Circuits I – Tutorial 03

Circuits Simplification techniques

#	Student ID	Student Name	Grade (10)
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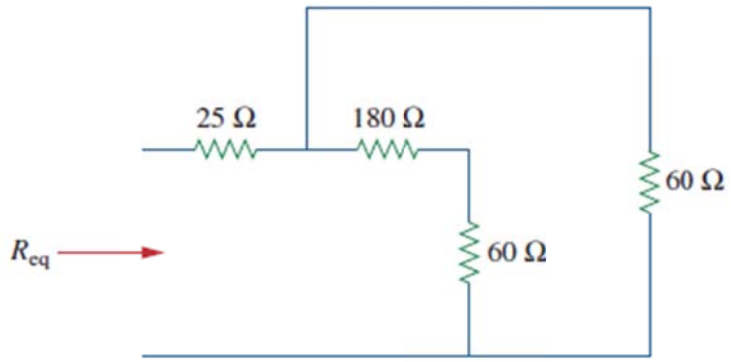
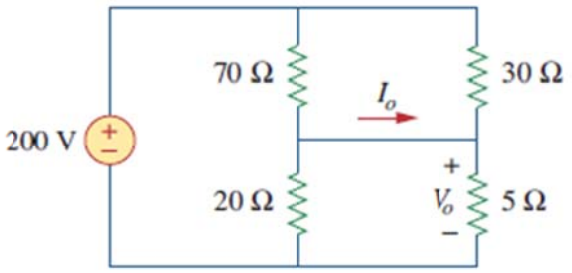
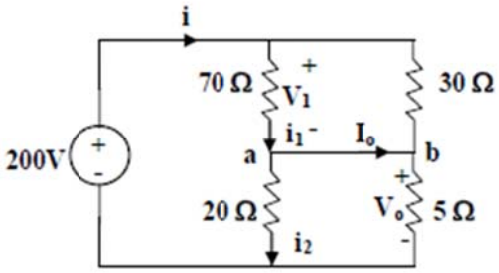
Q1	**2.30** Find R_{eq} for the circuit in Fig. 2.94. 
Sol 1	We start by combining the 180-ohm resistor with the 60-ohm resistor which in turn is in parallel with the 60-ohm resistor or = [60(180+60)/(60+180+60)] = 48. Thus, $R_{eq} = 25+48 = \mathbf{73\ \Omega}$.

Q2

2.35 Calculate V_o and I_o in the circuit of Fig. 2.99.



Sol 2



Combining the resistors that are in parallel,

$$70\|30 = \frac{70x30}{100} = 21\Omega, \qquad 20\|5 = \frac{20x5}{25} = 4\,\Omega$$

$$i = \frac{200}{21+4} = 8\text{ A}$$

$$v_1 = 21i = 168\text{ V}, \; v_o = 4i = 32\text{ V}$$

$$i_1 = \frac{v_1}{70} = 2.4\text{ A}, \; i_2 = \frac{v_o}{20} = 1.6\text{ A}$$

At node a, KCL must be satisfied

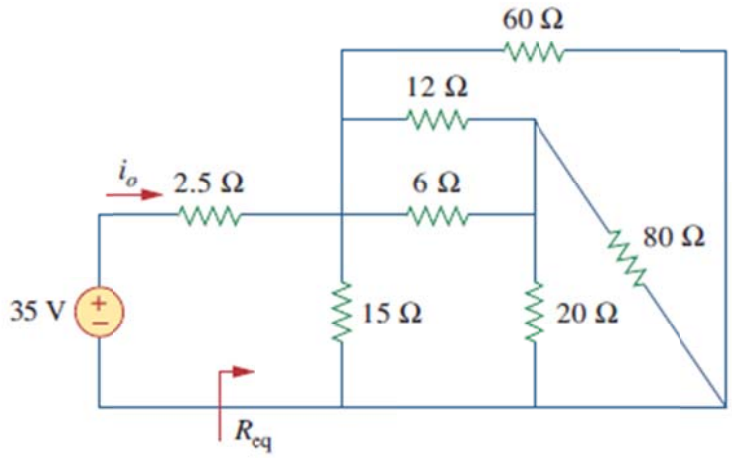
$$i_1 = i_2 + I_o \longrightarrow 2.4 = 1.6 + I_o \longrightarrow I_o = 0.8\text{ A}$$

Hence,

$$v_o = 32\text{ V and } I_o = 800\text{ mA}$$

Q3

2.38 Find R_{eq} and i_o in the circuit of Fig. 2.102.

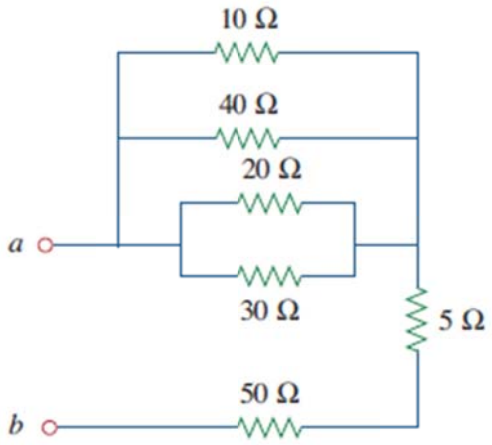


Sol 3

$(4 + 16)//60 = 20x60/80 = 15$

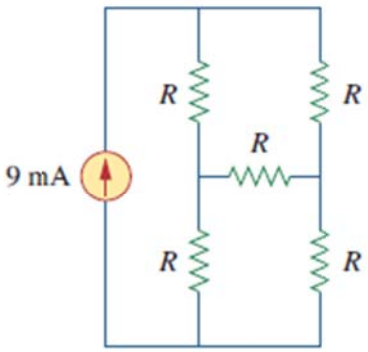
$R_{eq} = 2.5+15||15 = 2.5+7.5 = \mathbf{10\ \Omega}$ and

$i_o = 35/10 = \mathbf{3.5\ A}.$

Q4	**2.45** Find the equivalent resistance at terminals *a-b* of each circuit in Fig. 2.109.  (a)
Sol 4	(a) $10//40 = 8,\ 20//30 = 12,\ 8//12 = 4.8$ $R_{ab} = 5 + 50 + 4.8 = \underline{59.8\Omega}$

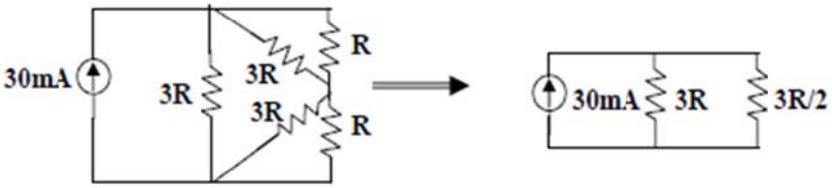
Q5

2.50 Design a problem to help other students better understand wye-delta transformations using Fig. 2.114.



Sol 5

Using $R_\Delta = 3R_Y = 3R$, we obtain the equivalent circuit shown below:



$$3R \| R = \frac{3R \times R}{4R} = \frac{3}{4}R$$

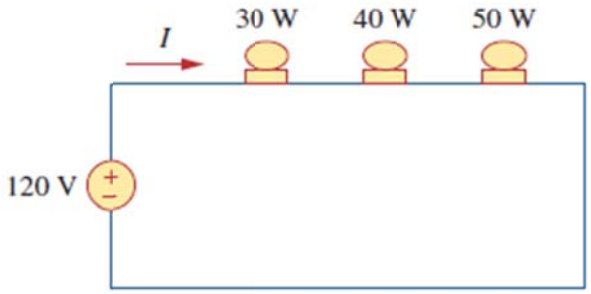
$$3R \| \left(\frac{3}{4}R + \frac{3}{4}R \right) = 3R \| \frac{3}{2}R = \frac{3R \times \frac{3}{2}R}{3R + \frac{3}{2}R} = R$$

$$P = I^2R \qquad 800 \times 10^{-3} = (30 \times 10^{-3})^2 R$$

$$R = \underline{889\ \Omega}$$

Q6

2.59 Three light bulbs are connected in series to a 120-V source as shown in Fig. 2.123. Find the current I through the bulbs. Each bulb is rated at 120 volts. How much power is each bulb absorbing? Do they generate much light?



Sol 6

Using $p = v^2/R$, we can calculate the resistance of each bulb.

$R_{30W} = (120)^2/30 = 14{,}400/30 = 480\ \Omega$

$R_{40W} = (120)^2/40 = 14{,}400/40 = 360\ \Omega$

$R_{50W} = (120)^2/50 = 14{,}400/50 = 288\ \Omega$

The total resistance of the three bulbs in series is $480+360+288 = 1128\ \Omega$.

The current flowing through each bulb is $120/1128 = 0.10638$ A.

$p_{30} = (0.10638)^2 480 = 0.011317 \times 480 = \mathbf{5.432\ W}$.

$p_{40} = (0.10638)^2 360 = 0.011317 \times 360 = \mathbf{4.074\ W}$.

$p_{50} = (0.10638)^2 288 = 0.011317 \times 288 = \mathbf{3.259\ W}$.

Clearly these values are well below the rated powers of each light bulb so we would not expect very much light from any of them. To work properly, they need to be connected in parallel.

Q7	**2.66** A 20-kΩ/V voltmeter reads 10 V full scale. (a) What series resistance is required to make the meter read 50 V full scale? (b) What power will the series resistor dissipate when the meter reads full scale?
Sol 7	$20\ \text{k}\Omega/\text{V} = \text{sensitivity} = \frac{1}{I_{fs}}$ $\text{i.e., } I_{fs} = \frac{1}{20}\text{k}\Omega/\text{V} = 50\ \mu\text{A}$ $\text{The intended resistance } R_m = \frac{V_{fs}}{I_{fs}} = 10(20\text{k}\Omega/\text{V}) = 200\text{k}\Omega$ (a) $R_s = \frac{V_{fs}}{i_{fs}} - R_m = \frac{50\ \text{V}}{50\,\mu\text{A}} - 200\ \text{k}\Omega = \mathbf{800\ k\Omega}$ (b) $p = I_{fs}^2 R_s = (50\ \mu\text{A})^2(800\ \text{k}\Omega) = \mathbf{2\ mW}$