Midterm Exam No. 02 (2016 Spring)

PHYS 205B: University Physics

Date: 2016 Mar 22

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(Name)   (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 4.

2. Total time = 75 minutes.

3. There are 10 questions in this exam.

4. Equation sheet is provided separately.

5. To be considered for partial credit you need to show your work in detail and organize it clearly.

6. A simple calculator (with trigonometric functions) is allowed.

7. Use of mobile phones is strictly prohibited. It should stay out of reach during the exam.

1. (**10 points.**) Two conductors having net charges of $+20.0\,\mu C$ and $-20.0\,\mu C$ have a potential difference of $20.0\,V$ between them. Determine the capacitance of the system.

2. (**10 points.**) One hundred identical capacitors, each with capacitance C, are connected in series. What is the equivalent capacitance of this arrangement?

3. (**10 points.**) A potential difference $V = 10.0\,\text{V}$ is applied across a capacitor arrangement with two capacitances connected in parallel, $C_1 = 10.0\,\mu\text{F}$ and $C_2 = 20.0\,\mu\text{F}$. Find the potential energies U_1 and U_2 stored inside each of the capacitors.

4. (**10 points.**) Consider the circuit in Figure 1. Let $V = 10.0\,\text{V}$, $C_1 = 10.0\,\mu\text{F}$, $C_2 = 20.0\,\mu\text{F}$, and $C_3 = 30.0\,\mu\text{F}$. Determine the charge on capacitor C_1.
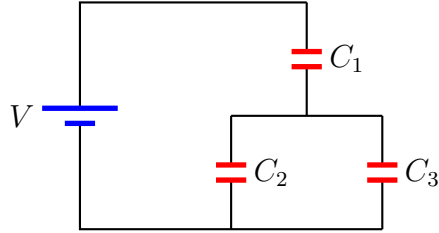
V C_1 C_2 C_3

Figure 1: Capacitor circuit.

5. (**10 points.**) A cylindrical copper rod has resistance R. It is reformed to thrice its original length with no change of volume. What is its new resistance in terms of the original resistance R?

6. (**10 points.**) A student kept her 60.0 Watt 120 Volt study lamp turned on for 12 hours. How much charge in coulombs went through it?

7. (**10 points.**) Figure 2 shows three resistors connected in parallel to a battery. The battery has a voltage of $V = 10.0\,\text{V}$, and the resistors have equal resistances of $R = 300.0\,\Omega$. Determine the power consumed by each resistor.
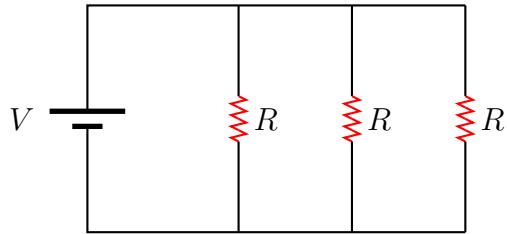

Figure 2: Problem 7

8. (**10 points.**) Consider the circuit in Figure 3. Determine the current (with direction) through the resistor R_1. Let $R_1 = 100.0\,\Omega$, $R_2 = 200.0\,\Omega$, $V_1 = 10.0\,\text{V}$, and $V_2 = 20.0\,\text{V}$.
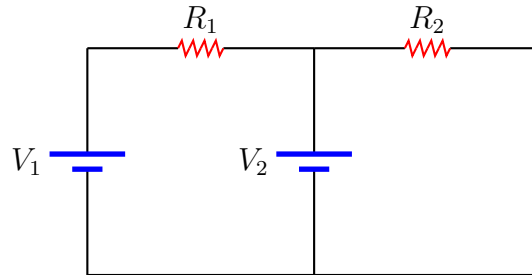

Figure 3: Problem 8

9. (**10 points.**) Consider the circuit in Figure 4 with $V_1 = 10.0\,\text{V}$, $V_2 = 20.0\,\text{V}$, $R_1 = R_2 = 10.0\,\Omega$, $R_3 = 30.0\,\Omega$. Find the currents i_3 (with direction) through the resistor R_3.
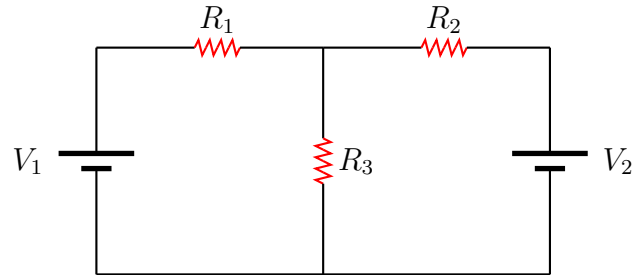

Figure 4: Problem 9

10. (**10 points.**) Consider the process of charging the capacitor C in Figure 10.
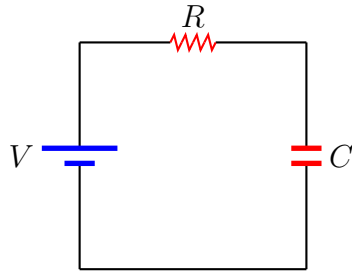

Figure 5: Problem 10

(a) Using Kirchoff's law, write down the equation relating the current I in the circuit and the charge Q on the capacitor.

(b) The solution to the equation, in Question (10a), for the initial condition $Q(0) = 0$ is given by

$$Q(t) = CV \left[1 - e^{-\frac{t}{RC}} \right]. \tag{1}$$

What is the maximum charge the capacitor attains? How much time does it take to charge the capacitor to this maximum value? Given $C = 10.0\,\mu\text{F}$, $R = 30.0\,\text{k}\Omega$, and $V = 10.0\,\text{V}$.