Principles of Physics II (PHY 112)
Spring 2010

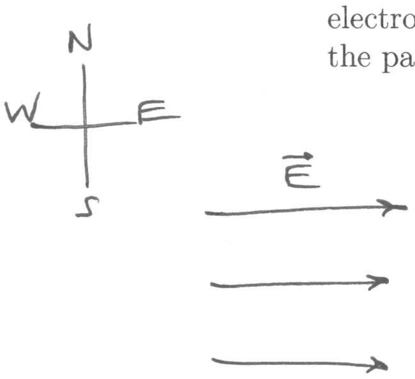
Exam 2

Question 1 (4 points) Particle A has a charge of 3 nC. Particle B has a charge of 1 nC. These particles are placed a distance of 10 cm from each other and released. After a short time, they are moving away from each other. Which particle is moving faster? Explain.

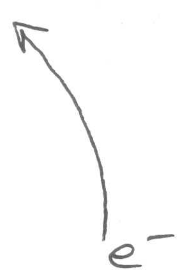
IT DEPENDS ON THEIR MASSES. THE PARTICLES WILL EXPERIENCE THE SAME FORCE, BUT EACH PARTICLE'S ACCELERATION, AND CONSEQUENT VELOCITY, WILL DEPEND ON ITS MASS. THE LIGHTER PARTICLE WILL MOVE FASTER.

Question 2 (4 points) Consider an electric field that points east at every point in a certain region of space. At $t = 0$, an electron is traveling north through this region of space. Describe the force on the electron and the subsequent motion of the electron. Draw a picture of the path the electron will take.

$\vec{F} = q\vec{E}$



FORCE ON ELECTRON IS TO THE WEST

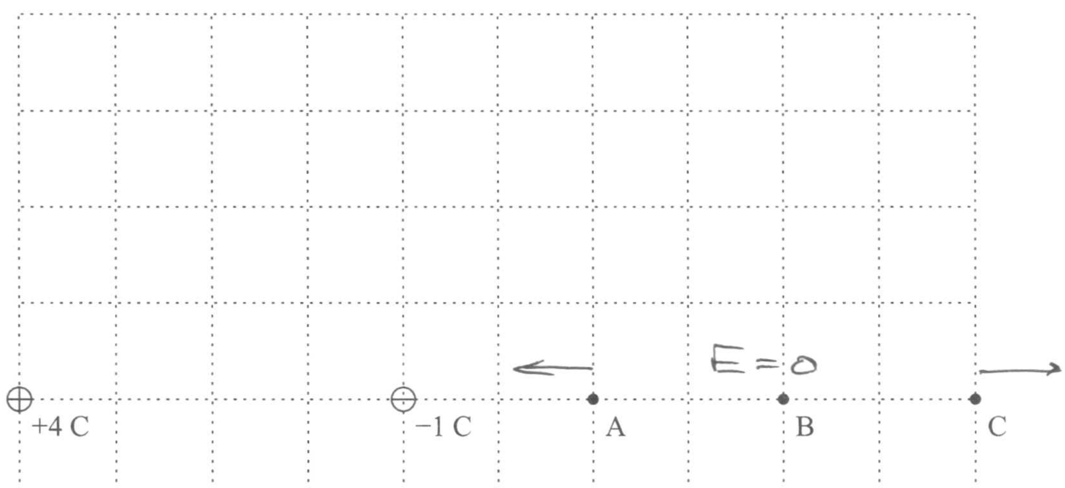


ELECTRON PATH

ELECTRON WILL ACCELERATE TO THE WEST

Question 3 (4 points) Draw the direction of the electric field at each of the labeled points. Which of the labeled points has the highest electric potential? Use words or formulas to show how you arrive at your answers.

$E = k\frac{q}{r^2}$



$E_A \propto \frac{4}{36} - \frac{1}{4} < 0$ TO LEFT

$E_B \propto \frac{4}{64} - \frac{1}{16} = 0$

$E_C \propto \frac{4}{100} - \frac{1}{36} > 0$ TO RIGHT

V_B IS HIGHEST. $\vec{E}$ POINTS IN DIRECTION OF DECREASING ELECTRIC POTENTIAL.

Question 4 (4 points) Consider a parallel-plate capacitor with charge $+Q$ on one plate and charge $-Q$ on the other plate. If we increase the charge on the positive plate to $+2Q$ and the charge on the negative plate to $-2Q$, what happens to the electric field, the potential difference between the plates, and the capacitance? Explain how you know.

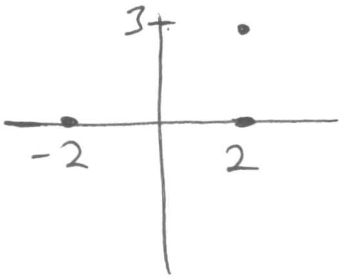
ELECTRIC FIELD DOUBLES, $E = \frac{\sigma}{\epsilon_0}$

POTENTIAL DIFFERENCE DOUBLES, $V = Ed$

CAPACITANCE STAYS THE SAME, $C = \epsilon_0 \frac{A}{d}$

OR $Q = CV$

Problem 1 (8 points) A particle with charge 125 nC is located at -2 m $\hat{\mathbf{i}}$. A particle with charge 75 nC is located at 2 m $\hat{\mathbf{i}}$. Both of these particles contribute to the electric field. Find the electric field at 2 m $\hat{\mathbf{i}} + 3$ m $\hat{\mathbf{j}}$.



$$\vec{E}_1 = K\frac{q_1(\vec{r}_p - \vec{r}_1)}{|\vec{r}_p - \vec{r}_1|^3} = (9\times10^9)(125\times10^{-9})\frac{(4\hat{i}+3\hat{j})}{125}\ \text{V/m}$$

$$= (36\hat{i} + 27\hat{j})\ \text{V/m}$$

$$\vec{E}_2 = \frac{Kq_2(\vec{r}_p - \vec{r}_2)}{|\vec{r}_p - \vec{r}_2|^3} = (9\times10^9)(75\times10^{-9})\frac{(3\hat{j})}{27}\ \text{V/m}$$

$$= 75\hat{j}\ \text{V/m}$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = 36\ \text{V/m}\ \hat{i} + 102\ \text{V/m}\ \hat{j}$$

Problem 2 (8 points) Two identical particles, each with charge 2.96 μC and mass 9.8 g are held a distance of 2.62 m from each other. They are released from rest. When they are a distance of 8.02 m from each other, how fast is the first particle moving?

2 PARTICLES MOVING

$$2\frac{1}{2}mv_i^2 + K\frac{q_1q_2}{r_i} = 2\frac{1}{2}mv_f^2 + K\frac{q_1q_2}{r_f}$$

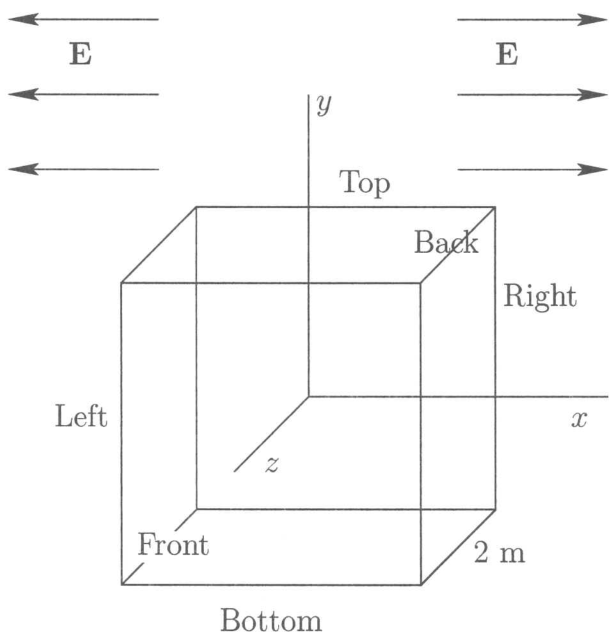
($v_i = 0$)

$$mv_f^2 = Kq_1q_2\left(\frac{1}{r_i} - \frac{1}{r_f}\right)$$

$$v_f = \sqrt{\frac{Kq_1q_2}{m}\left(\frac{1}{r_i} - \frac{1}{r_f}\right)}\ \text{m/s} = \sqrt{\frac{(9\times10^9)(2.96\times10^{-6})^2}{(0.0098)}\left(\frac{1}{2.62} - \frac{1}{8.02}\right)}\ \text{m/s}$$

$$= 1.438\ \text{m/s}$$

Problem 3 (8 points) An electric field is given by $\mathbf{E} = 50$ V/m $\hat{\mathbf{i}}$ in the region where $x > 0$, and $\mathbf{E} = -50$ V/m $\hat{\mathbf{i}}$ in the region where $x < 0$, as shown in the figure below. A cube of length 2 m has its center at the origin. The top and bottom surfaces of the cube are parallel to the xz plane; the left and right surfaces are parallel to the yz plane; the front and back surfaces are parallel to the xy plane. (a) Find the electric flux through each of the six surfaces of the cube. In other words, find $\Phi_{E\text{Top}}$, $\Phi_{E\text{Bottom}}$, $\Phi_{E\text{Left}}$, $\Phi_{E\text{Right}}$, $\Phi_{E\text{Front}}$, and $\Phi_{E\text{Back}}$. (b) What is the electric flux through the entire closed surface of the cube? (c) What is the net charge inside the cube?



(a) $\Phi_{E_{TOP}} = \Phi_{E_{BOTTOM}} = \Phi_{E_{FRONT}} = \Phi_{E_{BACK}} = 0$

$\Phi_{E_{LEFT}} = \Phi_{E_{RIGHT}} = (50\ V/m)(4\ m^2) = 200\ V\cdot m$

(b) $\Phi_E = 400\ V\cdot m$

(c) $Q_{enc} = \epsilon_0 \Phi_E = (8.85\times10^{-12}\ C^2/Nm^2)(400\ Nm^2/C)$

$= 3.54\ nC$