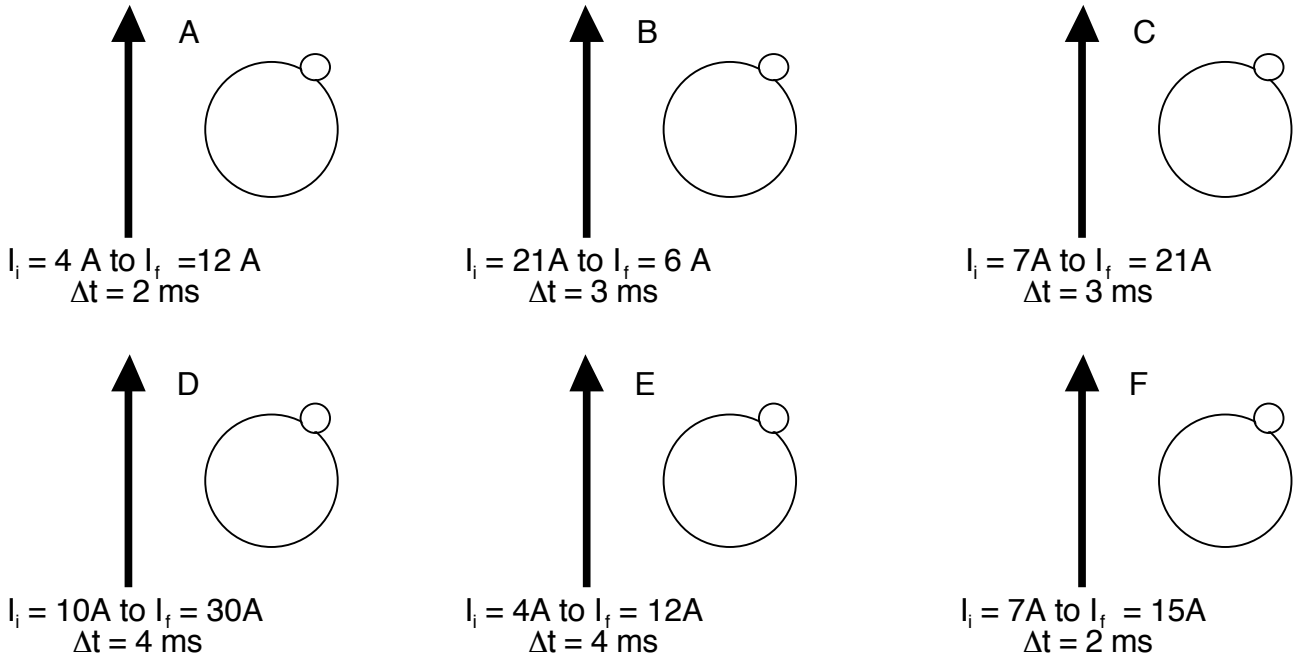
EMI 3B: CHANGING CURRENT AND BULB BRIGHTNESS

EMI3B—RT1: CHANGING CURRENT AND BULB BRIGHTNESS

Shown below are six situations where a long straight wire is sitting next to a circular wire loop that has a small light bulb in it. The currents in the long wires are changing at uniform rates. The initial current, the final current, and the time interval during which the change occurs are given in each figure. All of the wire loops are the same diameter and made of the same material. The bulbs are all identical, and the straight wires are all the same distance from the wire loops.

Rank these situations, from greatest to least, on the basis of how bright the bulbs will be during the current changes.



Greatest 1 __*B,D*___ 2 _____ 3 __*C*____ 4 __*A,F*___ 5 _____ 6 ___*E*___ Least

OR, The bulbs in all six of these cases will have the same brightness. _____

OR, None of the bulbs will light for these six cases. _____

Carefully explain your reasoning.

A current in the wire creates a magnetic field. A changing current in the wire creates a changing magnetic field (and magnetic flux) which induces a current in the wire loop and cause the bulb to light. The bulb brightness is dependent on the flux which is proportional to the current difference per unit time. Calculate the current difference and divide by the time interval.

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

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

EMI3B—WBT1: CHANGING CURRENT AND BULB BRIGHTNESS

Two small light bulbs in circular coils of wire that do not have batteries in them are found to be lit. One bulb is brighter than the other.

Construct a physical situation involving these coils and long, straight, current-carrying wires that could produce this situation.

The bulb in the coil on the left is brighter because the current in that wire is changing at a faster rate than the current in the wire on the right.

EMI3B—CCT1: CHANGING CURRENT AND BULB BRIGHTNESS

Given below are three statements by different students about a situation where there are two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases these loops are the same distance away from their respective current-carrying wires. The bulbs differ in brightness. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another.

Student A*: "The one bulb is brighter than the other because the long wire next to the brighter bulb has a larger current in it."*

Student B: *"No, the one bulb is brighter than the other because the current in the long wire next to it is changing at a faster rate than the current in the other wire."*

Student C: *"You both have part of the answer. The one bulb is brighter because the current in the long wire next to it has changed and now has the larger current."*

With which, if any, of these students do you agree?

Student A _____ Student B __*X*__ Student C _____ None of these students _____

Please carefully explain your reasoning.

Student B is correct because this is an induced emf situation which depends on the rate of change of flux.

The flux changes because the field changes and the field changes because the current changes. The bulb will be brightest, therefore, where the current changes at the greatest rate.

EMI3B—WWT1: CHANGING CURRENT AND BULB BRIGHTNESS

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 the way it does.

We have a situation where there are two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases these loops are the same distance away from their respective current-carrying wires. The bulbs are lit but differ in brightness. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another.

A student says:
"At this instant, the current in the wire next to the brighter bulb has the larger value."

The student is wrong. What matters is the rate of change of the flux which is produced by the changing current, not the specific current values.

EMI3B—TT1: CHANGING CURRENT AND BULB BRIGHTNESS

We have a situation where there are two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases these loops are the same distance away from their respective current-carrying wires. The bulbs are both lit but differ in brightness. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another.

A student says:
"The long wire next to the brighter bulb has the larger current in it."

There is something wrong with the student's contention. Identify the problem and explain how to correct it.

The student is wrong because the important factor is the rate of change, not the specific current value.

EMI3B—QRT1: CHANGING CURRENT AND BULB BRIGHTNESS

We have a situation where there are two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases these loops are the same distance away from their respective current-carrying wires. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another.

For each of the situations described below, explain how the brightness of the two bulbs will compare at all times.

(a) The left wire starts with a larger current, but the rate of change of current is the same for both wires.

The bulbs will be equally bright since they have the same rate of change.

(b) Both wires have the same initial current, but the left one has a greater rate of change of current.

The bulb on the left will be brighter since it has the greater rate of change.

(c) Both wires start with the same current and both change at the same rate, but the left one changes for longer than the right one does.

The bulbs will be equally bright since the rates of change are the same, but the bulb on the left will be lit for a longer time.

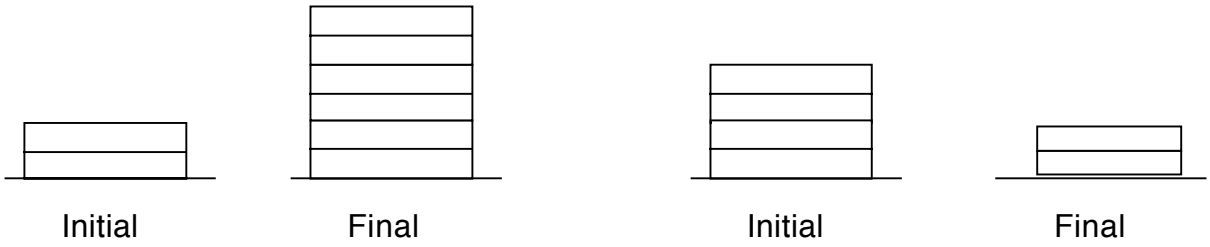
(d) The left wire starts with a larger current, but it has a lower rate of change than the right one does.

The bulb on the right will be brighter since the rate is what matters.

EMI3B—BCT1: CHANGING CURRENT AND BULB BRIGHTNESS

The figure below shows a situation where there are two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases these loops are the same distance away from their respective current-carrying wires. The bulbs are both lit but differ in brightness, with the bulb on the left being brighter. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another.

The bar charts below show the initial and final current in the long straight wire for the left-hand situation during a 1 sec interval. **Complete the final bar chart below right for the current in the long straight wire for the right-hand situation during the same 1 sec interval.**

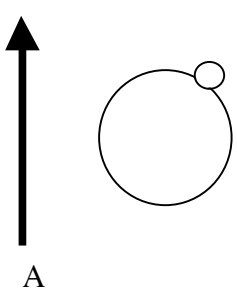


Carefully explain your reasoning.

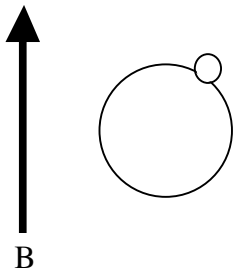
The change for the right-hand wire has to be less since the rate has to be less and the time interval is the same for both.

EMI3B—PET1: CHANGING CURRENT AND BULB BRIGHTNESS

We have two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases these loops are the same distance away from their respective current-carrying wires. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another. The initial current in wire A is 4A and the initial current in the other wire B is 10 A. Both currents increase by 8 A in a 250 millisecond interval.



A



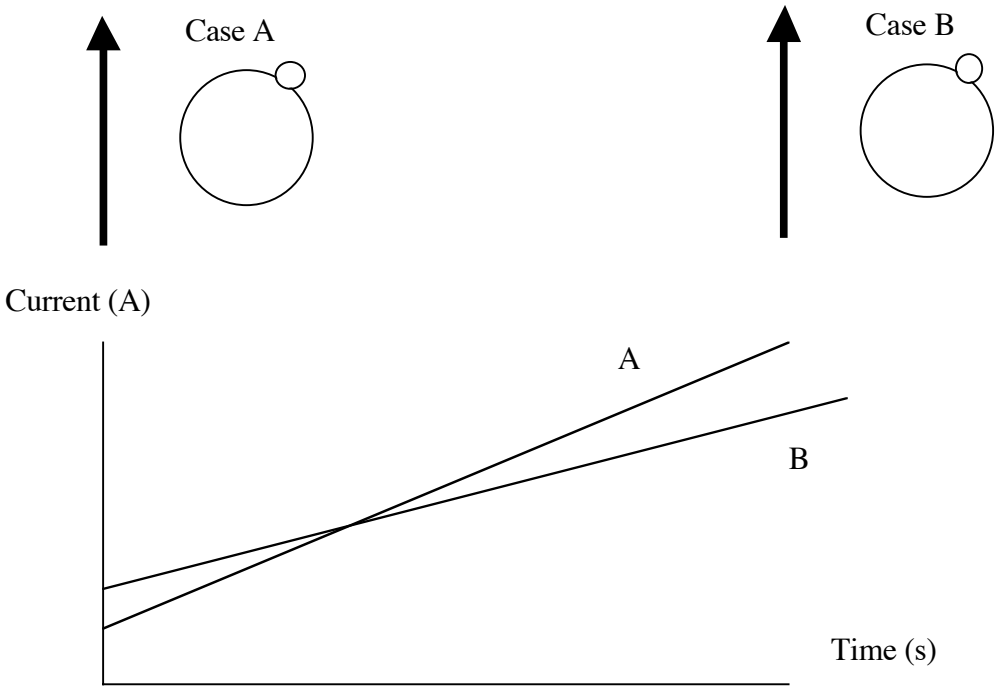
B

What will happen to the two bulbs and why?

The two bulbs will be equally bright since the rates of change of the currents, and consequently, the flux, will be the same for both.

EMI3B—CRT1: CHANGING CURRENT AND BULB BRIGHTNESS

We have two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases, these loops are the same distance away from their respective current-carrying wires. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another. Given below are the graphs of current versus time for the currents in the two long straight wires in the situations below.



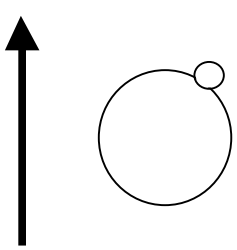
The bar chart below left shows the brightness of the bulb in case A. Complete the bar chart below right to show the brightness of the bulb for case B.

Explain your answer and reasoning fully.

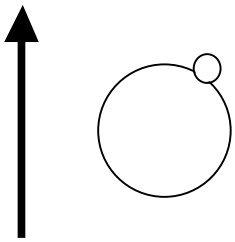
Both bulbs will light and bulb A will be a little brighter since its rate of change is a little larger.

EMI3B—LMCT1: CHANGING CURRENT AND BULB BRIGHTNESS

The figure below shows a situation where there are two circular coils of wire with small bulbs in them that are sitting beside two long straight current-carrying wires. In both cases, these loops are the same distance away from their respective current-carrying wires. The wire coils, bulbs, and long straight wires are identical for the two situations. There are no batteries in the coils. The distance between these two situations is so great that they can be viewed as independent of one another.



Situation A



Situation B

Described below are a number of situations involving the currents in the two long straight wires. For each of these situations, **identify how the brightness of the two bulbs will compare.** The possible choices for these comparisons are:

(a) Neither bulb is lit.
(b) Only the bulb in situation A is lit.
(c) Only the bulb in situation B is lit.
(d) Both bulbs are lit and equally bright.
(e) Both bulbs are lit, and the one in situation A is brighter.
(f) Both bulbs are lit, and the one in situation B is brighter.

1) Both wires have a constant current of 5 A. __*A*__
2) Both wires start with 5 A of current, but the current in the wire in situation B doubles in a 3 sec interval while that in A remains constant. __*C*__
3) The current in the wire in situation A goes from 2 A to 14 A in a 2 sec interval, while at the same time, the current in the wire in situation B goes from 4 A to 24 A. __*F*__
4) The current in the wire in A decreases from 17 A to 4 A in a 2 sec interval, while the current in the wire in B is constant at 22 A. __*B*__
5) The current in the wire in A starts at 3A, the current in the wire in B starts at 8A, and both double in a 1.5 sec interval. __*F*__
6) Both currents decrease from 32 A to 9 A, but the time interval in A is 2 sec, while in B, the interval is 5 sec. __*E*__