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 :

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

Parallel :

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

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

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

$$q = q_{\max}\left(1 - e^{-t/\tau_{\rm C}}\right)$$
$$q = q_0 e^{-t/\tau_{\rm C}}$$
$$I = I_{\max}\left(1 - e^{-t/\tau_{\rm L}}\right)$$
$$I = I_0 e^{-t/\tau_{\rm L}}$$
$$I = \int \vec{J}\cdot d\vec{A}$$
$$\vec{J} = \sigma\vec{E}$$
$$\mathcal{E} = -N\frac{d\Phi_{\rm B}}{dt}$$
$$I_d = \epsilon_0\frac{d\Phi_{\rm E}}{dt}$$
$$\mathcal{E} = -L\frac{dI}{dt}$$
$$c = f\lambda = \frac{|\vec{E}|}{|\vec{B}|}$$
$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$
$$I = \frac{P}{4\pi r^2}$$
$$P_r = \frac{(2)I}{c}$$
$$I_{\rm trans} = I_0\cos^2\theta$$

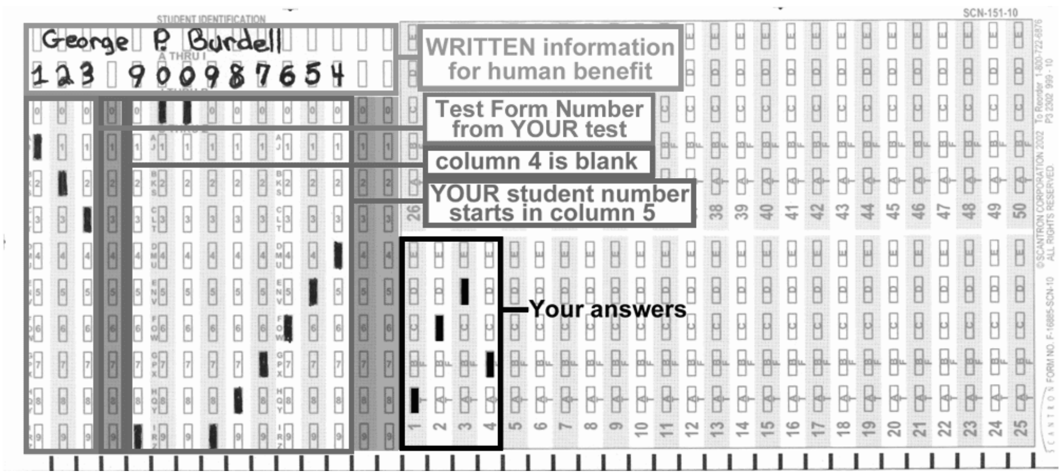
Fundamental Charge $e = 1.602\times10^{-19}\,\mathrm{C}$
Coulomb constant $K = 8.988\times10^{9}\,\mathrm{N{\cdot}m^2/C^2}$
Earth's gravitational field $g = 9.81\,\mathrm{N/kg}$

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

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

Please remove this sheet from your Quiz or Exam

Version: A



YOUR form number is **231**

Recitation Sections

	Howey S-104	Howey S-106	Howey S-107
Wednesday			
1:05 pm		J01 Barrios, Maryrose	
2:05 pm		G01 Barrios, Maryrose	G02 Koh, Daegene
3:05 pm	J02 Naegele, James	G06/J05 Koh, Daegene	
4:05 pm		G08 Koh, Daegene	
5:05 pm	J06 Barrow, Kirk	G03 Koh, Daegene	J09 Barrios, Maryrose
Thursday			
12:05 pm		G04 Barrios, Maryrose	
1:05 pm		J10 Barrios, Maryrose	
2:05 pm	J03/J08 Barrow, Kirk	G09 Barrios, Maryrose	
3:05 pm	G10/J07 Barrow, Kirk		
4:05 pm		J04 Koh, Daegene	
5:05 pm		G05/G07 Koh, Daegene	

Version	Quiz #3 Form #231	Name:________________________
A	Physics 2212 GJ Fall 2015	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 1–10. 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) The electric potential in a certain region of space depends on position according to

$$V(x,y,z) = \left(2.0\,\mathrm{V/m^2}\right)\left(x^2+y^2\right) + (3.0\,\mathrm{V})\sin\left(\frac{z}{4.0\,\mathrm{m}}\right) + 6.0\,\mathrm{V}$$

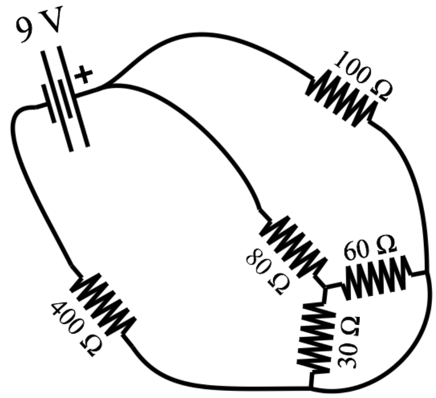
Find an algebraic and/or trigonometric expression for the electric field in that same region of space.

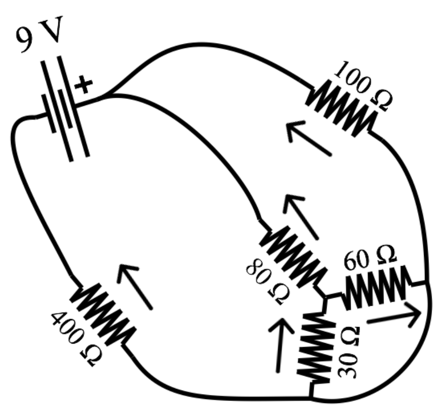
II. (17 points) The starter motor of a car engine draws a current of 220 A from the battery. The copper wire to the motor has a conduction-electron density of 8.5×10^{28} per cubic meter. It is 3.8 mm in diameter and 1.5 m long. The starter motor runs for 1.2 s until the car engine starts. How far does an electron travel along the wire while the starter motor is on?

1. (5 points) If, in the problem above, the 220 A flowed through an iron wire rather than a copper wire, how would the distance traveled by an electron compare? Iron has a conduction-electron density about twice that of copper.

   (a) An electron would travel the same distance in an iron wire as in a copper wire.
   (b) An electron would travel one-fourth as far in an iron wire as in a copper wire.
   (c) An electron would travel four times as far in an iron wire as in a copper wire.
   (d) An electron would travel twice as far in an iron wire as in a copper wire.
   (e) An electron would travel half as far in an iron wire as in a copper wire.

III. (17 points) In the circuit shown, what is the current through the $400\,\Omega$ resistor?



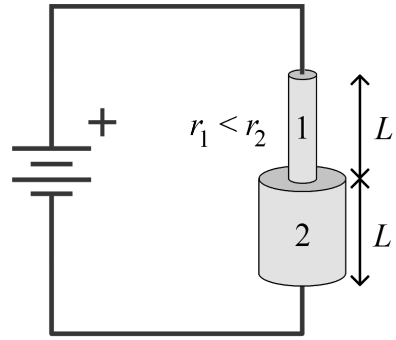


2. (5 points) If positive current directions are defined by the arrows as shown, and current through the $400\,\Omega$ resistor is I_{400}, *etc.*, which equation is a valid expression of Kirchhoff's Loop Law?

   (a) $+9\,\mathrm{V} + I_{100}\,(100\,\Omega) + I_{60}\,(60\,\Omega) + I_{30}\,(30\,\Omega) - I_{400}\,(400\,\Omega) = 0$
   (b) $+9\,\mathrm{V} + I_{100}\,(100\,\Omega) + I_{60}\,(60\,\Omega) - I_{80}\,(80\,\Omega) = 0$
   (c) $+9\,\mathrm{V} - I_{30}\,(30\,\Omega) - I_{60}\,(60\,\Omega) - I_{80}\,(80\,\Omega) - I_{100}\,(100\,\Omega) - I_{400}\,(400\,\Omega) = 0$
   (d) $+9\,\mathrm{V} + I_{80}\,(80\,\Omega) - I_{30}\,(30\,\Omega) + I_{400}\,(400\,\Omega) = 0$
   (e) $+9\,\mathrm{V} + I_{80}\,(80\,\Omega) + I_{30}\,(30\,\Omega) - I_{100}\,(100\,\Omega) = 0$

3. (5 points) Two cylindrical conductors of equal length L are connected to a battery, as shown. The conductors are made of the same material, but have different radii. Which conductor, if either, dissipates more power?

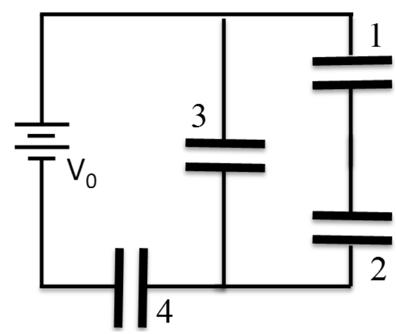
(a) The two conductors dissipate the same power.
(b) Conductor 1 dissipates more power if $L > (r_1 + r_2)/2$, otherwise conductor 2 dissipates more power.
(c) Conductor 2 dissipates more power if $L > (r_1 + r_2)/2$, otherwise conductor 1 dissipates more power.
(d) Conductor 2.
(e) Conductor 1.



4. (5 points) In the circuit shown, the four capacitors are identical: each capacitor has the same capacitance; furthermore, each capacitor has the same rating for the maximum potential that it can withstand without suffering dielectric breakdown (i.e, without "shorting out" across the gap, permanently ruining the capacitor).

Suppose the applied potential difference V_0 is gradually increased from zero until one of the capacitors finally breaks down. Which capacitor is it?

(a) Capacitor 4
(b) Capacitors 1 and 2 break down first, and at the same time
(c) Capacitor 1
(d) Capacitor 3
(e) Capacitor 2



5. (5 points) An air-gap parallel-plate capacitor with capacitance C_0 is brought to a charge Q_0 by attaching it to a battery with emf $\mathcal{E}$. The battery is then detached. With the battery still detached, a slab of dielectric with dielectric constant κ is inserted between the capacitor plates, completely filling the air gap. What are the charge Q on the capacitor, and the potential difference ΔV across it, after the dielectric is inserted?

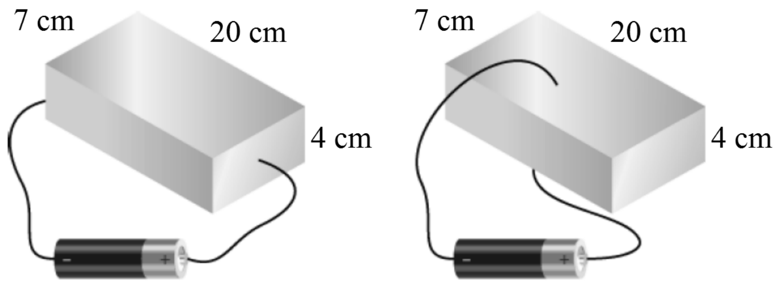
(a) $Q = \kappa Q_0$ and $\Delta V = \mathcal{E}/\kappa$
(b) $Q = Q_0$ and $\Delta V = \mathcal{E}/\kappa$
(c) $Q = Q_0$ and $\Delta V = \kappa\mathcal{E}$
(d) $Q = \kappa Q_0$ and $\Delta V = \mathcal{E}$
(e) $Q = \kappa Q_0$ and $\Delta V = \kappa\mathcal{E}$

6. (5 points) An air-gap parallel-plate capacitor with capacitance C_0 is brought to a charge Q_0 by attaching it to a battery with emf $\mathcal{E}$. With the battery still attached, a slab of dielectric with dielectric constant κ is inserted between the capacitor plates, completely filling the air gap. What are the charge Q on the capacitor, and the potential difference ΔV across it, after the dielectric is inserted?

(a) $Q = \kappa Q_0$ and $\Delta V = \kappa\mathcal{E}$
(b) $Q = Q_0$ and $\Delta V = \kappa\mathcal{E}$
(c) $Q = \kappa Q_0$ and $\Delta V = \mathcal{E}/\kappa$
(d) $Q = Q_0$ and $\Delta V = \mathcal{E}/\kappa$
(e) $Q = \kappa Q_0$ and $\Delta V = \mathcal{E}$

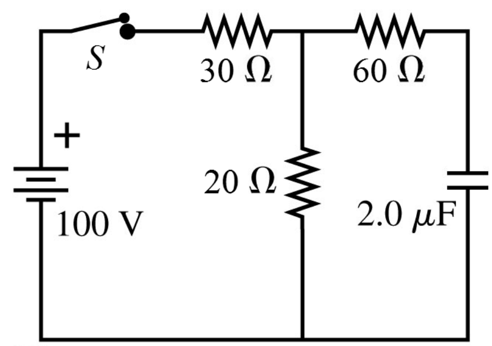
7. (5 points) When a 6 V battery is connected across a solid conducting slab as shown on the left diagram, a current of 3.0 A flows through the circuit. What is the current if instead the battery is connected as shown on the right diagram?

(a) 8.6 A
(b) 3.0 A
(c) 15 A
(d) 1.1 A
(e) 75 A

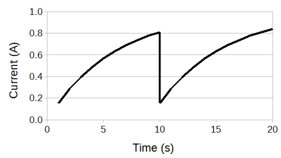


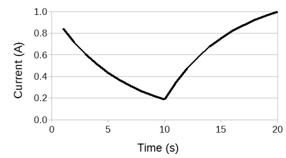
8. (5 points) The switch S has been closed for a long time. Immediately upon opening the switch, what is the current through the 20 Ω resistor?

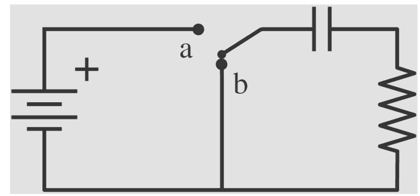
(a) 0.80 A
(b) 1.25 A
(c) 0.50 A
(d) 2.67 A
(e) 2.00 A

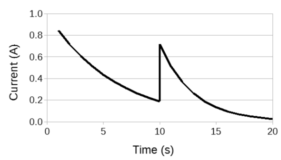


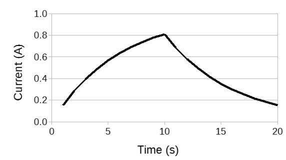
9. (5 points) The capacitor is initially uncharged. The switch is thrown to position a at time $t = 0$, and then to b at time $t = 10\,\text{s}$. Which graph could represent the magnitude of the current through the resistor as a function of time?

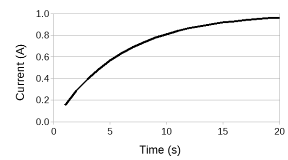
(a) 

(b) 

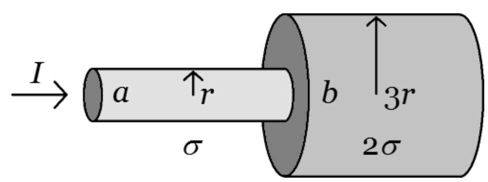


(c) 

(d) 

(e) 

10. (5 points) A current I flows to the right through a cylindrical wire made of two segments, as shown. First, it flows through segment a, with radius r and conductivity σ. It continues on to flow through segment b, with radius $3r$ and conductivity 2σ. What is the ratio of the electric field magnitude in segment a to that in segment b?



(a) $E_a/E_b = 3/2$
(b) $E_a/E_b = 9/2$
(c) $E_a/E_b = 2/3$
(d) $E_a/E_b = 6$
(e) $E_a/E_b = 18$