Midterm Exam No. 02 (2021 Fall)

PHYS 205B: University Physics

Date: 2021 Oct 5

(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 5 conceptual questions and 5 problems 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. (**5 points.**) The electric potential on the surface of a solid perfectly conducting sphere of radius R with charge Q on it is

$$\frac{1}{4\pi\varepsilon_0}\frac{Q}{R}. \tag{1}$$

What is the electric potential at a distance $R/2$ from the center on this sphere?

2. (**5 points.**) What is an equipotential surface? Draw the equipotential surfaces between two parallel plates with equal and opposite charge per unit area on the two plates.

3. (**5 points.**) Determine the total electrical energy required to assemble two identical positive charges $+Q$ at two corners and one negative change $-Q$ at the third corner of an equilateral triangle of length L. Assume that the charges are brought from infinity.

4. (**5 points.**) The electric potentials at the two ends of a $1.5\,\mathrm{k}\Omega$ resistor in a circuit is measured to be $6.0\,\mathrm{V}$ and $1.5\,\mathrm{V}$. Determine the current passing through the resistor.

5. (**5 points.**) A zero-watt bulb consumes about 12 watts of power. In early days this was too low power and it came to be known as zero-watt bulb. How much energy (in Joules) is consumed by a zero-watt bulb in one year if it is left on continuously.

6. (**10 points.**) Four charges $q_1 = q$, $q_2 = -q$, $q_3 = -q$, and $q_4 = q$, are placed at the corners of a square of side L, such that q_1 and q_4 are at diagonally opposite corners. Refer Figure 1. What is the electric potential difference between points a and c?

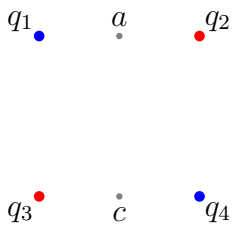

Figure 1: Problem 6

7. (**10 points.**) Determine the equivalent capacitance between points A and B in the circuit in Figure 2. Given $C_1 = 1.0\,\text{nF}$, $C_2 = 2.0\,\text{nF}$, $C_3 = 3.0\,\mu\text{F}$, and $C_4 = 4.0\,\mu\text{F}$.
Caution: Note that C_1 and C_2 are in nF while C_3 and C_4 are in μF. Report the answer with correct significant digits.

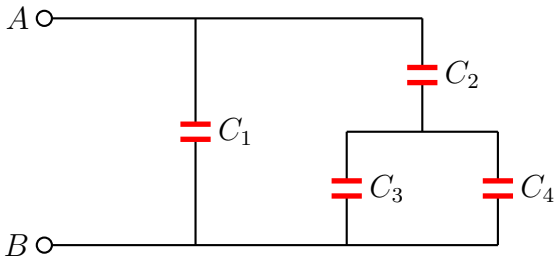

Figure 2: Problem 7

8. (**10 points.**) Consider the circuit in Figure 3 with $V_1 = 7.0\,\mathrm{V}$, $V_2 = 5.0\,\mathrm{V}$, $R_1 = 10.0\,\Omega$, $R_2 = 20.0\,\Omega$. For what resistance R_3 is the current in R_2 zero?

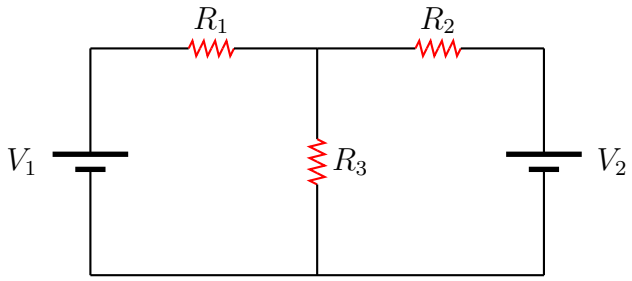

Figure 3: Problem 8

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

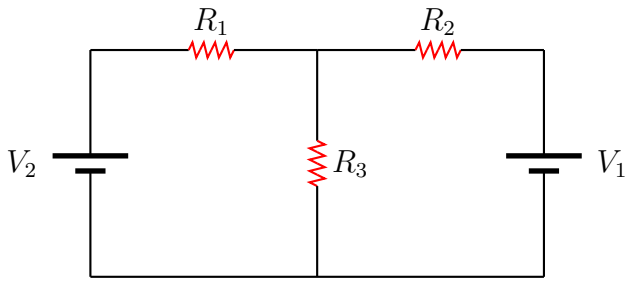

Figure 4: Problem 9

10. (**10 points.**) Consider the process of discharging the capacitor C through a resistor R. Refer Figure 5.

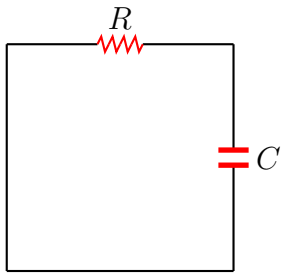

Figure 5: Problem 10

(a) Using Kirchoff's law, write down the (differential) 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 $Q(0) = Q_0$ is given by

$$Q(t) = Q_0 e^{-\frac{t}{RC}}. \tag{2}$$

How much time does it take to discharge the capacitor completely? How much time does it take to discharge the capacitor to half of the maximum value? Given $C = 10.0\,\mu\text{F}$, $R = 30.0\,\text{k}\Omega$, and $Q_0 = 150\,\mu\text{C}$.