Printed Name

Nine-digit GT ID

signature

Fall 2020 **PHYS 2212 G** **Test 01**

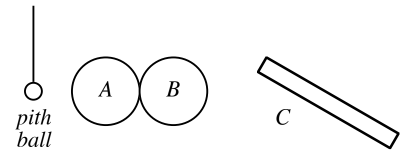
Test Form:

1A

- 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.

Question value 8 points

(01) Two identical conducting spheres A and B are in direct contact. They are initially uncharged. An uncharged pith ball hangs from an insulating thread near A. Charged rod C is then held near sphere B. When this occurs, the pith ball is attracted to A, briefly contacts the sphere, and is then repelled from A. While rod C is *still* held nearby, spheres A and B are separated.

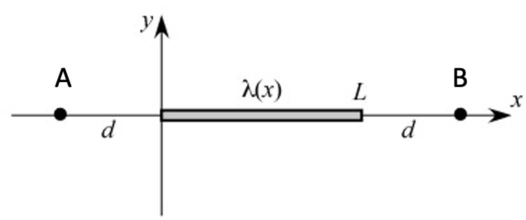


Which of the objects would be repelled by Sphere B?

(a) Only the pith ball will be repelled by sphere B.
(b) Sphere A and the pith ball will be repelled by sphere B.
(c) None of the other objects will be repelled by sphere B.
(d) Only rod C will be repelled by sphere B.
(e) All of the other objects will be repelled by sphere B.
(f) The pith ball and rod C will be repelled by sphere B.

Question value 8 points

(02) An insulating rod lies along the x-axis, extending from $x = 0$ to $x = L$. The rod is given a non-uniform linear density, given by $\lambda(x) = C\,x$, where C is a negatively-valued constant. Consider the two points illustrated in the figure, each at a distance d from either end of the rod. Compare the electric field at A to the electric field at B.



(a) $\vec{E}_A$ is in the same direction as $\vec{E}_B$, and $|\vec{E}_A| = |\vec{E}_B|$.

(b) $\vec{E}_A$ is in the opposite direction to $\vec{E}_B$, and $|\vec{E}_A| > |\vec{E}_B|$.

(c) $\vec{E}_A$ is in the opposite direction to $\vec{E}_B$, and $|\vec{E}_A| = |\vec{E}_B|$.

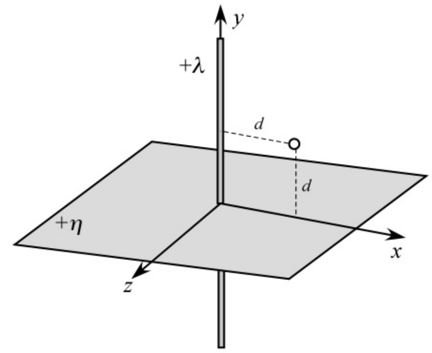
(d) $\vec{E}_A$ is in the opposite direction to $\vec{E}_B$, and $|\vec{E}_A| < |\vec{E}_B|$.

(e) $\vec{E}_A$ is in the same direction as $\vec{E}_B$, and $|\vec{E}_A| < |\vec{E}_B|$.

(f) $\vec{E}_A$ is in the same direction as $\vec{E}_B$, and $|\vec{E}_A| > |\vec{E}_B|$.

Question value 8 points

(03) A very long charged rod having uniform linear density λ lies along the y-axis. Perpendicular to the rod, a very large flat sheet lies in the xz-plane, having uniform surface density η. The electric field is measured at $(x,y) = (d,d)$, and it is found that $|\vec{E}_x| = |\vec{E}_y|$. What is the mathematical relationship between λ and η?



(a) $\lambda = \eta$

(b) $\lambda = 2\, d\, \eta$

(c) $\lambda = 2\, \eta$

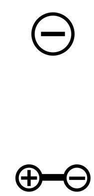
(d) $\lambda = d\, \eta/2$

(e) $\lambda = \pi\, d\, \eta$

(f) $\lambda = (\pi/2)\, \eta$

Question value 8 points

(04) An electric dipole is placed in the vicinity of a fixed negative point charge, as shown at right. What effect will the charge have on the dipole, after the dipole is released?



(a) The dipole will rotate counter-clockwise, but experience zero net force.

(b) The dipole will rotate clockwise, and then will be pulled in toward the charge.

(c) The dipole will rotate counter-clockwise, and then be repelled by the charge.

(d) The charge will have no effect on the dipole, because the dipole is electrically neutral.

(e) The dipole will rotate clockwise, but experience zero net force.

(f) The dipole will not rotate, but will be pulled in toward the charge.

Question value 4 points

(5.1) Two identical positive point charges are held at an initial separation distance *D*, and then released. As they move freely, they move with…

(a) …constant velocity.

(b) …decreasing acceleration.

(c) …increasing acceleration.

(d) …constant non-zero acceleration.

(e) …decreasing velocity.

Question value 4 points

(5.2) Two equal and opposite point charges are held at an initial separation distance *D*, and then released. As they move freely, they move with…

(a) …decreasing acceleration.

(b) …constant velocity.

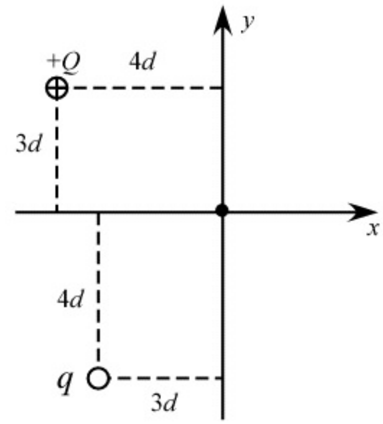
(c) …constant non-zero acceleration.

(d) …decreasing velocity.

(e) …increasing acceleration.

The following problem will be hand-graded. *<u>Show all supporting work for this problem</u>.*

(6) *(20 points)* A positive charge $+Q$ is placed at coordinates $(x, y) = (-4d, +3d)$. An unknown charge q is placed at coordinates $(x, y) = (-3d, -4d)$. It is found that the net electric field at the origin has no y-component.



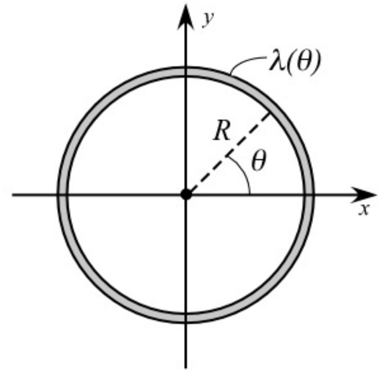
(a) What is the charge q? Express the magnitude as a fraction or muliple of Q, and be sure to specify the sign of q.

(b) What is the net electric field at the origin? Express your answer as a vector, using k, Q, and d as appropriate.

Form 1A

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

(7) *(20 points)* A charged ring of radius R lies in the xy-plane. It is given a linear charge density $\lambda(\theta) = A\cos\theta$, where A is a positive constant and θ is an angle measured counter-clockwise from the positive x-axis.



(a) What is the total charge on the ring? Express your answer in terms of A and R.

(b) What is the electric field at the origin? Express your answer as a vector, in terms of the parameters k, A, and R.

Some trig relations you might find helpful are:

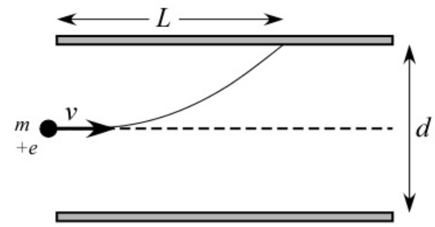
$$\cos^2\theta = \frac{1+\cos(2\theta)}{2}$$

$$\sin^2\theta = \frac{1-\cos(2\theta)}{2}$$

$$\sin\theta\cos\theta = \frac{\sin(2\theta)}{2}$$

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

(8) *(20 points)* The figure at right shows an edge-on view of a charged capacitor, with plates seprated by a distance d. A proton (mass m, charge $+e$) is fired laterally through the capacitor. It enters halfway between the plates, travelling parallel to the plates with initial speed v. The proton is observed to strike the top plate after travelling a horizontal distance L.



Suppose instead that an alpha-particle (mass $4m$, charge $+2e$) is fired into the capacitor with the shalf the speed of the proton, $v/2$. How far laterally will it travel before striking the top plate? Express your answer as a fraction or multiple of L.

1D kinematics reminder:

$$\overrightarrow{\Delta x} = \vec{v}_i \, \Delta t + 1/2 \, \vec{a} \, \Delta t^2$$
$$\overrightarrow{\Delta v} = \vec{a} \, \Delta t$$
$$v_f^2 = v_i^2 + 2 \, \vec{a} \cdot \overrightarrow{\Delta x}$$