Physics for Scientists and Engineers II

Physics 202

Sample Exam #2

Useful Information

Kirchhoff's Laws

$$\sum_i (\Delta V)_i = 0$$

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$

Capacitors

$$C = \frac{Q}{\Delta V_C}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$u_C = \frac{1}{2} C (\Delta V_C)^2$$

$$\frac{1}{C_{\text{eq}}} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \right) \quad \text{series circuit}$$

$$C_{\text{eq}} = C_1 + C_2 + C_3 + \cdots \quad \text{parallel circuit}$$

Resistors

$$\Delta V_R = IR$$

$$R = \frac{\rho L}{A}$$

$$P = I \Delta V_R = I^2 R = \frac{(\Delta V_R)^2}{R}$$

$$R_{\text{eq}} = R_1 + R_2 + R_3 + \cdots \quad \text{series circuit}$$

$$\frac{1}{R_{\text{eq}}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \right) \quad \text{parallel circuit}$$

Constants

$$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N\,m^2}$$

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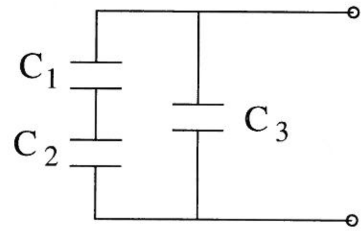
1. Three capacitors of equal capacitance are arranged as shown. The voltage drop across C_1 is 90.0 V. What is the voltage drops across C_2 and C_3?



Since the capacitors are equal and C_1 and C_2 are in series ($Q_1 = Q_2$), then the voltage drops are equal.

$$\Rightarrow V_2 = \underline{\underline{90\text{ V}}}$$

Since C_3 is in parallel with the combination of C_1 and C_2, then the voltage drop equals $V_1 + V_2$

$$\Rightarrow V_3 = V_1 + V_2 = \underline{\underline{180\text{ V}}}$$

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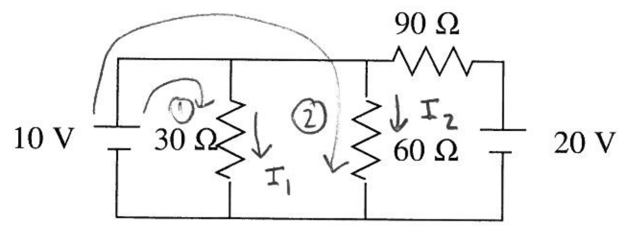
2. What is the current through the 30 Ω and 60 Ω resistors in the circuit below?



For loop 1,

$$\Sigma(\Delta V) = 0$$

$$10\,V - I_1(30\,\Omega) = 0$$

$$I_1 = \frac{10\,V}{30\,\Omega} = \underline{\underline{0.33\,A}}$$

For loop 2,

$$\Sigma(\Delta V) = 0$$

$$10\,V - I_2(60\,\Omega) = 0$$

$$I_2 = \frac{10\,V}{60\,\Omega} = \underline{\underline{0.17\,A}}$$

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3. A 1.0 m length of gold wire is connected to a 1.5 V battery, and a current of 2.0 mA flows through it. What is the diameter of the wire? (The resistivity of gold is 2.24×10^{-8} Ω·m.)

By Ohm's Law, the resistance is

$$R = \frac{\Delta V}{I} = \frac{1.5\ V}{0.002\ A} = 750\ \Omega$$

The radius of the wire is

$$R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2}$$

$$r = \sqrt{\frac{\rho L}{\pi R}}$$

$$= \sqrt{\frac{(2.24 \times 10^{-8}\ \Omega m)(1.0\ m)}{\pi (750\ \Omega)}}$$

$$= 3.08 \times 10^{-6}\ m$$

Thus, the diameter is

$$d = 2r = \underline{\underline{6.2 \times 10^{-6}\ m}} = \underline{\underline{6.2\ \mu m}}$$

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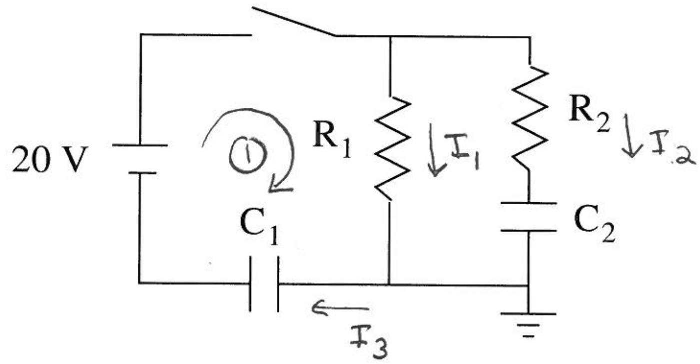
4. For the circuit below, $R_1 = 120\ \Omega$, $R_2 = 300\ \Omega$, $C_1 = 25$ pF, and $C_2 = 40$ pF. All the capacitors are initially uncharged. What is the power dissipated by R_1, (a) just after the switch is closed and (b) when the switch was been closed for a very long time?



A single ground does not affect the operation of the circuit.

a) For loop 1 just after the switch is closed,

$$\Sigma(\Delta V) = 0$$

$$\varepsilon - I_1 R_1 - \cancel{\frac{Q_1}{C_1}}^{\,0} = 0$$

$$I_1 = \frac{\varepsilon}{R_1} = \frac{20\text{ V}}{120\,\Omega} = 0.167\text{ A}$$

Thus, the power dissipated by R_1 is

$$P = I_1^2 R_1 = (0.167\text{ A})^2(120\,\Omega) = \underline{\underline{3.3\text{ W}}}$$

b) when C_1 and C_2 are fully charged, $I_2 = I_3 = 0$

By the junction law

$$I_1 + I_2 = I_3 \implies I_1 = 0$$

Thus, the power dissipated by R_1 is

$$P = \cancel{I_1^2} R_1^{\,0} = \underline{\underline{0\text{ W}}}$$