Physics 122 Assignment 5B

Prof. E. F. Redish

There will be a full period mid-semester exam next Thursday, March 6. If will cover the material covered in lecture through Thursday, February 28th and the readings in

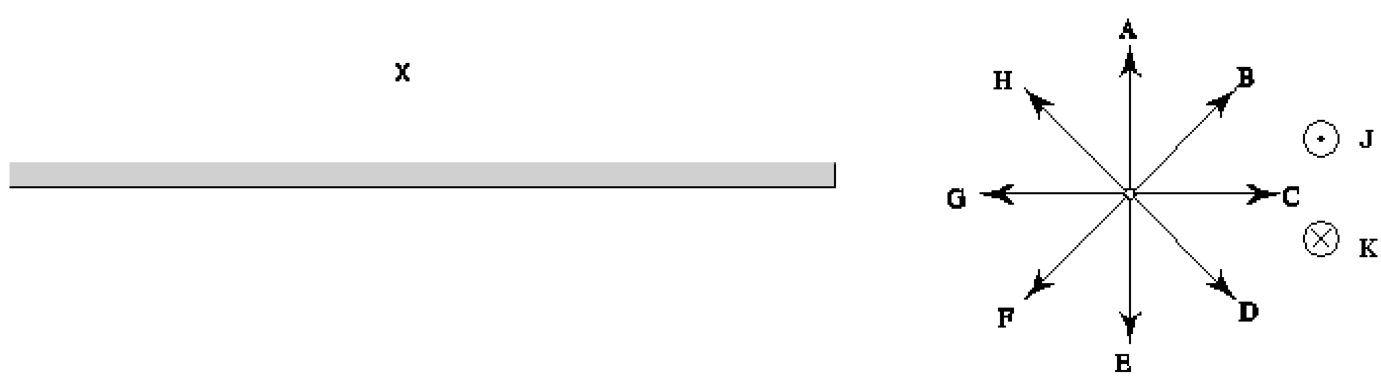
- CLRC 3, Chapters 22-23 and 25--30 or
- C&J Chapters 18-21.

All problems this week are practice exam problems. Most of them actually appeared on previous exams in this class.

Do the following problems:

1.(From an exam) In this problem, we will consider situations corresponding to three different long thin lines of matter containing charges:

a. a copper wire carrying an electric current,
b. a long amber rod that has been rubbed with fur and has a uniform excess of negative charge, and
c. a beam of electrons passing through a vacuum inside a cathode ray tube. They are represented schematically in the figure below. The direction of the electric current and of the electron flow are from left to right. A location marked x is indicated on the diagram and a set of directions with labels are shown at the right.



For each of the three cases, indicate in what direction the electric and magnetic fields at the location x would point. If any of the fields are zero, write 0.

Case	Direction of Electric Field at x	Direction of Magnetic Field at x
current carrying wire		
rubbed amber rod		

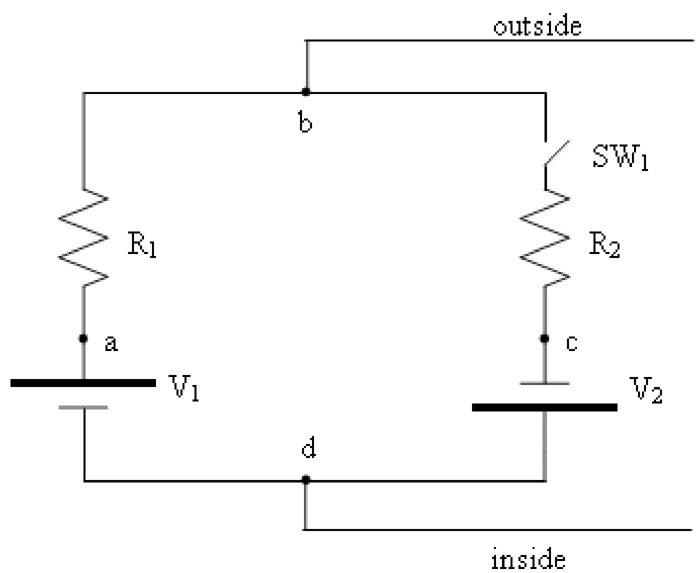
electron beam		

Now consider placing a positive charge at the location x. In one case it is stationary, while in a second case it is moving in the direction C. Indicate the direction you believe nearest to the total force the charge would feel. (Ignore gravity and air resistance.)

Case	**Direction of force on stationary + charge at x**	**Direction of force on + charge moving in C direction at x**
current carrying wire		
rubbed amber rod		
electron beam		

2. (From an exam) Flourescent bulbs deliver the same amount of light using much less power. If one kW-hr costs 7¢, estimate the amount of money you would save each month by replacing all the 75 W incandescent bulbs in your house by 10 W flourescent ones. *Be sure to clearly state your assumptions, since grading on this problem will be mostly based on your reasoning, not on your answer.*

3. (From a homework set in a graduate course in synaptic physiology) As a result of a complex set of biochemical reactions, the cell membrane of a nerve cell pumps ions (Na^+ and K^+) back and forth across itself, thereby maintaining an electrostatic potential difference from the inside to the outside of the membrane. Modifications of the conditions can result in changes in those potentials.



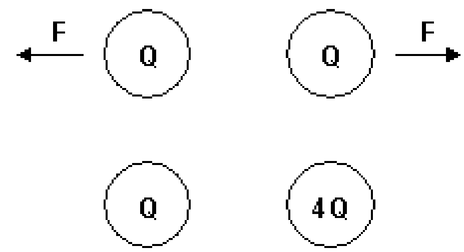
Part of the process can be modeled by treating the membrane as if it were a simple electric circuit consisting of batteries, resistors, and a switch. A simple model of the membrane of a nerve cell is shown in the figure at the right. It consists of two batteries (ion pumps) with voltages V_1 = 100 mV and V_2 = 50 mV. The resistance to flow across the membrane is represented by two resistors with resistances R_1 = 10 K W and R_2 = 90 K W. The variability is represented by a switch, SW_1.

Four points on the circuit are labelled by the letters a-d. The point b represents the outside of the membrane and the point d the inside of the membrane.

a. What is the voltage difference across the membrane (i.e., between d and b) when the switch is open?
b. What is the current flowing around the loop when the switch is closed?

c. What is the voltage drop across the resistor R_1 when the switch is open? closed?
d. What is the voltage drop across the resistor R_2 when the switch is open? closed?
e. What is the voltage difference across the membrane (i.e., between d and b) when the switch is closed?
f. If the locations of resistances R1 and R2 were reversed would the voltages across the cell membrane be different?

4. Two small objects each with a net charge of Q (where Q is a positive number) exert a force of magnitude F on each other. We replace one of the objects with another whose net charge is 4Q.



(i) The original magnitude of the force on the Q charge was F; what is the magnitude of the force on the Q now?

(a)	(b)	(c)	(d)	(e)
16F	4F	F	F/4	other

(ii). What is the magnitude of the force on the 4Q charge?

(a) 16F (b) 4F (c) F (d) F/4 (e) other

(iii) Next, we move the Q and 4Q charges to be 3 times as far apart as they were. Now what is the magnitude of the force on the 4Q?

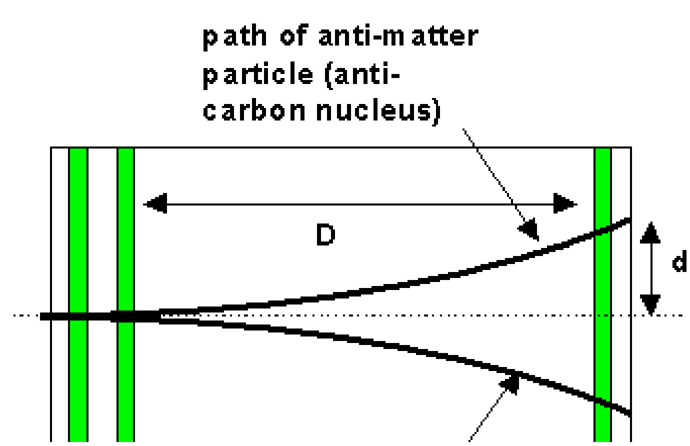
(a) F/9 (b) F/3 (c) 4F/9 (d) 4F/3 (e) other

(iv) In the original state (2 charges Q) if the symbol Q were taken to have a negative value, how would the forces change compared to the original state?

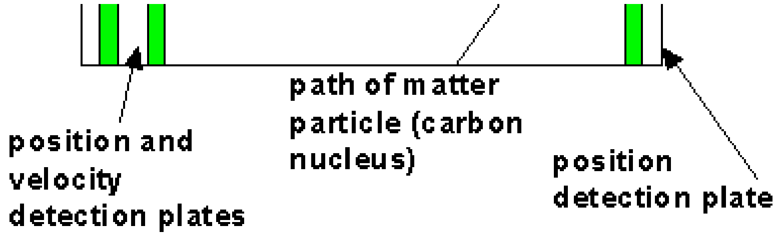
(a) stay the same	(b) both would reverse	(c) left one would reverse	(d) right one would reverse	(e) none of the above.

5. (From an exam) An international consortium is presently building a device to look for anti-matter nuclei in cosmic rays to help us decide if there are galaxies made of anti-matter. Anti-matter is just like ordinary matter except the basic particles (anti-protons and anti-electrons) have opposite charge from ordinary matter counterparts. (Anti-protons are negative, and anti-electrons are positive.)

A schematic of the device is shown at the right. A cosmic ray -- say a carbon nucleus or an anti-carbon nucleus -- enters the device at the left where its position and velocity are measured. It then passes through a (reasonably uniform) magnetic field. Its path is bent in one direction if its charge is positive, in the opposite direction if its charge is negative. Its deflection is measured as it goes out of the device.



a. On the figure shown, what is the direction of the magnetic field? How do you know?
b. What is the path followed by each particle in the device? Why?
c. If you were given the magnetic field, B, the size of the device, D, the amount of charge on the incoming particle, q, and the mass of the incoming particle, M, would this be enough to calculate the displacement of the charge, d? If so, describe briefly how you would do it (but don't do it). If not, explain what additional information you would need (but don't estimate it).



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