

### Exam 1 (October 7, 2010)

*Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given.*

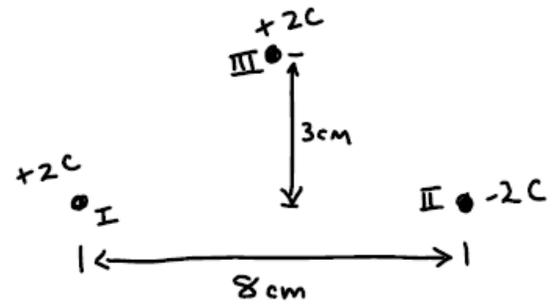
**Problem 1 (9 pts, show your work):**

Charge  $q$  experiences a repulsive force of  $0.50 \text{ mN}$  when placed at a distance of  $25 \text{ cm}$  from charge  $Q_1$ , and it experiences an attractive force of  $0.25 \text{ mN}$  when placed a distance of  $75 \text{ cm}$  from charge  $Q_2$ . The magnitude of the ratio  $Q_1/Q_2$  is

- a)  $2/9$
- b)  $2/3$
- c)  $9/2$
- d)  $6$
- e)  $3/2$
- f)  $18$

**Problem 2 (12 pts, show your work):**

Consider the arrangement of charges shown in the sketch. Determine the electric field at the position of charge III.



**Problem 3 (9 pts, show your work):**

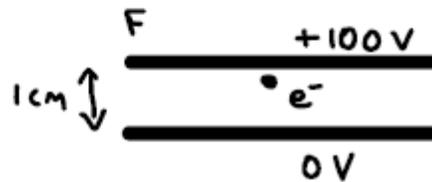
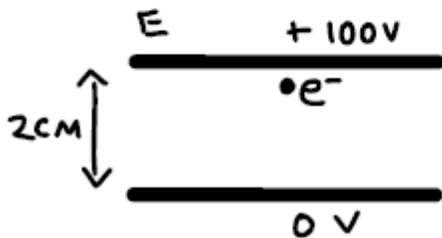
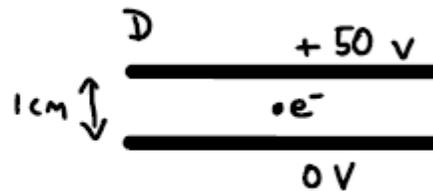
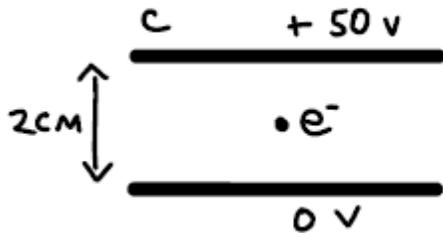
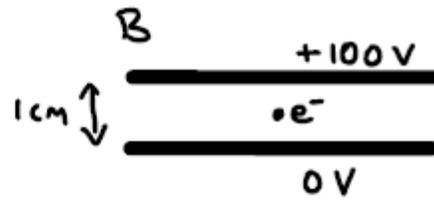
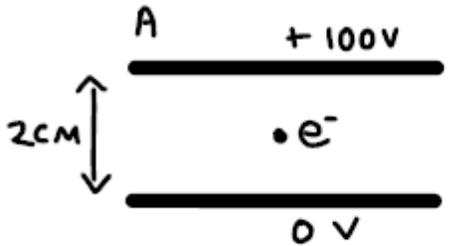
The net electrical flux through a spherical Gaussian surface of radius 1.0 cm is  $24 \text{ Nm}^2/\text{C}$ . If the radius of the surface is doubled to 2.0 cm, the electric flux will become

- a)  $96 \text{ Nm}^2/\text{C}$
- b)  $24 \text{ Nm}^2/\text{C}$
- c)  $12 \text{ Nm}^2/\text{C}$
- d)  $6 \text{ Nm}^2/\text{C}$
- e)  $3 \text{ Nm}^2/\text{C}$

1)	/9
2)	/12
3)	/9
4)	/17
5)	/15
6)	/18
7)	/20
<hr/>	
tot	/100

**Problem 4 (17 pts):**

Consider the six situations below labeled A-F. In each situation, two charged plates with the voltages shown are separated by a specified distance. Rank these situations from greatest to least according to the magnitude of the force felt by the electron. If the force is equal in two different situations, specify that with a “=” symbol. (Your answer should be in a form that looks something like  $C > E = A > B > D > F$ .)



**Problem 5 (15 pts, justify your answer):**

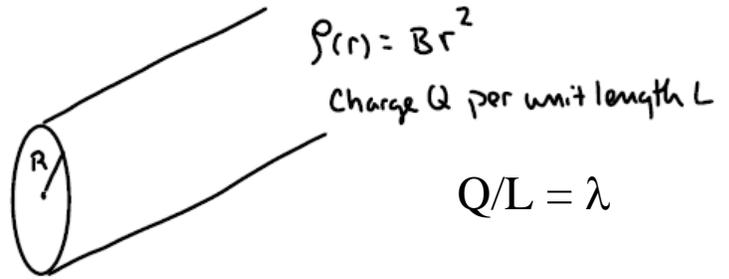
In a few years you take a job as a consulting physicist for Bob's Particle Accelerator and Washing Machine Design Company. After you've been on the job for a few weeks, you attend a meeting where some of the engineers are fretting about static electric charges building up on the inside of the new model of washing machines. The big boss Bob is in the meeting and he says, "Where did you bozos go to school? Huh? Don't you know anything? We don't need to worry about that big static charge in the middle of the washing machine. We're surrounding that charge with a big conducting metal case, right? You guys have heard about electrostatic shielding haven't you?" Then Bob looks at you and says, "Explain it to these bozos."

Briefly defend or criticize Bob's argument, assuming you are independently wealthy and need not fear for your job.

**Problem 6 (18 pts, justify your answer):**

Consider a very long straight cable of radius  $R$  carrying a total charge  $Q$  per unit length  $L$  distributed as  $\rho(r)=Br^2$ , where  $B$  is a constant.

- a) Determine  $B$  in terms of the variables  $R$ ,  $Q$  and  $L$ .



- b) Determine the electric field for  $r < R$ .

- c) Determine the electric field for  $r > R$ .

**Problem 7 (20 pts, justify your answer):**

Before the success of the Bohr model in explaining atomic spectra, the plum-pudding model of the atom was advocated by some physicists. In this model, the atom consists of a diffuse cloud of positive charge in which the electrons are embedded like bits of fruit in pudding. Light was emitted or absorbed by the electrons as they oscillated in the positive medium. The frequency of the light corresponded to the frequency of the oscillation of the electron. (We've not yet seen it in our course, but light is emitted by accelerating electric charge; so, this picture of the atom has merit).

Consider a positive charge  $+4e$ , distributed uniformly in a sphere of radius  $R$ . Suppose a single electron with mass  $m$  and charge  $e$  is placed in the center of this spherical distribution of charge. Assume that the electron is displaced by a very small distance,  $d$ , from the center and released. Show that the electron undergoes simple harmonic motion and calculate the frequency of oscillation for that electron.

## EXAM 1 Formulas

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

$$\vec{F} = k \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12}$$

$$\phi_E = \oint \vec{E} \cdot d\vec{A}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

$$\vec{E} = \int_{\text{vol}} k \frac{dQ}{r^2} \hat{r}$$

$V = \text{work/charge}$

$$V_{\text{POINT charge}} = \frac{kQ}{r}$$

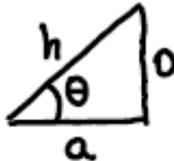
$$V = \int_{\text{vol}} \frac{k dQ}{r}$$

$$E_s = -dV/ds$$

$$|e| = 1.6 \times 10^{-19} \text{ coulombs}$$

$$k = 8.99 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$$



$$\sin \theta = \frac{o}{h} \quad \cos \theta = \frac{a}{h}$$

$$\tan \theta = o/a$$

Sphere:  $A = 4\pi r^2$   $V = \frac{4}{3}\pi r^3$

cylinder:  $A = 2\pi rL + 2\pi r^2$   
 $V = \pi r^2 L$

$$\int u^n du = \frac{u^{n+1}}{n+1}$$

$$\int \frac{du}{u} = \ln|u|$$

$$\int e^u du = e^u$$

$$\int \frac{x dx}{(x^2+a^2)^{1/2}} = \sqrt{x^2+a^2}$$