

Printed Name

Nine-digit GT ID

signature

Fall 2019

PHYS 2212 GJ

Test 01

- Put nothing other than your name and nine-digit GT ID in the blocks above. Print clearly so that OCR software can properly identify you. Sign your name on the line immediately below your printed name.
- Free-response problems are numbered I–III. Show all your work clearly, including all steps and logic. Write darkly. Blue or black ink is recommended. Do not make any erasures in your free-response work. Cross out anything you do not want evaluated. Box your answer.
- Multiple-choice questions are numbered 1–6. For each, select the answer most nearly correct, circle it on your test, and fill the bubble for your answer on this front page.
- Initial the odd pages in the top margin, in case the pages of your quiz get separated.
- The standard formula sheet is on the back of this page, which may be removed from the quiz form if you wish, but it must be submitted.
- If the page for a free-response problem has insufficient space for your work, ask a proctor for an additional sheet. If you wish this work to be evaluated, put your name on the sheet and make a note on the problem page, so graders know where to find your work. Place any added pages at the **back** of your test, when submitting your exam.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.
- Scores will be posted when your test has been graded. Test grades become final when the next is given.

Test Form:

1A

*Fill in bubbles for your Multiple Choice answers darkly and neatly.
If you wish to change an answer, draw a clear "X" through the non-answer!*

- 1 (a) (b) (c) (d) (e)
- 2 (a) (b) (c) (d) (e)
- 3 (a) (b) (c) (d) (e)
- 4 (a) (b) (c) (d) (e)
- 5 (a) (b) (c) (d) (e)
- 6 (a) (b) (c) (d) (e)

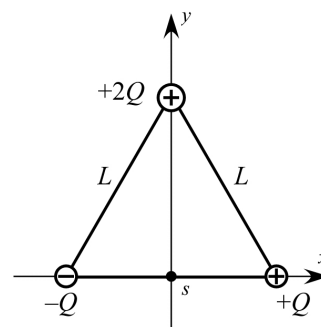
Form 1A

Extra Worksapace: If you use this space for a free-response problem, be sure to point it out on that problem's page!

The following problem will be hand-graded. Show all supporting work for this problem.

- [I] (20 points) Three charges, $+Q$, $-Q$, and $+2Q$ are arranged at the corners of an equilateral triangle having sides of length L , as shown at right. Determine the electric field at the origin (point s in the figure).

Express the magnitude of $\vec{E}$ in terms of the parameters k , Q , and L . Express the direction of $\vec{E}$ as a numerical angle relative to one of the coordinate axes. Give the angle to three-digit precision.



$$\begin{aligned}\sin 60^\circ &= \sqrt{3}/2 = \cos 30^\circ \\ \cos 60^\circ &= 1/2 = \sin 30^\circ\end{aligned}$$

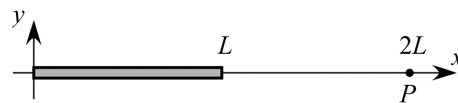
Form 1A

The following problem will be hand-graded. Show all supporting work for this problem.

- [II] (20 points) An insulating rod lies along the x axis, extending from $x = 0$ to $x = L$. A non-uniform distribution of charge is placed on the rod, given by the linear density function:

$$\lambda(x) = \frac{A}{(2L-x)^2} \quad \text{for } 0 \leq x \leq L$$

Here, A is a positive constant—and consequently, λ is positively-valued for all x in the given range.

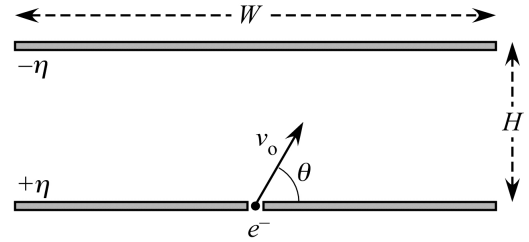


- (i) Determine the total charge Q on the rod. Express your answer in terms of the parameters A and L .
- (ii) Find an expression for the electric field on the positive x -axis at a distance $2L$ from the origin (point P in the figure). Express your answer in terms of k , A , and L —and remember that $\vec{E}$ is a vector, and must have a direction specified as well as a magnitude!

The following problem will be hand-graded. Show all supporting work for this problem.

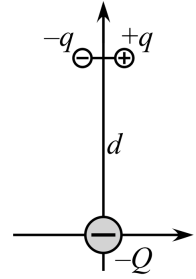
- [III] (20 points) An electron (mass m , charge $-e$) is fired into a charged parallel-plate capacitor, through a small hole in one plate. The capacitor plates are separated by a height H , and have width W . The hole is in the very middle of the positive plate, and the electron enters moving at an angle θ above the horizontal. If the charge densities on the two plates are $\pm\eta$, what maximum initial speed can the electron have without hitting the negative plate?

Express your answer symbolically in terms of the parameters provided here, plus the permittivity constant ϵ_0 .



Question value 8 points

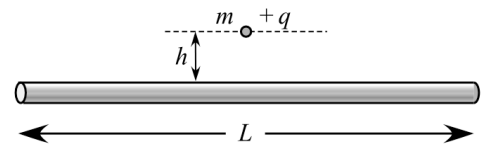
- (01) A point charge $-Q$ is fixed at the origin. A small electric dipole (size s , charges $\pm q$) is placed on the positive y -axis as shown at right. When the dipole is released, what interaction(s) will it experience?



- (a) It will experience a torque directed into the page, followed by a force directed straight down.
- (b) It will experience a torque directed to the right.
- (c) It will experience a force directed to the left.
- (d) It will experience a torque directed out of the page, followed by a force directed straight down.
- (e) It will experience a torque directed to the left, followed by a force directed to the right.

Question value 8 points

- (02) A conducting wire of length $L = 24$ cm is laid out horizontally. A small insulating bead of mass $m = 0.33$ grams is charged to $q = +11$ nC and placed at a height $h = 1.0$ cm above the midpoint of the wire. How much charge would have to be placed on the wire in order to suspend the bead in midair, balancing its weight electrostatically? (Hint: charged placed on a conducting wire will distribute itself uniformly along the wire.)



- (a) $Q = +160$ nC
- (b) $Q = +3.2$ nC
- (c) $Q = +1.2$ μ C
- (d) $Q = +17$ nC
- (e) $Q = +39$ nC

Question value 8 points

- (03) Three insulating rods—rubber R , plastic P , and glass G —are rubbed with three separate burlap rags. It is found afterwards that R attracts P , P attracts G , and G attracts R . We conclude from this that
- (a) all three rods must have the same kind of charge.
 - (b) at least two of the rods must be *uncharged*.
 - (c) only one of the rods can be charged.
 - (d) exactly one of the rods must be *uncharged*.
 - (e) all three rods must have different kinds of charge.

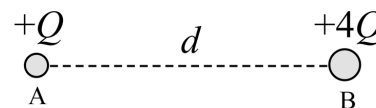
Question value 8 points

- (04) A spherical rubber balloon has a radius R . A total charge Q is then uniformly distributed over the balloon's entire surface. The balloon is then carefully inflated from radius R to radius $1.5R$, without losing any charge in the process. The balloon is then sloppily deflated to radius $0.5R$, losing *half* its total charge in the process. Rank, from greatest to least, the surface charge densities on the balloon: initial (η_o); when inflated (η_{inf}); and when deflated (η_{def}).
- (a) $\eta_o > \eta_{inf} > \eta_{def}$
 - (b) $\eta_{inf} > \eta_{def} > \eta_o$
 - (c) $\eta_{def} > \eta_o = \eta_{inf}$
 - (d) $\eta_{def} > \eta_o > \eta_{inf}$
 - (e) $\eta_{inf} = \eta_o > \eta_{def}$

Form 1A

The next two questions involve the following situation:

Two charged spheres, $+Q$ and $+4Q$, are separated by a fixed distance d . The size of both spheres is much smaller than their separation distance.



Question value 4 points

(05) Compare the magnitude of the coulomb force acting on A to the magnitude of the coulomb force acting on B.

- (a) $|\vec{F}_{on A}| = 4|\vec{F}_{on B}|$
- (b) $|\vec{F}_{on A}| = |\vec{F}_{on B}|/2$
- (c) $|\vec{F}_{on A}| = |\vec{F}_{on B}|$
- (d) $|\vec{F}_{on A}| = 2|\vec{F}_{on B}|$
- (e) $|\vec{F}_{on A}| = |\vec{F}_{on B}|/4$

Question value 4 points

(06) Compare the magnitude of the electric field acting on A to the magnitude of the electric field acting on B.

- (a) $|\vec{E}_{on A}| = 4|\vec{E}_{on B}|$
- (b) $|\vec{E}_{on A}| = |\vec{E}_{on B}|/2$
- (c) $|\vec{E}_{on A}| = |\vec{E}_{on B}|/4$
- (d) $|\vec{E}_{on A}| = |\vec{E}_{on B}|$
- (e) $|\vec{E}_{on A}| = 2|\vec{E}_{on B}|$