Physics 212E **Classical and Modern Physics**

Some Study Questions for Unit I: Electricity and Magnetism
(taken from previous years' PHYS212 exams)

1. A conducting sphere is connected to ground. A positively charged rod is then brought close to the sphere. The connection to ground is then broken and the rod is removed. After this procedure, what is the net charge on the sphere (or is it neutral)? Explain your answer.

2. On a sunny afternoon in Chicago, a baseball pitcher throws a baseball toward home plate. Considering only the pitcher's hand and the ball, briefly explain why electrical forces are so critical in this process.

3. Describe two ways in which electrical interactions are affecting you right now as you are answering this question. None of your answers should involve anything that uses batteries or is plugged into outlets (or in any way gets electricity from a power generator).

4. Two batteries and a flash light bulb are connected in series so the bulb glows brightly. Briefly describe a change you could make so the bulb would still glow, but not as brightly.

5. In a lecture demonstration, a light bulb connected to a loop of wire was made to glow by holding the wire loop over a magnetic solenoid powered by current from the wall outlet. Would the light bulb also glow if the solenoid were connected instead to a battery? Explain why or why not.

6. Are the following statements true or false?

   a) The electric force on a positively charged particle always points in the direction of decreasing potential difference.

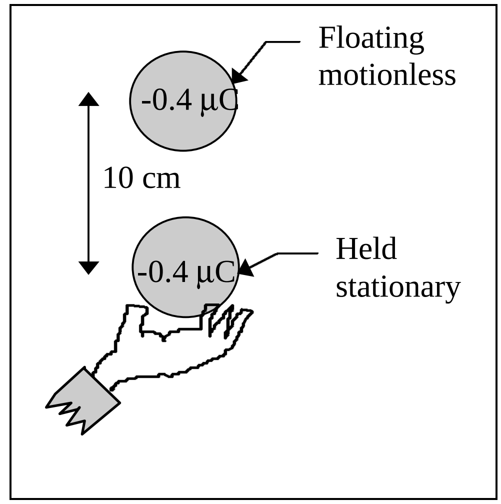
   b) In lecture a charged balloon was able to stick to the ceiling because the ceiling was not neutral but had a net surface charge.

   c) Charges q_1 and q_2 attract each other. If the distance between the two charges is increased by a factor of 3, the force of attraction is increased by a factor of nine.

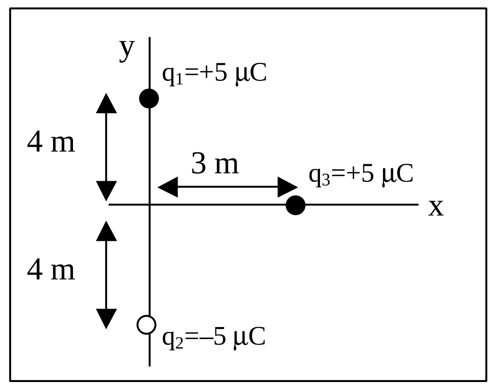
   d) The strength of the magnetic field at a point inside of a long solenoid depends on where the point is.

   e) If the magnetic force on a moving charged particle is zero, then the magnitude of the magnetic field must be zero.

7. You rub two balloons (each with the same mass) on your shirt, giving them each a charge of -0.4 μC. You then hold one balloon and release the other balloon a distance 10 cm above the first, where it floats motionless. Calculate the mass of the upper balloon. (You can treat each balloon as a point charge here.)



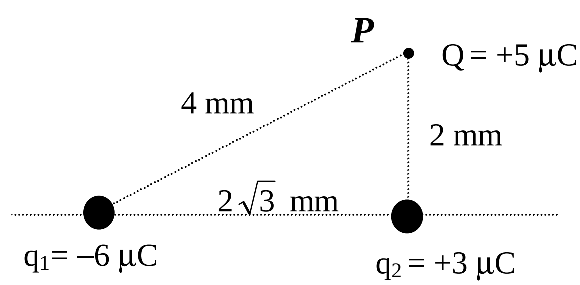
8. Three charges are arranged as shown in the diagram. Charges 1 and 3 both have charge +5 μC, whereas #2 has charge –5 μC. Determine the **magnitude** of the net force acting on the charge #3 (the one on the x-axis).



9. The illustration below shows an arrangement of two charges of opposite sign, one –6 μC and the other +3 μC, lying along the x-axis. A third charge Q = + 5μC is placed at the point *P* located 2 mm directly above the positive charge and 4mm away from the negative charge.

a) On the diagram indicate an arrow labeled F_1 for the direction of the force on Q due to q_1 and an arrow labeled F_2 for the direction of the force on Q due to q_2 .

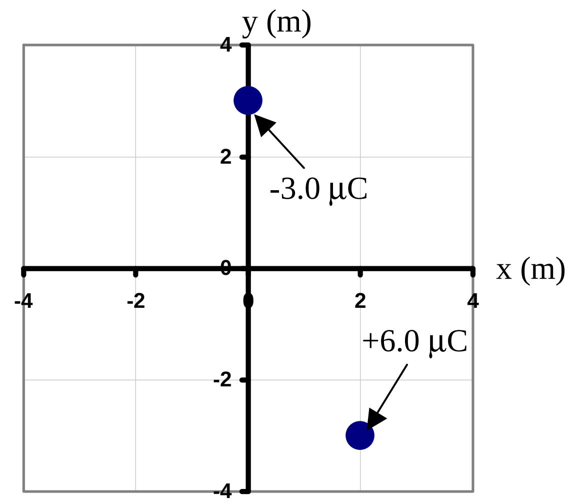
b) Calculate the magnitude of the net force on the charge Q at point *P* due to both q_1 and q_2 .



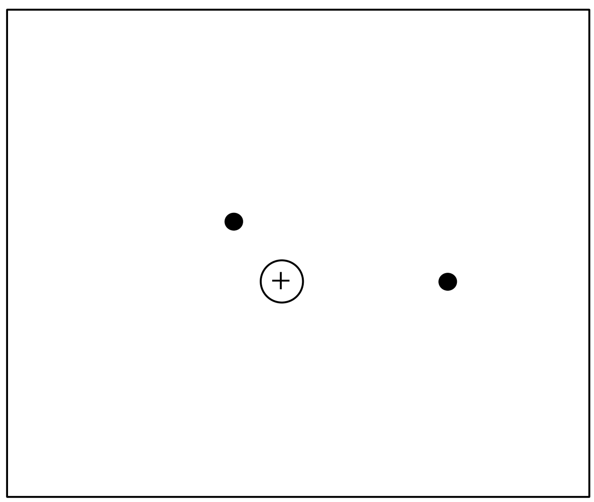
10. A particle with a charge of -3.0 μC is on the y-axis at y=3 m, and another particle with charge +6.0 μC is located at x=2m and y=-3 m, as shown in the diagram.

    a) On the diagram, draw an arrow (with its tail at the origin), showing the direction of the total electric field at the origin, due to these two charges.

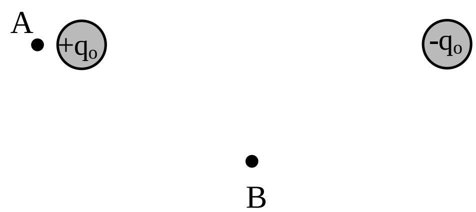
    b) Calculate the x-component of the total electric field at the origin due to these two charges.



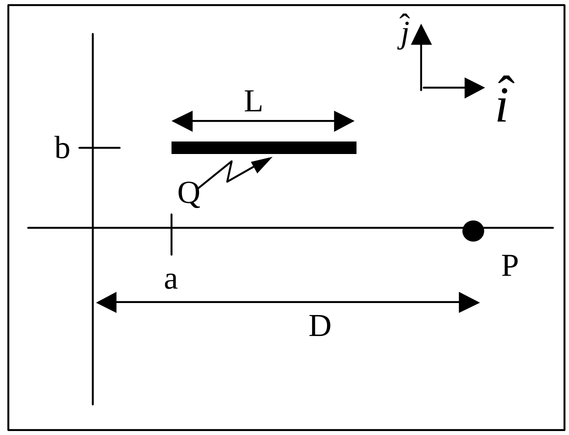
11. The diagram shows a proton. At each of the filled dots, draw an arrow representing the electric field at that point (both the magnitude and direction). Draw each arrow with the tail at the dot. The lengths of the arrows should correctly represent the relative magnitudes of the fields.



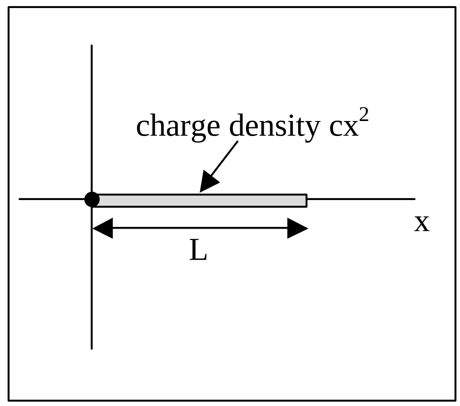
12. Two equal and opposite charges $+q_o$ and $-q_o$ are shown in the diagram below. On the diagram, draw arrows at points A and B corresponding to the **net** electric field at those points due to the two charges. The arrows should be drawn carefully to show **both** the correct direction ***and*** the relative magnitudes (i.e., draw longer arrows for larger E).



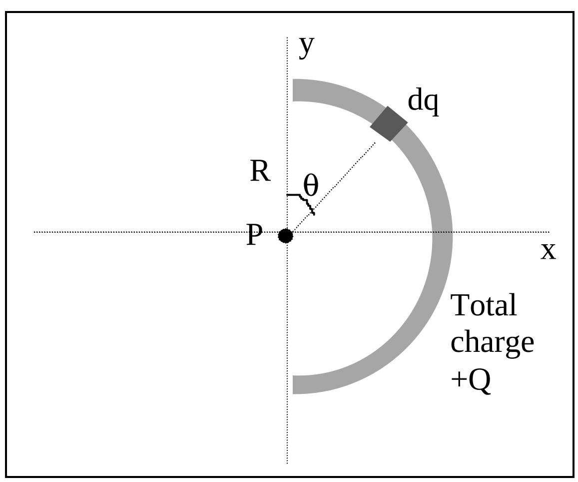
13. A total charge Q is distributed uniformly over a line of length L, as shown in the figure. Determine the total electric field at the point P. Your answer should be in terms of quantities shown in the diagram along with Coulomb's constant k and any x-, y- or z-coordinates that you feel are appropriate.



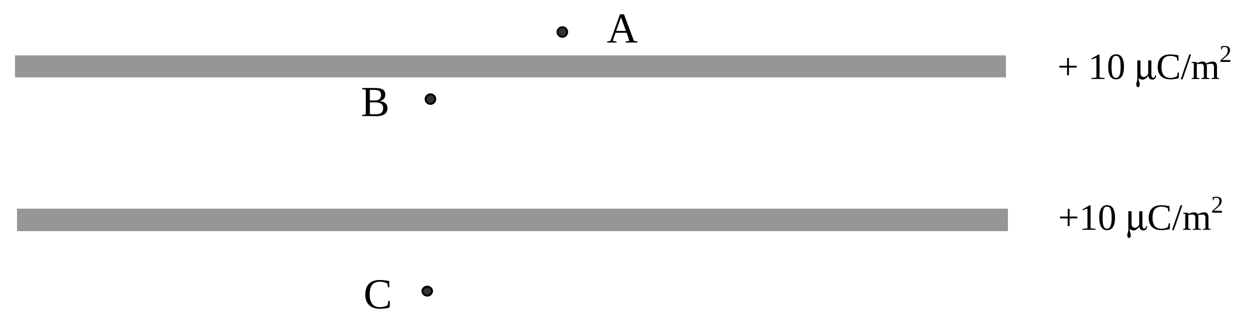
14. A thin rod with length L lies on the x-axis with one end at the origin, as shown in the diagram. The rod has a linear charge density (i.e., charge per unit length) cx^2 where c is a positive constant. Determine an expression for the magnitude of the electric field at the origin. Make sure that you evaluate the integral in the expression.



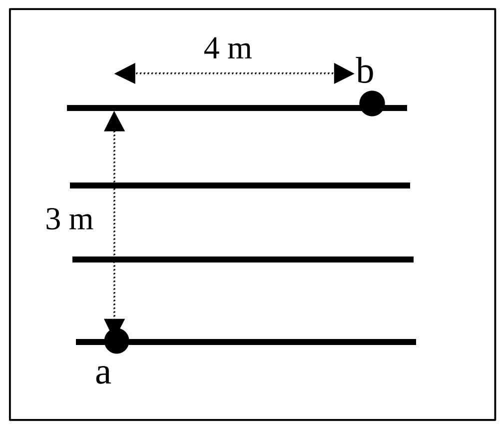
15. The figure shows a semi-circular arc with radius R and a total charge of +Q, spread uniformly around the arc. Determine the total electric field at the point P.



16. Two parallel infinite sheets of charge are placed near one another as shown in the diagram with equal positive surface charge densities as given. At each of the three points A, B and C draw the vector corresponding to the total electric field due to both plates. If the field is zero indicate this by writing "zero".



17. The figure shows points *a* and *b* in a uniform horizontal electric field of magnitude 650 N/C. The electric potential at b is greater than the electric potential at a.

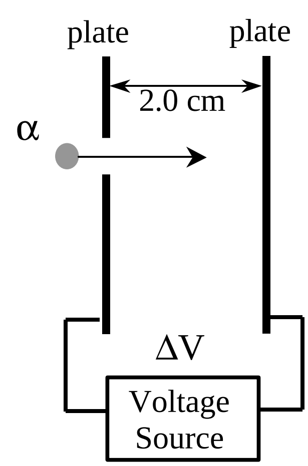


a) Mark the direction of the electric field with arrows on the horizontal field lines.

b) Determine the magnitude of the potential difference between points a and b.

c) An electron with charge -e moves from *a* to *b* solely under the influence of the uniform electric field. At *a*, its kinetic energy is 4000 eV. Find its kinetic energy when it reaches point *b*.

18. One method of measuring the kinetic energy of a beam of α-particles (charge = + 2*e*, mass = 4 m_p) is to use the configuration shown at right called a *retarding field analyzer*. The α-particles are shot through the hole in the left plate into the electric field region between the plates. The potential difference ΔV of a voltage source is increased from 0 until it is observed that the particles stop hitting the plate on the right.

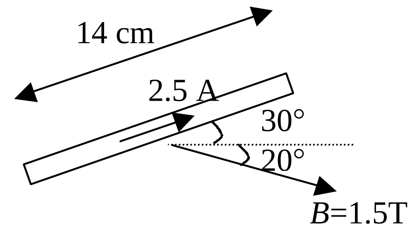


a) What is the direction of the electric field between the two plates that will decelerate the α-particles? Indicate your answer by drawing an arrow on the diagram.

b) It is observed that the potential difference when the α-particles no longer hit the plate is ΔV= 4.5 V. Calculate the kinetic energy of the incoming α-particles.

19. A 2-m long straight wire segment in a circuit carries a current of 0.23A in the $+\hat{i}$ direction. A magnetic field in the region is given by $\vec{B} = \left(1.1\,\hat{i} + 2.2\,\hat{j} - 3.3\,\hat{k}\right)T$. Calculate the magnetic force on the wire segment. (Answer in terms of unit vectors.)

20. The 14 cm long wire segment shown in the figure carries a current of 2.5 A through a region of uniform magnetic field with magnitude 1.5T. Calculate the magnetic force on the wire segment (magnitude and direction).



21. A proton traveling to the right with speed *v* enters a velocity selector made from a uniform *B* field that points out of the page and a uniform *E* field (not shown). The proton passes through undeflected.

a) In which direction does the *E* field point? (circle one)

↑ ↓ → ← ⊙ (out of page) ⊗ (into page)

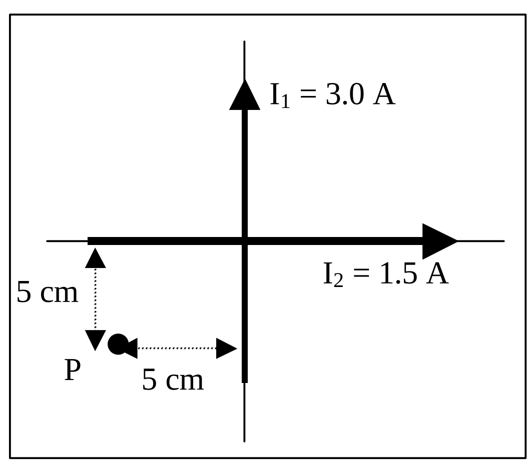
b) Another proton enters, traveling to the right with speed 2*v*. It will: (circle one)

bend up bend down go straight

c) Now, a particle with charge -2*e* enters, traveling to the right with speed *v*. It will: (circle one)

bend up bend down go straight

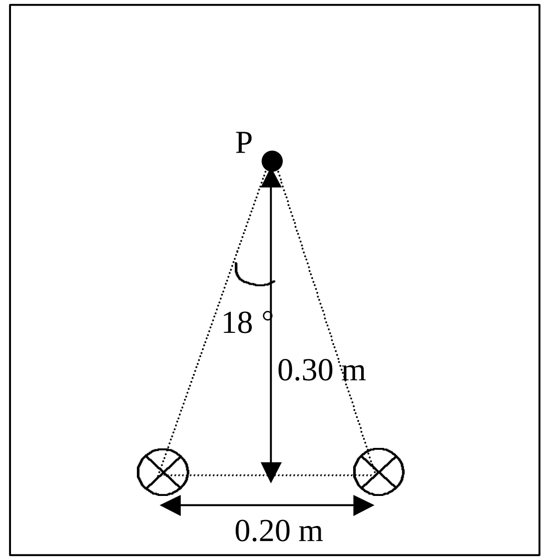
22. Two long perpendicular wires carry currents as shown. Determine the **magnitude** and **direction** of the magnetic field at the point P.



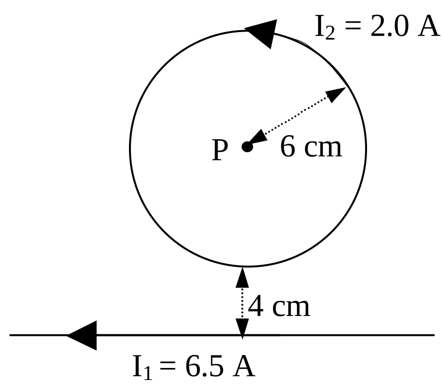
23. Two wires are separated by 0.20 m; each wire carries a current of 1.5 A, directed into the page.

a) Draw an arrow on the diagram showing the direction of the **total** magnetic field due to these two wires at the point P, 0.30 m above the midpoint of the line connecting the two wires.

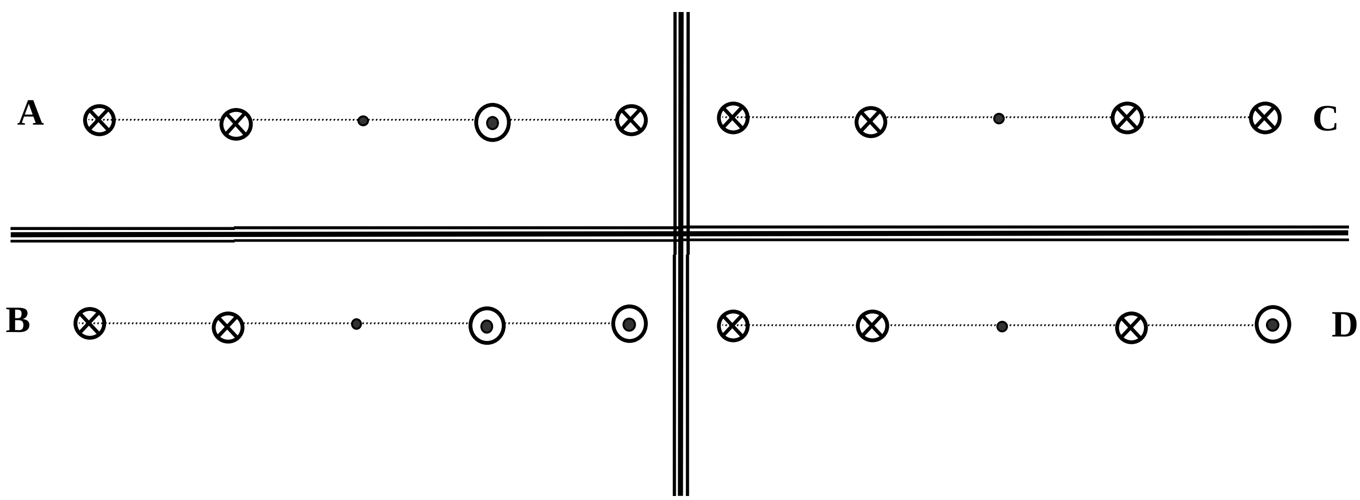
b) Determine the magnitude of the total magnetic field at the point P.



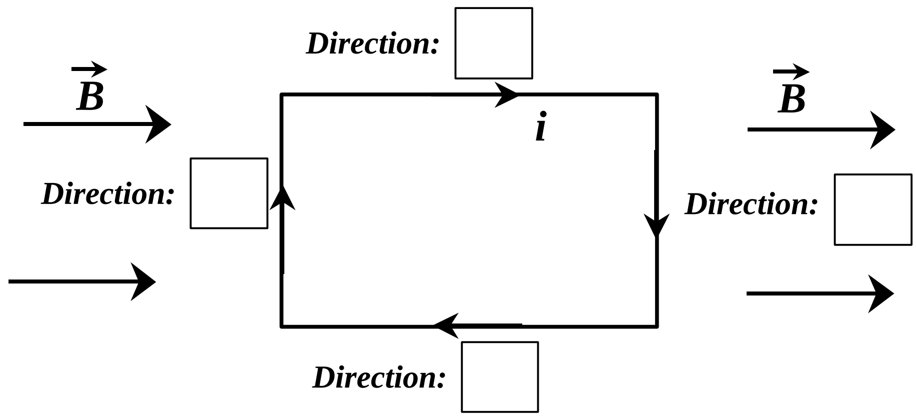
24. A loop of wire and a long straight wire each carry current as shown in the diagram. Determine the ***magnitude*** of the magnetic field B at the point P which is at the center of the circular loop.



25. Each of the diagrams below show four wires carrying ***equal*** currents either into or out of the page. For each diagram, consider the net magnetic field at the center point due to the four wires, and rank the magnitudes of these magnetic fields in order from greatest to least.



26. A rectangular loop carries a current *i* in the clockwise direction as shown. The loop is placed in a uniform magnetic field **B** pointing to the right as shown below.



a) For each segment of the loop, label the direction of the magnetic force by placing one of the following symbols in each box above

$\uparrow$	$\downarrow$	$\leftarrow$	$\rightarrow$	$\odot$ (out)	$\otimes$ (in)	***Zero***

b) Determine the direction of the net magnetic torque on the loop(circle one):

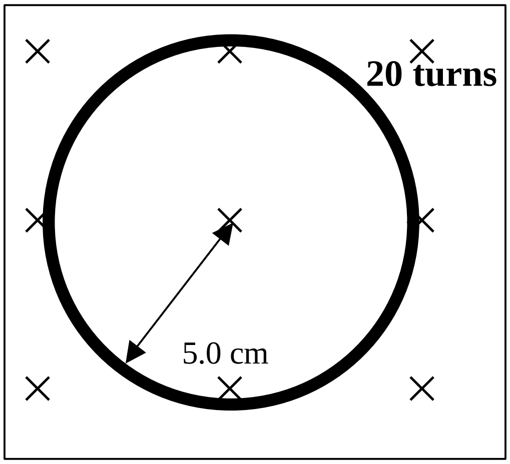
$\uparrow$	$\downarrow$	$\leftarrow$	$\rightarrow$	$\odot$ (out)	$\otimes$ (in)	***Zero***

27. A wire loop of radius 15 cm sits in the plane of the paper. A current of 1.2 A flows through the wire in the counter-clockwise direction and a uniform magnetic field of 0.8T is directed to the right.

a) Determine the magnitude of the torque on the loop.

b) Calculate the magnetic flux through the loop.

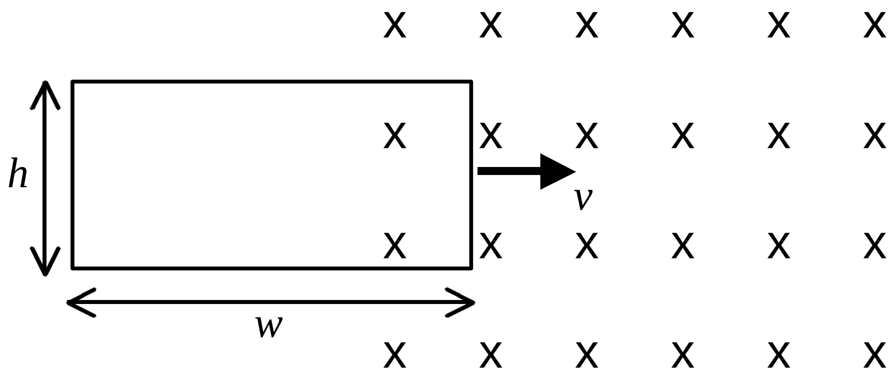
28. A circular coil of wire with 20 turns and radius 5.0 cm is in a magnetic field which is uniform in space and pointing into the page, but which varies in time via the relation $B = 0.2 + 0.3t^2$, where B is in Tesla and t is in seconds. The coil has a total resistanceof 25 Ω.



a) Calculate the magnitude of the emf induced in the loop at time $t = 2.0$ s.

b) What is the magnitude and direction of the current in the loop at $t = 2.0$ s? (Draw on the diagram)

29. A rectangular wire loop is being pushed with constant velocity v into a region with a uniform magnetic field B directed into the page. The loop has height h and width w as shown in the figure.

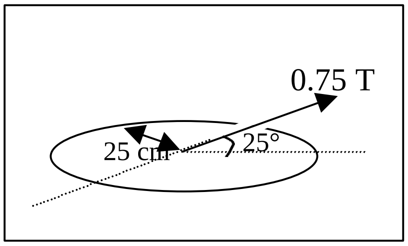


a) What is the direction of the induced current in the loop at the instant pictured? (Circle one)

Clockwise Counter-clockwise No current

b) Calculate the magnitude of the emf produced in the loop at the instant pictured in terms of the given quantities.

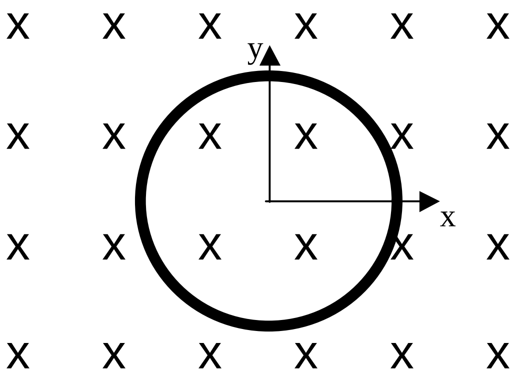
30. A circular loop of wire rests in a region with a constant magnetic field of 0.75 T, with the field directed at an angle of 25° relative to the plane of the loop (***not*** in the plane of the loop), as shown in the sketch. The loop has a radius of 25 cm, and the wire has a resistance of 3 Ω.



a) Determine the magnetic flux through the coil.

b) Determine the electrical current that is induced in the coil.

31. A loop of wire in the x-y plane is in a magnetic field directed into the page, as shown in the diagram. For each of these cases, determine if there is an induced current and its direction if not zero.



a) Field is decreasing in strength.

No current   Clockwise   Counter-clockwise

b) Constant field, but a mutant squid is crushing the coil.

No current   Clockwise   Counter-clockwise

c) Constant field, coil rotating around the y-axis, just **after** the time shown in the diagram.

No current   Clockwise   Counter-clockwise