Physics 208 Test 3 Name _____

Equations:

$F = k\frac{q_1 q_2}{r_{12}^2}$ $\quad \vec{F} = q\vec{E}$

$E = k\frac{q}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

$\Phi = \int \vec{E} \bullet d\vec{a}$

$\Phi_{Total} = \oint \vec{E} \bullet d\vec{A} = \frac{q_{enclosed}}{\varepsilon_0}$

$\Delta V = V_f - V_i = -\frac{W}{q} = -\int \vec{E} \bullet d\vec{s}$ $\quad V = \frac{U_e}{q}$

$V = k\frac{q}{r}$ $\quad \vec{E} = -\nabla V = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$

$C = \frac{Q}{\Delta V}$ $\quad C = \kappa\frac{\varepsilon_0 A}{d}$ $\quad U_e = \frac{1}{2}QV$ $\quad C_{eq} = (C_1 + C_2 + \ldots)$ $\quad \frac{1}{C_{eq}} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \ldots\right)$

$R = \frac{V}{i}$ $\quad P = i\,V$ $\quad i = \vec{J} \bullet \vec{A}$ $\quad \frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \ldots\right)$ $\quad R_{eq} = (R_1 + R_2 + \ldots)$

$\Sigma i_{in} = \Sigma i_{out}$ $\quad \sum_{closed\ loop} \Delta V = 0$ $\quad i = \frac{dq}{dt}$ $\quad q = q_0 e^{-t/RC}$ $\quad q = C\,\Delta V\left(1 - e^{-t/RC}\right)$

Constants:

| e | = 1.60 x 10^{-19} C

$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ $\ \mathrm{Nm^2 / C^2}$

ε_0 = 8.85 x 10^{-12} $\mathrm{C^2 / Nm^2}$

From 205:

$\Delta x = v_0 t + \frac{1}{2}at^2$ $\quad v = v_0 + at$ $\quad \vec{a} = \frac{\sum \vec{F}}{m}$ $\quad \Delta\vec{P} = \vec{F}_{avg}\ \Delta t$

$\Delta E = \Delta U + \Delta K = W_{nc}$ $\quad \Delta KE = W_{net}$ $\quad Power = \frac{\Delta E}{\Delta t}$ $\quad f_{Friction} \le \mu N$

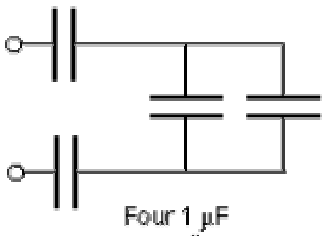
Physics 208 Test 3 Name _____

Part I. Multiple Choice/Short Answer (4 points each / 20 points total)
no explanation required, but no partial credit either

1. Two isolated neutral conductors A and B are connected to the terminals of a 20 V battery that produces charges on A and B of $Q_A = -Q_B = +200$ mC. What is their capacitance in mF?
   (A) 5
   (B) 10
   (C) 20
   (D) 2000
   (E) 4000

2. Four air filled parallel plate capacitors are constructed as follows: #1 has capacitance C_1, area A, and gap d; #2 has capacitance C_2, area 2A and gap d; #3 has capacitance C_3, area A and gap 2d; #4 has capacitance C_4, area 2A and gap 2d. Rank their capacitances, in order of increasing C (i.e. smallest first).
   (A) C_3, $C_1 = C_4$, C_2
   (B) C_1, C_2 , C_3, C_4
   (C) C_4, C_3 , C_2, C_1
   (D) C_2, C_1 , C_4, C_3
   (E) C_2, $C_1 = C_4$, C_3

3. What is the overall capacitance of this combination of four 1 μF capacitors? In μF, the overall capacitance is ___ ?

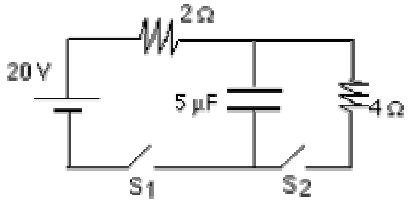


   (A) 0.40
   (B) 2.5
   (C) 4.0
   (D) 0.25
   (E) 1.5

4. A capacitor is charged by a 5 volt battery storing energy U_1. If a 10 volt battery were used instead, the stored energy would by

   (A) U_1
   (B) $4\ U_1$
   (C) $U_1 / 2$
   (D) $U_1 / 4$
   (E) $2\ U_1$

5. An uncharged 5 μF capacitor is in the circuit shown. Initially the capacitor is uncharged and both switches are open. Switch S_1 is then closed at t=0. The capacitor's charge Q as a function of time t is



(A) $Q = 100\ mC\ [1 - e^{(-\ t\ /20\ ms)}\ ]$
(B) $Q = 100\ mC\ e^{(-\ t\ /20\ ms)}$
(C) $Q = 100\ mC\ [1 - t/20\ ms\ ]$
(D) $Q = 100\ mC\ e^{(-\ t\ /10\ ms)}$
(E) $Q = 100\ mC\ [1 - e^{(-\ t\ /10\ ms)}\ ]$

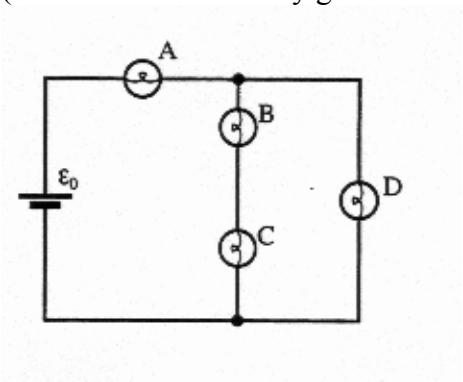
6. (10 points) An **isolated** air filled parallel plate capacitor has capacitance C_0, voltage V_0, and charge Q_0. If an insulator of dielectric constant 3.0 is inserted filling the gap between plates, explain in words what happens to each of the capacitor's parameters and why?

7. **GOAL Problem** (15 points): Do the "G" and "O" steps of GOAL. Your "O" step should include a list of basic physics principles you will use to solve the problem, the equations you will use, and the procedure you will use to solve the problem. DO NOT SOLVE the problem.

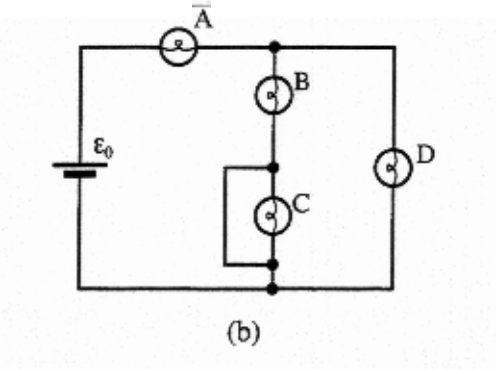
   You and a friend are studying for an exam and the session goes until the early morning. About 4 AM you decide to cook some breakfast. Despite being sleepy, things are going well. The waffles are cooking and the coffee is perking. The 1000-watt waffle iron and the 600-watt coffee maker are plugged into kitchen wall electrical outlets. You will also use a kitchen wall outlet for the 700-watt toaster. You know that if you plug in too many appliances you will overload the circuit breaker.
   Should you make some toast now?
   The kitchen wall outlets are all part of the same 110-V circuit which has a 20-A circuit breaker (with negligible resistance) to protect the wire carrying the largest current from getting too hot. (The circuit breaker protects those kitchen circuit wires that have the most current from carrying too much current. It opens a switch if the current through the circuit breaker exceeds its rating. Some homes have fuses to do the same job). You are trying to figure out how the electrical outlets are connected together in a circuit when your friend reminds you that when you disconnect the coffeepot, the waffle iron stays on. Now everything is clear.

8. (15 points) The circuit chosen has 4 identical light bulbs and an ideal battery with voltage ε_0.

a. Rank the brightness of the bulbs from brightest to dimmest. Explain your reasoning (Be sure to mention any given information that you use in your reasoning.)



b. A wire is now added to the circuit as shown in figure (b) below

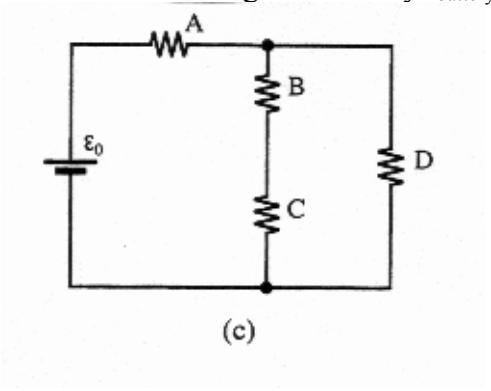


i. Does the brightness of bulb C increase, decrease, or stay the same? Explain.

ii. Does the brightness of bulb A increase decrease or stay the same? Explain

iii. Does the brightness of bulb D increase, decrease, or remain the same? Explain

c. The bulbs in the original circuit are replaced by identical resistors with resistance R. Find the current through resistor D in terms of the current through the battery $i_{battery}$



9. If R = 2 Ω and ε_0 = 6V, find the current supplied by the battery and the power dissapated by resistor D.