first (given)	*last (family)*	

Name, *printed* as it appears in Canvas

Physics 2212 K

Summer 2019

Nine-digit Tech ID

Quiz

2A

- **Print** your name and nine-digit Tech ID *very neatly* in the spaces above.
- 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 1–7. For each, select the answer most nearly correct, circle it on your quiz, 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 will know where to look for your work.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.
- Your score will be posted when your quiz has been graded. Quiz grades become final after the first Reading Day, Wednesday, April 24.

Fill in bubbles for your Multiple Choice answers darkly and neatly.

	a	b	c	d	e
1	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
2	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
3	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
4	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
5	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
6	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
7	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
	a	b	c	d	e

Quiz and Exam Formulæ & Constants

$$k = \frac{1}{4\pi\epsilon_0}$$
$$\Delta V = -\int \vec{E}\cdot d\vec{s}$$
$$V = k\frac{q}{r}$$
$$\Delta U = q\,\Delta V$$
$$I = dq/dt$$
$$P = I\,\Delta V$$
$$R = \frac{\Delta V}{I}$$

Series :

$$\frac{1}{C_{\text{eq}}} = \sum \frac{1}{C_i}$$
$$R_{\text{eq}} = \sum R_i$$

Parallel :

$$\frac{1}{R_{\text{eq}}} = \sum \frac{1}{R_i}$$
$$C_{\text{eq}} = \sum C_i$$

$$\vec{E} = k\frac{q}{r^2}\hat{r}$$
$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r}$$
$$\vec{F} = q\vec{E}$$
$$\vec{p} = q\vec{d}$$
$$\vec{\tau} = \vec{p}\times\vec{E}$$
$$U = -\vec{p}\cdot\vec{E}$$
$$|\vec{E}| \propto \frac{|\vec{p}|}{r^3}$$
$$\Phi_{\text{E}} = \int \vec{E}\cdot d\vec{A}$$
$$\epsilon_0 \oint \vec{E}\cdot d\vec{A} = q_{\text{enclosed}}$$
$$\oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_{\text{B}}}{dt}$$
$$C = \frac{Q}{\Delta V}$$
$$C = \epsilon_0\frac{A}{d}$$
$$U = \tfrac{1}{2}C\,[\Delta V]^2$$
$$R = \rho\frac{\ell}{A}$$
$$\tau_{\text{C}} = RC$$
$$u_{\text{E}} = \tfrac{1}{2}\epsilon_0 E^2$$

$$\vec{B} = \frac{\mu_0 q}{4\pi}\,\frac{\vec{v}\times\hat{r}}{r^2}$$
$$d\vec{B} = \frac{\mu_0 I}{4\pi}\,\frac{d\vec{\ell}\times\hat{r}}{r^2}$$
$$\vec{F} = q\vec{v}\times\vec{B}$$
$$\vec{F} = I\vec{\ell}\times\vec{B}$$
$$\vec{\mu} = NI\vec{A}$$
$$\vec{\tau} = \vec{\mu}\times\vec{B}$$
$$U = -\vec{\mu}\cdot\vec{B}$$
$$\Phi_{\text{B}} = \int \vec{B}\cdot d\vec{A}$$
$$\oint \vec{B}\cdot d\vec{A} = 0$$
$$\oint \vec{B}\cdot d\vec{\ell} = \mu_0(I_{\text{c}} + I_{\text{d}})$$
$$L = \frac{\Phi_{\text{B}}}{I}$$
$$L = \mu_0 N^2\frac{A}{\ell}$$
$$U = \tfrac{1}{2}LI^2$$
$$B = \mu_0 nI$$
$$\tau_{\text{L}} = L/R$$
$$u_{\text{B}} = \frac{1}{2\mu_0}B^2$$

$$q = q_{\max}\left(1 - e^{-t/\tau_{\text{C}}}\right)$$
$$q = q_0 e^{-t/\tau_{\text{C}}}$$
$$I = I_{\max}\left(1 - e^{-t/\tau_{\text{L}}}\right)$$
$$I = I_0 e^{-t/\tau_{\text{L}}}$$
$$I = \int \vec{J}\cdot d\vec{A}$$
$$\vec{J} = \sigma\vec{E}$$
$$\mathcal{E} = -N\frac{d\Phi_{\text{B}}}{dt}$$
$$I_d = \epsilon_0\frac{d\Phi_{\text{E}}}{dt}$$
$$\mathcal{E} = -L\frac{dI}{dt}$$
$$c = f\lambda = \frac{|\vec{E}|}{|\vec{B}|}$$
$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$

Fundamental Charge $e = 1.602\times10^{-19}\,\text{C}$
Earth's gravitational field $g = 9.81\,\text{N/kg}$
Coulomb constant $K = 8.988\times10^{9}\,\text{N}\cdot\text{m}^2/\text{C}^2$
Speed of Light $c = 2.998\times10^{8}\,\text{m/s}$

Mass of an Electron $m_{\text{e}} = 9.109\times10^{-31}\,\text{kg}$
Mass of a Proton $m_{\text{p}} = 1.673\times10^{-27}\,\text{kg}$
Vacuum Permittivity $\epsilon_0 = 8.854\times10^{-12}\,\text{C}^2/\text{N}\cdot\text{m}^2$
Vacuum Permeability $\mu_0 = 4\pi\times10^{-7}\,\text{T}\cdot\text{m/A}$

Unless otherwise directed, friction, drag, and gravity should be neglected, and all batteries and wires are ideal.
All derivatives and integrals in free-response problems must be evaluated.

You may remove this sheet from your Quiz or Exam

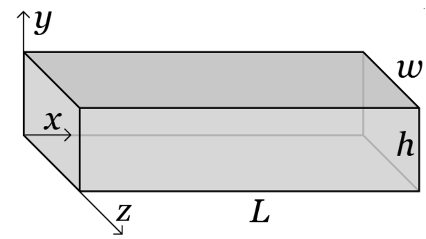
I. (16 points) A wire of length L has rectangular cross-section h high and w wide. There is a uniform electric field of magnitude E_0 within it, in the x direction.

$$\vec{E} = E_0\,\hat{\imath}$$

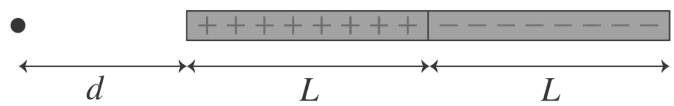
The conductivity of the wire is non-uniform, however, and depends on position z according to

$$\sigma = \sigma_0\,\frac{z}{w}$$

where σ_0 is a positive constant. In terms of parameters defined in the problem, and physical or mathematical constants, what is the current in the wire?



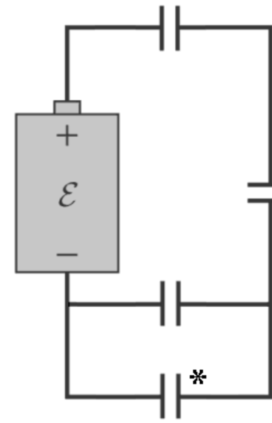
II. (16 points) The two halves of a rod, each of length L, are uniformly charged to $\pm Q$, with the left half positive and the right half negative, as shown. What is the electric potential (with respect to zero at infinity) at the point indicated by the dot, a distance d from the positively-charged end of the rod? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants. If the potential is necessarily zero, prove it.



1. (6 points) In the problem above, what is the direction of the electric potential at the dot?

   (a) Toward the right.
   (b) This is not a meaningful question.
   (c) Direction cannot be determined from the information provided.
   (d) Toward the left.
   (e) No direction, as the electric potential magnitude is zero.

III. (16 points) The battery in the illustrated circuit has emf $\mathcal{E}$. Each of the four capacitors has the same capacitance, C. Once the circuit has been connected for a long time, what energy is stored in the bottom-most capacitor, marked with an asterisk, with respect to zero energy at zero charge? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.



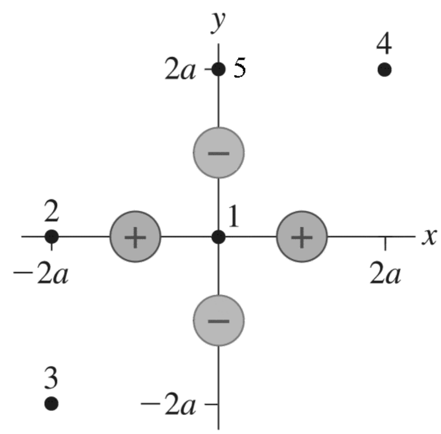
2. (6 points) If the energy found in the problem above is U_0, what energy would be stored in that same capacitor if the battery were replaced by one with twice the emf, $2\mathcal{E}$?

When the battery has emf $2\mathcal{E}$, the energy stored in the bottom-most capacitor is ...

(a) $8U_0$. (b) $2U_0$. (c) $4U_0$. (d) $4U_0$. (e) $U/2_0$.

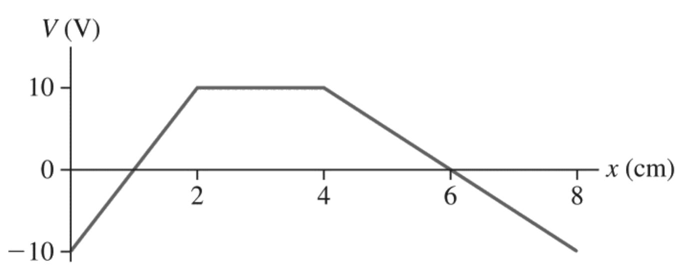
3. (8 points) Two positive charges are located on the x axis at the points $(-a, 0)$ and $(a, 0)$; two more charges of the same magnitude, but opposite sign, are located on the y axis at the points $(0, -a)$ and $(0, a)$. Rank the electric potentials V_i at the points $P_1 = (0, 0)$, $P_2 = (-2a, 0)$, $P_3 = (-2a, -2a)$, $P_4 = (2a, 2a)$, and $P_5 = (0, 2a)$.

(a) $V_1 > V_2 = V_5 > V_3 = V_4$
(b) $V_5 > V_1 > V_3 > V_4 > V_2$
(c) $V_2 > V_1 = V_3 = V_4 > V_5$
(d) $V_5 > V_1 = V_3 = V_4 > V_2$
(e) $V_2 > V_1 > V_3 > V_4 > V_5$



4. (8 points) Electric potential is graphed as a function of position. Where is the electric field magnitude greatest? At that location, in which direction does the electric field point?

(a) Electric field has greatest magnitude between 2 and 4 cm. The direction question is not meaningful.
(b) Electric field has greatest magnitude between 0 and 2 cm. It points in the positive direction.
(c) Electric field has greatest magnitude between 4 and 8 cm. It points in the negative direction.
(d) Electric field has greatest magnitude between 0 and 2 cm. It points in the negative direction.
(e) Electric field has greatest magnitude between 4 and 8 cm. It points in the positive direction.

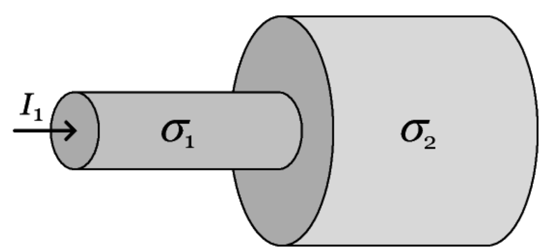


5. (8 points) A parallel plate capacitor has been connected to a battery for a long time. Insulating handles will be attached to the plates, and the plates will be pushed closer together. How does the energy stored in the capacitor change, depending on whether or not the battery is disconnected before moving the plates?

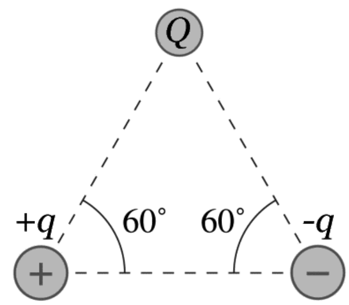
   (a) If the plates remain connected the stored energy increases, and if they are disconnected it increases.
   (b) If the plates remain connected the stored energy increases, but if they are disconnected it decreases.
   (c) If the plates remain connected the stored energy decreases, and if they are disconnected it decreases.
   (d) If the plates remain connected the stored energy decreases, but if they are disconnected it remains the same.
   (e) If the plates remain connected the stored energy decreases, but if they are disconnected it increases.

6. (8 points) The illustrated wire is composed of two segments, 1 and 2, having different conductivities σ_1 and σ_2, and different radii R_1 and R_2. The conductivity of segment 2 is only half the conductivity of segment 1. The radius of segment 2 is three times the radius of segment 1. What is the ratio of the electric field magnitude in segment 1 to that in segment 2, E_1/E_2?

   (a) $E_1/E_2 = 2/3$
   (b) $E_1/E_2 = 2/9$
   (c) $E_1/E_2 = 3/2$
   (d) $E_1/E_2 = 1$
   (e) $E_1/E_2 = 9/2$



7. (8 points) A system consists of three charged particles at the vertices of an equilateral triangle, as illustrated. Two of the particles have charge of equal magnitude, q, but opposite sign. The third particle has charge Q. How does the electric potential energy of the system change if the particle with charge Q is removed to infinitely far away?



(a) It decreases.
(b) It increases if Q is positive, but decreases if Q is negative.
(c) It remains the same.
(d) It increases.
(e) It increases if Q is negative, but decreases if Q is positive.