Homework No. 05 (Spring 2022)

PHYS 203B-001: COLLEGE PHYSICS

Department of Physics, Southern Illinois University–Carbondale

Due date: Wednesday, 2022 Feb 23, 10:00am, on D2L

Instructions

- To the extent to which you depend on resources to complete this homework is a measure of how much extra work you need to put in to master the related concepts.
- Describe your thought process in detail and organize it clearly. Make sure your answer has the correct units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (Assessments → Assignments).

Problems

1. (**10 points.**) A capacitor of capacitance 10.0 nF is connected to a 10.0 V balltery. Let us assume that the capacitor consists of two parallel plates of area A separated by distance d.

   (a) Determine the charge accumulated on each plate of the capacitor.

   (b) Determine the energy stored in the capacitor.

   Solution

2. (**10 points.**) Determine the equivalent capacitance between points A and B in the circuit in Figure 1. Given $C_1 = 1.0\,\mu$F, $C_2 = 2.0\,\mu$F, $C_3 = 3.0\,\mu$F, and $C_4 = 4.0\,\mu$F.

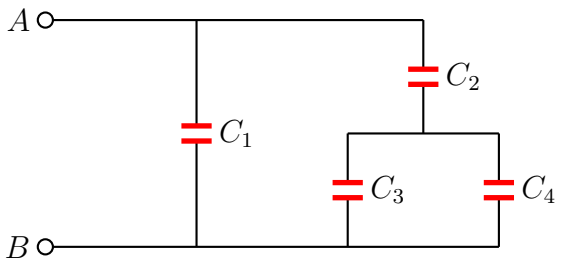

Figure 1: Problem 2

Solution

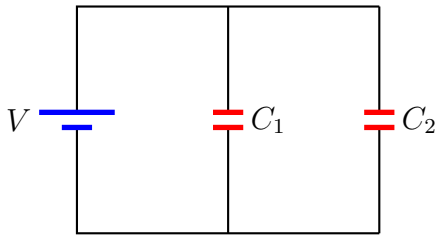

Figure 2: Problem 3

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 $C_2 = 20.0\,\mu\text{F}$.

   (a) Find the equivalent capacitance.

   (b) Find the charges Q_1 and Q_2 on each of the capacitors.

   (c) Find the voltages V_1 and V_2 across each of the capacitors.

   (d) Find the potential energies U_1 and U_2 stored inside each of the capacitors.

   (e) Find the ratio V_1/V_2 of the voltages across the capacitors.

   (f) Find the ratio Q_1/Q_2 of the charges on the capacitors.

   (g) Find the ratio U_1/U_2 of the potential energies stored inside the capacitors.

Solution

4. (**10 points.**) A potential difference $V = 10.0\,\text{V}$ is applied across a capacitor arrangement with two capacitances connected in series, $C_1 = 10.0\,\mu\text{F}$ and $C_2 = 20.0\,\mu\text{F}$.

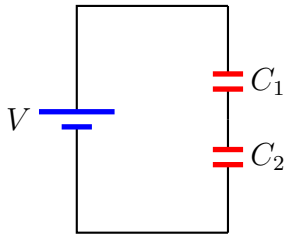

Figure 3: Problem 4

   (a) Find the equivalent capacitance.

   (b) Find the charges Q_1 and Q_2 on each of the capacitors.

   (c) Find the voltages V_1 and V_2 across each of the capacitors.

   (d) Find the potential energies U_1 and U_2 stored inside each of the capacitors.

   (e) Find the ratio V_1/V_2 of the voltages across the capacitors.

(f) Find the ratio Q_1/Q_2 of the charges on the capacitors.

(g) Find the ratio U_1/U_2 of the potential energies stored inside the capacitors.

Solution

5. (**10 points.**) Estimate the drift velocity of conduction electrons in a copper wire of radius 1.0 mm using

$$I = neAv_d. \tag{1}$$

Copper has one free electron per atom available for conduction. For reference copper wire has 9×10^{28} atoms/m^3. Use $I = 1.0$ A. How much time (in hours) does it take for an individual electron to begin from the light switch and reach the bulb that is connected by a 2.0 m long copper wire?

Solution

6. (**10 points.**) Watt is the unit of power. Watt-hour is a unit of energy. How much is kWh (kilo Watt-hour) in Joules? The average cost of electricity in the United States, for residential users, is about 0.15 USD/kWh (15 cents per kiloWatt-hour). At this rate your electricity bill for a month came out to be 50.00 USD. How much electric energy (in Joules) did you use in the month?

Solution

7. (**10 points.**) Resistance is inversely proportional to the area of crosssection A and proportional to the length l, such that

$$R = \frac{\rho l}{A}, \tag{2}$$

where ρ is the resistivity of the material. 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?

Solution

8. (**10 points.**) Figure 4 shows three resistors connected in parallel to a battery. The battery has a voltage of $V = 10.0$ V, and the resistors have equal resistances of $R = 300.0\,\Omega$.

(a) Determine the equivalent resistance across the battery.

(b) Determine the voltage across each of the resistor.

(c) Determine the current passing through each resistor.

(d) Determine the power consumed by each resistor.

Solution

9. (**10 points.**) Figure 5 shows two resistors connected in series to a battery. The battery has a voltage of $V = 10.0$ V, and the resistors have resistances $R_1 = 100.0\,\Omega$ and $R_2 = 200.0\,\Omega$.

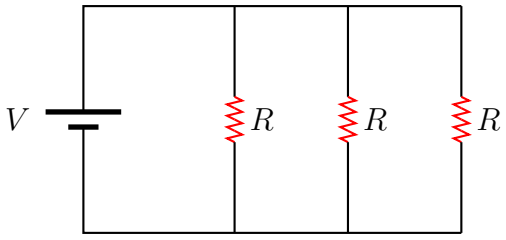

Figure 4: Problem 8

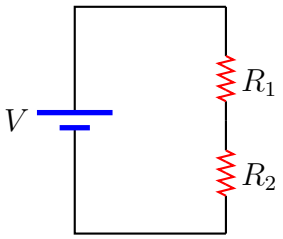

Figure 5: Problem 9

(a) Determine the equivalent resistance across the battery.

(b) Determine the voltage across each of the resistor.

(c) Determine the current passing through each resistor.

(d) Determine the power consumed by each resistor.

(e) Find the ratio P_1/P_2 of the powers of the resistors.

(f) If the resistors represented electric bulbs, which bulb would glow brighter?

Solution

10. (**10 points.**) Figure 6 shows two resistors connected in parallel to a battery. The battery has a voltage of $V = 10.0\,\text{V}$, and the resistors have resistances $R_1 = 100.0\,\Omega$ and $R_2 = 200.0\,\Omega$.

(a) Determine the equivalent resistance across the battery.

(b) Determine the voltage across each of the resistor.

(c) Determine the current passing through each resistor.

(d) Determine the power consumed by each resistor.

(e) Find the ratio P_1/P_2 of the powers of the resistors.

(f) If the resistors represented electric bulbs, which bulb would glow brighter?

Solution

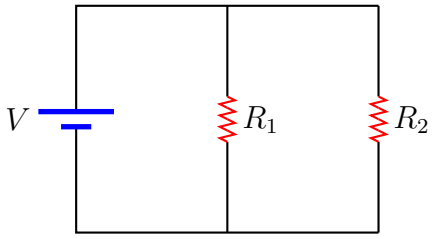

Figure 6: Problem 10