Principles of Physics II (PHY 112)
Spring 2009

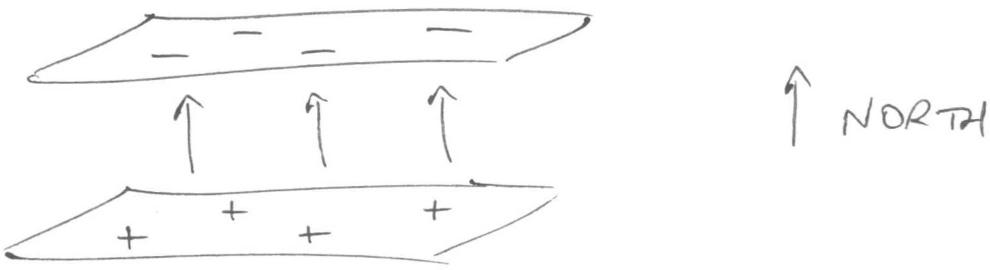
Exam 2

Question 1 (4 points) Consider a positively-charged particle and a negatively-charged particle. Which situation has higher potential energy: (a) the two particles being close together, or (b) the two particles being far apart? Explain how you know.

(b) FAR APART – IT'S HARDER TO MAKE THEM FAR APART

$$K\frac{(q)(-q)}{\text{SMALL}} < K\frac{(q)(-q)}{\text{BIG}}$$

Question 2 (4 points) Describe a charge distribution that would produce a uniform electric field pointing North in some region of space.



COULD USE A PARALLEL-PLATE CAPACITOR

Question 3 (4 points)

(a) If the electric field 1 cm from a charged particle is 10 V/m, what is the electric field 2 cm from the particle?

(b) If the electric field 1 cm from a very long charged rod is 10 V/m, what is the electric field 2 cm from the rod?

(c) If the electric field 1 cm from a very large charged plate is 10 V/m, what is the electric field 2 cm from the plate?

Briefly explain your reasoning.

(a) 2.5 V/m $\qquad V = k\frac{q}{r^2}$

(b) 5 V/m $\qquad V \propto \frac{1}{r}$

(c) 10 V/m $\qquad V \propto$ CONSTANT

Question 4 (4 points) Two identical charged particles, separated by 1 m, are released from rest. They will fly away from each other because of the electrical repulsion. Suppose that we know the charge and mass of these particles. Pat will calculate the velocity of the particles after 6 s has elapsed. Chris will calculate the velocity of the particles when they are 6 m apart. One of these problems is much harder than the other. Explain which problem is harder, why it is harder, and briefly explain how to do the easier problem.

HARD: PAT'S – MUST USE LORENTZ FORCE LAW, BUT FORCE CHANGES WITH POSITION.

EASY: CHRIS'S – USE CONSERVATION OF ENERGY

Problem 1 (8 points) Consider two identical charged particles, each with charge 225 nC. One is located at the origin of our coordinate system, and the other is located at (4 m)$\hat{\mathbf{i}}$. Find the electric field produced by these two particles at the position (3 m)$\hat{\mathbf{j}}$.

$$\vec{E}_1 = \frac{kq_1(\vec{r}_P - \vec{r}_1)}{|\vec{r}_P - \vec{r}_1|^3} = \frac{(9\times10^9\,Nm^2/C^2)(225\times10^{-9}\,C)(3m\,\hat{j})}{(3m)^3}$$

$$\vec{r}_P = (3m)\hat{j} \qquad \vec{E}_2 = \frac{kq_2(\vec{r}_P - \vec{r}_2)}{|\vec{r}_P - \vec{r}_2|^3}$$

$$\vec{r}_1 = 0$$

$$\vec{r}_2 = (4m)\hat{i} \qquad = \frac{(9\times10^9\,Nm^2/C^2)(225\times10^{-9}\,C)(3m\,\hat{j} - 4m\,\hat{i})}{(5m)^3}$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = -64.8\,V/m\,\hat{i} + 273.6\,V/m\,\hat{j}$$

Problem 2 (8 points) Consider a very long charged rod with linear charge density 3 nC/m. The rod is so long that we will regard it as infinitely long. We choose our coordinate system so that this rod lies along the z axis. Find the electric flux produced by the rod through a cylinder with radius 2 m and height 5 m. The central axis of the cylinder lies along the z axis.

$$\Phi_E = \frac{q_{enc}}{\epsilon_0} = 4\pi k\, q_{enc}$$

$$= 4\pi k(3\times10^{-9}\,C/m)(5m)$$

$$= 4\pi(9\times10^9\,Nm^2/C^2)(3\times10^{-9}\,C/m)(5m)$$

$$= 1696\ V\cdot m$$

Problem 3 (8 points) Consider two large squares of sheet metal, each 1 m by 1 m. They are placed 1 cm from each other to make a parallel-plate capacitor. A 9-V battery is connected to the plates, so that the voltage across the capacitor is 9 V. Find the electric field inside the capacitor. Every now and then, an electron (mass 9.1×10^{-31} kg, charge -1.6×10^{-19} C) escapes from the negative plate and flies over to the positive plate. Find the force on the electron, and how long it takes to get to the positive plate.

$$V = Ed$$

$$E = V/d = 900\,V/m$$

$$F = qE = (-1.6\times10^{-19}\,C)(900\,V/m)$$

$$|\vec{F}| = 1.44\times10^{-16}\,N$$

$$a = \frac{1.44\times10^{-16}\,N}{9.1\times10^{-31}\,kg} = 1.58\times10^{14}\,m/s^2$$

$$d = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2d}{a}}$$

$$t = 11.2\,ns$$