Printed Name

Nine-digit GT ID

signature

Spring 2020 **PHYS 2212 G** **Test 02**

Test Form:

2A

- 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.

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 ⓐ ⓑ ⓒ ⓓ ⓔ

2 ⓐ ⓑ ⓒ ⓓ ⓔ

3 ⓐ ⓑ ⓒ ⓓ ⓔ

4 ⓐ ⓑ ⓒ ⓓ ⓔ

5 ⓐ ⓑ ⓒ ⓓ ⓔ

6 ⓐ ⓑ ⓒ ⓓ ⓔ

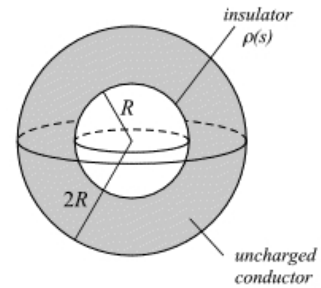
Extra Worksapace: If you use this space for a free-response problem, be sure to point it out on that problem's page!

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

[I] *(20 points)* A spherical insulator of radius R has a non-uniform but spherically-symmetric charge distributed on it, given by the expression

$$\rho(s) = \rho_o \frac{s^2}{R^2}$$

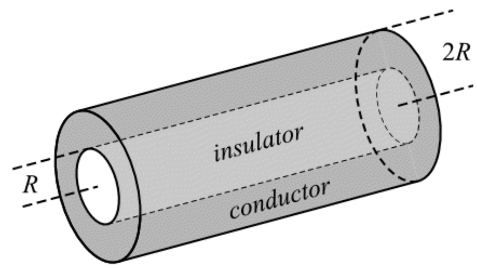
where s is the distance from the center of the sphere, and ρ_o is a positive constant. The insulator is then encased in an uncharged conducting spherical shell that extends from radius R to radius $2R$.



Consider following regions: (*i*) within the inner sphere (i.e. for $r < R$); (*ii*) within the conducting shell (i.e. for $R < r < 2R$); and (*iii*) outside the conducting shell (i.e. for $r > 2R$). In each region find an expression for the magnitude of the electric field as a function of the distance r from the center of the inner sphere, $E(r)$. Express each answer in terms of r, ρ_o, R, and ε_o.

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

[II] *(20 points)* A very long insulating rod of radius R has a uniform positive charge density ρ distributed throughout its volume. The insulator is then encased in a conducting cylindrical shell that extends from radius R to radius $2R$. This shell is then given a charge equal to twice the total charge (of the same sign) that was placed on the insulator.



Determine the charge density at all locations in/on the conductor. Keep in mind that there are two surfaces and one volume to consider. Express each answer in terms of ρ and R.

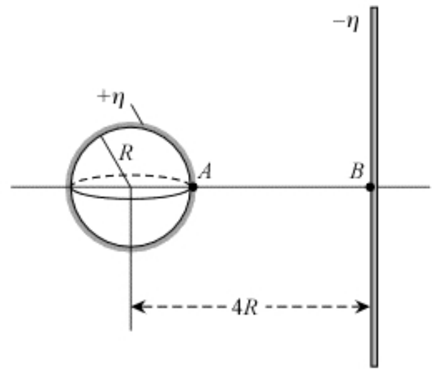
Hint: start by finding the total charge on a sublength L of the insulator.

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

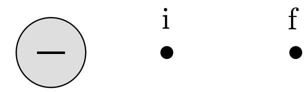
[III] *(20 points)* An insulating sphere of radius R has a uniform charge density $+\eta$ on its surface. The sphere is held near an infinite charged sheet having surface density $-\eta$ (yes, the same magnitude η), with the center of the sphere at a distance $4R$ from the charged sheet.

Determine the the electric potential difference between point *A* on the sphere and point *B* on the sheet, $\Delta V_{A\to B}$. Express your answer in terms of the parameters R, η, and ε_0. Be sure to include a sign for your answer.

Hint: the principle of Superposition applies here, so think of each object separately.



The next two questions involve the following situation:
A negative source charge is fixed in place, at the position shown. A positive test charge (not shown) is then observed to move from position *i* to position *f*.



Question value 4 points

(01) Describe the work done by the electric field during the displacement, the potential energy change of the system, and the potential difference moved through by the test charge.

(a) The work done by the electric field is **positive**; the electric potential energy of the system **decreases**; and the test charge moves through a **negative** potential difference.

(b) The work done by the electric field is **negative**; the electric potential energy of the system **decreases**; and the test charge moves through a **negative** potential difference.

(c) The work done by the electric field is **positive**; the electric potential energy of the system **increases**; and the test charge moves through a **positive** potential difference.

(d) The work done by the electric field is **negative**; the electric potential energy of the system **decreases**; and the test charge moves through **zero** potential difference.

(e) The work done by the electric field is **negative**; the electric potential energy of the system **increases**; and the test charge moves through a **positive** potential difference.

Question value 4 points

(02) Assume that the test charge began at rest at position *i*. What can we say about the external work that may have been done on the system, during the displacement of the test charge?

(a) N*on-zero* extrnal work much have been done on the system, but its sign cannot be determined from the information given.

(b) *Negative* external work must have been done on the system.

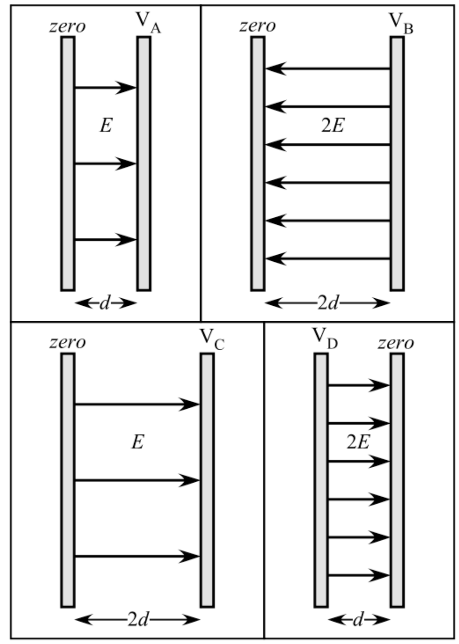
(c) *Zero* external work must have been done on the system.

(d) *Positive* external work must have been done on the system.

(e) There is not enough information provided to deduce anything about the work that might have been done by an external agent.

Question value 8 points

(03) In the diagrams at right, four charged capacitors each have one plate specified as being at "zero volts". The field strength and plate separation within each capacitor is indicated. Rank, from highest to lowest, the potentials V_A through V_D at the second plate of each capacitor.



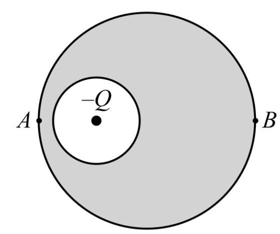
(a) $V_B = V_D > V_A = V_C$

(b) $V_B > V_D > V_A > V_C$

(c) $V_B > V_C = V_D > V_A$

(d) $V_C > V_A > V_D > V_B$

(e) $V_B > V_A > V_D = V_C$



Question value 8 points

(04) An uncharged conducting sphere has an <u>off-center</u> spherical cavity within it. If a point charge $-Q$ is placed at the center of the cavity, what can be said about the distribution of charge on the *outside* surface of the sphere?

(a) There will be a total charge $-Q$, distributed <u>non-uniformly</u> with a higher density at position A (nearest the cavity) and a lower density at position B (furthest from the cavity).

(b) There will be a total charge $-Q$, distributed <u>uniformly</u> around the outer surface of the sphere.

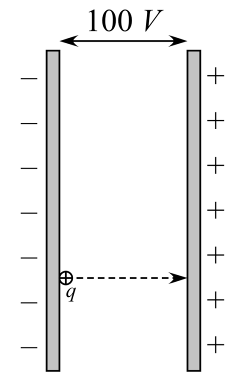
(c) There will be a total charge $+Q$, distributed <u>non-uniformly</u> with a lower density at position A (nearest the cavity) and a higher density at position B (furthest from the cavity).

(d) There will be <u>no</u> charge on the outer surface of the conductor, since it is "shielded" from the interior by the conducting material.

(e) There will be a total charge $+Q$, distributed <u>uniformly</u> around the outer surface of the sphere.

Question value 8 points

(05) A capacitor has a potential difference $\Delta V = 100$ volts between its plates. A test charge $q = +1$ C is initially at rest, at the negative plate of the capacitor. An externally applied force moves the charge from the negative plate to the positive plate, in such a way that it arrives at the positive plate with 50 joules of kinetic energy. How much work was done by the applied force during this process?



(a) + 50 J

(b) – 50 J

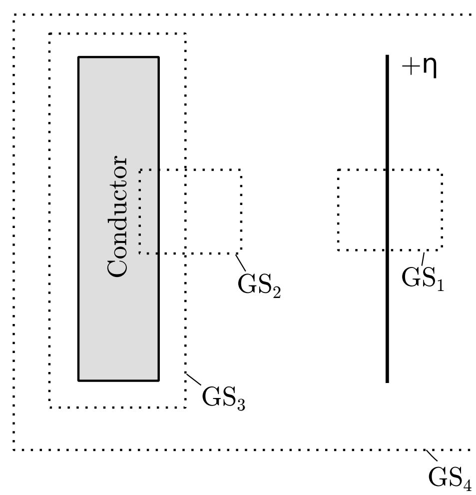
(c) 0 J

(d) + 150 J

(e) – 150 J

Question value 8 points

(06) A plane with positive surface charge density $+\eta$ is placed next to an uncharged slab of conducting material, as shown. Rank, from greatest to least, the electric flux Φ_i that passes through each of the Gaussian surfaces (GS_i) shown in the figure.



(a) $\Phi_4 = \Phi_1 > \Phi_3 = \Phi_2$

(b) $\Phi_2 > \Phi_3 > \Phi_1 > \Phi_4$

(c) $\Phi_4 > \Phi_1 > \Phi_3 > \Phi_2$

(d) $\Phi_3 = \Phi_2 > \Phi_1 > \Phi_4$

(e) $\Phi_4 > \Phi_1 = \Phi_2 > \Phi_3$