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

Parallel :
$$\frac{1}{R_{\mathrm{eq}}} = \sum \frac{1}{R_i}$$
$$C_{\mathrm{eq}} = \sum C_i$$

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

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

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

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

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

Version: 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.

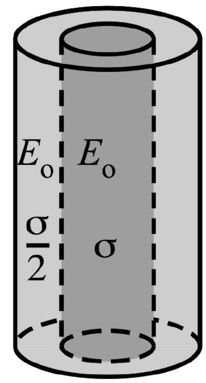
Please remove this sheet from your Quiz or Exam

Version Quiz #3 Form #325 Name:________________

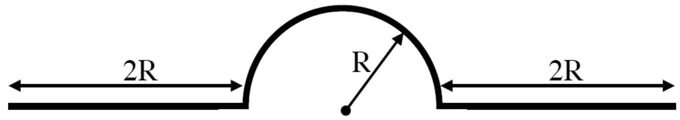
A Physics 2212 G&J Fall 2017 Recitation Section:________________

- Print your name, quiz form number (3 digits at the top of this form), and student number (9 digit Georgia Tech ID number) in the section of the answer card labeled "Student Identification."
- Bubble the Quiz Form Number in columns 1–3, skip column 4, then bubble your Student Number in columns 5–13.
- Free-response questions are numbered I–III. For each, make no marks and leave no space on your card. Show all your work clearly, including all steps and logic. Box your answer.
- Multiple-choice questions are numbered 1–7. For each, select the answer most nearly correct, circle this answer on your quiz, and bubble it on your answer card. Do not put any extra marks on the card.
- Turn in your quiz and answer card as you leave. Your score will be posted when your quiz has been graded. Quiz grades become final when the next quiz is given.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.

I. (16 points) A tungsten-clad aluminum wire consists of a solid aluminum core (having conductivity σ) of radius R, which is then covered in a tungsten sheath (having conductivity $\sigma/2$) that extends to radius $2R$. When a potential difference is applied across the ends of the wire, an internal field of magnitude E_0 is induced within both the core and the sheath. What is the total current that will be flowing in the wire, under these circumstances? Express your answer in terms of the parameters defined in the problem, and physical or mathematical constants.

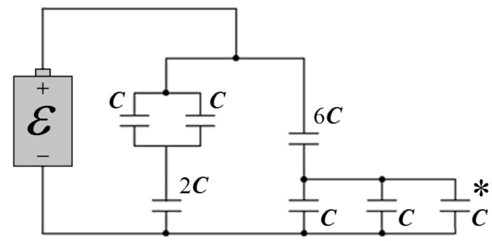


II. (16 points) The wire in the figure has uniform linear charge density λ. What is the electric potential, with respect to zero at infinite distance, at the center of the semicircle? Express your answer in terms of the parameters defined in the problem, and physical or mathematical constants.



1. (6 points) In the problem above what is the direction of the electric potential at the center of the semicircle?
   (a) This is not a meaningful question.
   (b) Up the page.
   (c) Into the page.
   (d) Down the page.
   (e) The potential is zero, so the direction is not defined.

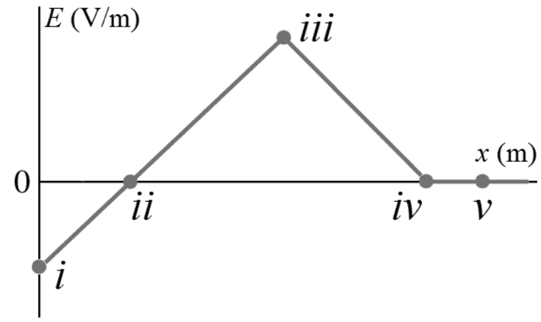
III. (16 points) A battery with emf $\mathcal{E}$ is connected to a network of seven capacitors (five with capacitance C, one with capacitance $2C$, and one with capacitance $6C$) as shown. With respect to zero in the uncharged state, what energy is stored in the capacitor farthest to the right, marked with an asterisk? Express your answer in terms of the parameters defined in the problem, and physical or mathematical constants.



2. (6 points) In the problem above, let your answer (the energy stored in the capacitor farthest to the right) be U_0. If the battery with emf $\mathcal{E}$ is replaced by a battery with emf $2\mathcal{E}$, what energy U' will now be stored in that capacitor?

(a) $U' = U_0\sqrt{2}$
(b) $U' = 2U_0$
(c) $U' = 4U_0$
(d) $U' = U_0/2$
(e) $U' = U_0$

3. (8 points) An electric field varies with position x, as shown. At what point does the electric potential have its maximum value? (Remember, potential is a signed scalar.)



(a) Point v.
(b) Point ii.
(c) Point i.
(d) Point iii.
(e) Point iv.

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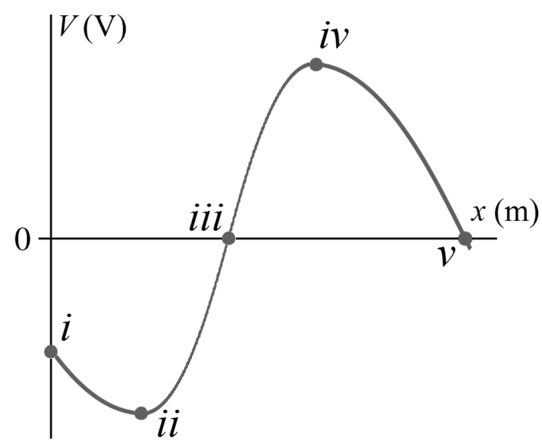
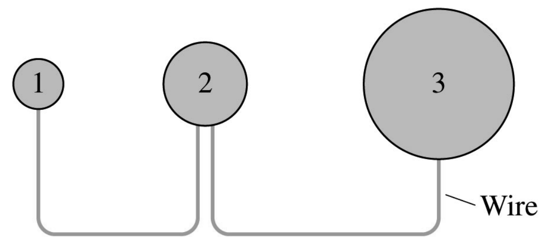
4. (8 points) The electric potential varies with position x, as shown. At what point does the electric field magnitude have its maximum value?



(a) Point iii.
(b) Point iv.
(c) Point v.
(d) Point i.
(e) Point ii.

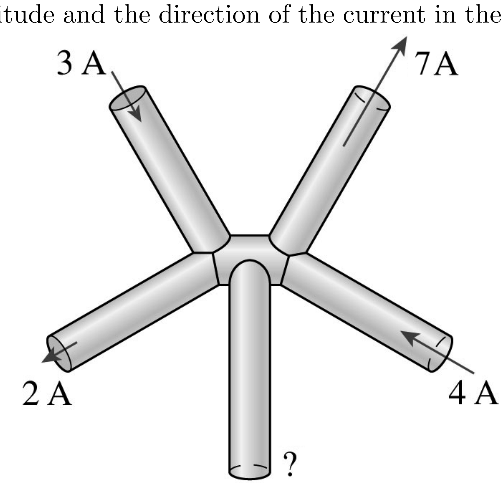
5. (8 points) Three charged metal spheres of different radii are connected by a thin metal wire. Choose the expression that best describes the relationships among the potentials, charge, and electric fields at the surface of each sphere. The spheres are sufficiently far apart that they do not affect each other's charge distribution.

(a) $V_1 > V_2 > V_3$ and $Q_1 > Q_2 > Q_3$ and $E_1 = E_2 = E_3$
(b) $V_1 = V_2 = V_3$ and $Q_1 < Q_2 < Q_3$ and $E_1 > E_2 > E_3$
(c) $V_1 < V_2 < V_3$ and $Q_1 < Q_2 < Q_3$ and $E_1 < E_2 < E_3$
(d) $V_1 > V_2 > V_3$ and $Q_1 = Q_2 = Q_3$ and $E_1 < E_2 < E_3$
(e) $V_1 = V_2 = V_3$ and $Q_1 = Q_2 = Q_3$ and $E_1 = E_2 = E_3$



6. (8 points) Currents in four wires are shown. What are the magnitude and the direction of the current in the fifth (bottom) wire?

(a) 6 A into the junction
(b) 4 A into the junction
(c) 4 A out of the junction
(d) 2 A out of the junction
(e) 2 A into the junction



7. (8 points) A parallel-plate capacitor is connected to a battery, allowed to charge, then disconnected. Insulating handles are then used to push the plates closer together, until they are only half as far apart as they were originally. How does the energy now stored in the capacitor (with respect to zero in the uncharged state) compare to that stored originally?

(a) The new energy is **half as much** as the original energy.
(b) The new energy is **the same** as the original energy.
(c) The new energy is **twice as much** as the original energy.
(d) The new energy is **four times as much** as the original energy.
(e) The new energy is **one-fourth as much** as the original energy.