Name, *printed* as it appears in Canvas

Physics 2212 G

Spring 2019

Nine-digit Tech ID

Quiz

3A

- **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 when the next is given.

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 :

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

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

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

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

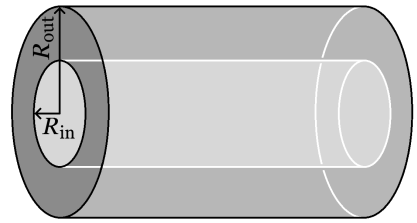
Fundamental Charge $e = 1.602\times10^{-19}\,\text{C}$
Earth's gravitational field $g = 9.81\,\text{N/kg}$
Coulomb constant $K = 8.988\times10^{9}\,\text{N}\cdot\text{m}^2/\text{C}^2$
Speed of Light $c = 2.998\times10^{8}\,\text{m/s}$

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

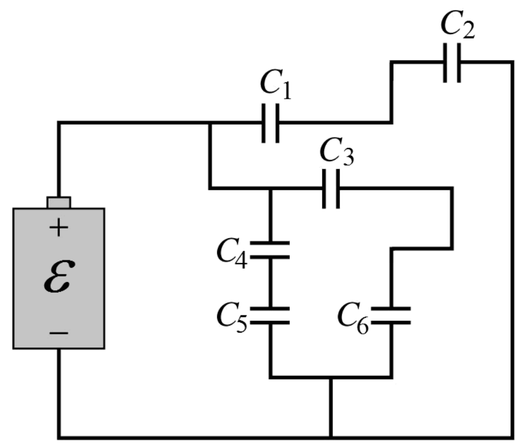
I. (16 points) A hollow conducting wire has inner radius $R_{\text{in}} = 1.8\,\text{mm}$. It carries a current whose density magnitude J varies with distance r from the central axis of the wire according to



$$J = J_0 \frac{R_{\text{in}}}{r}$$

where $J_0 = 24\,\text{A/m}^2$. If the wire carries a total current of $1.2\,\text{mA}$, what is the outer radius of the wire?

II. (16 points) The circuit shown has a battery with emf (potential difference) $\mathcal{E}$, and six capacitors $C_1 \ldots C_6$ with capacitances $C_1 = 1C$, $C_2 = 2C$, $C_3 = 3C$, etc. In terms of $\mathcal{E}$, C, and physical or mathematical constants, what energy is stored in capacitor C_3?



1. (6 points) In the problem above, how is the potential difference ΔV_3 across capacitor C_3 related to the potential difference ΔV_6 across capacitor C_6?

   (a) $\Delta V_3 = \Delta V_6/4$
   (b) $\Delta V_3 = 2\Delta V_6$
   (c) $\Delta V_3 = \Delta V_6$
   (d) $\Delta V_3 = \Delta V_6/2$
   (e) $\Delta V_3 = 4\Delta V_6$

III. (16 points) The electric potential in a region of space depends on location (x, y) according to

$$V = Ax^2 - By^3$$

where $A = 4.0\,\mathrm{V/m^2}$ and $B = 3.0\,\mathrm{V/m^3}$, with respect to zero at infinity. What is the electric field at $(x, y) = (3.0, 2.0)$ m?

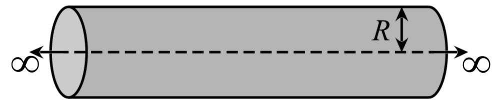
2. (6 points) If, in the problem above, you had been provided with an expression for the electric potential with respect to zero **at the origin**, instead of at infinity, how would your answer above for the electric field be affected?

   (a) My answer above would be multiplied by an arbitrary factor.
   (b) This is a meaningless question, as potentials must be measured with respect to zero at infinity.
   (c) My answer above would change by 180°.
   (d) My answer above would have an arbitrary constant added to it.
   (e) My answer above would remain exactly the same.

3. (8 points) An infinite conducting cylinder has radius R and area charge density η. Outside the cylinder, the electric potential depends on distance r from the central axis according to

$$V = \frac{-\eta}{\epsilon_0} \ln\left(\frac{r}{R}\right)$$

with respect to zero at $r = R$. With respect to that same zero point, what is the electric potential at a point $r = R/3$, inside the cylinder?



(a) $V = -(\eta/\epsilon_0)\ln(3)$
(b) $V = +(\eta/\epsilon_0)\ln(3)$
(c) $V = 0$
(d) $V = +(\eta/\epsilon_0)\ln(3/2)$
(e) $V = -(\eta/\epsilon_0)\ln(3/2)$

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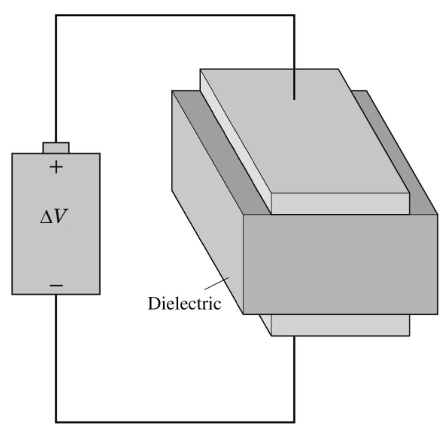
4. (8 points) A parallel-plate capacitor has capacitance C with vacuum between the plates. A dielectric with dielectric constant κ is positioned to fill the space between the plates, then the capacitor is attached to a battery with potential difference ΔV, as shown. How much work must an agent or agents external to the capacitor do to remove the dielectric at constant speed?



(a) $W_{\text{ext}} = \frac{1}{2}C(\Delta V)^2(1-\kappa)$

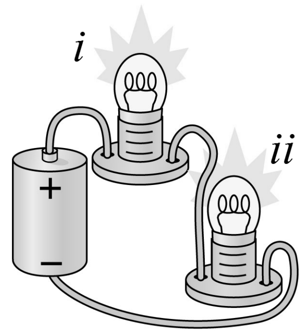
(b) $W_{\text{ext}} = 0$

(c) $W_{\text{ext}} = \frac{1}{2}C(\Delta V)^2\left(\frac{1}{\kappa} - 1\right)$

(d) $W_{\text{ext}} = \frac{1}{2}C(\Delta V)^2\left(1 - \frac{1}{\kappa}\right)$

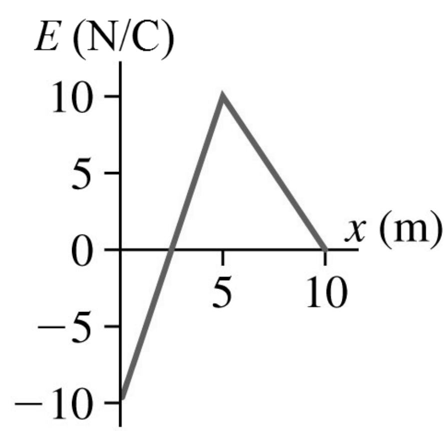
(e) $W_{\text{ext}} = \frac{1}{2}C(\Delta V)^2(\kappa - 1)$

5. (8 points) Two identical bulbs, i and ii, are attached to a battery, as shown. Because the bulbs are identical, the potential difference between the terminals of each socket (the point where the wires are attached) are the same, $\Delta V_i = \Delta V_{ii}$. If bulb ii is removed by unscrewing it from its socket, how are these two potential differences affected?



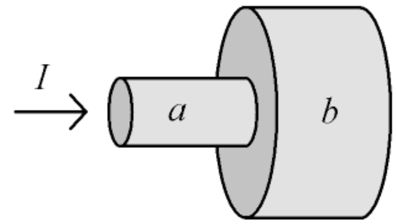
(a) ΔV_i decreases. ΔV_{ii} increases.
(b) ΔV_i remains the same. ΔV_{ii} increases.
(c) ΔV_i increases. ΔV_{ii} decreases.
(d) ΔV_i remains the same. ΔV_{ii} remains the same.
(e) ΔV_i remains the same. ΔV_{ii} decreases.

6. (8 points) An electric field depends on position x as shown. Where, in the region from $x = 0$ to $x = 10$ m inclusive, is the electric potential greatest?



(a) This cannot be determined unless a reference for electric potential is specified.
(b) At $x = 2.5$ m.
(c) At $x = 0$ m.
(d) At $x = 5$ m.
(e) At $x = 10$ m.

7. (8 points) Current flows from the left into the wire shown. Segment b on the right has three times the diameter of segment a on the left. The electric field magnitude in segment b on the right is one half that in segment a on the left. Compare the conductivity of segment b with that of segment a.



(a) $\sigma_b = (2/9)\,\sigma_a$
(b) $\sigma_b = (4/3)\,\sigma_a$
(c) $\sigma_b = (3/2)\,\sigma_a$
(d) $\sigma_b = (2/3)\,\sigma_a$
(e) $\sigma_b = (4/9)\,\sigma_a$