Physics 2212G/H Test form **711** Name _____
Spring 2017
Test 1 Recitation Section (see back of test):_____

A

1) Print your name, test form number (above), and nine-digit student number in the section of the answer card labeled "STUDENT IDENTIFICATION".

2) Bubble your test form number (**ABOVE**) in columns 1-3, skip column 4, then bubble in your student number in columns 5-13.

3) For each free-response question, show all relevant work supporting your answer. **Clearly box or underline your final answer.** "Correct" answers which are not supported by adequate calculations and/or reasoning will be counted wrong.

4) For each multiple-choice question, select the answer most nearly correct, **circle this answer on your test**, and bubble it in on your answer card. **Show all relevant work on your quiz.**

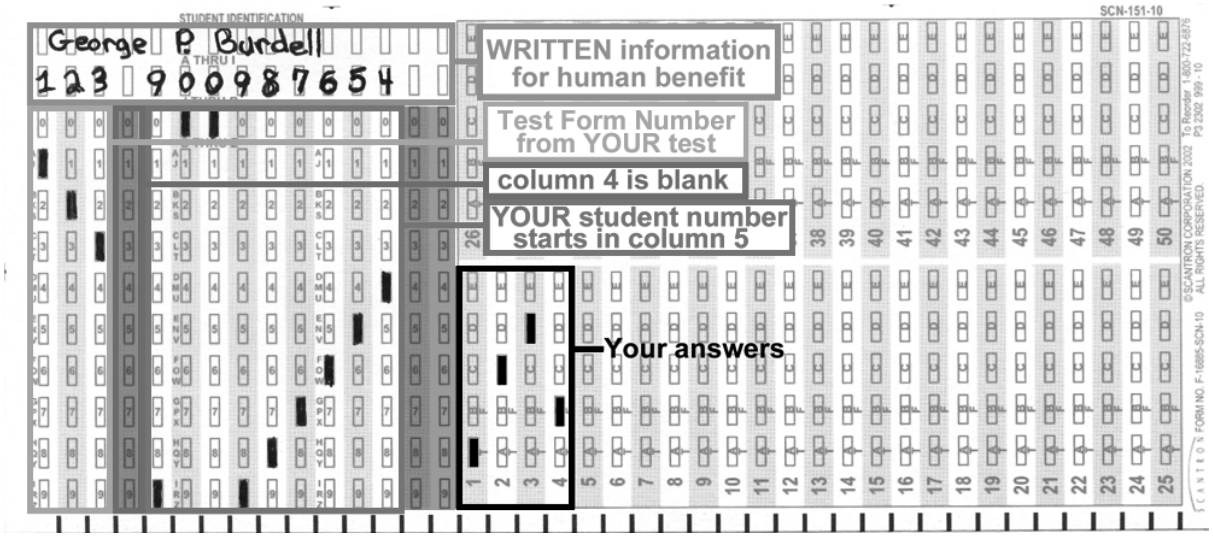
5) Be prepared to present your Buzzcard as you turn in your test. Scores will be posted to WebAssign after they have been been graded. **Quiz grades become final when the next quiz is given.**

6) You may use a simple scientific calculator capable of logarithms, exponentials, and trigonometric functions. **Programmable engineering calculators with text or graphical capabilities are not allowed. Wireless devices are prohibited.**

Numerical Constants:

$k = 8.99\times10^{9}\ \mathrm{N\cdot m^2/C^2}$	$e = 1.60\times10^{-19}\ \mathrm{C}$	$m_e = 9.11\times10^{-31}\ \mathrm{kg}$
$e_o = 8.85\times10^{-12}\ \mathrm{C^2/N\cdot m^2}$	$g = 9.81\ \mathrm{m/s^2}$	$m_p = 1.67\times10^{-27}\ \mathrm{kg}$

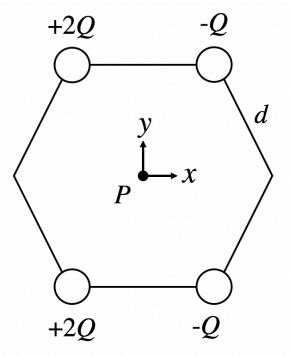
Your test form is:711



Our next test will be on Tuesday, February 21

The following problem will be hand-graded. Show all your work for this problem. Make no marks and leave no space on your answer card for it.

[I] *(20 points)* Four point charges are placed at the vertices of a regular hexagon having sides of length $d = 4.00$ cm, as shown at right. A point charge $+3Q$ is then placed at point P, at the center of the hexagon. For all five charges, the parameter Q has the value $Q = 12.5$ nC.

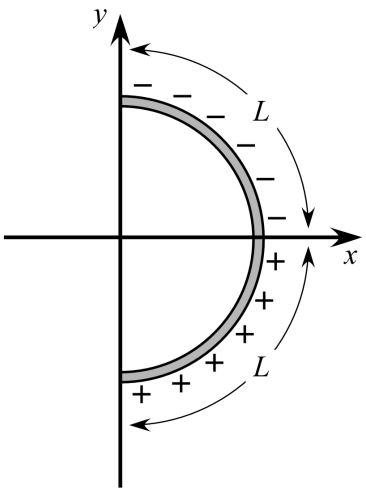


What is the magnitude and direction of the electrostatic force on charge $+3Q$? (*Hint*: The principle of superposition for the electric field is your friend!)

Express your answer by first solving algebraically in terms of the parameters Q and d, and then performing all numerical calculations at the very end. Your grader is likely to deduct points if you fill the page with numerical calculations!

The following problem will be hand-graded. Show all your work for this problem. Make no marks and leave no space on your answer card for it.

[II] *(20 points)* An insulating rod of length L is uniformly charged with a total charge $-Q$, and then bent into a quarter-circle arc. An identical rod is uniformly charged with a total charge $+Q$, and also bent into a quarter-circle arc. The two rods are placed as shown at right.



(*i*) Use integration techniques to determine the electric field vector at the origin **due to the negative rod only.** Your final answer should be an algrebraic vector expression (i.e. evaluate any integrals in your answer).

(*ii*) Use the principle of superposition to determine the net electric field at the origin, **due to both rods** (positive and negative).

Express both answers in terms of the parameters k, Q, and L.

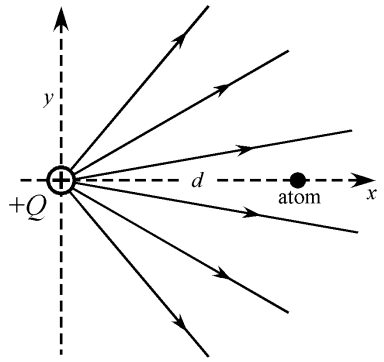
The following problem will be hand-graded. Show all your work for this problem. Make no marks and leave no space on your answer card for it.

[III] *(20 points)* A neutral atom placed in an electric field can become polarized. This strength of this effect is quantified by the ***polarizability*** of the atom. For such an atom, the induced electric dipole moment is given by:

$$\vec{p} = \alpha \vec{E}$$

where α is the polarizability of the atom (i.e. a fixed constant for that atom), and $\vec{E}$ is the electric field vector at the location of the atom. Note that this is a vector expression— the dipole is aligned parallel to the field that induces it.

Consider an atom placed at a distance d from a point charge $+Q$, as shown in the figure at right.



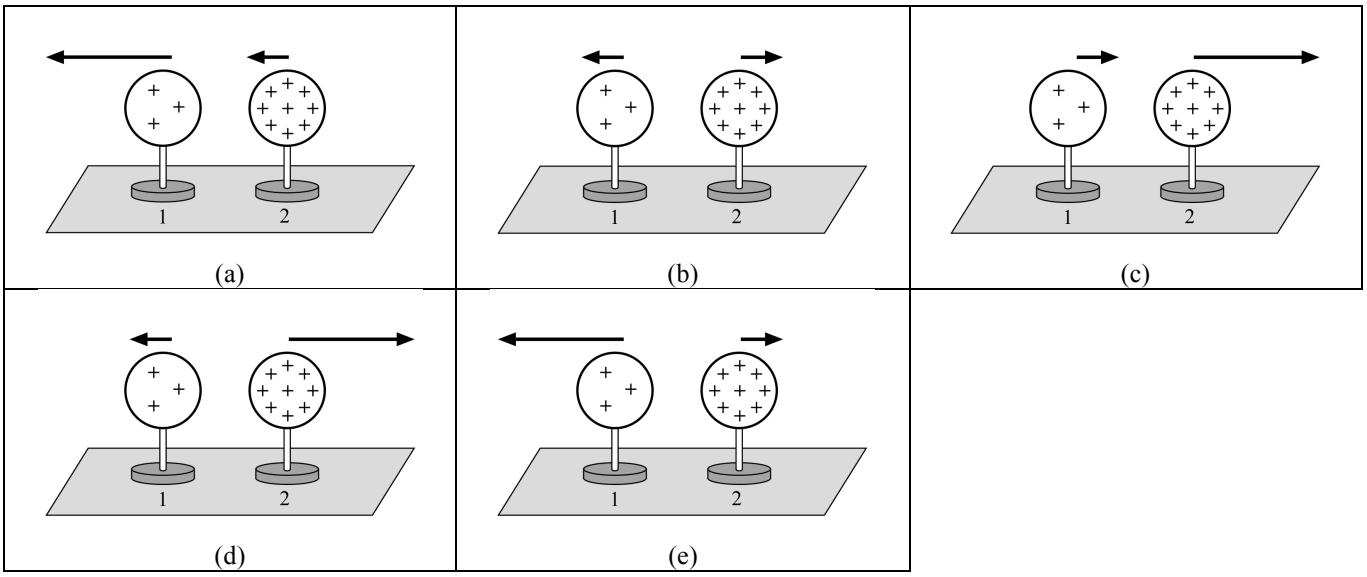
(*i*) Determine the induced electric dipole moment $\vec{p}$ of the atom, **due to the field of the point charge.** Express you answer as a vector, using the parameters Q, d, α, and the electrostatic constant k. (Coulomb's Law is your friend, here).

(*ii*) Determine the electric field **due to the induced dipole**, back at the location of the original charge Q. You may assume that the distance d is much greater that the size of the induced dipole, so you can use the large-distance dipole approximation. Again, your answer should be a vector expression involving Q, d, α, and the electrostatic constant k.

(*iii*) Determine the force **on the original point charge**, by the induced dipole field. In particular, how does the strength of the force vary with the separation distance d? (Recall that for two point charges, their mutual force varies as "one over distance squared"…but this is not a "two point charge" situation!)

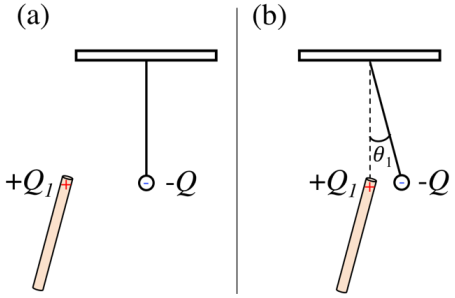
Question value 8 points

(1) Two uniformly charged spheres on insulating stands are attached to pucks on a frictionless air table, with charge Q on sphere 1 and charge $3Q$ on sphere 2. Which diagram below correctly depicts the magnitude and the direction of the electrostatic forces on the two spheres?



Question value 8 points

(2) A small sphere carrying charge $-Q$ is attached to an insulating string and subject to Earth's gravity. An insulating rod has a charge $+Q_1$ at its very tip (figure a). Both charges are small enough to be considered pointlike. The tip of the rod is slowly brought to the starting position of the charged sphere, causing the sphere itself to be deflected by an angle θ_1 (figure b). The rod is removed and more charge is added at the very tip, so that it now carries a charge $Q_2 = 2Q_1$. What can we say about the deflection angle θ_2, if the tip of the rod is again moved to the starting position of the sphere?



(a) $\theta_2 = 2\theta_1$

(b) $\theta_1 < \theta_2 < 2\theta_1$

(c) $\theta_2 = \theta_1$

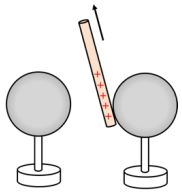
(d) $\theta_2 > \theta_1$

(e) $\theta_2 < \theta_1$

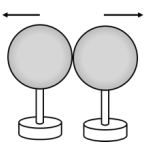
Question value 4 points

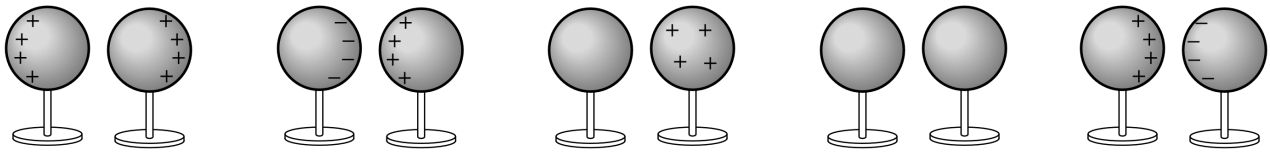
(3) Two conducting spheres are mounted on insulating supports. A positively charged rod is brought between the two spheres and now touches the sphere on the right, (situation a). The rod is then removed and the two spheres allowed to briefly touch (situation b). Finally, the two spheres are separated. Which of the figures below best characterizes the final charge states of the two spheres?

(a)



(b)



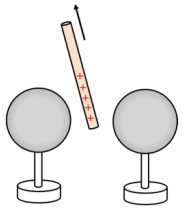


(a) (b) (c) (d) (e)

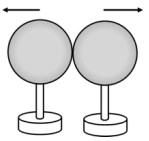
Question value 4 points

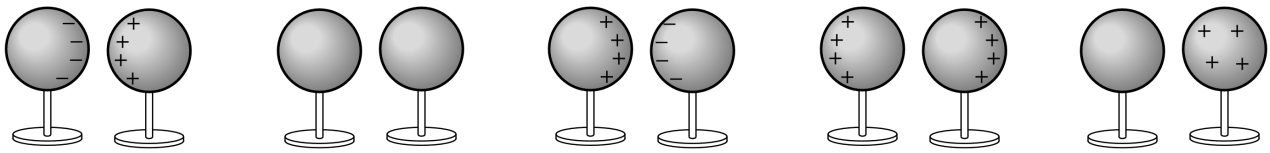
(4) Two conducting spheres are mounted on insulating supports. A positively charged rod is brought between the two spheres without touching them (situation a). The rod is then removed and the two spheres allowed to briefly touch (situation b). Finally the two spheres are separated. Which of the figures below best characterizes the final charge states of the two spheres?

(a)



(b)

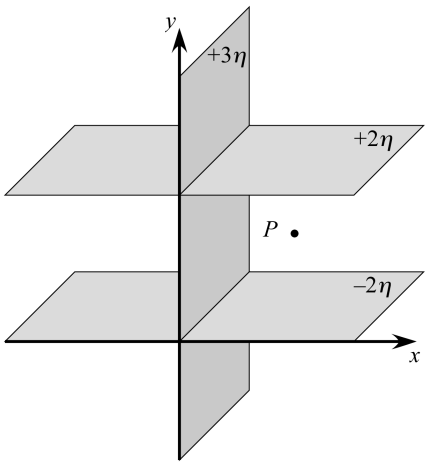




(a) (b) (c) (d) (e)

Question value 8 points

(5) The figure at right displays three uniformly charged sheets that can be assumed to be very large in extent. (That is, they extend well beyond the boundaries of the figure itself.) What is the magnitude of the electric field at the point P indicated?



(a) $\frac{3\eta}{2\epsilon_0}$

(b) $\frac{\sqrt{13}\,\eta}{2\epsilon_0}$

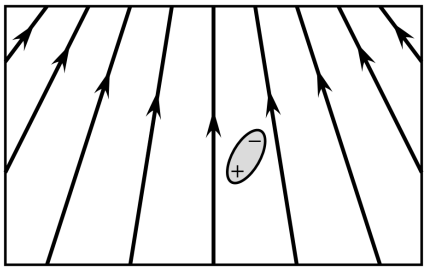
(c) $\frac{5\eta}{2\epsilon_0}$

(d) $\frac{7\eta}{2\epsilon_0}$

(e) $\frac{\sqrt{7}\,\eta}{2\epsilon_0}$

The next two questions both involve the following situation:

The figure at right depicts a permanent electric dipole that has been placed within a non-uniform electric field.



Question value 4 points

(6) What net force will the dipole experience, at the moment shown?

(a) A force directed *leftward*.
(b) No force at all.
(c) A force directed *upward*.
(d) A force directed *downward*.
(e) A force directed *rightward*.

Question value 4 points

(7) What net torque will the dipole experience, at the moment shown?

(a) A torque directed *upward*.
(b) A torque directed *out of the page*.
(c) No torque at all.
(d) A torque directed *downward*.
(e) A torque directed *into the page*.

PHYS 2212 G/J Recitation TA and Room Assignments

	Clough 127	Clough 131	Clough 323
WEDNESDAY			
1:05 pm		G01 Zhou, Boli	
2:05 pm	G06/H01 Zhou, Boli		
3:05 pm	G05/H05 Daum, Marcus		
4:05 pm	G02 Daum, Marcus	H02 Zhou, Boli	
5:05 pm	G09/H06/H09 Daum, Marcus		
THURSDAY			
12:05 pm			H07 Zhou, Boli
1:05 pm			
2:05 pm			
3:05 pm		G07/H03 Daum, Marcus	G03 Zhou, Boli
4:05 pm		G04 Daum, Marcus	
5:05 pm		G08/H04/H08 Daum, Marcus	

Tests will be returned in recitation, in the week *after* the test. In order to ensure that you receive your test back as soon as possible, please enter your recitation section from the table above (G01–G10) on the front of this test.