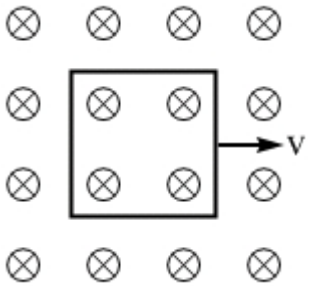
**PROBLEM 1 – 15 points**

For each situation below determine the direction of the induced current in the loop (if there is one). In each case the multiple-choice part is worth one point, and the justification is worth two points.

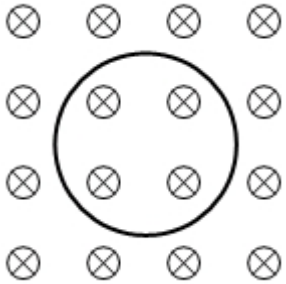
(a) A square loop is **moving at a constant velocity to the right through a uniform magnetic field** that is directed into the page and which extends out of the picture to the left and right. In which direction is the induced current in the loop?




[ ] clockwise [ ] counter-clockwise
[ ] there is no induced current

Justify your answer:

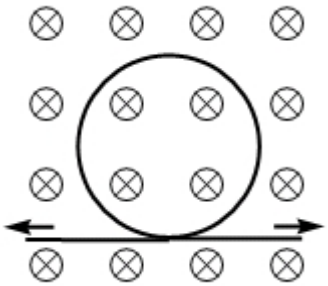
(b) A circular loop is at rest in a magnetic field directed into the page. **The magnetic field is increasing in magnitude.** In which direction is the induced current in the loop?



[ ] clockwise [ ] counter-clockwise
[ ] there is no induced current

Justify your answer:

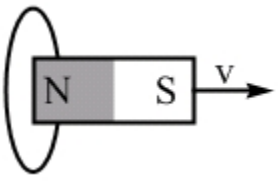
(c) A piece of wire is wrapped into a loop and placed in a uniform magnetic field that is directed into the page. You then pull on the ends of the wire so **the area of the loop is decreasing**. In which direction is the induced current in the loop?



[ ] clockwise [ ] counter-clockwise
[ ] there is no induced current

Justify your answer:

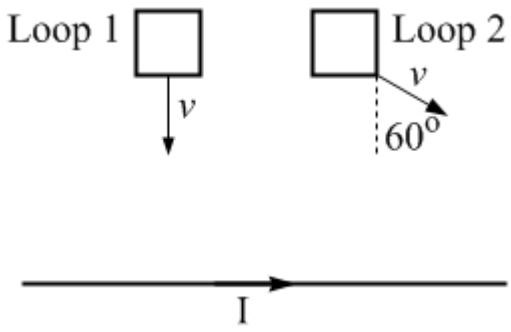
(d) A bar magnet is held near the center of a wire loop. **The magnet is then pulled away from the loop.** The north pole is always closest to the loop. In which direction is the induced current in the loop?




[ ] clockwise [ ] counter-clockwise
[ ] there is no induced current

Justify your answer:

**PROBLEM 2 – 15 points**




Two identical square wire loops are placed near a long straight wire that has a current directed to the right.

[3 points] (a) Sketch a graph showing how the magnitude of the magnetic field produced by the current in the long straight wire changes as a function of *r*, the distance from the wire.


[6 points] (b) In what direction is the induced current in loop 1 if …

(i) loop 1 remains at rest and the current in the long straight wire is constant?

[ ] clockwise [ ] counter-clockwise [ ] neither, there is no induced current

(ii) loop 1 remains at rest and the current in the long straight wire is increasing in magnitude?

[ ] clockwise [ ] counter-clockwise [ ] neither, there is no induced current

(iii) the current in the long straight wire is constant and loop 1 moves toward the wire?

[ ] clockwise [ ] counter-clockwise [ ] neither, there is no induced current

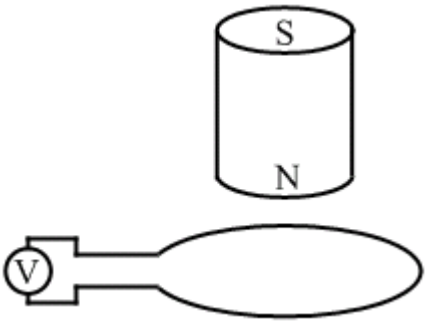
[3 points] (c) At the instant shown in the diagram above, loop 1 and loop 2 are the same distance from the wire, with loop 1 moving at a speed *v* directly toward the wire and loop 2 moving at a speed *v* in a direction 60° to the velocity of loop 1. Which loop has a larger induced current?

[ ] loop 1 [ ] loop 2 **Briefly justify your answer**

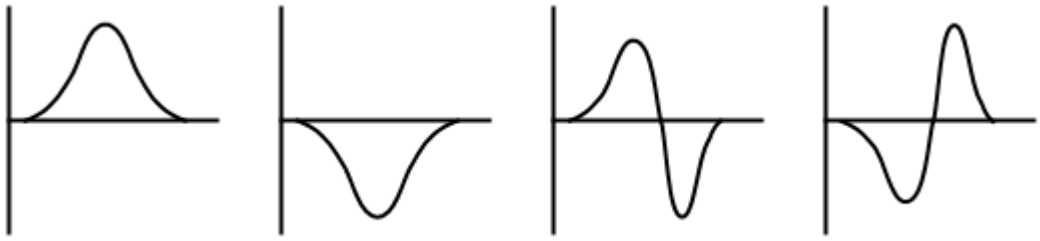
[3 points] (d) Returning to the situation described in part (c), with what speed would loop 1 have to move toward the wire to have exactly the same induced current as loop 2, if loop 2 has a speed *v* in the direction shown?

**PROBLEM 3 – 10 points**

In a Faraday's Law experiment, a magnet is dropped from rest. As shown in the diagram, the north pole of the magnet is at the bottom of the magnet and the south pole is at the top. The magnet accelerates down, passing through the center of a loop of wire connected to a voltmeter. Assume that the magnet is always oriented as shown in the diagram, with the south pole at the top of the magnet and the north pole at the bottom.



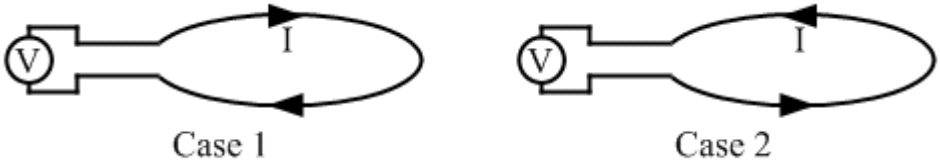

[3 points] (a) Let us define positive flux as coming from magnetic field lines that are directed up through the loop. Circle the graph below that best represents the graph of **magnetic flux** as a function of time for the magnet passing through the loop.



[2 points] (b) If the magnet is released from rest from a point higher above the loop than it was in part (a), what happens to the height of the peak(s) in the flux vs. time graph? The height of the peak(s) is:

[ ] increased [ ] decreased [ ] unchanged

The two pictures below show two possibilities for the current induced in the loop as the magnet falls through the loop.




[3 points(c) As the magnet falls, what is the direction of the induced current in the loop?

[ ] as shown in "Case 1" the entire time
[ ] as shown in "Case 2" the entire time
[ ] as in "Case 1" initially, then as in "Case 2" after the magnet has passed through the loop
[ ] as in "Case 2" initially, then as in "Case 1" after the magnet has passed through the loop

[2 points] (d) Where is the center of the magnet when the induced current in the loop reaches its peak magnitude?

[ ] above the loop [ ] below the loop [ ] at the center of the loop