Name	**Physics 2212 GJ** Fall 2018	Nine-digit Tech ID

Quiz #
3A

- Put *nothing* other than your name and nine-digit Tech ID 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 know where to find 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	(a)	(b)	(c)	(d)	(e)
2	(a)	(b)	(c)	(d)	(e)
3	(a)	(b)	(c)	(d)	(e)
4	(a)	(b)	(c)	(d)	(e)
5	(a)	(b)	(c)	(d)	(e)
6	(a)	(b)	(c)	(d)	(e)
7	(a)	(b)	(c)	(d)	(e)
	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 :

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

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

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

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

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 $c = 2.998\times10^{8}\,\text{m/s}$

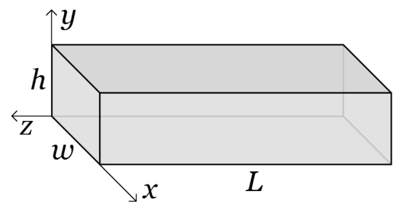
Mass of an Electron $m_{\text{e}} = 9.109\times10^{-31}\,\text{kg}$
Mass of a Proton $m_{\text{p}} = 1.673\times10^{-27}\,\text{kg}$
Vacuum Permittivity $\epsilon_0 = 8.854\times10^{-12}\,\text{C}^2/\text{N}\cdot\text{m}^2$
Vacuum Permeability $\mu_0 = 4\pi\times10^{-7}\,\text{T}\cdot\text{m/A}$

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

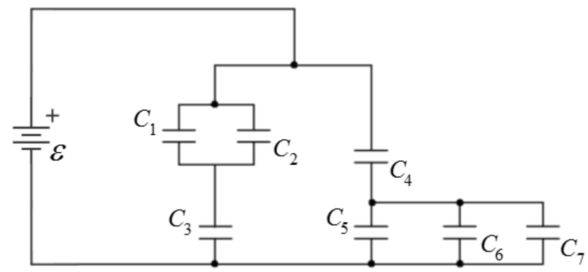
I. (16 points) A wire is rectangular in cross-section, with height h and width w. A segment of length L lies along the $-z$ axis, as shown. The current density in the wire is non-uniform, depending on position x according to

$$\vec{J} = -J_0 \left(\frac{x}{w}\right) \hat{z}$$



where J_0 is a positive constant. What magnitude current flows through the wire? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.

II. (16 points) The battery in the circuit shown has emf (potential difference) $\mathcal{E}$. All seven capacitors have identical capacitances C. What is the charge on capacitor C_7? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.



1. (6 points) Let your answer to the problem above be Q_7. If the emf of the battery were doubled, and the capacitance of all the capacitors was halved, what charge Q_7' would be on capacitor C_7?

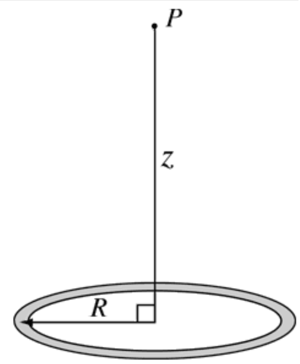
   (a) $Q_7' = Q_7/4$
   (b) $Q_7' = 4Q_7$
   (c) $Q_7' = Q_7$
   (d) $Q_7' = Q_7/2$
   (e) $Q_7' = 2Q_7$

Initial:

III. (16 points) The electric potential on the axis of a uniform ring of charge, with respect to zero at infinity, is

$$V = K\frac{Q}{\sqrt{z^2 + R^2}}$$

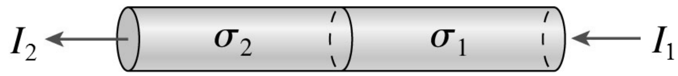
where Q is the charge on the ring, R is the radius of the ring, and z is the distance along the axis from the center of the ring. From this potential, derive an expression for the magnitude of the electric field on the axis of the ring, as a function of distance z, and in terms of other parameters defined in the problem, and physical or mathematical constants.



2. (6 points) If, in the problem above, you had been provided with an expression for the electric potential on the axis of a uniform ring of charge with respect to zero at **the center**, how would your expression above for the magnitude of the electric field be affected?

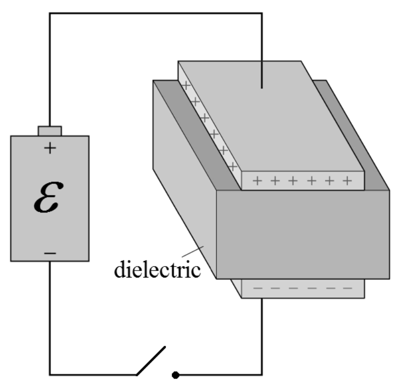
(a) My expression above would become $E = +\infty$.
(b) My expression above would be multiplied by an arbitrary factor.
(c) My expression above would remain exactly the same.
(d) My expression above would become $E = -\infty$.
(e) My expression above would have an arbitrary constant added to it.

3. (8 points) A wire of uniform diameter is made by joining two different pieces, each with its own conductivity. Current I_1 flows into piece 1, which has conductivity σ_1. Current I_2 flows out of piece 2, which has conductivity σ_2. Under what circumstances, if any, will there be a layer of **positive** charge at the junction between the pieces?



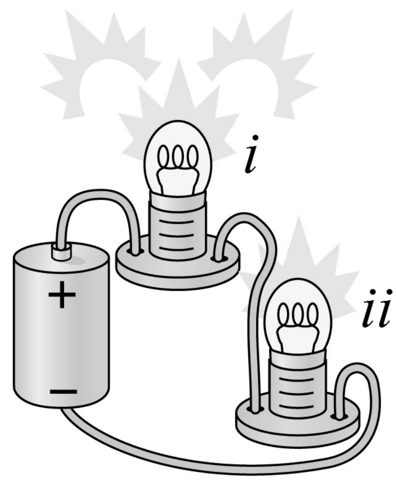
(a) When $\sigma_1 > \sigma_2$.
(b) Under no circumstances.
(c) When $\sigma_1 < \sigma_2$.
(d) When $I_1 > I_2$.
(e) When $I_1 < I_2$.

4. (8 points) When the capacitor shown has no dielectric between the plates, its capacitance is C_0. An insulating slab with dielectric constant κ is inserted to fill the space between the plates. The capacitor is then connected to a battery with emf (or potential difference) $\mathcal{E}$, allowed to fully charge, then disconnected. How much work, if any, must be done by an agent external to the capacitor to remove the insulating slab?



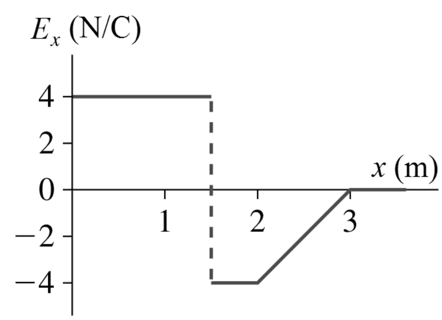
(a) $\frac{1}{2}\kappa C_0 \mathcal{E}^2 (1 - 1/\kappa)$
(b) Zero
(c) $\frac{1}{2}\kappa C_0 \mathcal{E}^2 (1 - \kappa)$
(d) $\frac{1}{2}\kappa C_0 \mathcal{E}^2 (1/\kappa - 1)$
(e) $\frac{1}{2}\kappa C_0 \mathcal{E}^2 (\kappa - 1)$

5. (8 points) Bulbs *i* and *ii* are attached to a battery, as shown. The bulbs are **NOT** identical, and bulb *i* is brighter than bulb *ii*. If the polarity of the battery was reversed, so bulb *ii* was now attached to the positive terminal, compare the resulting bulb brightnesses and the currents though each bulb.



(a) Bulb *i* is still brighter. The current through bulb *i* is **the same as** the current through bulb *ii*.
(b) Bulb *i* is still brighter. The current through bulb *i* is **greater than** the current through bulb *ii*.
(c) Bulb *ii* is now brighter. The current through bulb *ii* is **the same as** the current through bulb *i*.
(d) Bulb *ii* is now brighter. The current through bulb *ii* is **greater than** the current through bulb *i*.
(e) Bulb *ii* is now brighter. The relative currents through the bulbs **cannot be determined**.

6. (8 points) An electric field depends on position x as shown. Where, in the region from $x = 0$ to $x = 3\,\text{m}$ inclusive, is the electric potential greatest?



(a) At $x = 3\,\text{m}$.
(b) At $x = 1.5\,\text{m}$.
(c) At $x = 0\,\text{m}$.
(d) At $x = 2\,\text{m}$.
(e) This cannot be determined unless a reference for electric potential is specified.

7. (8 points) Three identical ideal parallel-plate capacitors are attached to three identical batteries. All three look like system i. While the capacitors remain attached to their batteries, insulating handles are used to double the distance between the plates in system ii, and to stretch the plates in system iii to double their original area. Compare the potential energies stored in each capacitor.

(a) $i > ii > iii$
(b) $iii > ii > i$
(c) $ii > iii > i$
(d) $iii > i > ii$
(e) $ii > i > iii$