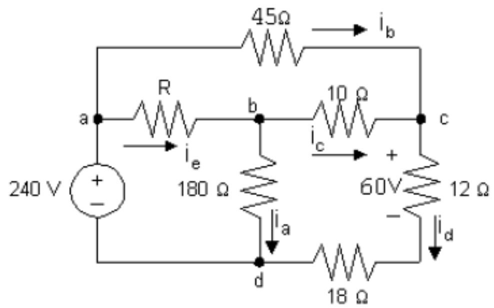
P 2.24



$i_{\rm d} = 60/12 = 5\,{\rm A};$ therefore, $v_{\rm cd} = 60 + 18(5) = 150\,{\rm V}$
$-240 + v_{\rm ac} + v_{\rm cd} = 0;$ therefore, $v_{\rm ac} = 240 - 150 = 90\,{\rm V}$
$i_{\rm b} = v_{\rm ac}/45 = 90/45 = 2\,{\rm A};$ therefore, $i_{\rm c} = i_{\rm d} - i_{\rm b} = 5 - 2 = 3\,{\rm A}$
$v_{\rm bd} = 10 i_{\rm c} + v_{\rm cd} = 10(3) + 150 = 180\,{\rm V};$
therefore, $i_{\rm a} = v_{\rm bd}/180 = 180/180 = 1\,{\rm A}$
$i_{\rm e} = i_{\rm a} + i_{\rm c} = 1 + 3 = 4\,{\rm A}$
$-240 + v_{\rm ab} + v_{\rm bd} = 0$ therefore, $v_{\rm ab} = 240 - 180 = 60\,{\rm V}$
$R = v_{\rm ab}/i_{\rm e} = 60/4 = 15\,\Omega$

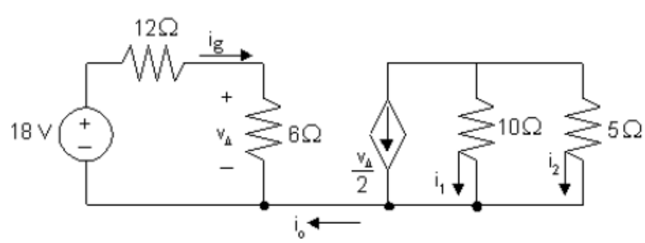
CHECK: $i_g = i_{\rm b} + i_{\rm e} = 2 + 4 = 6$ A

$p_{\rm dev} = (240)(6) = 1440$ W

$$\sum P_{\rm dis} = 1^2(180) + 4^2(15) + 3^2(10) + 5^2(12) + 5^2(18) + 2^2(45)$$
$$= 1440 \text{ W (CHECKS)}$$

P 2.27 [a] $i_o = 0$ because no current can exist in a single conductor connecting two parts of a circuit.

[b]



$18 = (12 + 6) i_g$ $\quad i_g = 1$ A

$v_\Delta = 6 i_g = 6\text{V}$ $\quad v_\Delta/2 = 3$ A

$10 i_1 = 5 i_2,$ so $i_1 + 2 i_1 = -3$ A; therefore, $i_1 = -1$ A

[c] $i_2 = 2 i_1 = -2$ A.

P 3.5 [a] $R_{\text{ab}} = 10 + (5\|20) + 6 = 10 + 4 + 6 = 20\,\Omega$

[b] $R_{\text{ab}} = 30\text{ k}\|60\text{ k}\|[20\text{ k} + (200\text{ k}\|50\text{ k})] = 30\text{ k}\|60\text{ k}\|(20\text{ k} + 40\text{ k})$

$$= 30\text{ k}\|60\text{ k}\|60\text{ k} = 15\ \text{k}\Omega$$

P 3.13 [a] $R_{\text{eq}} = R\|R = \dfrac{R^2}{2R} = \dfrac{R}{2}$

[b]
$$\begin{aligned} R_{\text{eq}} &= R\|R\|R\|\cdots\|R \qquad (n\ R\text{'s}) \\ &= R\|\frac{R}{n-1} \\ &= \frac{R^2/(n-1)}{R + R/(n-1)} = \frac{R^2}{nR} = \frac{R}{n} \end{aligned}$$

[c] $\dfrac{R}{2} = 5000 \quad \text{so} \quad R = 10\ \text{k}\Omega$

This is a resistor from Appendix H.

[d] $\dfrac{R}{n} = 4000 \quad \text{so} \quad R = 4000n$

If $n = 3 \qquad r = 4000(3) = 12\ \text{k}\Omega$

This is a resistor from Appendix H. So put three 12k resistors in parallel to get 4kΩ.

P 3.20 $\dfrac{(24)^2}{R_1 + R_2 + R_3} = 80, \qquad$ Therefore, $R_1 + R_2 + R_3 = 7.2\,\Omega$

$$\frac{(R_1 + R_2)24}{(R_1 + R_2 + R_3)} = 12$$

Therefore, $2(R_1 + R_2) = R_1 + R_2 + R_3$

Thus, $R_1 + R_2 = R_3; \qquad 2R_3 = 7.2; \qquad R_3 = 3.6\,\Omega$

$$\frac{R_2(24)}{R_1 + R_2 + R_3} = 5$$

$4.8R_2 = R_1 + R_2 + 3.6 = 7.2$

Thus, $R_2 = 1.5\,\Omega; \qquad R_1 = 7.2 - R_2 - R_3 = 2.1\,\Omega$

P 3.28 $5\,\Omega \| 20\,\Omega = 4\,\Omega;\qquad 4\,\Omega + 6\,\Omega = 10\,\Omega;\qquad 10\|(15+12+13) = 8\,\Omega;$

Therefore, $i_g = \dfrac{125}{2+8} = 12.5$ A

$$i_{6\Omega} = \frac{8}{6+4}(12.5) = 10 \text{ A};\quad i_o = \frac{5\|20}{20}(10) = 2 \text{ A}$$

P 3.30 [a] The voltage across the $9\,\Omega$ resistor is $1(12+6) = 18$ V.
The current in the $9\,\Omega$ resistor is $18/9 = 2$ A. The current in the $2\,\Omega$ resistor is $1+2 = 3$ A. Therefore, the voltage across the $24\,\Omega$ resistor is $(2)(3) + 18 = 24$ V.
The current in the $24\,\Omega$ resistor is 1 A. The current in the $3\,\Omega$ resistor is $1+2+1 = 4$ A. Therefore, the voltage across the $72\,\Omega$ resistor is $24 + 3(4) = 36$ V.
The current in the $72\,\Omega$ resistor is $36/72 = 0.5$ A.
The $20\,\Omega \| 5\,\Omega$ resistors are equivalent to a $4\,\Omega$ resistor. The current in this equivalent resistor is $0.5 + 1 + 3 = 4.5$ A. Therefore the voltage across the $108\,\Omega$ resistor is $36 + 4.5(4) = 54$ V.
The current in the $108\,\Omega$ resistor is $54/108 = 0.5$ A. The current in the $1.2\,\Omega$ resistor is $4.5 + 0.5 = 5$ A. Therefore,

$$v_g = (1.2)(5) + 54 = 60 \text{ V}$$

[b] The current in the $20\,\Omega$ resistor is

$$i_{20} = \frac{(4.5)(4)}{20} = \frac{18}{20} = 0.9 \text{ A}$$

Thus, the power dissipated by the $20\,\Omega$ resistor is

$$p_{20} = (0.9)^2(20) = 16.2 \text{ W}$$

P 3.43 [a] $v_{\text{meter}} = 180$ V

[b] $R_{\text{meter}} = (100)(200) = 20$ kΩ

$$20\|70 = 15.555556 \text{ k}\Omega$$

$$v_{\text{meter}} = \frac{180}{35.555556} \times 15.555556 = 78.75 \text{ V}$$

[c] $20\|20 = 10$ kΩ

$$v_{\text{meter}} = \frac{180}{80}(10) = 22.5 \text{ V}$$

[d] $v_{\text{meter a}} = 180$ V

$v_{\text{meter b}} + v_{\text{meter c}} = 101.26$ V

No, because of the loading effect.

P 3.45 [a]

$$R_1 = (100/2)10^3 = 50\ \text{k}\Omega$$

$$R_2 = (10/2)10^3 = 5\ \text{k}\Omega$$

$$R_3 = (1/2)10^3 = 500\,\Omega$$

[b] Let i_{a} = actual current in the movement

i_{d} = design current in the movement

$$\text{Then \% error } = \left(\frac{i_{\text{a}}}{i_{\text{d}}} - 1\right)100$$

For the 100 V scale:

$$i_{\text{a}} = \frac{100}{50{,}000 + 25} = \frac{100}{50{,}025}, \qquad i_{\text{d}} = \frac{100}{50{,}000}$$

$$\frac{i_{\text{a}}}{i_{\text{d}}} = \frac{50{,}000}{50{,}025} = 0.9995 \qquad \text{\% error } = (0.9995 - 1)100 = -0.05\%$$

For the 10 V scale:

$$\frac{i_{\text{a}}}{i_{\text{d}}} = \frac{5000}{5025} = 0.995 \qquad \text{\% error } = (0.995 - 1.0)100 = -0.4975\%$$

For the 1 V scale:

$$\frac{i_{\text{a}}}{i_{\text{d}}} = \frac{500}{525} = 0.9524 \qquad \text{\% error } = (0.9524 - 1.0)100 = -4.76\%$$