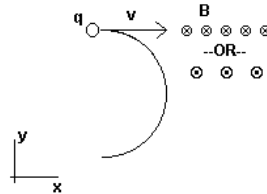


State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions ☆1a ☆1d ☆1e ☆2c

The Empire Strikes Back (50,000 points)

1.) In the *Star Wars* movies, as well as *Star Trek*, the big starships have something called *deflectors*, which are designed to keep the ship from running into things. We can make a *deflector*, or something that works like one, by first shooting some electrons at the object, and then applying a large magnetic field.

☆(a)¹ Identify the directions that \vec{F}_B and \vec{B} must point in this problem.



(b) Given that $q = -1.25 \text{ C}$, $v_{0x} = 19,500 \text{ m/s}$, $m = 125 \text{ kg}$, $r = 125 \text{ m}$, find the magnitude of B .

(c) What electric field vector, \vec{E} , would cause this charged object to continue on in a straight line?

☆(d) Find the work it takes for the magnetic force to turn the charged object around by 180° by integrating $\int_a^b \vec{F}_B \cdot d\vec{s}$ as needed, where a and b are the starting and end points.

☆(e)² The time it takes for the charged object to go halfway around is half the period, T , of the whole orbit. Since we have a *charge* moving in a certain *time*, then this defines a current, I . Find I .

¹ Dr. Phil had trouble inventing calculus star problems, so Right Hand Rule will have to suffice.

² This isn't actually a calculus problem, but rotational motion can be trouble all the same.

"Hot Dogs! Getcher Red Hot, Hot Dogs! Rightthere!" (50,000 points)

2.) (a) Consider a hot dog that has been in its package long enough so that it is roughly rectangular in shape (length = 13.0 cm, ends 2.50 cm × 2.50 cm). It is filled with the usual assortment of stuff that makes up a hot dog, and has a dielectric constant, $\kappa = 35.5$. (a) If the capacitance of this hot dog is $C_1 = 1.51 \text{ pF}$, if we go from left to right, then find the capacitance, C_2 of this hot dog if we go from top to bottom.



(b) There are typically eight hot dogs in a pack. Draw a circuit diagram which has a 12.0 volt battery, then four hot dog capacitors all in series, and then four hot dog capacitors in parallel. Find the equivalent capacitance of the hot dogs and the charge Q stored on this equivalent capacitor. *All the hot dogs have $C = 1.51 \text{ pF}$.*

☆(c) As our eight 1.51 pF capacitors charge, it takes work which is stored in the capacitors as potential energy. Integrate $W = \int_0^Q \Delta V dq$ to find this energy. *If you did not get an answer to (b), just use $C = 1.51 \text{ pF}$ and treat the circuit as if it had just one capacitor.*

(d) All the hot dogs also have a resistance, $R_1 = 58,900 \Omega$. Draw a circuit diagram which has a 12.0 volt battery, then four hot dog resistors all in series, and then four hot dog resistors in parallel. Find the equivalent resistance of the hot dogs.

(e) Since the hot dogs have both a capacitance and a resistance, find the time constant of this circuit. This time constant is very short. PTPBIP: What is wrong with this problem, if the current continues to flow for $t \gg \tau$? *If you did not get answers for (b) and (c), just use C_1 and R_1 to find the time constant.*