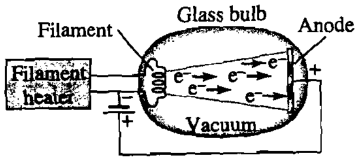
3. (a) What is the direction of the current in the vacuum tube shown in the figure? (b) Electrons hit the anode at a rate of 6.0×10^{12} per second. What is the current in the tube?



a) current flow is opposite electron movement

$\therefore$ $\overleftarrow{I}$ anode to filament

b) $6.0\times10^{12} \frac{\text{electrons}}{\text{sec}}$

$I = \frac{\text{charge}}{\text{time}}$

$= \frac{(1.6\times10^{-19}C)}{e} \times 6.0\times10^{12} \frac{e}{s}$

$= 9.6\times10^{-7} \frac{C}{s}$

$I = 9.6\times10^{-7}$ A or $0.96\mu A$

10. The label on a 12.0-V truck battery states that it is rated at 180.0 A·h (ampere-hours). Treat the battery as ideal. (a) How much charge in coulombs can be pumped by the battery? [*Hint:* Convert A·h to A·s.] (b) How much electric energy can the battery supply? (c) Suppose the radio in the truck is left on when the engine is not running. The radio draws a current of 3.30 A. How long does it take to drain the battery if it starts out fully charged?

a) $Q = ?$

$180 \text{ A}\cdot\text{h} \times \frac{3600 s}{h}$

$= 648000 \text{ A}\cdot\text{s}$

$= 648000 \frac{C}{s} s$

$Q = 6.48\times10^{5} C$

b) Energy $= qV$

$= (6.48\times10^{5}C)(12.0V)$

$= 7.78\times10^{6} J$

$E = 7.78$ MJ

c) $I = 3.30$ Amp $= 3.30 \frac{C}{s}$

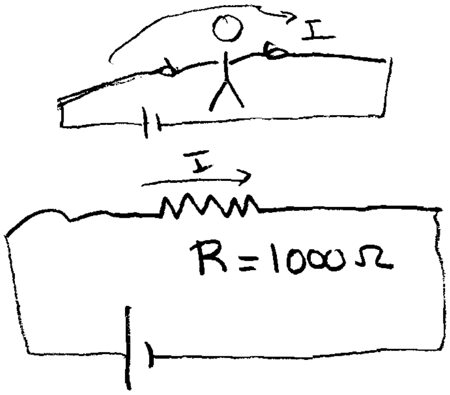
$I = \frac{\text{charge}}{\text{time}} = \frac{Q}{t}$

$t = \frac{Q}{I} = \frac{6.48\times10^{5}C}{3.3 C/s}$

$= 1.96\times10^{5} s \times \frac{1h}{3600 s}$

time = 54.5 hours

25. A person can be killed if a current as small as 50 mA passes near the heart. An electrician is working on a humid day with hands damp from perspiration. Suppose his resistance from one hand to the other is 1 kΩ and he is touching two wires, one with each hand. (a) What potential difference between the two wires would cause a 50-mA current from one hand to the other? (b) An electrician working on a "live" circuit keeps one hand behind his or her back. Why?



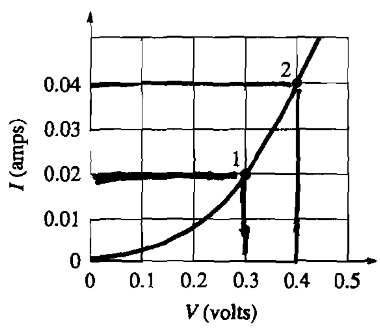
a) $V = IR$

$= (50\times10^{-3}\,A)(1\times10^{3}\,\Omega)$

$= 50\,V$

b) With one hand in a pocket the electrician can't create a circuit between their hands which would allow current to flow across the heart

26. An electric device has the current-voltage (*I-V*) graph shown. What is its resistance at (a) point 1 and (b) point 2? [*Hint:* Use the definition of resistance.]



a) $V = IR$

$R = \frac{V}{I}$

at point ①

$I = 0.02\,A \qquad V = 0.3\,V$

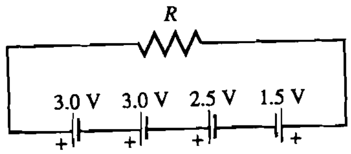
$R = \frac{0.3\,V}{0.02\,A} = 15\,\Omega$

b) point ②

$I = 0.04\,A \qquad V = 0.4\,V$

$R = \frac{V}{I} = \frac{0.4\,V}{0.04\,A} = 10\,\Omega$

37. Suppose four batteries are connected in series as shown. (a) What is the equivalent emf of the set of four batteries? Treat them as ideal sources of emf. (b) If the current in the circuit is 0.40 A, what is the value of the resistor *R*?



a) Voltages in series add

$\mathcal{E}mf_{eq} = \Sigma \mathcal{E}mf$

$= \mathcal{E}_1 + \mathcal{E}_2 + \mathcal{E}_3 + \mathcal{E}_4$

$= 3.0V + 3.0V + 2.5V - 1.5V$

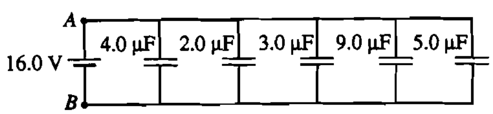
$\boxed{\mathcal{E}mf_{eq} = 7.0V}$

note $\mathcal{E}_4$ is opposite the other 3 batteries

b) $V = IR$

$R = \frac{V}{I} = \frac{7V}{0.4A} = \boxed{.18\ \Omega = R}$

39. (a) Find the equivalent capacitance between points *A* and *B* for the five capacitors. (b) If a 16.0-V emf is connected to the terminals *A* and *B*, what is the charge on a single equivalent capacitor that replaces all five? (c) What is the charge on the 3.0-μF capacitor?



(a) Capacitors in parallel add

$C_{eq} = C_1 + C_2 + C_3 + \ldots$

$C_{eq} = 4.0\mu F + 2.0\mu F + 3.0\mu F + 9.0\mu F + 5.0\mu F$

$\boxed{C_{eq} = 23\mu F}$

b) $Q = C\Delta V = C_{eq}\Delta V$

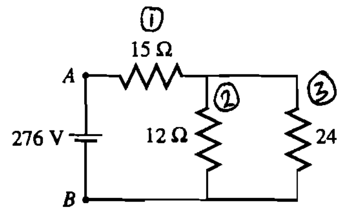
$= (23\times10^{-6} F)(16.0V)$

$\boxed{Q = 368\mu C}$

c) $Q = C\Delta V = (3\times10^{-6}\ F)(16.0V)$

$\boxed{Q = 48\mu C}$

40. (a) What is the equivalent resistance between points *A* and *B*? (b) A 276-V emf is connected to the terminals *A* and *B*. What is the current in the 12-Ω resistor?



$$R_{eq\,series} = R_1 + R_2$$

$$\frac{1}{R_{eq\,parallel}} = \frac{1}{R_1} + \frac{1}{R_2}$$

a) Resistors ② and ③ are in parallel (12Ω and 24Ω)

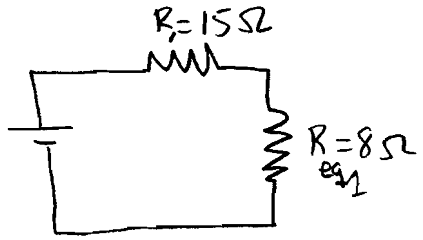
$$\frac{1}{R_{eq_1}} = \frac{1}{R_1} + \frac{1}{R_2}$$ find a common denominator

$$\frac{1}{R_{eq_1}} = \frac{R_2 + R_1}{R_1 R_2}$$ now we can invert both sides of the equation

$$R_{eq_1} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(12\Omega)(24\Omega)}{12\Omega + 24\Omega} = \frac{288\ \Omega^2}{36\ \Omega} = 8\ \Omega$$

Notice that the equivalent resistance is less than either resistor!

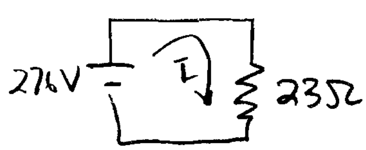
Now we have



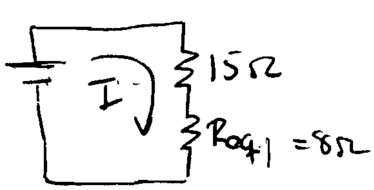
These are in series so

$$R_{eq_2} = R_1 + R_{eq_1}$$
$$= 15\Omega + 8\Omega = \boxed{23\ \Omega = R_{eq_2}}$$

So



↓ series



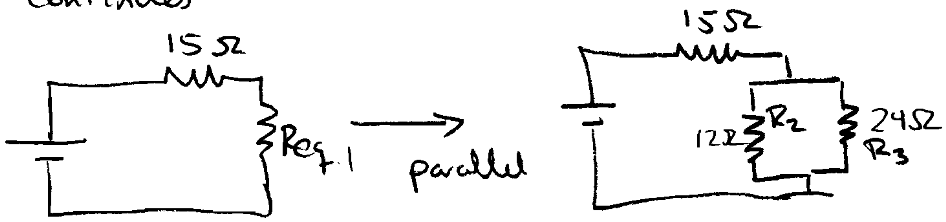
$$V = I R_{eq_2} \quad I = \frac{V}{R} = \frac{276V}{23\Omega} = 12\ A$$

The current through both resistors R_1 and R_{eq_1} is the same as R_{eq_2} since it is formed from the series combination.

The voltage across R_{eq_2}

$$V = I R_{eq_1} = (12A)(8\Omega) = 96V$$

40 continues

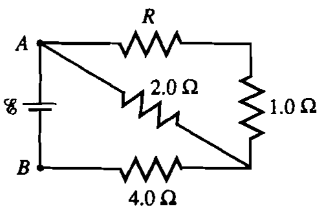


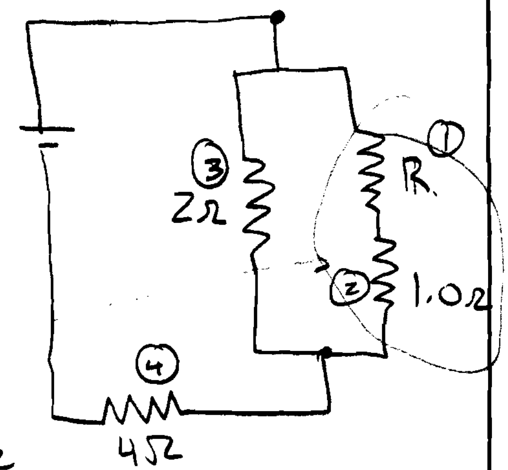
The voltage across R_2 = Voltage across R_3 since they are in parallel.

It is also equal to the voltage across Req 1 since they are formed from the parallel combination

$$I = \frac{V}{R_2} = \frac{96\,V}{12\,\Omega} = \boxed{8.0\,A = I}$$

41. (a) What is the equivalent resistance between points *A* and *B* if *R* = 1.0 Ω? (b) If a 20-V emf is connected to the terminals *A* and *B*, what is the current in the 2.0-Ω resistor?

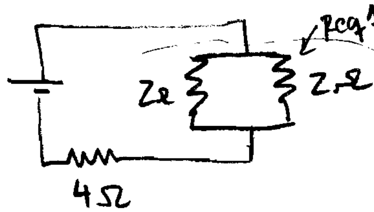




a) series $R_{eq} = R_1 + R_2$

$R_{eq_1} = R + 1.0\,\Omega = 1.0\,\Omega + 1.0\,\Omega = 2.0\,\Omega$

Now

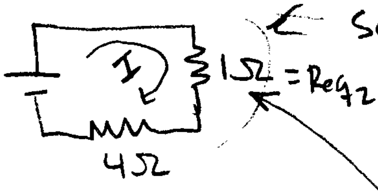


← parallel

$\frac{1}{R_{eq}} = \frac{1}{R_3} + \frac{1}{R_{eq_1}} = \frac{1}{2\Omega} + \frac{1}{2\Omega} = \frac{1}{1\Omega}$

$R_{eq_2} = 1\Omega$

Now

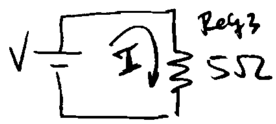


← series

$R_{eq_3} = R_4 + R_{eq_2}$

$= 1\Omega + 4\Omega = 5\Omega = R_{eq_3}$

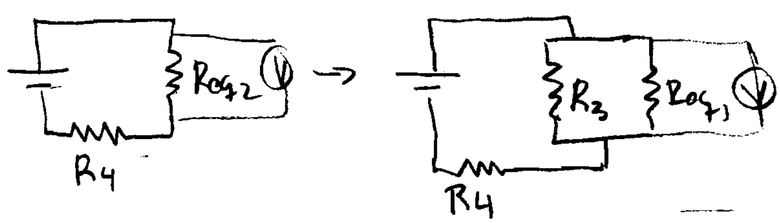
(b) Now



$I = \frac{V}{R} = \frac{20V}{5\Omega} = 4A$ = current through R_{eq_3}

So the current through $R_{eq_2} = 1\Omega$ is 4A since R_{eq_2} is in series w/ R_4

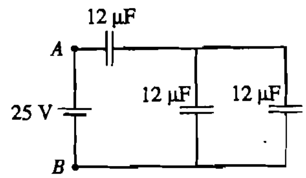
∴ $V = IR_{eq_2} = (1\Omega)(4A) = 4V$

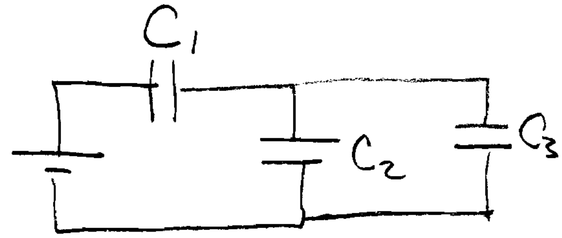


The voltage across R_{eq_2} is the same as the voltage across R_3 and R_{eq_1} since they are a parallel combination

$I = \frac{V}{R_3} = \frac{4V}{2\Omega} = 2A = I$

49. (a) Find the value of a single capacitor to replace the three capacitors in the diagram. (b) What is the potential difference across the 12-μF capacitor at the left side of the diagram? (c) What is the charge on the 12-μF capacitor to the far right side of the circuit?

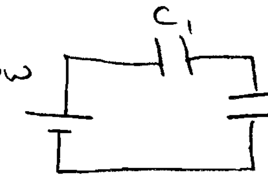




a) C_2 and C_3 are in parallel ∴ $C_{eq_1} = C_2 + C_3 = 12\mu F + 12\mu F$

$C_{eq_1} = 24\mu F$

Now

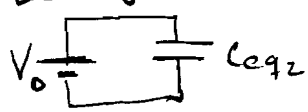


these are in series

$$\frac{1}{C_{eq_2}} = \frac{1}{C_1} + \frac{1}{C_{eq_1}} \Rightarrow C_{eq_2} = \frac{C_1 C_{eq_1}}{C_1 + C_{eq_1}} = \frac{(12\mu F)(24\mu F)}{36\mu F}$$

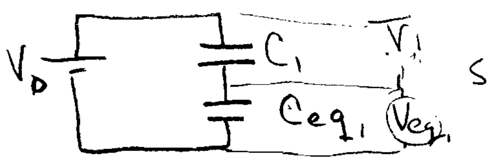
$$\boxed{C_{eq_2} = 8\mu F}$$

b) Looking for ΔV_1



$$Q = C\Delta V_1 = (8\mu F)\,25\,V = 200\mu C$$

charges are the same in series



So Q on C_{eq_1} = Q on C_{eq_2}

The voltage across $C_1 = V_1$

$$V_1 = \frac{Q}{C_1} = \frac{200\mu C}{12\mu F} = 16.7V$$

The charge on the 12 μF capacitor on the far right or C_3

The voltage accross C_3 is the same as the voltage accross C_{eq_1} or $V_0 - V_1 = 25V - 16.7V$

$= 8.33\,V$.

$$Q = C_3\,\Delta V = (12\mu F)(8.33V)$$

$$\boxed{Q_3 = 100\mu C}$$

62. A portable CD player does not have a power rating listed, but it has a label stating that it draws a maximum current of 250.0 mA. The player uses three 1.50-V batteries connected in series. What is the maximum power consumed?

$I = 250.0\ mA$

Three 1.50 V batteries in series

$V = V_1 + V_2 + V_3 = 3V = 3(1.50V) = 4.5V$

$P = IV = (250 \times 10^{-3} A)(4.5\ V)$

$\boxed{P = 1.125\ W}$

CAMPAD

Chapter 18

67. (a) What is the equivalent resistance if $R_1 = 10.0\,\Omega$ and $R_2 = 15.0\,\Omega$

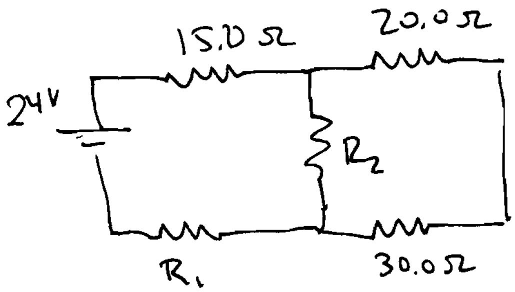
(b) What current flows through R_1

(c) What is the voltage drop across R_2?

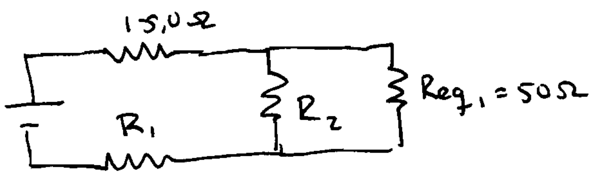
(d) What current flows through R_2?

(e) How much power is dissipated in R_2?

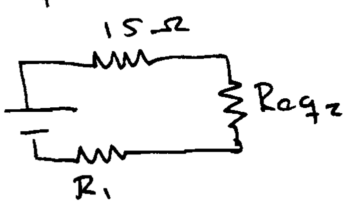
a)



The 20 Ω and 30 Ω are in series so $R_{eq1} = 20\,\Omega + 30\,\Omega = 50\,\Omega$



R_{eq1} and R_2 are in parallel so $R_{eq2} = \left(\frac{1}{R_{eq1}} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{50} + \frac{1}{15}\right)^{-1} = 11.5\,\Omega$



R_1, R_{eq2} and 15 Ω are in series so

$$R_{eq3} = R_1 + 15\,\Omega + R_{eq2} = 15\,\Omega + 10\,\Omega + 11.5\,\Omega =$$

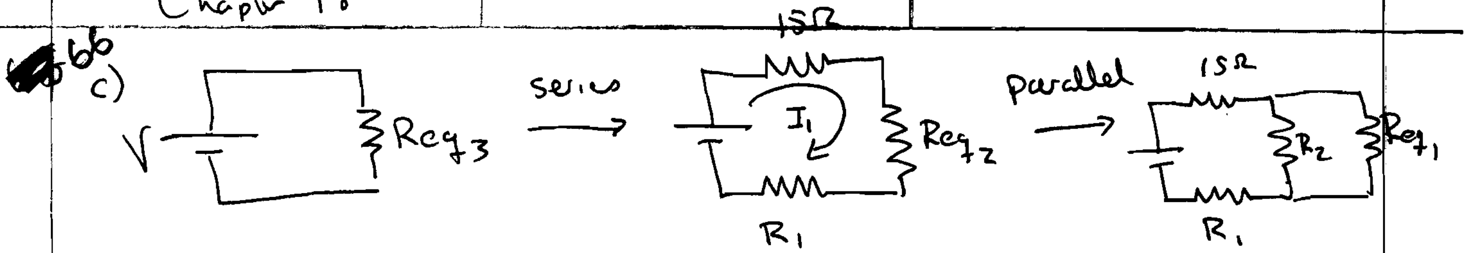
$$\boxed{R_{eq3} = 36.5\,\Omega}$$

b) The current flowing through R_{eq3} = The current through R_1 since R_{eq3} is formed from R_1 in series.

$$I = \frac{V}{R} = \frac{24\text{V}}{36.5\,\Omega} = \boxed{0.66\text{ A} = I_1}$$

Chapter 18

66 c)



The voltage across Req2 is the same as the voltage across R_2 and Req_1

$$V_{Req_2} = I_1 Req_2 = (0.66\,A)(11.5\,\Omega) = \boxed{7.55\,V} = V_2$$

d) The current through R_2

$$V_2 = I_2 R_2 \qquad I_2 = \frac{V_2}{R_2} = \frac{7.55\,V}{15\,\Omega} = \boxed{0.5\,A = I_2}$$

Aside:

Why isn't the current 0.66 A ? Because it splits between R_2 and Req_1 because of the junction.

e) Power in R_2 $\quad P = I_2 V_2 = (0.5A)(7.55V$

$$\boxed{P = 3.77\,W}$$