Physics 241 Exam 1
September 28, 2004

One (both sides) 8 1/2" x 11" crib sheet is allowed. It must be of your own creation.
Useful equations and constants:

$$F = k\frac{q_1 q_2}{r^2} \qquad \vec{E} = \frac{\vec{F}}{q_o} \qquad dE = k\frac{dq}{r^2}$$

$$\vec{\tau} = \vec{p} \times \vec{E} \qquad \phi_E = \oint \vec{E} \cdot d\vec{A} \qquad \varepsilon_0 \phi_E = \frac{Q_{inside}}{\varepsilon_o}$$

$$V_b - V_a = \frac{\Delta U}{q_0} = -\int_a^b \vec{E} \cdot d\vec{l} \qquad W_{ab} = q\Delta V \qquad V = k\frac{q}{r} \qquad \vec{E} = -\vec{\nabla} V$$

$$Q = CV \qquad U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV \qquad v_f^2 - v_i^2 = 2a\Delta y$$

$$k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9 \frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}} \qquad \varepsilon_0 = 8.85\times10^{-12}\frac{\mathrm{C^2}}{\mathrm{N\cdot m^2}}$$

$$e = 1.602\times10^{-19}\mathrm{C} \qquad c = 2.99792458\times10^8 \mathrm{m/s\ (speed\ of\ light)}$$

$$N_{Avogadro} = 6.022\times10^{23} \qquad m_p = 1.67\times10^{-27} kg$$

$$\mathrm{m} \Rightarrow 10^{-3} \quad \mu \Rightarrow 10^{-6} \quad \mathrm{n} \Rightarrow 10^{-9} \quad \mathrm{p} \Rightarrow 10^{-12} \quad \mathrm{f} \Rightarrow 10^{-15}$$

$$\mathrm{k} \Rightarrow 10^{3} \quad \mathrm{M} \Rightarrow 10^{6} \quad \mathrm{G} \Rightarrow 10^{9} \quad \mathrm{T} \Rightarrow 10^{12} \quad \mathrm{P} \Rightarrow 10^{15}$$

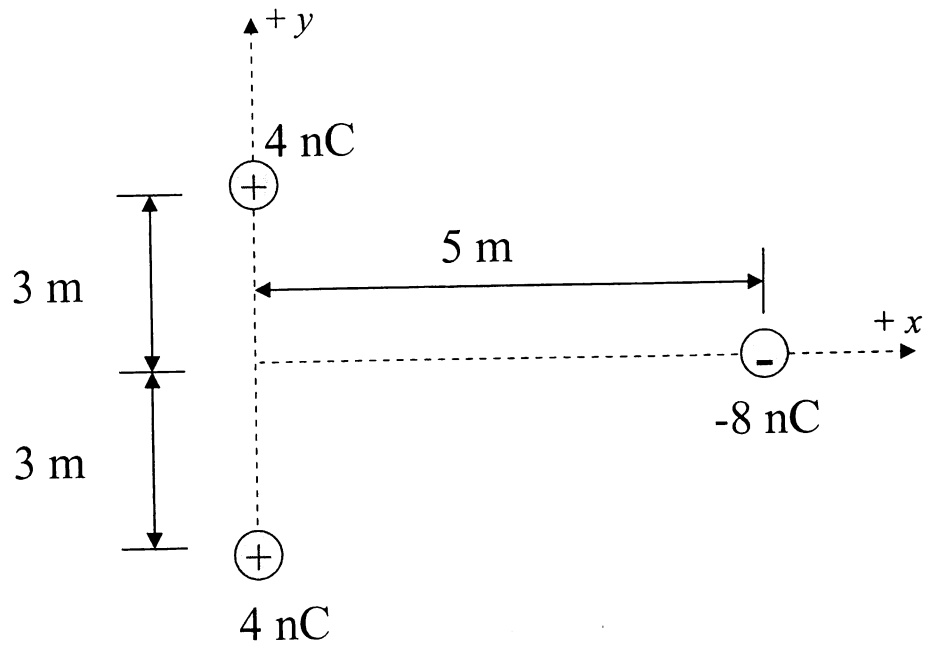
$$\text{For } ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

1. Please sign the opscan sheet and print your name on it.
2. Use a #2 pencil to fill in your full name, your social security number, and finally the answers for problems 1–12.
3. Please be prepared to show your Purdue ID when you hand in your opscan sheet.

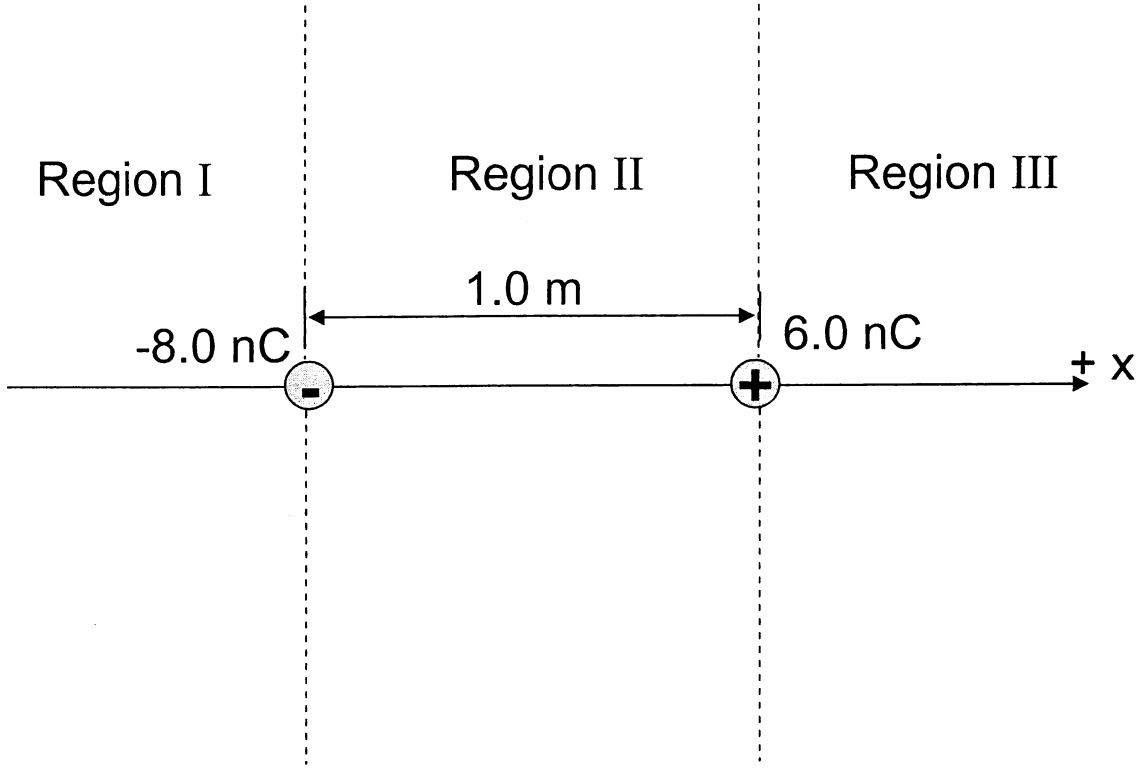
blue

1.- Three charges are arranged as shown in the figure below. Find the magnitude and direction of the electrostatic force on the -8 nC charge.



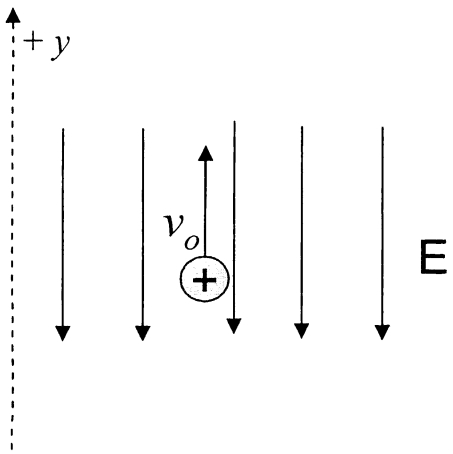
a) 1.45×10^{-8} along the $+x$ direction
b) 1.45×10^{-8} along the $-x$ direction
c) 1.45×10^{-8} along the $+y$ direction
d) 1.69×10^{-8} along the $-x$ direction
e) 1.69×10^{-8} along the $-y$ direction

2.- Two point charges lie on the x-axis. Determine which region(s) along the x axis would contain a point where the electric field is zero other than infinity.



a) Region I
b) Region II
c) Region III
d) Region I and III
e) None

3.- A proton is shot vertically upward with a velocity $v_0 = (2\times10^5 \text{ m/s})\hat{j}$ in a uniform electric field $E=(-500 \text{ N/C})\ \hat{j}$. How far does the proton travel before it is brought momentarily to rest? **(neglect gravity)**



a) ∞

b) 200 m

c) 0.25 m

d) 0.84 m

e) 0.42 m

4.- How much work, done by an external agent, is required to move an electron from a point 50 cm away from a proton to a point 100 cm away from the same proton?

a) $+2.3\times10^{-28}$ J
b) $+6.9\times10^{-28}$ J
c) -2.3×10^{-28} J
d) -6.9×10^{-28} J

e) none of the above

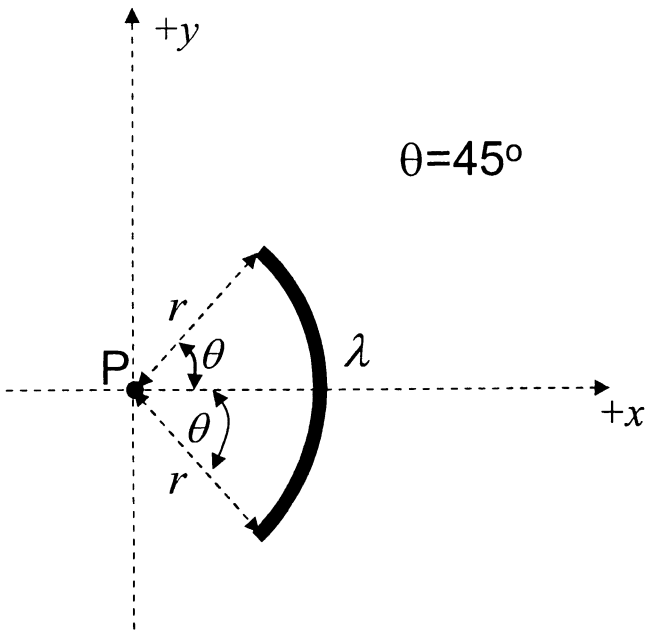
5.- An empty hollow metal sphere of radius R= 1.35 m has a potential of 40 V with respect to ground (defined to be zero at infinity) and has a charge of 6.0×10^{-9} C. Find the electric potential at the center of the sphere

a) 0 V
b) 29.6 V
c) 20 V
d) 40 V
e) none of the above

6.- An isolated single neutral water molecule (H_2O) has an electric dipole moment of magnitude 6.2×10^{-30} C·m. If the molecule is placed in an electric field of 1.5×10^{4} N/C, what maximum torque can the field exert on it?

a) 1 Nm
b) 4.1×10^{-34} Nm
c) 18.6×10^{-26} Nm
d) 8.2×10^{-34} Nm
e) 9.3×10^{-26}Nm

7.- A thin glass rod is bent into a quarter of a circle of radius *r*. The rod has a uniform linear charge density λ. Find the magnitude of the E field at the point P (at the origin)?



a) $E = \frac{k\lambda}{r}$

b) $E = \frac{k\lambda}{r^2}$

c) $E = \frac{2k\lambda}{r^2}$

d) $E = 0$

e) $E = \frac{\sqrt{2}k\lambda}{r}$

8.- Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is 6.0 kN $\cdot m^2/C$. Which one of the following answers could describe the charge(s) enclosed in the box?

a) $+8.54 \times 10^{-8}$ C and -3.23×10^{-8} C

b) $+6 \times 10^{-9}$ C

c) -8.54×10^{-8} C and $+3.23 \times 10^{-8}$ C

d) -6×10^{-9} C

e) none of the above

9.- Consider an infinitely long line of charge of uniform charge density $\lambda = 9$ nC/m. Find the magnitude of the E field at a radial distance of $r = 9$m from the rod.

a) 9×10^2 N/C
b) 9 N/C
c) 18 N/C
d) 1.01×10^3 N/C
e) 18×10^2 N/C

10.- A positive point charge of magnitude +2.5 μC is at the center of a spherical conducting shell of inner radius 60 cm and outer radius 90 cm. The shell carries a net charge of +3.5 μC. Find the surface charge densities on the inner (σ_{60}) and outer surfaces (σ_{90}) of the shell.

a) $\sigma_{60} = -2.50\times10^{-6}$ C/m^2 and $\sigma_{90} = +6.0\times10^{-6}$ C/m^2

b) $\sigma_{60} = -5.53\times10^{-7}$ C/m^2 and $\sigma_{90} = +5.89\times10^{-7}$ C/m^2

c) $\sigma_{60} = -5.53\times10^{-7}$ C/m^2 and $\sigma_{90} = +7.74\times10^{-7}$ C/m^2

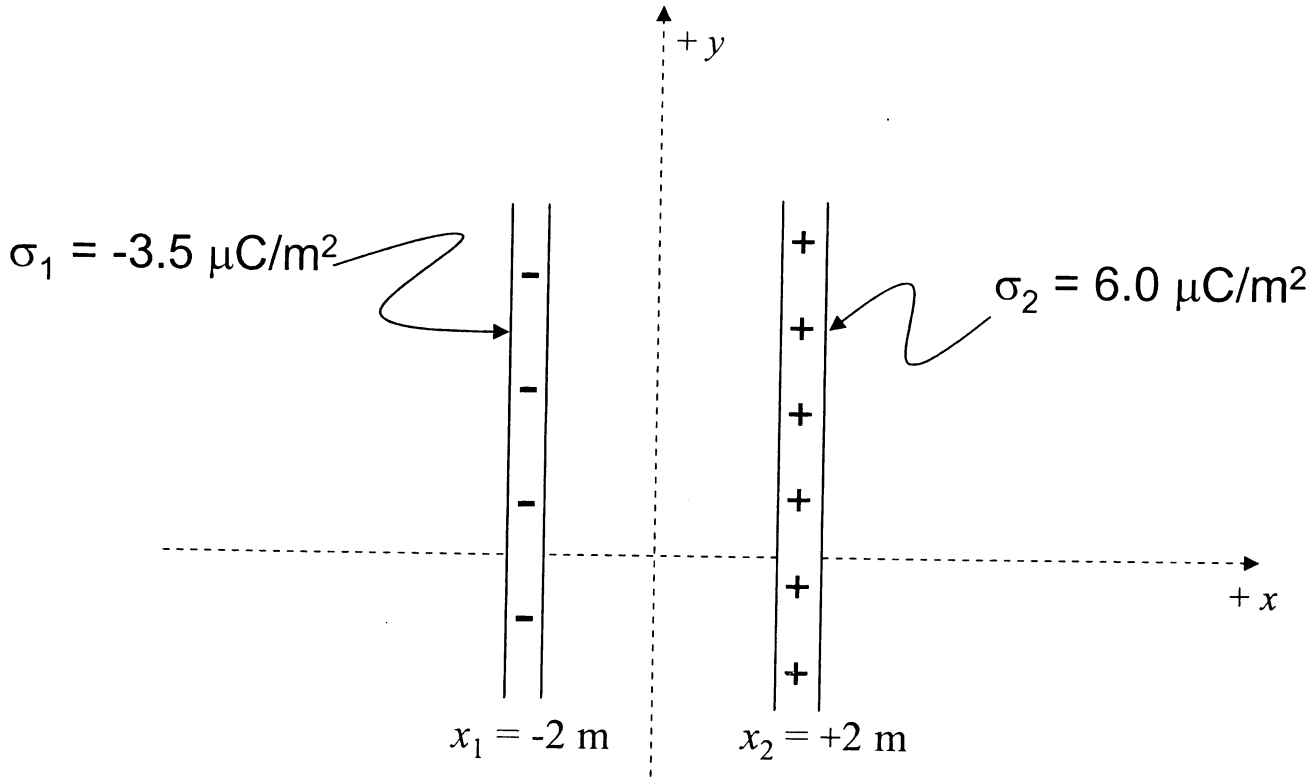
d) $\sigma_{60} = -5.89\times10^{-7}$ C/m^2 and $\sigma_{90} = +5.89\times10^{-7}$ C/m^2

e) $\sigma_{60} = 0$ and $\sigma_{90} = +7.74\times10^{-7}$ C/m^2

11.- An air-filled parallel-plate capacitor has plates of area 40 cm^2, plate separation of 1.0 mm and is charged to a potential difference V_1=100 V. The charging battery is then disconnected, and the plates are pulled apart until the separation is 2.0 mm. What is the new potential difference V_2 between the plates of the capacitor?

a) V_2= 200 V
b) V_2= 50 V
c) V_2= 0V
d) V_2= 100V
e) V_2= 400V

12.- Two infinite (non-conductive) planes lie parallel to each other and to the yz plane. One is at $x_1 = -2$ m and has a surface charge density of $\sigma_1 = -3.5\ \mu C/m^2$. The other is at $x_2 = 2$ m and has a surface charge density of $\sigma_2 = 6.0\ \mu C/m^2$. Find the electric field at $x = -4$ m.



a) 0 MV/m
b) 0.53 MV/m along the $-x$ direction
c) 0.14 MV/m along the $+x$ direction
d) 0.53 MV/m along the $+x$ direction
e) 0.14 MV/m along the $-x$ direction

1. B
2. C
3. E
4. A
5. D
6. E
7. E
8. A
9. C
10. B
11. A
12. E