

$$k = \frac{1}{4\pi\epsilon_0}$$

$$\Delta V = - \int \vec{E} \cdot d\vec{s}$$

$$V = k \frac{q}{r}$$

$$\Delta U = q \Delta V$$

$$I = dq/dt$$

$$P = I \Delta V$$

$$R = \frac{\Delta V}{I}$$

Series :

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

$$R_{\text{eq}} = \sum R_i$$

Parallel :

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

$$C_{\text{eq}} = \sum C_i$$

$$\vec{E} = k \frac{q}{r^2} \hat{r}$$

$$\vec{F} = k \frac{q_1 q_2}{r^2} \hat{r}$$

$$\vec{F} = q \vec{E}$$

$$\vec{p} = q \vec{d}$$

$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$U = -\vec{p} \cdot \vec{E}$$

$$|\vec{E}| \propto \frac{|\vec{p}|}{r^3}$$

$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

$$\epsilon_0 \oint \vec{E} \cdot d\vec{A} = q_{\text{enclosed}}$$

$$\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_E}{dt}$$

$$C = \frac{Q}{\Delta V}$$

$$C = \epsilon_0 \frac{A}{d}$$

$$U = \frac{1}{2} C [\Delta V]^2$$

$$R = \rho \frac{\ell}{A}$$

$$\tau_C = RC$$

$$u_E = \frac{1}{2} \epsilon_0 E^2$$

$$\vec{B} = \frac{\mu_0 q}{4\pi} \frac{\vec{v} \times \hat{r}}{r^2}$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{\ell} \times \hat{r}}{r^2}$$

$$\vec{F} = q \vec{v} \times \vec{B}$$

$$\vec{F} = I \vec{\ell} \times \vec{B}$$

$$\vec{\mu} = NI \vec{A}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$U = -\vec{\mu} \cdot \vec{B}$$

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\oint \vec{B} \cdot d\vec{A} = 0$$

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 (I_c + I_d)$$

$$L = \frac{\Phi_B}{I}$$

$$L = \mu_0 N^2 \frac{A}{\ell}$$

$$U = \frac{1}{2} LI^2$$

$$B = \mu_0 n I$$

$$\tau_L = L/R$$

$$u_B = \frac{1}{2\mu_0} B^2$$

$$q = q_{\text{max}} \left(1 - e^{-t/\tau_c} \right)$$

$$q = q_0 e^{-t/\tau_c}$$

$$I = I_{\text{max}} \left(1 - e^{-t/\tau_L} \right)$$

$$I = I_0 e^{-t/\tau_L}$$

$$I = \int \vec{J} \cdot d\vec{A}$$

$$\vec{J} = \sigma \vec{E}$$

$$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

$$\mathcal{E} = -L \frac{dI}{dt}$$

$$c = f\lambda = \frac{|\vec{E}|}{|\vec{B}|}$$

$$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

Fundamental Charge $e = 1.602 \times 10^{-19} \text{ C}$

Earth's gravitational field $g = 9.81 \text{ N/kg}$

Coulomb constant $K = 8.988 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$

Mass of an Electron $m_e = 9.109 \times 10^{-31} \text{ kg}$

Mass of a Proton $m_p = 1.673 \times 10^{-27} \text{ kg}$

Vacuum Permittivity $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$

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.

STUDENT IDENTIFICATION

George P. Burdell

123 900987654

WRITTEN information for human benefit

Test Form Number from YOUR test

column 4 is blank

YOUR student number starts in column 5

26

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

—Your answers

SCN-151-10

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YOUR form number is **231**

Recitation Sections

	Clough 123	Clough 127	Clough 131	Clough 325	Clough 423
WEDNESDAY					
1:05 pm				G01 Chang, Patrick Note: Meets in 323	
2:05 pm					G06/H01 Daum, Marcus
3:05 pm			G05/H05 Daum, Marcus		
4:05 pm		G02 Daum, Marcus		H02 Chang, Patrick	
5:05 pm	G09 Chang, Patrick	H06/H09 Daum, Marcus			
THURSDAY					
12:05 pm		H07 Daum, Marcus			
1:05 pm					
2:05 pm					
3:05 pm			G03 Daum, Marcus	G07 Chang, Patrick	H03 Tao, Liangyu
4:05 pm				G04 Chang, Patrick	
5:05 pm		G08 Tao, Liangyu		H04/H08 Chang, Patrick	

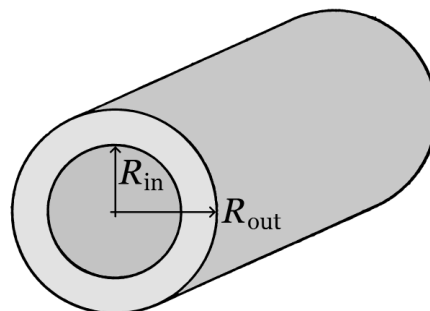
A

- 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.

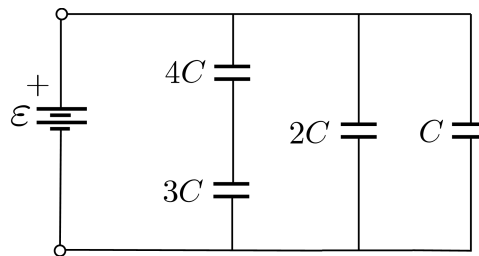
I. (18 points) A hollow conducting wire has inner radius R_{in} and outer radius R_{out} . Between those radii, it has a non-uniform current density $\vec{J}$, whose magnitude depends on distance r from the central axis according to

$$J = J_0 \left(\frac{R_{\text{out}}}{r} \right)^2$$

where J_0 is a positive constant. What is the current carried by the wire, in terms of parameters defined in the problem, and physical or mathematical constants?



II. (16 points) The network of capacitors shown is connected to a battery of emf $\mathcal{E} = 24\text{ V}$ where $C = 6.0\text{ nF}$. Calculate the potential energy U_0 stored in the network of capacitors once equilibrium is reached, relative to zero in the uncharged state.



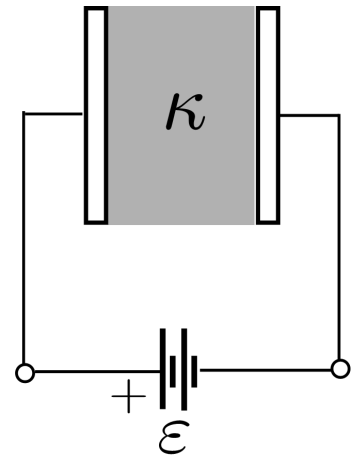
1. (5 points) The emf of the battery is increased to $\mathcal{E} = 48\text{ V}$. How much potential energy U is now stored in the network of capacitors?
- (a) $U = 2U_0$
 - (b) $U = 8U_0$
 - (c) $U = U_0/4$
 - (d) $U = U_0/2$
 - (e) $U = 4U_0$

-
2. (5 points) A capacitor contains a dielectric material of dielectric constant $\kappa = 3.4$. The capacitance of the capacitor is $C = 12\ \mu\text{F}$ when the dielectric material is inside. The capacitor is connected to a battery of emf $\mathcal{E} = 10.0\ \text{V}$. The battery remains connected to the capacitor and the dielectric is removed from the capacitor.

What, if anything, remains constant as the dielectric is removed?

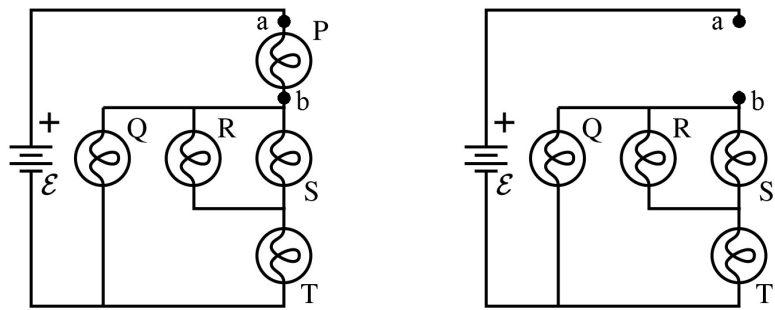
- (a) The charge on the capacitor.
- (b) The capacitance of the capacitor.
- (c) The potential difference across the capacitor.
- (d) The potential energy stored in the capacitor.
- (e) Nothing remains constant.

- III. (16 points) Calculate the work required for agents external to the capacitor to remove the dielectric at constant speed.



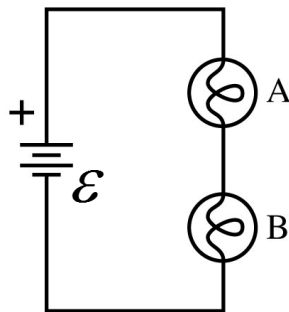
3. (5 points) When the five identical bulbs P , Q , R , S , and T are attached to emf $\mathcal{E}$ as shown on the left, all five light up. If bulb P is removed, as shown on the right, what is the potential difference **from** point “a” **to** point “b”?

- (a) $-5\mathcal{E}/8$
- (b) $+5\mathcal{E}/8$
- (c) Zero
- (d) $-\mathcal{E}$
- (e) $+\mathcal{E}$



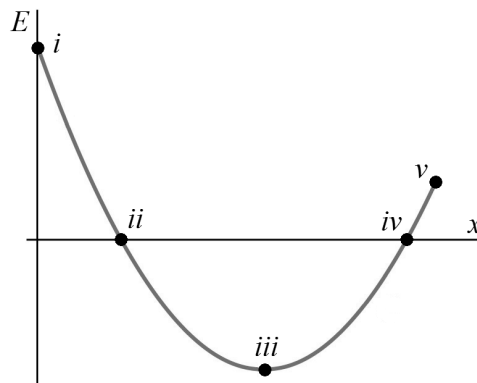
4. (5 points) Bulbs “A” and “B” are ordinary 120 V household bulbs. Bulb “A” is rated at 150 W, and bulb “B” is rated at 60 W. They are connected to a 120 V emf $\mathcal{E}$ as shown. Which bulb, if either, is brighter? Which bulb will be brighter if the position of the bulbs is swapped?

- (a) Bulb “B” is brighter, but bulb “A” will be brighter if the positions are swapped.
- (b) Bulb “A” is brighter, and will still be brighter if the positions are swapped.
- (c) The bulbs have equal brightness, and will remain so even if the positions are swapped.
- (d) Bulb “B” is brighter, and will still be brighter if the positions are swapped.
- (e) Bulb “A” is brighter, but bulb “B” will be brighter if the positions are swapped.



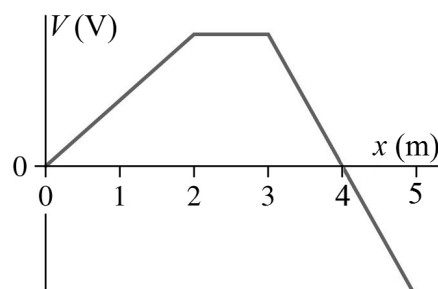
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5. (5 points) The graph shows the value of a one-dimensional electric field $\vec{E}$ as a function of position x . At which point in this range is the electric potential greatest?

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



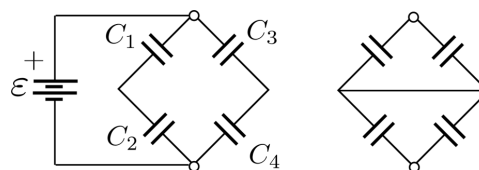
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6. (5 points) The graph shows the electric potential V as a function of position x . In which region of this range will the most negative electric field be found (that is, the negative electric field with the greatest magnitude)?

- (a) Somewhere between 2 and 3 meters.
- (b) Somewhere between 4 and 5 meters.
- (c) Somewhere between 0 and 2 meters.
- (d) Somewhere between 3 and 4 meters.
- (e) Somewhere between 3 and 5 meters.



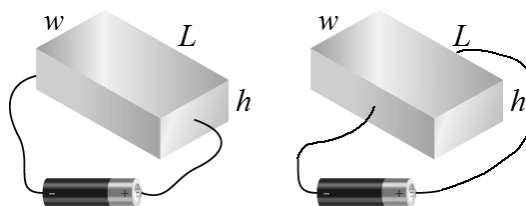
7. (5 points) The capacitor network below is connected to a battery and charged to a positive potential energy U_0 . The network is then disconnected from the battery and a wire is connected as shown. How does the potential energy U of the network change after the wire is connected? *Note:* The capacitors are all different. Define the potential energy of a capacitor to be zero when it is uncharged.

- (a) The potential energy remains unchanged.
- (b) The potential energy decreases, but remains positive.
- (c) The potential energy increases.
- (d) The potential energy decreases to zero.
- (e) The potential energy decreases, and becomes negative.



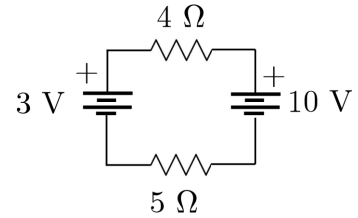
8. (5 points) A uniform rectangular conducting block has width $w = 3.0$ cm, length $L = 6.0$ cm, and height $h = 1.2$ cm. When a 4.5 V battery is connected across the ends (faces of area $w \times h$, as shown on the left), a 16 mA current flows. What current flows when the same battery is connected across the front and back (faces of area $L \times h$, as shown on the right)?

- (a) 6.4 mA
- (b) 400 mA
- (c) 4.0 mA
- (d) 100 mA
- (e) 64 mA



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9. (5 points) What is the magnitude and the direction of the current in the circuit?

- (a) $I = 3.15 \text{ A}$ counterclockwise.
- (b) $I = 0.78 \text{ A}$ clockwise.
- (c) $I = 1.44 \text{ A}$ counterclockwise.
- (d) $I = 0.78 \text{ A}$ counterclockwise.
- (e) $I = 1.44 \text{ A}$ clockwise.



-
10. (5 points) Current flows through a 2.5 mm diameter gold wire, then into an iron wire, as shown. Considering that the conductivity of gold is $4.0 \times 10^7 \Omega^{-1}\text{m}^{-1}$ and that of iron is $1.0 \times 10^7 \Omega^{-1}\text{m}^{-1}$, what diameter must the iron wire have, if the electric field magnitude in the iron wire is to be the same as that in the gold wire? *Note:* Although the iron wire has been pictured greater in diameter than the gold wire, no conclusion should be drawn from that.

- (a) 0.50 mm
- (b) 0.25 mm
- (c) 5.0 mm
- (d) 2.5 mm
- (e) 10.0 mm

