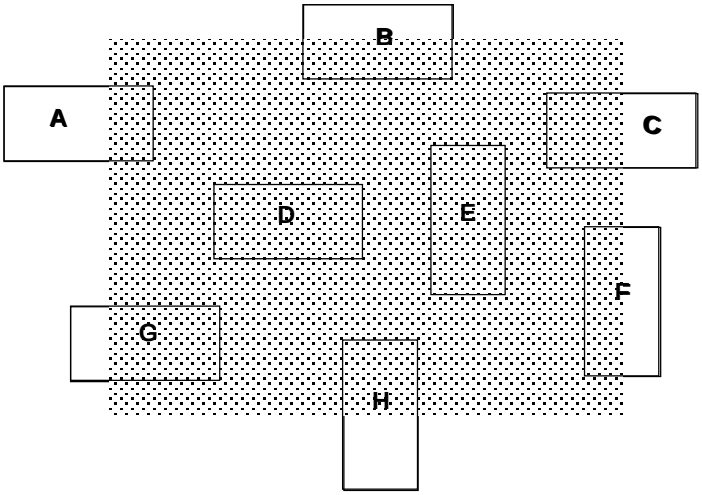
EMI 3A: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS-CURRENT

EMI3A—RT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

The situations below show eight rectangular wire loops that are moving to the right into, within or out of, region in which there is uniform magnetic field coming out of the page. The rectangular loops are the same size (5 cm by 10 cm) and are being pushed to the right at a constant velocity (2 cm/s). The loops are at various locations with various portions (25%, 50%, 75%, or 100%) within the field and orientations in the field as shown.

Rank these situations, from greatest to least, on the basis of the induced current in the rectangular loops at the time and positions shown (assume there is no effect between the loops).

5 cm x 10 cm rectangular conducting loops all moving to the right (Æ) at constant velocity v = 2 cm/s



Greatest 1 _*F*__ 2 _*ACG*_ 3 ____ 4 ____ 5 _*BDEH*_ 6 ___ 7 ____ 8 ___ Least

OR, All the loops have the same induced current. _____

OR, There is no induced current in any of the loops. _____

Carefully explain your reasoning.

The current is directly proportional to the induced emf since they all have same resistance due to same circumference. The induced emf is proportional to the rate of change of flux. BDEH has no change in flux since the portion within the magnetic field is constant (until they reach the limit of the field). For the others, the rate of change of flux is due to change of area that is proportional to the length of the rectangle perpendicular to the direction of motion. (Or, Emf = B*v*L where L is the length perpendicular to direction of motion and since B and v are constant the emf is proportional to L.)

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

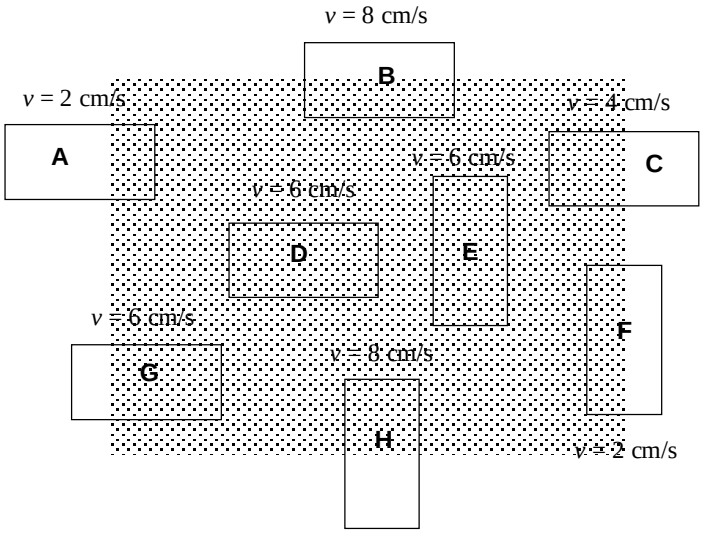
Basically Guessed					Sure				Very Sure
1	2	3	4	5	6	7	8	9	10

EMI3A—RT2: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

The situations below show rectangular wire loops that are moving to the right into, within or out of, region in which there is uniform magnetic field coming out of the page. The rectangular loops are the same size (5 cm by 10 cm) and are being pushed to the right at various constant velocities as shown. The loops are at various locations with various portions (25%, 50%, 75%, or 100%) within the field and orientations as shown.

Rank these situations, from greatest to least, on the basis of the induced current in the rectangular loops at the time and positions shown (assume there is no effect between the loops).

5 cm x 10 cm rectangular conducting loops moving to the right (Æ)



Greatest 1 _*G*__ 2 _*CF*__ 3 ____ 4 _*A*_ 5 _*BDEH*_ 6 ___ 7 ____ 8 ___ Least

OR, All the loops have the same induced current. _____

OR, There is no induced current in any of the loops. _____

Carefully explain your reasoning.

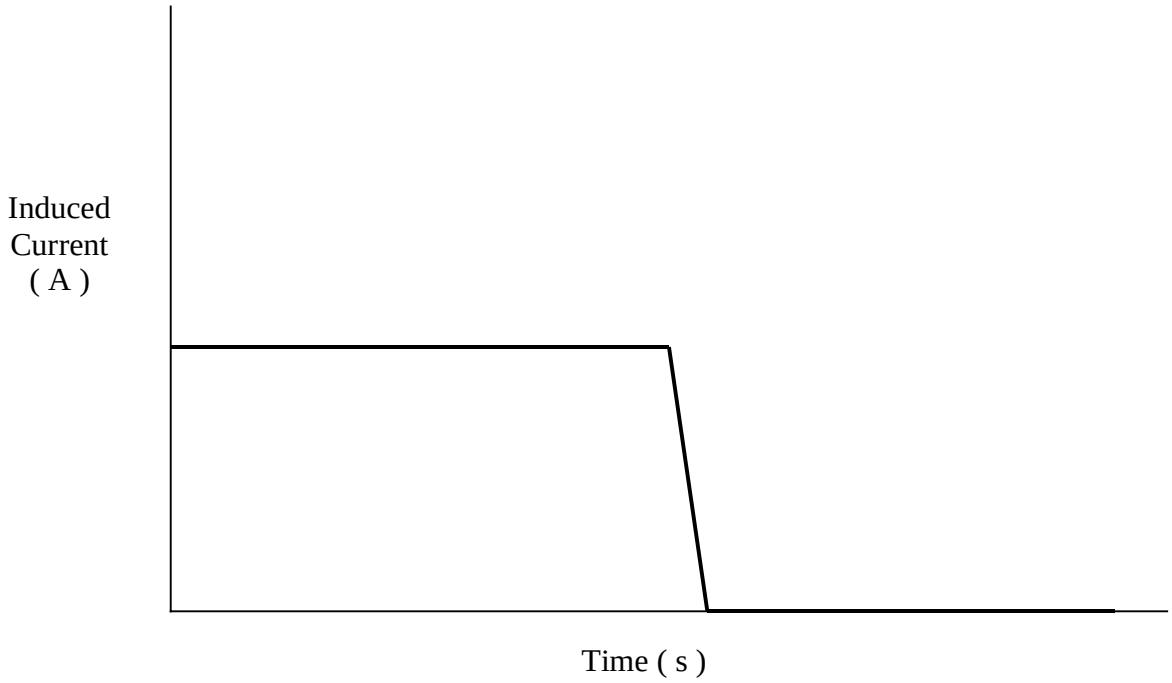
The current is directly proportional to the induced emf since the loops all have same resistance since they have the same circumference. The induced emf is proportional to the rate of change of flux. BDEH has no change in flux since the portion within the magnetic field is constant (until they reach the limit of the field). For the others, the rate of change of flux is due to the rate of change of area that is proportional to the length of the rectangle perpendicular to the direction of motion and the velocity. (Or, emf = B*v*L where L is the length perpendicular to direction of motion.)

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

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

EMI3A—WBT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

Construct a physical situation, involving a rectangular wire loop moving in a uniform magnetic field at a constant speed, to which the graph below could apply.



Explain fully.

A loop is initially moving into a region with a uniform magnetic field at a constant velocity. As soon as it is and it entirely within the field, the induced current drops to zero because there is no change in flux.

EMI3A—WWT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

What, if anything is wrong with the following?

> A student contends: ***"If a rectangular wire loop is pulled into a region where there is a uniform magnetic field, the induced current will increase as more of the loop gets into the field since there will be more flux inside the loop."***

Answer: What is wrong with the statement is that it is not the quantity of flux but the rate at which the flux is changing which determines the emf. This then results in a current if the loop is closed. The current will be constant if the speed that the wire loop is being pulled into the field is held constant until the loop is entirely within the magnetic field. If the speed of the loop were increasing as it is moved into the field, then the current would increase.

EMI3A—TT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

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

> A student contends: ***"If a rectangular wire loop is pulled into a region where there is a uniform magnetic field, the induced current will increase as more of the loop gets into the field since there will be more flux inside the loop."***

The current will increase if the speed that the loop is pulled into the field is increased. This produces a rate of change of flux that is increasing which produces an increasing induced emf.

EMI3A—CCT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

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

Student A: ***"If a rectangular wire loop is pulled at a constant speed into a region where there is a uniform magnetic field, the induced current will increase as more of the loop gets into the field since there will be more flux inside the loop."***

Student B: ***"No, the induced current in the wire loop will decrease as the loop moves into the field region since less of the loop will be outside of the field."***

Student C***: "No, the induced current in the wire loop will be constant from the time the loop starts into the field region until it is fully into the field region when the induced current will go to zero because the flux no longer changes."***

I agree with:

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

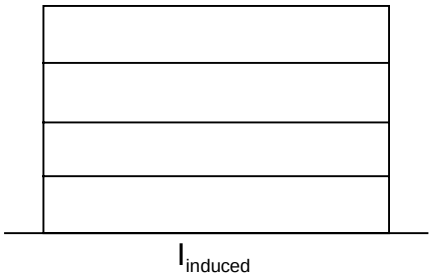
Explain your reasoning fully.

Student C accurately describes what will happen in the situation and why. Student A exhibits a common confusion connecting emf with the amount of magnetic flux rather than the rate of change of magnetic flux. Student B seems to be struggling with the same conceptual difficulty, but reverses the effect.

EMI3A—BCT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

The bar chart below left shows the magnitude of the induced current in a rectangular wire loop that is being pushed into a region of uniform magnetic field at constant speed. The bar chart is for the time just as the loop starts into the field.

Complete the bar chart below right to show the magnitude of the induced current when the loop is about three-fourths into the field region.

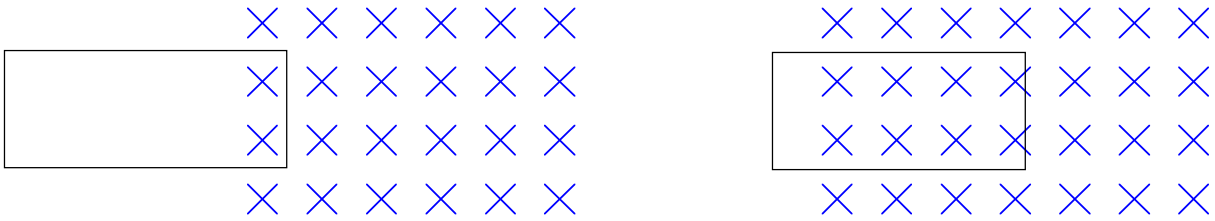


Explain your reasoning.

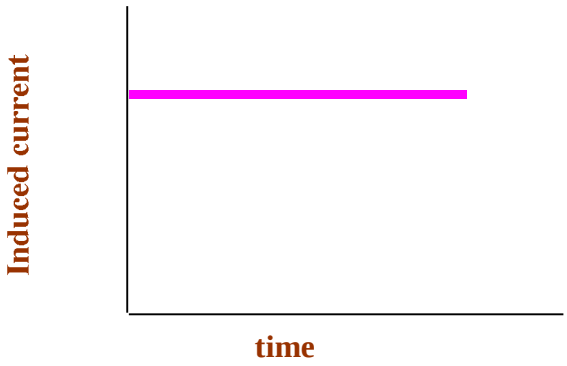
Since the loop is moving at a constant rate into the field, the flux changes at a constant rate; thus, the emf is constant which produces a constant current.

EMI3A—CRT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

Given below are two figures depicting a rectangular wire loop that is being pushed at a constant speed into a region in which there is a uniform magnetic field pointing into the page. The figures show the loop at two different times during the process.

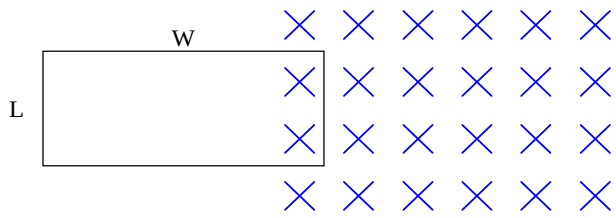


Draw a graph of the induced current in the rectangular wire loop as a function of time for the interval between the two times shown in the figures.



EMI3A—QRT1 MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS- CURRENT

A rectangular wire loop containing an 1-ohm resistor (not shown in the diagram) is being pushed into a region of uniform magnetic field. There is a current of 100 mA in the loop as it is entering the field (as indicated in the figure below).



How would the following changes affect, the current in the loop? Explain fully for each change.

(a) The width, W, of the loop in the direction of the velocity is doubled.

No change, the rate of change of flux does not depend on this length

(b) The height, L, of the loop is doubled, and the field strength is cut in half.

No change, the rate of change of flux depends on the product of the magnetic field and width

(c) The loop is completely inside the field.

The current would change to zero since the rate of change of flux is now zero

(d) The speed at which the loop is moving increases.

The current would increase since the rate of change of flux is now larger

(e) The loop is leaving the field rather than entering it.

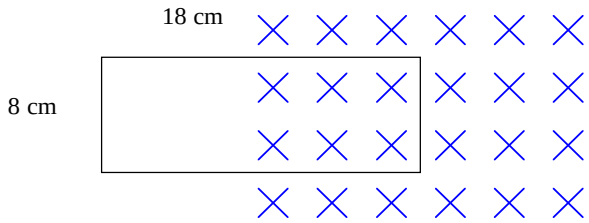
No change, the rate of change of flux does not depend on entering or leaving position

(f) The field strength increases.

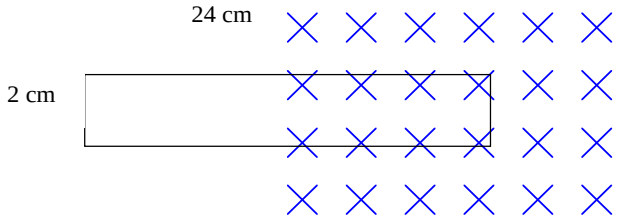
The current would increase since the rate of change of flux is now larger due to the larger magnetic field.

EMI3A—PET1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS-CURRENT

A moving rectangular loop of wire 8cm in width and 18cm in length is halfway into a region with a uniform magnetic field, and the induced current in the loop is 12 mA.



A second loop of wire 2 cm in width and 24 cm in length is being pulled at the same speed as the above loop into a magnetic field 4 times as strong. Compare the current in this second loop with the current in the first loop, when each is halfway into the field.



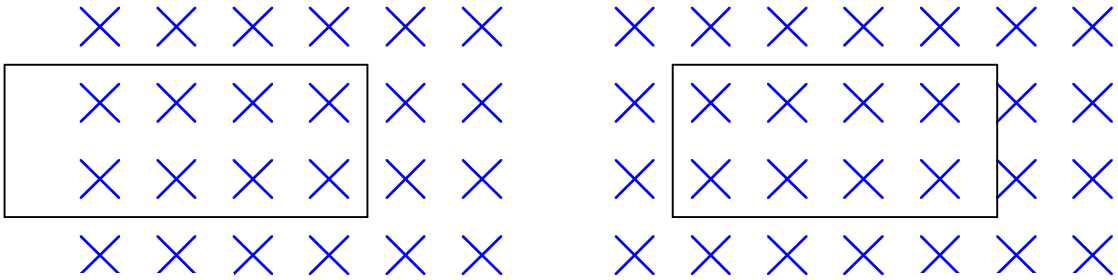
Explain the reasoning behind your prediction fully.

The second loop would have an induced current of I = (emf)/R. Since the length of the loop has not changed, the R has not changed; thus, the induced current μ induced emf. The induced emf = B * width * velocity = (4 * B) * (1/4 * w) * v, which is the same as the induced emf in the first loop.

Thus they both have the same current.

EMI3A—M/MCT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS-CURRENT

Shown below are two figures showing a rectangular loop being pushed into and through a region at a constant speed in which there is a uniform magnetic field pointing into the page. A student uses the equation below to determine the current for both times.



Case A

Case B

$I = Emf / R = v B l / R$

Will the answers this student gets be meaningful in Case A? Explain fully.

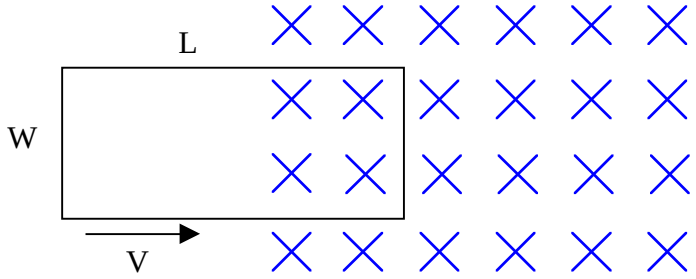
The current calculation is meaningful since the flux is changing producing an emf.

Will the answers this student gets be meaningful in Case B? Explain fully.

The current calculation is meaningless since the flux is not changing thus not producing any emf.

EMI3A—LMCT1: MOVING RECTANGULAR LOOPS AND UNIFORM MAGNETIC FIELDS-CURRENT

A rectangular wire loop containing an 1-ohm resistor (not shown in the figure) is being pulled at a constant speed v into a region in which there is a uniform magnetic field pointing into the page as shown in the figure below.



Indicate how the current in the loop will change if each of the following modifications are made from the original situation shown above.

Possible answers for all of these comparisons are:

a) The current will be larger
b) The current will be smaller but non-zero
c) The current will be the same magnitude
d) The current will be zero

1) The loop is almost completely in the field. ___*c*___

2) The speed of the loop is tripled. ___*a*___

3) The field direction is reversed. ___*c*___

4) The length, L, of the loop is increased. ___*c*___

5) The width, W, of the loop is decreased. ___*b*___

6) The loop is being pulled out the other end of the field region. ___*c*___

7) The field strength is decreased. ___*b*___

8) The loop is moving toward the bottom of the page at the same constant speed. ___*d*___

9) The loop is moving to the right at the speed v. ___*c*___