

Printed Name

Nine-digit GT ID

signature

Spring 2021

PHYS 2212 G

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.
- A standard formula sheet is provided as the cover page for this test. Please remove it from the test before you submit it to the proctor.
- 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.

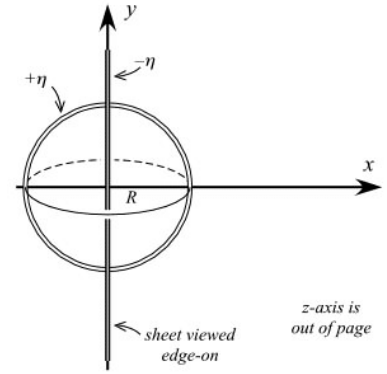
Test Form:

1A

Form 1A

Question value 8 points

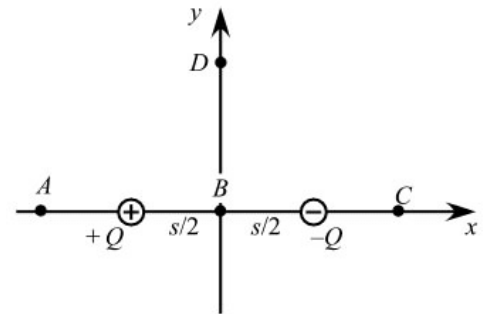
- (01) A hollow insulating spherical shell of radius R is placed at the origin. The shell has a uniform surface charge density $+\eta$. A very large flat sheet with surface charge density $-\eta$ is placed in the yz -plane, bisecting the sphere. At what point (if any) on the positive x -axis will the electric field be exactly zero? (You may assume that the sheet and shell overlap without effecting each other, at their points of contact.)



- (a) $x = (2 - \sqrt{2}) R$
- (b) $x = 2 R$
- (c) There is no such place on the positive x -axis.
- (d) $x = 4 R$
- (e) $x = (2 + \sqrt{2}) R$
- (f) $x = \sqrt{2} R$

Question value 8 points

- (02) A dipole consists of charges $\pm Q$ located on the x -axis at $\mp s$. Consider an electron that is placed at positions A through D, as shown in the figure at right. What is the direction of the electric field that the electron experiences, at each of the positions?



- (a) $\vec{E}_A = -\hat{i}$, $\vec{E}_B = +\hat{i}$, $\vec{E}_C = +\hat{i}$, $\vec{E}_D = +\hat{j}$
- (b) $\vec{E}_A = -\hat{i}$, $\vec{E}_B = 0$, $\vec{E}_C = +\hat{i}$, $\vec{E}_D = -\hat{i}$
- (c) $\vec{E}_A = +\hat{i}$, $\vec{E}_B = -\hat{i}$, $\vec{E}_C = +\hat{i}$, $\vec{E}_D = -\hat{i}$
- (d) $\vec{E}_A = -\hat{i}$, $\vec{E}_B = +\hat{i}$, $\vec{E}_C = -\hat{i}$, $\vec{E}_D = +\hat{i}$
- (e) $\vec{E}_A = +\hat{i}$, $\vec{E}_B = 0$, $\vec{E}_C = +\hat{i}$, $\vec{E}_D = -\hat{j}$

Question value 8 points

- (03) A plastic rod is rubbed with a cloth. If the rod is then touched to a neutral electroscope (see figure), the arms of the electroscope push apart, and remain apart after the rod is removed. What will happen if the cloth that charged the rod is then brought close to the electroscope—without touching it—and is then moved away?

- (a) The arms will push further apart when the cloth is nearby, but will return to their original separation after the cloth is removed.
- (b) The arms will fall together when the cloth is nearby, but will push apart again after the cloth is removed.
- (c) The arms will not change position if the cloth is nearby.
- (d) The arms will fall together when the cloth is nearby, and will stay that way after the cloth is removed.
- (e) The arms will push further apart when the cloth is nearby, and will stay that way after the cloth is removed.

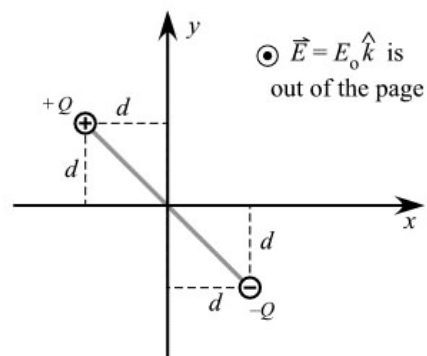
A simple electroscope:
all parts are conductors



Question value 8 points

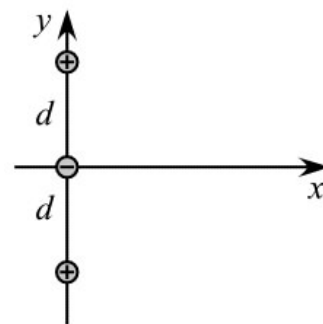
- (04) An electric dipole lies in the xy plane. It consists of a charge $+Q$ at coordinates $(x, y) = (-d, +d)$ and a charge $-Q$ at coordinates $(x, y) = (+d, -d)$. There is a uniform field present, having magnitude E_0 and pointing in the positive z-direction. What is the torque experienced by the dipole?

- (a) $\vec{\tau} = 2 Q d E_0 (+\hat{i} + \hat{j})$
- (b) $\vec{\tau} = 2 Q d E_0 (-\hat{i} - \hat{j})$
- (c) $\vec{\tau} = 2 Q d E_0 (+\hat{k})$
- (d) $\vec{\tau} = 2 Q d E_0 (+\hat{i} - \hat{j})$
- (e) $\vec{\tau} = 2 Q d E_0 (-\hat{i} + \hat{j})$
- (f) $\vec{\tau} = 2 Q d E_0 (-\hat{k})$



The next two questions involve the following situation:

Three charges of identical magnitude are arranged along the y-axis as shown at right. Consider the electric field at points on the positive x-axis.



Question value 4 points

- (5.1) For values of x that are much smaller than d , what is the approximate expression for the net electric field of the three charges?

- (a) $\vec{E} \approx k \frac{Q}{d^2} (+\hat{i})$
- (b) $\vec{E} \approx k \frac{Q}{x^2 + d^2} (-\hat{i})$
- (c) $\vec{E} \approx k \frac{Q}{x^2} (+\hat{i})$
- (d) $\vec{E} \approx k \frac{Q}{x^2} (-\hat{i})$
- (e) $\vec{E} \approx k \frac{Q}{x^2 + d^2} (+\hat{i})$
- (f) $\vec{E} \approx k \frac{Q}{d^2} (-\hat{i})$

Question value 4 points

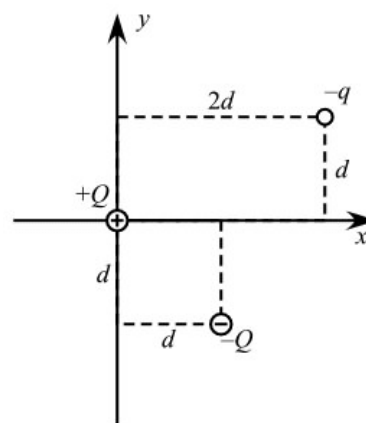
- (5.2) For values of x that are much larger than d , what is the approximate expression for the net electric field of the three charges?

- (a) $\vec{E} \approx k \frac{Q}{x^2} (-\hat{i})$
- (b) $\vec{E} \approx k \frac{Q}{x^2} (+\hat{i})$
- (c) $\vec{E} \approx k \frac{Q}{d^2} (+\hat{i})$
- (d) $\vec{E} \approx 0$
- (e) $\vec{E} \approx k \frac{Q}{d^2} (-\hat{i})$

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

- (6) (20 points) A charge $+Q$ is placed at the origin, and a second charge $-Q$ is placed at coordinates $(x, y) = (+d, -d)$, as shown in the figure below. Determine the net force (magnitude and direction) on a charge $-q$ that is placed at position $(x, y) = (+2d, +d)$.

Express the magnitude in terms of k , Q , and d . Express the direction as a numerical angle (to three significant digits) measured relative to the x-axis.

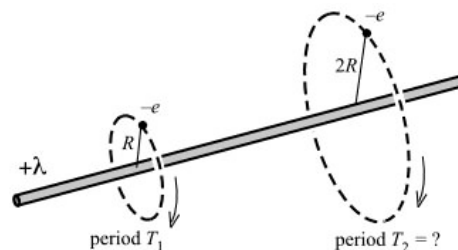


Form 1A

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

- (7) (20 points) An electron (mass m , charge $-e$) orbits around a long, uniformly-charged wire (linear charge density $+\lambda$). The orbit is an exactly circular path of radius R , centered on the wire and lying in a plane perpendicular to the wire. The period of the electron's orbit is T_1 . If a second electron orbits the wire, in a similar circular path but having a radius $2R$, what will be its period? Express your answer as a numerical multiple of T_1 .

(Recall that a particle orbiting in a circle of radius R at speed v experiences a centripetal acceleration of magnitude $a = v^2/R$.)



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

- (8) (20 points) An insulating rod lies along the x-axis from $x = L$ to $x = 2L$. The rod has a charge density given by $\lambda(x) = Ax^3$, where A is a positive constant. Determine the electric field (magnitude and direction) at the origin. Express your answer in terms of A , L , and ϵ_0 .

