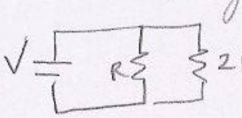
PHY 101 HW5 Solutions

Chapter 10 Exercises

(25) When someone tells a lie, typically, they perspire more. When someone perspires more, their body resistance changes, i.e. it is lowered. A lower resistance translates to a higher current via Ohm's law for a fixed voltage drop. The lie detector machine will register the change in (increase in) current.

(43) The pair of bulbs will glow more brightly in parallel than in series. In parallel the power for each bulb is $P_{\text{each bulb para.}} = IV = \frac{V^2}{R}$ (this is the rate of energy transferred to light). In series, $P_{\text{each bulb series}} = \left(\frac{V}{2}\right)^2 \frac{1}{R} = \frac{V^2}{4R}$, so $P_{\text{each bulb para}} = 4P_{\text{each bulb series}}$. The battery will run down faster for the parallel circuit because of the larger power (faster rate of energy conversion).

(45) Bulb C burns the most brightly since (as above) $P_C = \frac{V^2}{R}$ while $P_A = P_B = \frac{\left(\frac{V}{2}\right)^2}{R}$.
As for current:  2R (A and B combined) so larger resistance in the A/B path results in smaller current (half the current) than the current in the C path.

If A is unscrewed B will not light up because there is only one current path between them and C remains unaffected. If C is unscrewed, A and B remain unaffected.

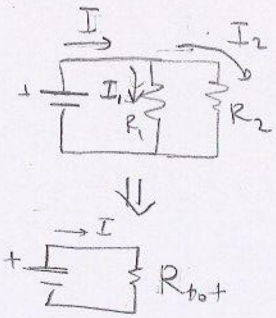
Chapter 10 Problems

(3) Let's use Coulomb's Law: $F_e = \frac{k_e q_1 q_2}{r^2}$. Since $q_1 = q_2 = q$ (given), we have $F_e = \frac{k_e q^2}{r^2}$. Solving for $q \Rightarrow$

$$q = \sqrt{\frac{F_e r^2}{k_e}} = \sqrt{\frac{(20N)(.06m)^2}{9\times10^9 Nm^2/C^2}}$$

$$= 8\times10^{-12}\ C^2.$$

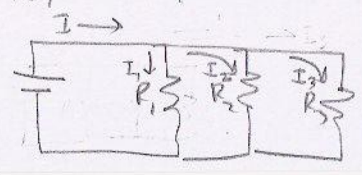
(7) Consider



Ohm's law applies to each resistor. Since charge is conserved, $I = I_1 + I_2$. Using $V = I_1 R_1$ and $V = I R_{tot}$ and $V = I_1 R_2$ (where both resistors see the same voltage) we can plug these three equations into $I = I_1 + I_2$ to arrive at

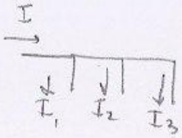
$$\frac{V}{R_{tot}} = \frac{V}{R_1} + \frac{V}{R_2} \Rightarrow \frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}.$$

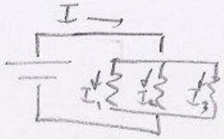
Now, lets do 3 resistors in parallel:



$I = I_1 + I_2 + I_3$

Such that $\frac{V}{R_{tot}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \Rightarrow \frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

One can continue this line of reasoning to obtain $\frac{1}{R_{tot}} = \sum_{i=1}^{n} \frac{1}{R_i}$ for n resistors in parallel. Note that  leads to $I = I_1 + I_2 + I_3$.

We could also draw it like . They are topologically equivalent.

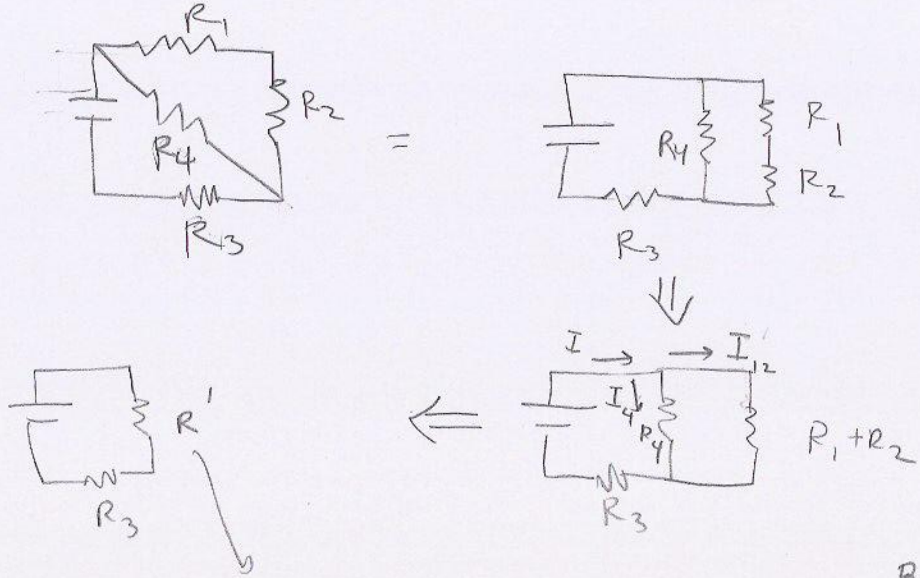
(12) Since the two headlights combined draw 6 A of current, a 60 A-hr battery will last 10 hours.

(13) Using $P = \frac{E}{t}$, $E = Pt = \underbrace{(0.1\,\text{kW})}_{\text{we want the power in terms of kW hrs}}\underbrace{(168\text{ hours})}_{\text{in a week}} = 16.8$ kW-hr. At 20 cents per kWhr, $(16.8) \times (.20) = \underline{\$3.36}$.

(17) Using $V = IR$, when $V = 120V$ and $I = 10$ Amps, $R = \frac{V}{I} = \frac{120V}{10A} = 12\,\Omega$.

So, when $V = 108V$, $I = \frac{V}{R} = \frac{108V}{12\Omega} = 9A$. So the current is lowered by $\underline{10\%}$, but the $\underline{\text{power}}$ $P = VI = (IR)I = I^2R$ is lowered by $(.9)(.9) = \underline{.81}$ or $\underline{81\%}$.

Extra Credit : Start w/

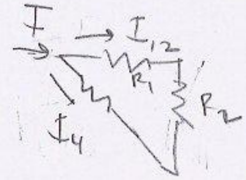


$$\frac{1}{R'} = \frac{1}{R_4} + \frac{1}{R_1+R_2} = \frac{R_1+R_2+R_4}{R_4(R_1+R_2)}$$

$$\Rightarrow R' = \frac{R_4(R_1+R_2)}{R_1+R_2+R_4}$$

Finally, $R_{tot} = R_3 + R' = R_3 + \frac{R_4(R_1+R_2)}{R_1+R_2+R_4} = 4\Omega + \frac{2\Omega(1\Omega+1\Omega)}{1\Omega+1\Omega+2\Omega}$

$$= 4\Omega + \frac{4\Omega^2}{4\Omega} = \underline{5\Omega}.$$

To find I_4, use this loop  to apply $\sum \Delta V = 0$

around a loop such that $I_{12}(R_1+R_2) = I_4 R_4 \rightarrow I_{12} = \frac{I_4 R_4}{R_1+R_2}$.

Now use $I = I_{12} + I_4 = \frac{I_4 R_4}{R_1+R_2} + I_4 = \frac{V}{R_{tot}} \Rightarrow I_4 = \frac{V}{R_{tot}}\left(1 + \frac{R_4}{R_1+R_2}\right)^{-1}$.

$\underline{I_4 = 2\ A}$!