University of Alberta
Department of Physics

Phys 230 ~~B~~A01 Midterm Exam
Thursday October 26, 2006
08:00 – 09:20

CEB 326
Prof. I. Isaac

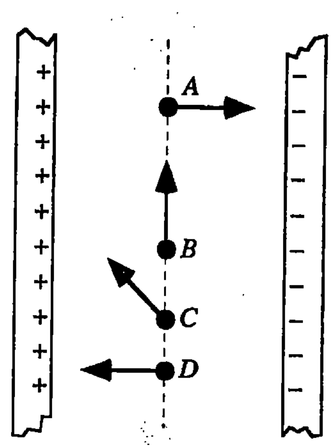
No notes or textbooks allowed
Formula sheet is provided with the exam
This exam eight has questions; the value of each is indicated in the table below. Budget your time accordingly.
Show all your work in a neat and logical manner in the space provided
Messy work will not be marked

Do not separate the pages of the exam

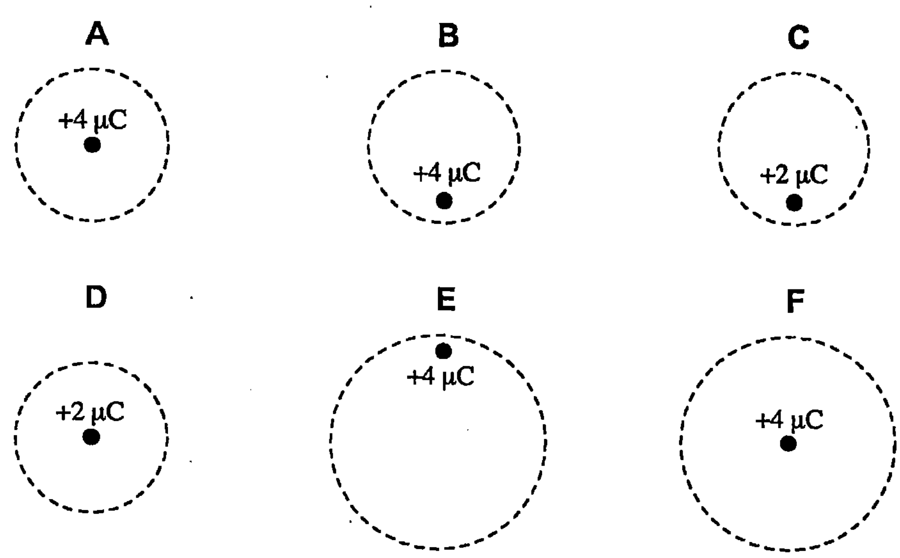
Student Name:
Student ID:

Question	Value	Mark
1	3	
2	3	
3	6	
4	3	
5	3	
6	12	
7	8	
8	12	
Total	50	

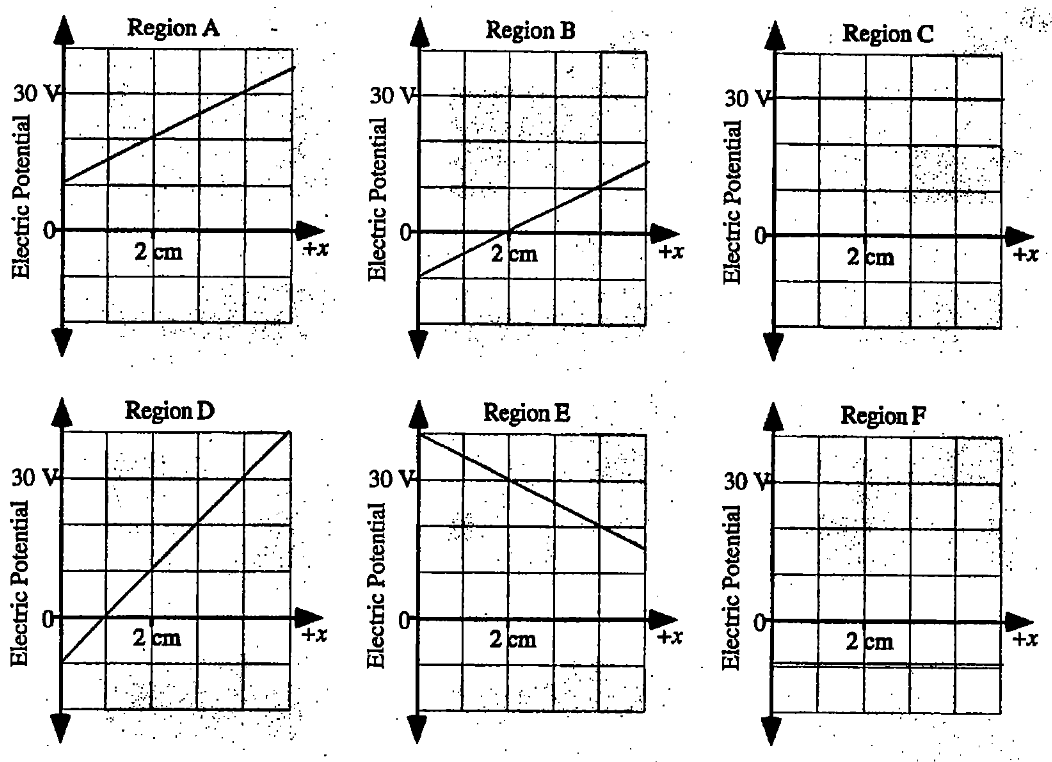
1. Four identical positive charges are each launched with a speed v_0 from a point halfway between two parallel plates. The plates are equally, but oppositely charged, are very large, and only a small portion near the center is shown. Neither charge C nor D touches the positive plate. Rank the speeds of the charges $A - D$, greatest first, just before they hit the negative plate. Indicate any ties.



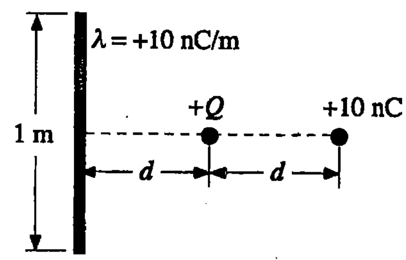
2. Each figure below shows a cross section of a spherical Gaussian surface surrounding a point charge. Rank the total electric flux through the given surfaces, greatest first (indicate any ties).



3. The graphs below of electric potential versus position are for regions in which there may be electric fields. On the graphs below, draw a second line that is consistent with each of the following modifications:
    a) The direction of the electric field in Region A is reversed while its magnitude is unchanged and the potential at x = 0 remains the same.
    b) The electric field in Region B remains the same but the potential at x = 2 cm increases to 10 volts.
    c) The electric field in Region C remains the same but the potential is cut in half at x = 2 cm.
    d) The magnitude of the electric field in Region D is increased keeping the same direction and the potential at x = 2 cm remains the same.
    e) The direction of the electric field in Region E is reversed and its magnitude increases but the potential at x = 4 cm remains the same.
    f) The electric field in Region F remains the same but the potential at x = 2 cm is 20 volts.



4. A point charge, +Q, is sitting midway between a +10 nC point charge and a rod with a uniform charge distribution. A student makes the following statement: *"The net force on +Q will be zero. Since the two charges have the same magnitude, they will exert forces on +Q that are equal in strength, but oppositely directed."* There is something wrong with the student's contention. Identify any problem(s) and explain how to correct it/them.



5. The following equations for electric potential and field were determined for a point near two charges.

$$V = k\left[\frac{q}{d} - \frac{q}{d}\right] = 0$$

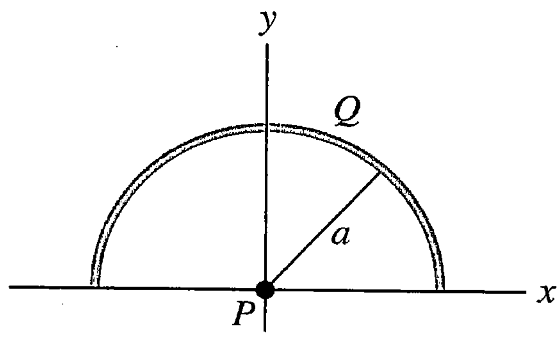
$$|E| = k\left[\frac{q}{d^2} + \frac{q}{d^2}\right] = 2k\frac{q}{d^2}$$

Construct and label a configuration of charges including the point that is consistent with these equations.

6. A point charge $q = +6.0$ nC is located at the centre of a spherical non-conducting shell of inner radius $a = 5.0$ cm and outer radius $b = 7.0$ cm. The spherical shell carries a total unknown charge Q, uniformly distributed throughout its volume.
   a) If the magnitude of the field at $r = 10.0$ cm is $2.7\text{x}10^3$ N/C, find the total net charge on the spherical shell.
   b) Find the field for (i) $r < a$ and (ii) $a < r < b$ *(your answer should be in terms of r)*
   c) Find the potential difference between the two spherical surfaces of the shell.

7. A hemisphere of radius r = 30.0 cm contains a total charge of +3.7 nC. The flux through the rounded portion of the surface is 8.6 x 10^3 $N.m^2/C$. Find the flux (sign included) though the flat base.

8. Positive charge Q is uniformly distributed around a semicircle of radius a. Find the electric field (magnitude and direction) at the center of curvature P.



Formula Sheet

Coulomb's Law $\mathbf{F} = k\frac{q_1 q_2}{r^3}\mathbf{r}$, $k = 8.99\times10^9\ \mathrm{Nm^2/C^2}$, $\varepsilon_0 = 8.85\times10^{-12}\ C^2/Nm^2$

Gauss's Law: $\Phi = \int_A \mathbf{E}\bullet d\mathbf{A} = \frac{q}{\varepsilon_0}$

E for a point charge: $\mathbf{E} = k\frac{q_1}{r^2}\hat{\mathbf{r}}$.

E for a dipole at a distant point z along the dipole axis: $E = \frac{1}{2\pi\varepsilon_0}\frac{p}{z^3}$, where $p=qd$.

Electric potential energy of dipole: $U = -\vec{p}.\vec{E}$.

Torque on dipole : $\tau = pE\sin(\theta) = \vec{p}\times\vec{E}$

E for an infinite plane conducting surface: $E = \frac{\sigma}{\varepsilon_0}$.

E for a plane non-conducting sheet of charge: $E = \frac{\sigma}{2\varepsilon_0}$.

E due to an infinite line charge: $E = \frac{\lambda}{2\pi\varepsilon_0 r}$.

E outside a spherical charged conductor: $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$.

Electric Potential: $V_i - V_f = \int_i^f \mathbf{E}\bullet d\mathbf{s}$

Electric Potential: $\Delta V = \int \frac{kdQ}{r}$

Electric potential due to a point charge: $V = k\frac{q}{r}$

Electric potential of electric dipole: $V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos(\theta)}{r^2}$, where $p=qd$.

E calculated from V: $E_s = -\frac{dV}{ds}$

Capacitance $C = \frac{Q}{V}$

Parallel-plate Capacitor $C = \varepsilon_0\frac{A}{d}$

$\int\frac{dr}{r} = \ln(r)$

$\int\cos\theta d\theta = \sin\theta$

$\int\frac{x\,dx}{\sqrt{x^2+a^2}} = \sqrt{x^2+a^2} + C$