#19. $R_1 = 100\Omega$, $R_2 = 50\Omega$,

teries have emfs $\mathscr{E}_1 = 6.0$ V, $\mathscr{E}_2 = 5.0$ V, and $\mathscr{E}_3 = 4.0$ V. Find (a) the current in resistor 1, (b) the current in resistor 2, and (c) the potential difference between points a and b. **SSM**

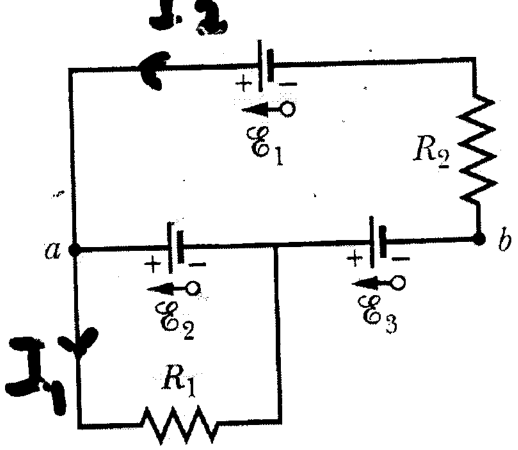


Fig. 27-34 Problem 19.

a) $-I_1 R_1 + \mathcal{E}_2 = 0 \Rightarrow I_1 = \frac{\mathcal{E}_2}{R_1} = \frac{5}{100}$

$= 0.05\text{A}.$

b) $-I_2 R_2 + \mathcal{E}_1 - \mathcal{E}_2 - \mathcal{E}_3 = 0$

$I_2 = \frac{\mathcal{E}_1 - \mathcal{E}_2 - \mathcal{E}_3}{R_2} = \frac{-3}{50} = -0.06\text{A}.$

c) $V_b - V_a = -\mathcal{E}_2 - \mathcal{E}_3$

$= -5 - 4 = -9\text{V}$

or $V_b - V_a = -I_1 R_1 - \mathcal{E}_3 = -0.05 \times 100 - 4$

$= -9\text{ V}$

or $V_b - V_a = -\mathcal{E}_1 - I_2 R_2 = -6 - 3 = -9\text{V}$

•48 Switch S in Fig. 27-52 is closed at time $t = 0$, to begin charging an initially uncharged capacitor of capacitance $C = 15.0\ \mu F$ through a resistor of resistance $R = 20.0\ \Omega$. At what time is the potential across the capacitor equal to that across the resistor?

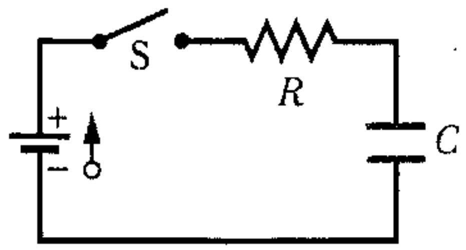


Fig. 27-52 Problems 48 and 69.

$$V_C = \mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right)$$

$$V_R = IR = \underbrace{R I_{max}}_{\mathcal{E}} e^{-\frac{t}{RC}}$$

$V_C = V_R$

$$\Rightarrow \quad \mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right) = \mathcal{E} e^{-\frac{t}{RC}}$$

$$2 e^{-t/RC} = 1$$

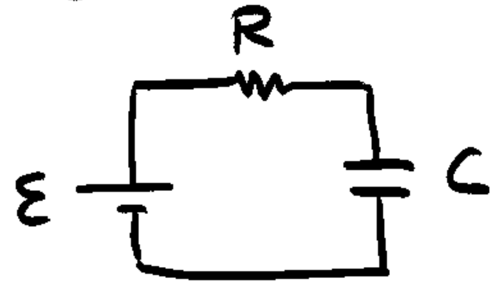
$$e^{-t/RC} = \frac{1}{2} \Rightarrow -\frac{t}{RC} = \ln\left(\frac{1}{2}\right)$$

$$= -\ln 2$$

$$t = RC \ln 2$$

$$t = 0.69 RC = 2.08 \times 10^{-4}\ s$$

(•46) In an RC series circuit, $\mathcal{E} = 12.0$ V, $R = 1.40$ MΩ, and $C = 1.80$ μF. (a) Calculate the time constant. (b) Find the maximum charge that will appear on the capacitor during charging. (c) How long does it take for the charge to build up to 16.0 μC?



a) $\tau = RC = 2.52 \text{ s.}$

b) $q_{max} = C\mathcal{E} = 21.6\ \mu C$ (after a long time)

c) $q(t) = q_{max}\left(1 - e^{-t/RC}\right)$

$16\ \mu C = 21.6\ \mu C\left(1 - e^{-t/2.52}\right)$

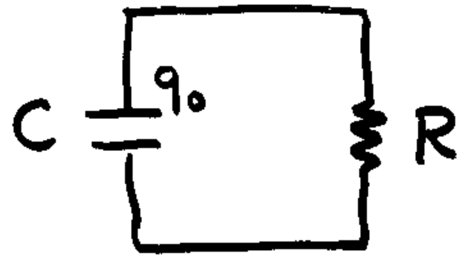
$0.74 = 1 - e^{-t/2.52}$

$e^{-t/2.52} = 1 - 0.74 = 0.26$

$-\frac{t}{2.52} = \ln(0.26) = -1.35$

$t = 3.4 \text{ s}$

(•44) A capacitor with initial charge q_0 is discharged through a resistor. What multiple of the time constant τ gives the time the capacitor takes to lose (a) the first one-third of its charge and (b) two-thirds of its charge?



$RC = \tau$

↑ time constant. It has unit of sec.

charge remaining

$$q(t) = q_0 e^{-t/RC}$$

a) $$\frac{2q_0}{3} = q_0 e^{-t/RC}$$

$$\ln\left(\frac{2}{3}\right) = -\frac{t}{RC}$$

$$t = RC \ln\left(\frac{3}{2}\right) = 0.41 \underbrace{RC}_{\tau}$$

$$= 0.41\tau$$

b) $$\frac{1}{3} q_0 = q_0 e^{-t/RC}$$

$$t = RC \ln 3 = 1.1 \, RC = 1.1\tau$$

••30 In Fig. 27-42, $R_1 = 100\ \Omega$, $R_2 = R_3 = 50.0\ \Omega$, $R_4 = 75.0\ \Omega$, and the ideal battery has emf $\mathscr{E} = 6.00$ V. (a) What is the equivalent resistance? What is i in (b) resistance 1, (c) resistance 2, (d) resistance 3, and (e) resistance 4?

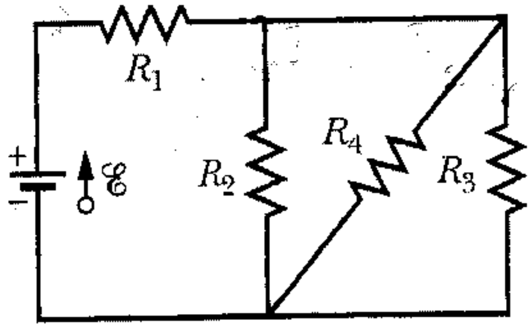
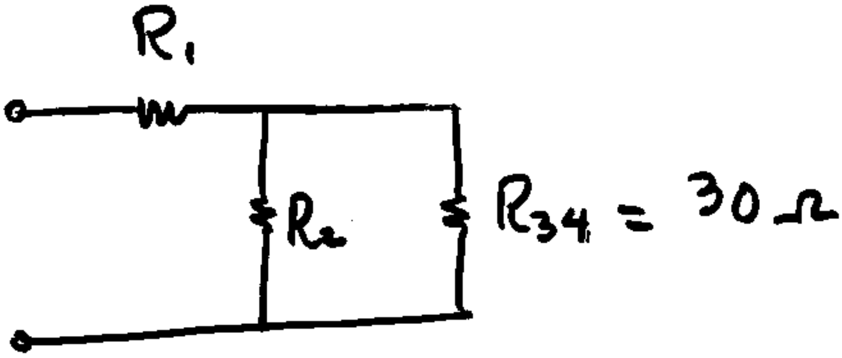
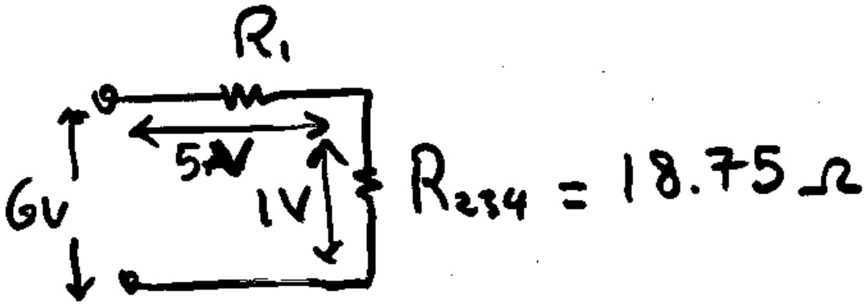
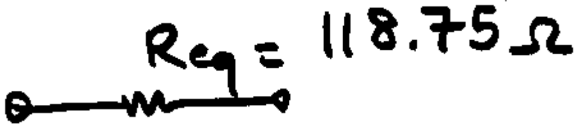


Fig. 27-42 Problems 30 and 36.

a)







b) $I = \frac{\mathcal{E}}{R_{eq}} = 0.05\text{ A}$

c) $V_2 = I_2 R_2 \Rightarrow I_2 = \frac{V_2}{R_2} = \frac{1}{50} = 0.02\text{A}.$

d) $I_3 = I_2 = 0.02\text{ A}.$

e) $I_4 = \frac{V_4}{R_4} = \frac{1}{75} = 0.01\text{ A}.$

#19. $R_1 = 100\Omega$, $R_2 = 50\Omega$,

teries have emfs $\mathscr{E}_1 = 6.0$ V, $\mathscr{E}_2 = 5.0$ V, and $\mathscr{E}_3 = 4.0$ V. Find (a) the current in resistor 1, (b) the current in resistor 2, and (c) the potential difference between points a and b. SSM

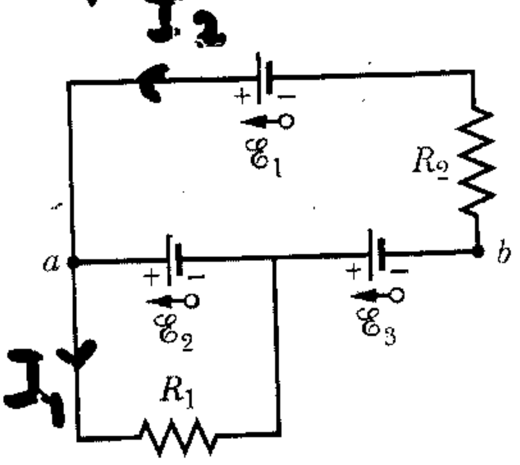


Fig. 27-34 Problem 19.

a) $-I_1R_1 + \mathcal{E}_2 = 0 \Rightarrow I_1 = \frac{\mathcal{E}_2}{R_1} = \frac{5}{100}$

$= 0.05\text{A}.$

b) $-I_2R_2 + \mathcal{E}_1 - \mathcal{E}_2 - \mathcal{E}_3 = 0$

$I_2 = \frac{\mathcal{E}_1 - \mathcal{E}_2 - \mathcal{E}_3}{R_2} = \frac{-3}{50} = -0.06\text{A}.$

c) $V_b - V_a = -\mathcal{E}_2 - \mathcal{E}_3$

$= -5 - 4 = -9\text{V}$

or $V_b - V_a = -I_1R_1 - \mathcal{E}_3 = -0.05\times100 - 4$

$= -9\text{ V}$

or $V_b - V_a = -\mathcal{E}_1 - I_2R_2 = -6 - 3 = -9\text{V}$

••49 A capacitor with an initial potential difference of 100 V is discharged through a resistor when a switch between them is closed at $t = 0$. At $t = 10.0$ s, the potential difference across the capacitor is 1.00 V. (a) What is the time constant of the circuit? (b) What is the potential difference across the capacitor at $t = 17.0$ s?

a) $$V_c(t) = \frac{q(t)}{C} = \frac{q_0}{C} e^{-t/RC} = V_0 e^{-t/RC}$$

$$1 = 100 e^{-\frac{10}{\tau}}$$

$$-\frac{10}{\tau} = \ln\left(\frac{1}{100}\right) = -\ln 100$$

$$\tau = \frac{10}{\ln 100} = 2.17 \text{ s.}$$

b) $$V_c = 100 e^{-\frac{17}{2.17}} = 0.04 \text{ V}$$