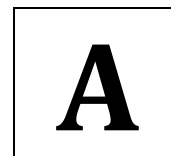


Test 4

Recitation Section (see back of test): _____

- 1) Print your name, test form number (above), and nine-digit student number in the section of the answer card labeled "STUDENT IDENTIFICATION".
- 2) Bubble your test form number (**ABOVE**) in columns 1-3, skip column 4, then bubble in your student number in columns 5-13.
- 3) For each free-response question, show all relevant work supporting your answer. **Clearly box or underline your final answer.** "Correct" answers which are not supported by adequate calculations and/or reasoning will be counted wrong.
- 4) For each multiple-choice question, select the answer most nearly correct, **circle this answer on your test**, and bubble it in on your answer card. **Show all relevant work on your quiz.**
- 5) Be prepared to present your Buzzcard as you turn in your test. Scores will be posted to T-Square after they have been graded. **Quiz grades become final when the next quiz is given.**
- 6) You may use a simple scientific calculator capable of logarithms, exponentials, and trigonometric functions. **Programmable engineering calculators with text or graphical capabilities are not allowed. Wireless devices are prohibited.**



Numerical Constants:

$$k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$$

$$m_o = 4\pi \times 10^{-7} \text{ T}\cdot\text{m}/\text{A}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

Your test form is: **742**

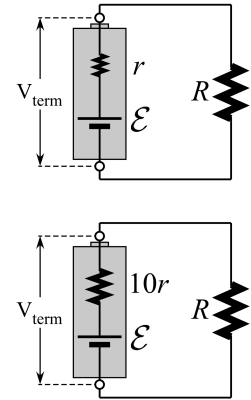
**Our final exam will be on Monday, May 1
from 6:00 pm to 8:50 pm**

The following problem will be hand-graded. Show all your work for this problem. Make no marks and leave no space on your answer card for it.

- [1] (20 points) All real batteries have an internal resistance in addition to their emf. Consider a fresh battery with emf \mathcal{E} and (small) internal resistance r . When the fresh battery is hooked up to a load resistance R , it is observed to have a *reduced* “terminal potential”, $\Delta V_{\text{term}} = \frac{9}{10} \mathcal{E}$.

Suppose that a used battery—with the same emf but internal resistance $10r$ —is hooked up to the same load resistance R . What will be the terminal potential across the used battery in that situation? Express your answer as a fraction of \mathcal{E} .

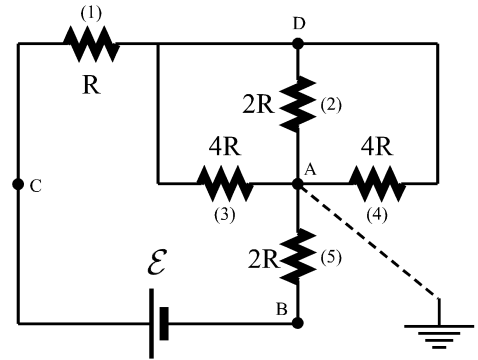
Hint: start by finding the internal resistance r of the fresh battery, as a fraction of R .



The following problem will be hand-graded. Show all your work for this problem. Make no marks and leave no space on your answer card for it.

[III] (20 points) In the circuit diagram at right, R represents an unspecified resistance, and each of the five labeled resistors, (1)—(5), has a resistance that is an integer multiple of R . The network is hooked up to an ideal battery having emf \mathcal{E} .

- (i) Determine the currents—magnitude AND direction through each of the resistors. Express each answer in terms of \mathcal{E} and R .



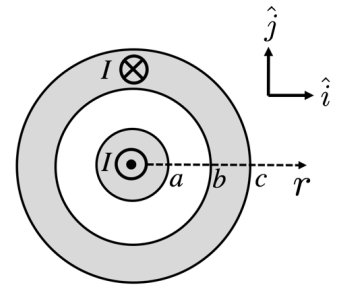
Extra Credit: 4 points

- (ii) If the circuit is grounded at position A , determine the voltages at positions B , C , and D . Express each answer as a multiple or fraction of \mathcal{E} . *Be sure to include the proper sign!*

The following problem will be hand-graded. Show all your work for this problem. Make no marks and leave no space on your answer card for it.

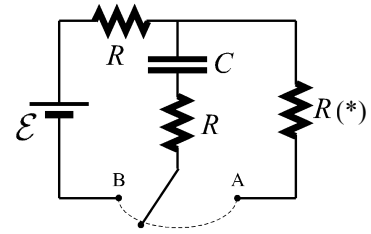
- [III] (20 points) A coaxial cable consists of a conducting wire of radius $a = R$ and an outer conducting shell, having inner radius $b = 2R$ and outer radius $c = 3R$. The space between the wire and the shell ($a < r < b$) is empty. The central wire carries a total current I in the $+\hat{k}$ direction (i.e. out of the page). The outer shell carries the same current I in the opposite direction, $-\hat{k}$ (i.e. into the page).

Use Ampere's Law to determine the magnetic field at a distance $r = 5R/2$ from the central axis of the cable. Be sure to specify the direction of the field, as well as the magnitude.



The next two questions involve the following situation:

A two-mode RC circuit is illustrated at right. A switch allows the circuit to be toggled back and forth between the two modes of operation. All resistances are identical, and all wires are ideal.



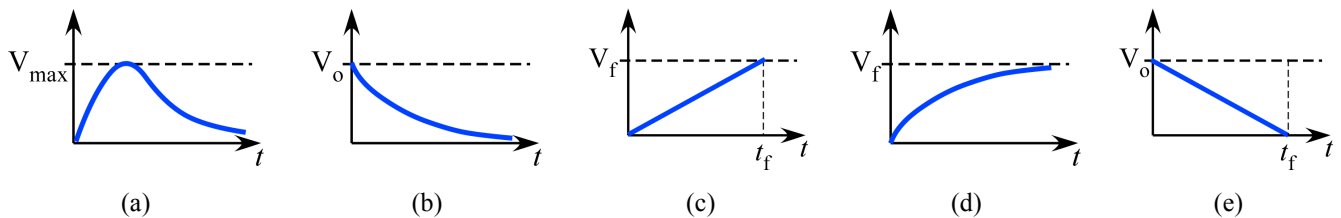
Question value 4 points

- (1) Assume the switch has been at position *B* for a very long time. It is then suddenly flipped over to position *A*. Which of the expressions below describes the initial rate at which charge on the capacitor is changing, immediately after the switch is flipped? Assume that Q_0 denotes the charge on the capacitor immediately *before* the switch is flipped.

- (a) $\frac{dQ}{dt} = -\frac{Q_0}{2R}$
 (b) $\frac{dQ}{dt} = +\frac{\varepsilon}{R}$
 (c) $\frac{dQ}{dt} = 0$
 (d) $\frac{dQ}{dt} = +\frac{Q_0}{2RC}$
 (e) $\frac{dQ}{dt} = +\frac{\varepsilon}{2R}$

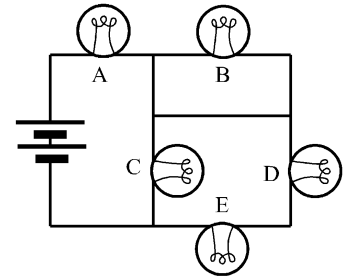
Question value 4 points

- (2) Assume the switch has been at position *B* for a very long time. It is then suddenly flipped over to position *A*. Which one of the graphs below best depicts the potential difference across the right-hand resistor (*) as a function of time?



Question value 8 points

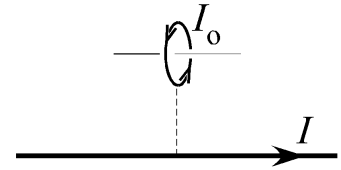
- (3) In the circuit diagrammed at right, all bulbs are identical and all wires are ideal. Rank, from greatest to least, the brightnesses of bulbs A through E



- (a) $A = C > B = D = E$
 (b) $A = B > C = D > E$
 (c) $A > C > D = E > B$
 (d) $A > C = D > E > B$
 (e) $A > B > D = E > C$

Question value 8 points

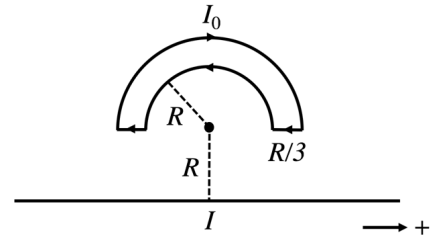
- (4) A small circular wire loop carrying current I_0 is placed near a very long straight wire, in the orientation shown at right. The long wire carries a *rightward* current I . If the loop is released and allowed to move freely, how will it move? You may assume that the size of the loop is small in comparison to the distance from loop to wire. (Ignore gravity.)



- (a) The loop will rotate around the negative y -axis.
 (b) The loop will move in a straight line, away from the wire (i.e. the in the positive y -direction).
 (c) The loop will rotate around the negative z -axis.
 (d) The loop will not move.
 (e) The loop will move in a straight line, toward the wire (i.e. in the negative y -direction).

Question value 8 points

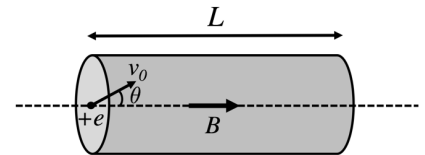
- (5) A wire is bent into a half-annulus, having inner radius R and outer radius $4R/3$. It carries a current I_0 in the indicated direction around its perimeter. A very long straight wire, carrying an unknown current I is placed at distance R from the center of curvature of the annulus. If the net magnetic field at the center of curvature is *zero*, what is the magnitude and direction of the current in the straight wire? (Note the sign convention for I , shown in the figure!).



- (a) $I = +\frac{\pi}{4}I_0$
 (b) $I = 0$
 (c) $I = -\frac{\pi}{8}I_0$
 (d) $I = +\frac{\pi}{8}I_0$
 (e) $I = -\frac{\pi}{4}I_0$

The next two questions involve the following situation:

A solenoid has radius R and length L along its axis, with a uniform magnetic field B within its interior. A proton (mass m , charge $+e$) is fired into the solenoid with an initial speed v_0 , traveling at an angle θ relative to the solenoid axis. (Assume that θ is small enough that the proton never strikes the solenoid walls.)



Question value 4 points

- (6) What type of path does the proton follow, as it passes through the solenoid?
- (a) A sinusoidal up-and-down trajectory as it moves from left to right.
 (b) A symmetric parabola that enters and exits exactly on the solenoid axis.
 (c) A clockwise helix, when viewed from behind (i.e. from the left).
 (d) A counter-clockwise helix, when viewed from behind (i.e. from the left).
 (e) A circular orbit that never allows it to leave the solenoid.

Question value 4 points

- (7) How much time does the proton spend within the solenoid?
- (a) $\Delta t = 2\pi R/v_0$
 (b) $\Delta t \rightarrow \infty$; the proton never escapes from the solenoid.
 (c) $\Delta t = L/v_0 \sin \theta$
 (d) $\Delta t = L/v_0$
 (e) $\Delta t = L/v_0 \cos \theta$

PHYS 2212 G/J Recitation TA and Room Assignments

	Clough 127	Clough 131	Clough 323
WEDNESDAY			
1:05 pm		G01 Zhou, Boli	
2:05 pm	G06/H01 Zhou, Boli		
3:05 pm	G05/H05 Daum, Marcus		
4:05 pm	G02 Daum, Marcus	H02 Zhou, Boli	
5:05 pm	G09/H06/H09 Daum, Marcus		
THURSDAY			
12:05 pm			H07 Zhou, Boli
1:05 pm			
2:05 pm			
3:05 pm		G07/H03 Daum, Marcus	G03 Zhou, Boli
4:05 pm		G04 Daum, Marcus	
5:05 pm		G08/H04/H08 Daum, Marcus	

Tests will be returned in recitation, in the week *after* the test. In order to ensure that you receive your test back as soon as possible, please enter your recitation section from the table above (G01–G10) on the front of this test.