PHYS 241 - Fall 2013 Exam IA

Instructor: Toggerson *Date:* 7 October 2013

First Name: ________________ **Last Name:** ________________

DO NOT BEGIN UNTIL INSTRUCTED

You **must** start from either an equation on the equation sheet **or** basic mathematical concepts like geometry and trigonometry.

You **must** show all work to get full credit for the problem

Please box your answers

If you need more space, use the back of the sheet, but indicate that you have done so.

Do not get hung up on algebra. It is only worth a small fraction of the points.

Do not spend too much time on any one problem. Points for each problem are given so that you can budget your time efficiently.

Some problems involve several steps. If you get stuck, write what you do know and/or what you would do next. For example, "If I could find the time t, which I do not know how to do, I could use it in equation blank to find blank."

GOOD LUCK!

Page 1	__________	**/12pts**
Page 2	__________	**/25pts**
Page 3	__________	**/18pts**
Page 4	__________	**/24pts**
Page 5	__________	**/21pts**
Total	__________	**/100pts**

Equations:

$$dq = \lambda d\ell = \sigma dA = \rho dV$$

$dV_{\text{rec}} = dx dy dz$	$dV_{\text{cyl}} = ds\, s d\phi\, dz$	$dV_{\text{sph}} = dr\, r d\theta\;\, r \sin\theta d\phi$
$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{\mathscr{r}^2}\hat{\mathscr{r}}$	$d\vec{E} = \frac{d\vec{F}}{q} = \frac{1}{4\pi\epsilon_0}\frac{dq}{\mathscr{r}^2}\hat{\mathscr{r}}$	$\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{\text{encl}}}{\epsilon_0}$
$W_{a\to b} = U_a - U_b$	$W = \int \vec{F}\cdot d\vec{\ell}$	$W = \Delta K$
$K_i + U_i = K_f + U_f$	$K = \frac{1}{2}mv^2$	$\Delta V = \frac{\Delta U}{q}$
$\vec{E} = -\nabla V$	$dV = \frac{1}{4\pi\epsilon_0}\frac{dq}{\mathscr{r}}$	$\Delta V = -\int \vec{E}\cdot d\vec{\ell}$

Data:

$e = 1.602 \times 10^{-19}$ C	$c = 3.0 \times 10^{8}$ m/s
$\epsilon_0 = 8.854 \times 10^{-12}$ F/m	$\mu_0 = 4\pi \times 10^{-7}$ V·s/(A·m)

1. [**12pts**] Consider the circular electric field shown in Figure 1 (just because you have never seen a field like this does not mean it is impossible!). Do not worry about how it got there, it just is. I place a particle with charge $Q = -1\text{C}$ and mass $m = 2\text{kg}$ at the point shown. What is the initial acceleration if any of the particle if the magnitude of the electric field at that location is $|\vec{E}| = 2\text{V/m}$? Do not forget that acceleration is a vector, so if you say there is an acceleration, you must also tell us the direction.

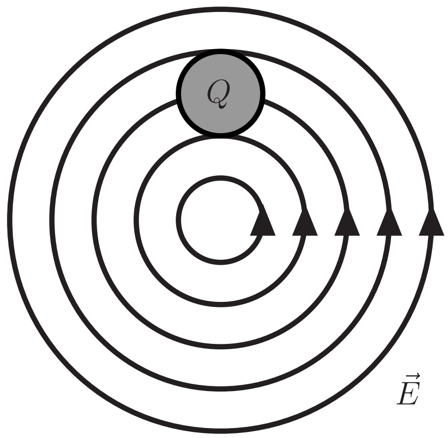

Figure 1: The circular electric field for Problem 1.

2. [**25pts**] Consider the three charges, each with mass m, in Figure 2. I release the point charge that is the furthest to the right (colored gray) from rest. The other two are held fixed

   a) [**5pts**] In which direction does the particle initially accelerate? Explain.

   b) [**10pts**] In the future, the particle is at $x = x_0$ where $x_0 > 0$. What is the magnitude and direction of the acceleration?

   c) [**10pts**] What is the magnitude and direction particle's velocity when it is infinitely far away from the other two charges?

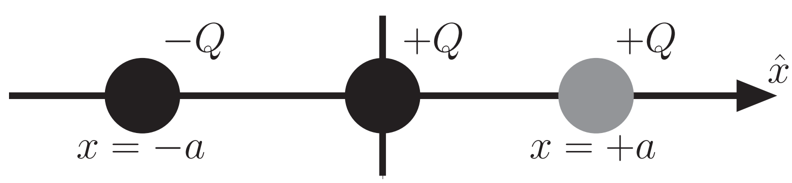

Figure 2: The initial setup for Problem 2.

3. [**18pts**] Consider a conducting hollow sphere. A point charge is held in place inside the sphere but off center by an insulating rod as shown in the diagram.

   a) [**8pts**] Draw the electric field lines everywhere. If the electric field in a region is zero, indicate that.

   b) [**10pts**] Is the surface charge on the *outside* of the sphere uniform? Explain your answer.

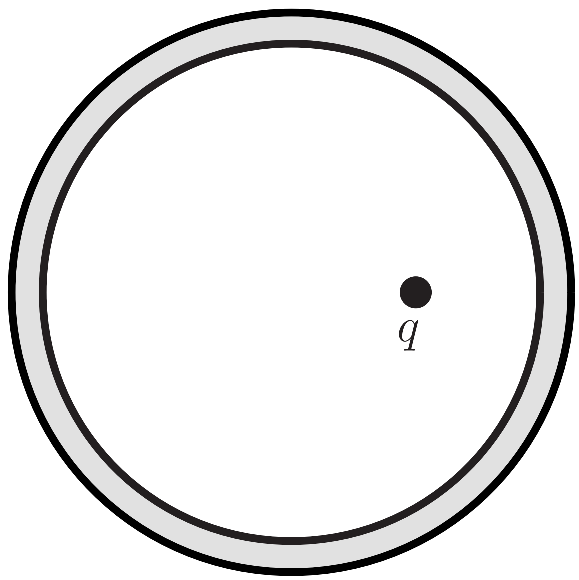

Figure 3: The conductor for Problem 3.

4. [**24pts**] One infinite wire lies along the $\hat{z}$-axis and another on the $\hat{y}$-axis as shown in Figure 4. Both wires have a uniform charge of 2C per meter. What is the electric field, magnitude and direction, at P a distance of 3m from each wire?
Hint: Note the high degree of symmetry in this problem!

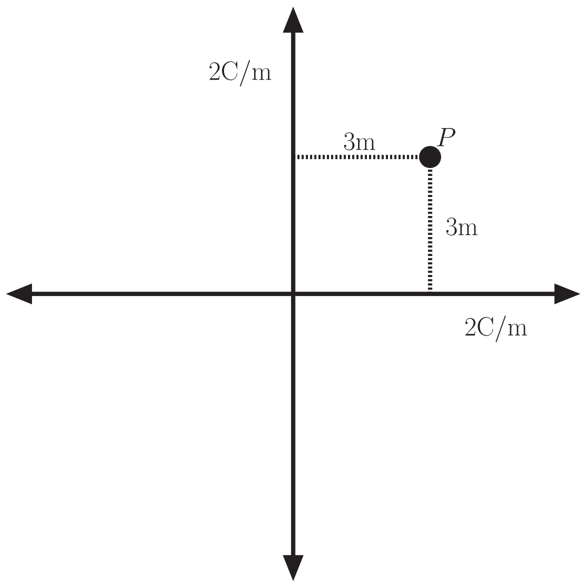

Figure 4: The wires in Problem 4.

5. **[21pts]** Two infinitely thin insulating wires are bent into quarter circles of radius R. One wire has a net charge $+Q$ and the other has net charge $-Q$ as shown in Figure 5. For both wires, the charge is uniformly distributed along the length of the wire.

   a) **[7pts]** What is the direction of the electric field at P?

   b) **[14pts]** Calculate $|\vec{E}|$

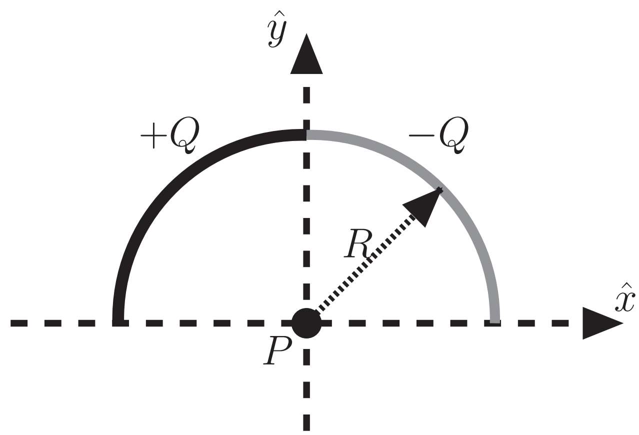

Figure 5: The setup for Problem 5.