Fall 2019   **PHYS 2212 GJ**   **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 yourtest, 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.

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)* An insulating sheet of charge having infinite extent lies in the
xy-plane. When viewed close-up and edge-on, the sheet appears to be a slab
of non-zero thickness h along the z-direction, containing a uniform volume
charge density ρ.

(i) Determine an expression for the magnitude of the electric field
<u>outside</u> the slab, for $z \geq h/2$.

(ii) Determine an expression for the magnitude of the electric field
<u>inside</u> the slab, for $z \leq h/2$

In each case, express your answer in terms of ρ, h, z, and ε_{o}.
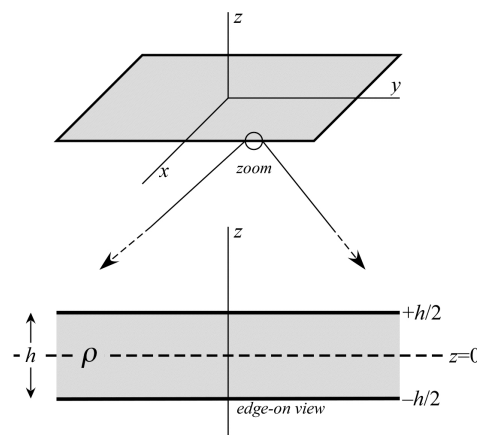
Form 2A

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

[II] *(20 points)* A coaxial cable consists of a solid cylindrical conducting wire of radius R, surrounded by an insulating collar of outer radius $5R$, surrounded in turn by a conducting sheath of outer radius $6R$. Both conductors are uncharged, but the insulating collar has a uniform charge density ρ throughout its volume.

Determine the surface charge density at each of the following locations:

    (i)   Outer surface of the inner wire, $\eta(R)$

    (ii)   Inner surface of the outer sheath, $\eta(5R)$

   *(iii)* Outer surface of the outer sheath, $\eta(6R)$

In each case, express the surface density in terms of ρ and R.
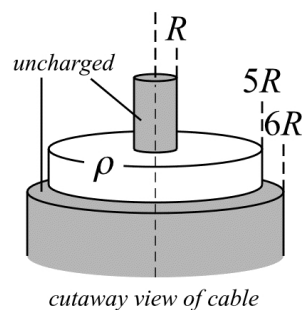
The following problem will be hand-graded. <u>Show all supporting work for this problem</u>.

[III] *(20 points)* A proton and two electrons (all having charge magnitude e) are placed at three corners of a square having sides of length d. An external agent then moves the electron at corner 'A' to corner 'B', while the other two charges are held stationary. The electron that is moved begins and ends at rest.

(i) Was the work done by the external agent in moving the electron *positive*, *negative*, or *zero*? Justify your answer with a brief explanation, in <u>words.</u>

(ii) Compute an expression for the work done by the external agent. Express your answer symbolically in terms of the electrostatic constant k, e, and d.
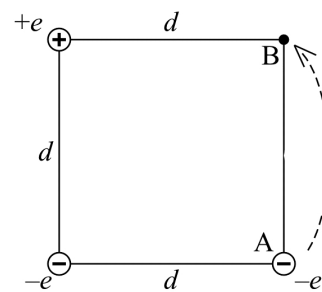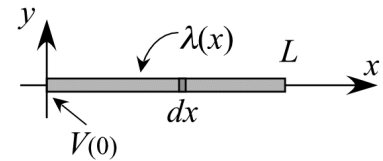
Question value 8 points

(01) A charged capacitor has plates that are separated by a distance d. The magnitude of the potential difference between the plates is $|\Delta V| = 12$V. A test charge $q = -500$ nC is placed a distance $d/4$ from the negative plate, and released from rest. How much work is done by the electric field, as the test charge moves all the way to the positive plate?

    (a) $-4.5\ \mu$J

    (b) $+6.0\ \mu$J

    (c) $+4.5\ \mu$J

    (d)   Zero work is done by the field, because electric fields are conservative.

    (e) $-6.0\ \mu$J

Question value 8 points

(02) A rod of length L lies along the x-axis, extending from $x = 0$ to $x = L$. A total charge Q is distributed non-uniformly along the rod, with a linear density given by the expresssion

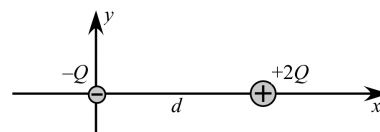$$\lambda(x) = \frac{3Q}{L^3} \cdot x^2 \quad \text{for } 0 \leq x \leq L.$$

Relative to an assumed value of $V = 0$ at infinity, what is the electric potential at the origin?

    (a) $V = \dfrac{kQ}{L}$

    (b) $V = \dfrac{2kQ}{L}$

    (c) $V = \dfrac{3kQ}{2L}$

    (d) $V = \dfrac{2kQ}{3L}$

    (e) $V = \dfrac{3kQ}{L}$

Question value 8 points

(03) A point charge $-Q$ is placed at the origin, and a point charge $+2Q$ is placed at $x = +d$. What is the electric <u>field</u> at a point on the x-axis where the electric <u>potential</u> is zero?

(a) $\vec{E} = -\dfrac{3kQ}{2d^2}\,\hat{\imath}$

(b) $\vec{E} = +\dfrac{3kQ}{2d^2}\,\hat{\imath}$

(c) $\vec{E} = 0$

(d) $\vec{E} = -\dfrac{kQ}{2d^2}\,\hat{\imath}$

(e) $\vec{E} = +\dfrac{kQ}{2d^2}\,\hat{\imath}$

Question value 8 points

(04) Four identical dipoles are placed in a uniform electric field, with varying orientations as shown at right. Rank in order, from the most positive to most negative, the potential energies U_a to U_d for those four dipoles.

(a) $U_b > U_c > U_d = U_a$
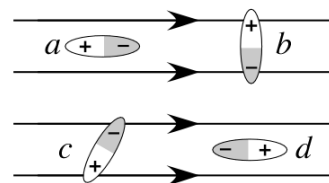
(b) All four dipoles have identically zero potential energy.

(c) $U_a > U_c > U_b > U_d$

(d) $U_d > U_c > U_b > U_a$

(e) $U_a = U_d > U_c > U_b$

The next two questions involve the following situation:

A conducting sphere of radius R has two off-center spherical cavities, both of radius $R/4$, within it. Cavity 'A' has a point charge $+q$ placed at its center. Cavity 'B' is empty.
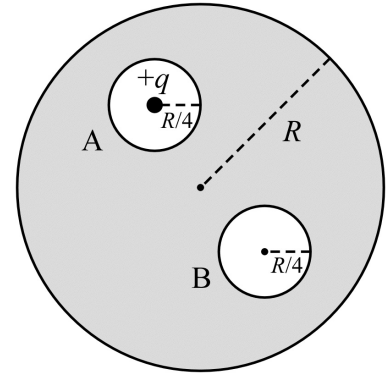
Question value 4 points

(05)   What is the surface charge density found on the inner wall of Cavity 'B'?

    (a) $\eta_B = 0$

    (b) $\eta_B = +q/4\pi R^2$

    (c) $\eta_B = -4q/\pi R^2$

    (d) $\eta_B = -q/4\pi R^2$

    (e) $\eta_B = +4q/\pi R^2$

Question value 4 points

(06)   What is the surface charge density found on the outer surface of the sphere?

    (a) $\eta_{out} = -4q/\pi R^2$

    (b) $\eta_{out} = 0$

    (c) $\eta_{out} = +q/4\pi R^2$

    (d) $\eta_{out} = -q/4\pi R^2$

    (e) $\eta_{out} = +4q/\pi R^2$