire.

MFF8B—TT1: THREE PARALLEL CURRENT-CARRYING WIRES I

There is something wrong with the following situation. Identify the problem and explain how to correct it.

The three long straight parallel wires, whose ends we see in the figure below, all carry the same current. The total magnetic field midway between wires X and Y has the same magnitude and direction as the total magnetic field midway between wires Y and Z.

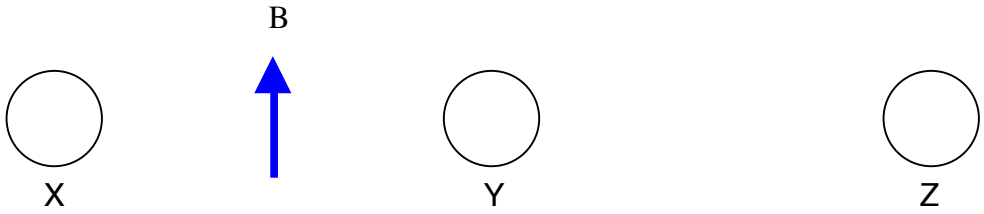


This is not possible. Although the fields at the two points could have the same magnitudes, they cannot also have the same direction.

MFF8B—PET1: THREE PARALLEL CURRENT-CARRYING WIRES I

The total magnetic field shown below is midway between wires X and Y and directed toward the top of the page. All wires have the same current.

How could a single current be changed to produce a total field at P pointing toward the bottom of the page?



If the currents in wires X and Y are in the same direction then this field is due to the current in wire Z, so reversing the current in Z will reverse the field. If the currents in X and Y are in opposite directions and the current in Z produces a field at this point directed toward the top of the page, then the current in either X or Y could be reversed. But if the currents in X and Y are in opposite directions and the current in Z produces a field at this point directed toward the bottom of the page, then it is not possible.

MFF8B—BCT1: THREE PARALLEL CURRENT-CARRYING WIRES I

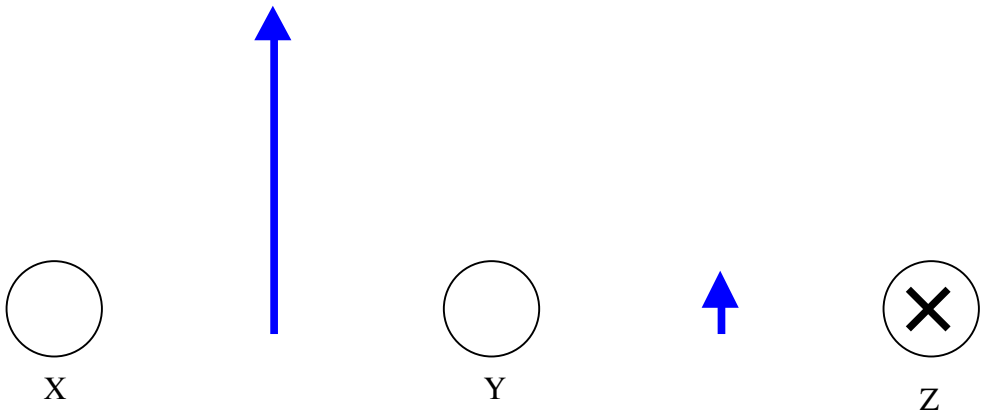
The bar chart below left shows the magnitude of the total magnetic field midway between wires X and Y in the figure. The currents in the three wires have the same value. **Complete the bar chart below right to show the magnitude of the total magnetic field midway between wires Y and Z.**

Please carefully explain how you determined your answer.

The field strength at the midpoint between Y and Z will be one-seventh of the field at the point midway between X and Y, so we need one bar.

MFF8B—QRT1: THREE PARALLEL CURRENT-CARRYING WIRES I

In the figure below, all currents in the three wires have the same value and the arrows represent the magnetic fields at the midway points between the two adjacent wires.



What is the direction of the current in wire X? *Up out of the page.*

What is the direction of the current in wire Y? *Down into the page.*

For the situation shown above, describe how each of the following changes will affect the total magnetic field at the point midway between wires X and Y.

a) **The current in wire Y is reversed.**

The field will be reduced because the contributions due to currents in X and Y will cancel instead of adding.

b) The currents in wires X and Z are doubled.

The field will increase.

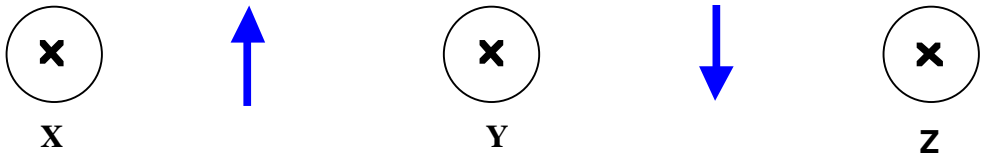
c) The current in Y goes to zero.

The field will decrease since there will be only two contributions instead of three.

d) The currents in all three wires are reversed.

The field direction will reverse, but have the same magnitude.

MFF8B—LMCT1: THREE PARALLEL CURRENT-CARRYING WIRES I



The arrows in the figure above represent the total magnetic field at points midway between wires X and Y and wires Y and Z. All three wires have the same magnitude of current in them directed into the page. Described below are possible changes to this situation.

For each change, choose the effect on the field midway between X and Y from the following choices:

a) Direction of the magnetic field remains the same, but the magnitude increases.
b) Direction of the magnetic field remains the same, but the magnitude decreases.
c) Magnitude of the magnetic field remains the same, but the direction reverses.
d) Both magnitude and direction change.
e) Both magnitude and direction will be unaffected.

1) The current in wire Z is reversed. ___*C*____

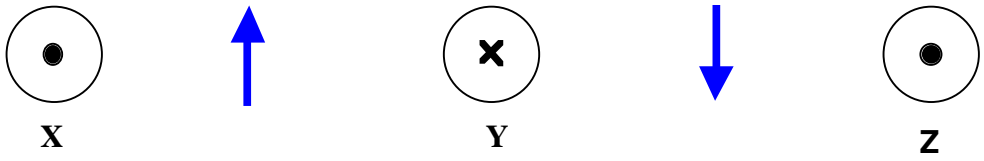
2) The currents in all three wires are doubled. ___*A*____

3) The currents in wires X and Z are reversed and cut in half. ___*A*____

4) The current in wire Y is reduced to zero. ___*D*____

5) The currents in X and Y are both reversed. ___*E*____

MFF8B—LMCT2: THREE PARALLEL CURRENT-CARRYING WIRES I



The arrows in the figure above represent the total magnetic field at points midway between wires X and Y and wires Y and Z. All three wires have the same magnitude of current in them directed out of the page for X and Z and into the page for Y. Described below are possible changes to this situation.

For each change, choose the effect on the field midway between X and Y from the following choices:

a) The direction of the magnetic field remains the same, but the magnitude increases.
b) The direction of the magnetic field remains the same, but the magnitude decreases.
c) The magnitude of the magnetic field remains the same, but the direction reverses.
d) Both magnitude and direction change.
e) Both magnitude and direction will be unaffected.

1) The current in wire Z is reversed. ___*A*____

2) The currents in all three wires are doubled. ___*A*____

3) The currents in wires X and Z are reversed and cut in half. ___*B*____

4) The current in wire Y is reduced to zero. ___*B*____

5) The currents in both X and Y are both reversed. ___*D*____

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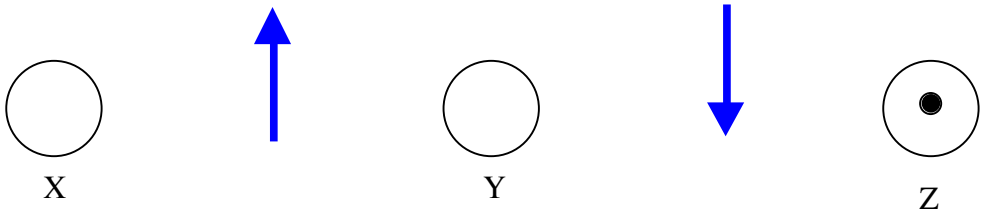
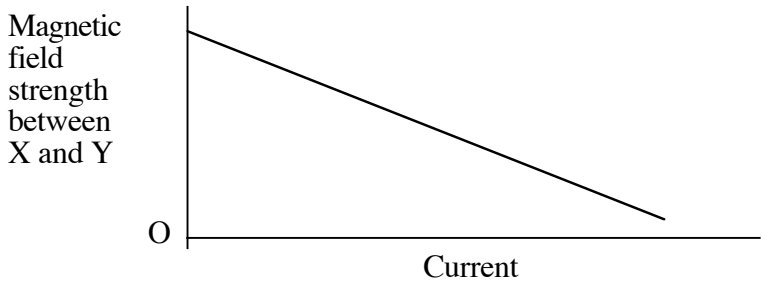
The arrows in the figure below represents the total magnetic fields at the midway points between wires X and Y and Y and Z. The graph shows how the magnitude of the total magnetic field at the point midway between wires X and Y changes as the current in only one of the wires increases. The currents in the other two wires remain constant and are the same.





In which wire is the current increasing and how do you know?

The current in X has to be up out of the page and the current in Y has to be down into the page. The only way for the field midway between X and Y to decrease is if the field due to Z is increasing, which it will be if the current in Z increases.