Physics 208, Spring 2016 – Exam #2

A

Name (Last, First): ________________________________

ID #: __________________

Section #: _________________

- You have 75 minutes to complete the exam.
- Formulae are provided on an attached sheet. You may NOT use any other formula sheet.
- You may use only a simple calculator: one without memory, or with a memory demonstrated to be cleared.
- When calculating numerical values, be sure to keep track of units. Results must include proper units.
- Be alert to the number of significant figures in the information given. Results must have the correct number of significant figures.
- If you are unable to solve a problem whose solution is needed in another problem, then assign a symbol for the solution of the first problem and use that symbol in solving the second problem.
- If you need additional space to answer a problem, use the back of the sheet it is written on.
- Show your work. Without supporting work, the answer alone is worth nothing.
- Mark your answers clearly by drawing boxes around them.
- Please write clearly. You may gain marks for a partially correct calculation if your work can be deciphered.

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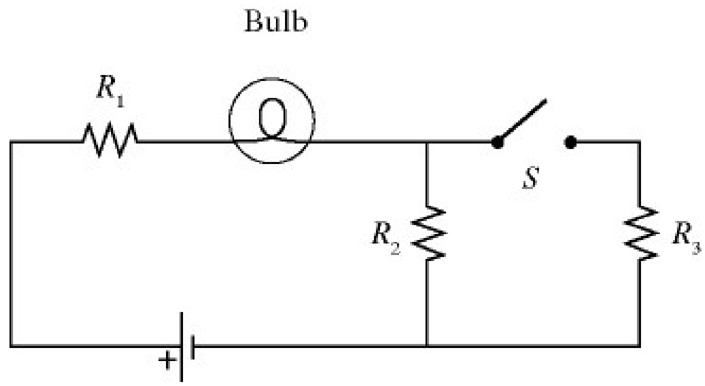
208 Mid-Term 2 POINTS TABLE	
Multiple Choice (out of 20)	
Problem 1 (out of 20)	
Problem 2 (out of 20)	
Problem 3 (out of 20)	
Problem 4 (out of 20)	
TOTAL SCORE (out of 100)	

MC1. (5 marks) A light bulb is connected in the circuit shown in the figure with the switch S open. All the connecting leads have no appreciable resistance and the battery has no internal resistance. When we close the switch, which statements below accurately describe the behavior of the circuit? (There may be more than one correct choice.)



A) The potential drop across R_2 will not change.

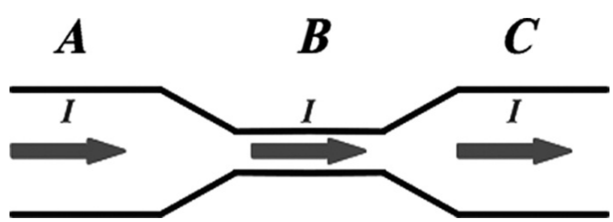
B) The potential drop across R_2 will decrease.

C) The brightness of the bulb will decrease.

D) The brightness of the bulb will increase.

E) The brightness of the bulb will not change.

MC2. (5 marks) The figure shows a steady electric current passing through a wire with a narrow region. What happens to the drift velocity of the moving charges as they go from region A to region B and then to region C?



A) The drift velocity increases from A to B and decreases from B to C.

B) The drift velocity decreases all the time.

C) The drift velocity remains constant.

D) The drift velocity increases all the time.

E) The drift velocity decreases from A to B and increases from B to C.

MC3. (5 marks) Three incandescent light bulbs are connected in series as shown in the figure. All of the bulbs can operate up to a maximum potential difference of 120 V across them. Their maximum power ratings are however different; one bulb can output a maximum power of 60W, another 120 W, and the third 240 W. If the potential difference between points ***a*** and ***b*** is 120 V, which bulb glows the brightest?

A) The 120-V, 60-W light bulb glows the brightest.

B) The 120-V, 120-W light bulb glows the brightest.

C) The 120-V, 240-W light bulb glows the brightest.

D) All three light bulbs glow with equal brightness.

MC4. (5 marks) Two capacitors, C_1 and C_2, are connected in series across a source of potential difference. With the potential source still connected, a dielectric is now inserted between the plates of capacitor C_1. What happens to the charge on capacitor C_2?

A) The charge on C_2 increases.

B) The charge on C_2 decreases.

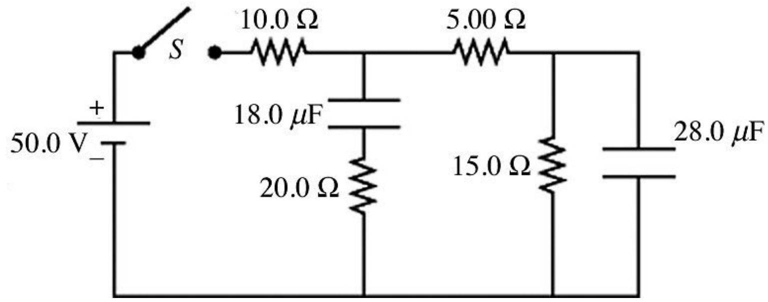
C) The charge on C_2 remains the same.

1. **(20 marks)** Two capacitors C_1 = 4 μF and C_2 = 12 μF are connected in series across a 12-V battery. They are carefully disconnected so that they are not discharged and are reconnected with positive plate to positive plate and negative plate to negative plate.

   a) Find the potential difference across each capacitor after they are reconnected.

   b) Find the initial and final energies stored in each of the two capacitors, *i.e.* before they are disconnected and after they are reconnected.

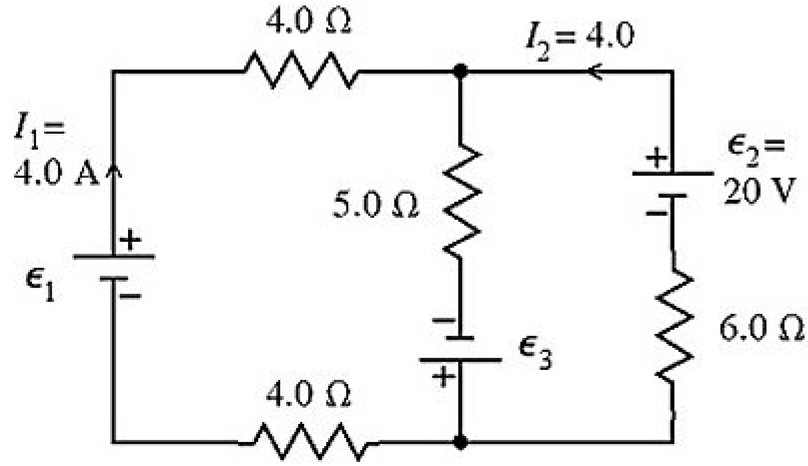
2. (20 marks) For the circuit shown in the figure, the capacitors are all initially uncharged, the connecting leads have no resistance, the battery has no appreciable internal resistance, and the switch *S* is originally open.



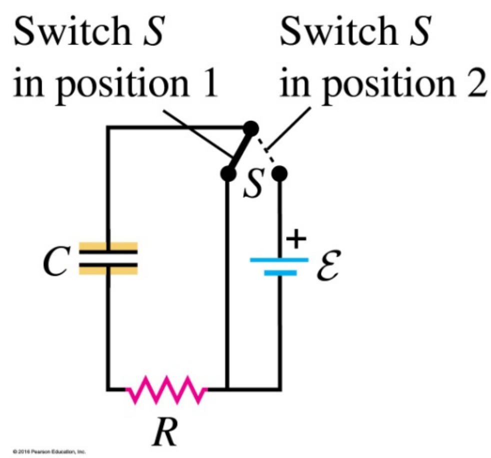
a) Just after closing the switch *S*, what is the current in the 15.0-Ω resistor?

b) After the switch *S* has been closed for a very long time, what is the potential difference across the 28.0-μF capacitor?

3. (20 marks) Consider the circuit shown in the figure. Note that two currents are shown. Calculate the emfs ε_1 and ε_3.



4. **(20 marks)** In the circuit shown, C = 11.8 μF, $\mathcal{E}$ = 56.0 V, and the emf has negligible resistance. Initially, the capacitor is uncharged, and the switch S is in position 1. The switch is then moved to position 2, so that the capacitor begins to charge.



a) What will be the charge on the capacitor a long time after S is moved to position 2?

b) After S has been in position 2 for 1.50 ms, the charge on the capacitor is measured to be 110 μC. What is the value of the resistance R?

c) How long after S is moved to position 2 will the charge on the capacitor be equal to 99.0% of the final value found in part (a)?

PHYSICS 208 EXAM II: Spring 2016
Formula/Information Sheet

- Basic constants:

Gravitational acceleration	g	$=$	9.8 m/sec^2
Permittivity of free space	ϵ_0	$=$	8.8542×10^{-12} C^2/N·m^2 [$k = 1/4\pi\epsilon_0 = 8.9875 \times 10^9$ N·m^2/C^2]
Permeability of free space	μ_0	$=$	$4\pi \times 10^{-7}$ T·m/A [$k_m = \mu_0/4\pi = 10^{-7}$ Wb/A·m]
Elementary charge	e	$=$	1.60×10^{-19} C
Unit of energy: electron volt	1 eV	$=$	1.60×10^{-19} J
Unit of energy: kilowatt-hour	1 kWh	$=$	3.6×10^6 J

- Properties of some particles:

Particle	Mass [kg]	Charge [C]
Proton	1.67×10^{-27}	$+1.60 \times 10^{-19}$
Electron	9.11×10^{-31}	-1.60×10^{-19}
Neutron	1.67×10^{-27}	0

- Some indefinite integrals:

$$\int \frac{dx}{x} = \ln x \qquad \int e^{ax} = \frac{e^{ax}}{a}$$

$$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2+a^2}} \qquad \int \frac{x\,dx}{(x^2+a^2)^{3/2}} = -\frac{1}{\sqrt{x^2+a^2}}$$

$$\int x^n dx = \frac{x^{n+1}}{n+1} \qquad \int \frac{x\,dx}{\sqrt{x^2 \pm a^2}} = \sqrt{x^2 \pm a^2}$$

Coulomb's law: $|\vec{F}| = k\,\dfrac{|q_1||q_2|}{r^2}$

Electric field [N/C = V/m] (point charge q): $\vec{E}(r) = k\,\dfrac{q}{r^2}\,\hat{r}$

($\hat{r}$ = unit vector radially from q)

(group of charges): $\vec{E} = \sum \vec{E}_i = k \sum \dfrac{q_i}{r_i^2}\,\hat{r}_i$

(continuous charge distribution): $\vec{E} = k \displaystyle\int \dfrac{dq}{r^2}\,\hat{r}$

($\hat{r}$ = unit vector radially from dq)

Electric force [N] (on q in $\vec{E}$): $\vec{F} = q\,\vec{E}$

Torque [N·m]: $\vec{\tau} = \vec{r} \times \vec{F}$

Electric flux (through a small area ΔA_i): $\Delta\Phi_i = \vec{E}_i \cdot \Delta\vec{A}_i = E_i\,\Delta A_i\,\cos\theta_i$

(through an entire surface area): $\Phi_{surface} = \displaystyle\lim_{\Delta A \to 0} \sum \Delta\Phi_i = \int \vec{E} \cdot d\vec{A}$

Gauss' law (through a closed surface area): $\Phi_{closed} \equiv \displaystyle\oint \vec{E} \cdot d\vec{A} = \dfrac{Q_{in}}{\epsilon_0}$

Electric potential [V = J/C] (definition): $V_A - V_B = \displaystyle\int_A^B \vec{E} \cdot d\vec{s}$

(point charge q): $V(r) = k\,\dfrac{q}{r}$ (with $V(\infty) = 0$)

(group of charges): $V(\vec{r}) = \sum V_i(|\vec{r}_i - \vec{r}|) = k \sum \dfrac{q_i}{|\vec{r}_i - \vec{r}|}$

($V_i(\infty) = 0$)

(continuous charge distribution): $V(\vec{r}) = k \displaystyle\int \dfrac{dq}{|\vec{r}\,' - \vec{r}|}$

($V(\infty) = 0$)

Electric potential energy [J] (definition): $U_A - U_B = q_0 \displaystyle\int_A^B \vec{E} \cdot d\vec{s} = q_0\,(V_A - V_B)$

$\vec{E}$ from V: $\vec{E} = -\vec{\nabla} V$ ($\vec{\nabla}$ = gradient operator)

$E_r = -\dfrac{\partial V}{\partial r}$

Electric potential energy of two-charge system: $U_{12} = k\,\dfrac{q_1 q_2}{r_{12}}$

Capacitance [F]	(definition)	C	$\equiv$	$\dfrac{Q}{\lvert\Delta V\rvert}$
	(parallel-plate capacitance)	C	$=$	$\kappa \dfrac{\epsilon_0 A}{d}$
Capacitors in series		$\frac{1}{C_{eq}}$	$=$	$\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$
Capacitors in parallel		C_{eq}	$=$	$C_1 + C_2 + C_3 + ...$
Electrostatic potential energy [J] stored in capacitance		$U_E(t)$	$=$	$\frac{1}{2}\, Q(t)^2/C$
Electric energy density [J/m^3] in a vacuum		u	$=$	$\frac{1}{2}\epsilon_0 E^2$
Electric dipole moment ($2a$ = separation between two charges)		$\lvert\vec{p}\rvert$	$=$	$2aq$
Torque on electric dipole moment		$\vec{\tau}$	$=$	$\vec{p} \times \vec{E}$
Potential energy of an electric dipole moment		U	$=$	$-\vec{p} \cdot \vec{E}$

Current [A]	(definition)	I	$\equiv$	$\frac{d\,Q(t)}{d\,t}$
	with motion of charges	I	$=$	$nqv_d A$
Current density [A/m^2]		J	$=$	$\frac{I}{A}$ (where $I = \int \vec{J} \cdot \vec{n}\, dA$)
Resistivity [Ω·m]		ρ	$=$	$\frac{\lvert\vec{E}\rvert}{\lvert\vec{J}\rvert}$
Resistance [Ω]	(definition)	R	$\equiv$	$\frac{V}{I}$
	for uniform cross-sectional area A	R	$=$	$\rho \frac{\ell}{A}$
Resistors in series		R_{eq}	$=$	$R_1 + R_2 + R_3 + ...$
Resistors in parallel		$\frac{1}{R_{eq}}$	$=$	$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$
Power delivered to R [W]		P	$=$	$I^2\, R = V^2/R = IV$
Time constant in RC circuit [s]		τ_{RC}	$=$	RC
Charge in RC circuit		$Q(t)$	$\propto$	$e^{-t/\tau}$ or $(1 - e^{-t/\tau})$