Example #1: A 10 ampere current flows through a wire in 60 seconds. Determine:

a) **The amount of charge that moves in 60 seconds.**
b) **The number of electrons that pass in 60 seconds.**

a) $I = \frac{q}{t}$

$\Rightarrow q = 10(60) = \boxed{6.0 \times 10^{2}\ C}$

b) $600\ C \times \frac{1 e^-}{1.6 \times 10^{-19} C}$

$= \boxed{3.8 \times 10^{21}\ e^-}$

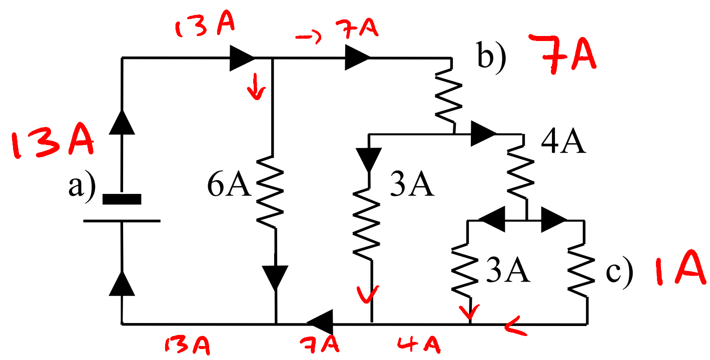
Example #2: If a current of 5.0 A flows for 20 minutes, what charge was transferred?

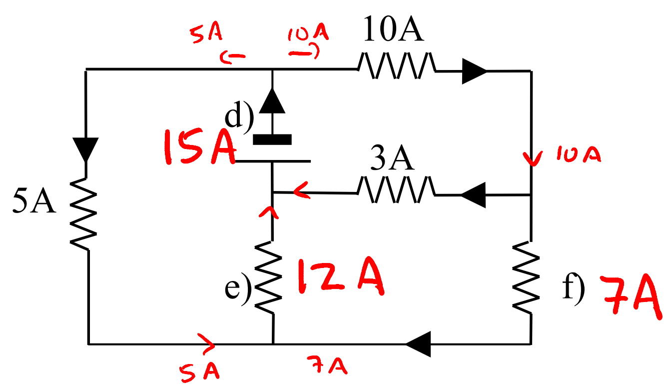
$$20 \text{ minutes} \times \frac{60 \text{ s}}{1 \text{ min}} = 1200 \text{ s}.$$

$$I = \frac{q}{t} \Rightarrow q = 5.0(1200)$$

$$\boxed{q = 6.0 \times 10^3 \text{ C}}$$

Example #3: Determine the unknown currents for each of the following circuits.



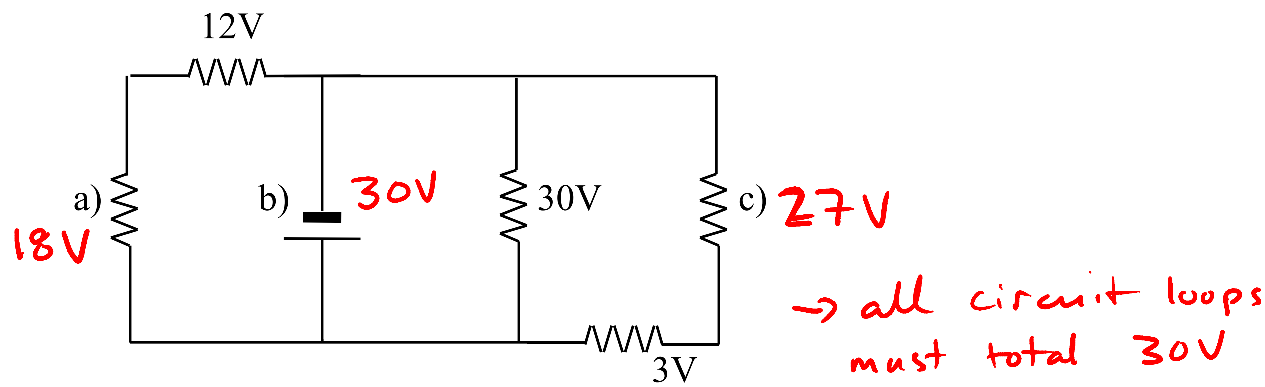


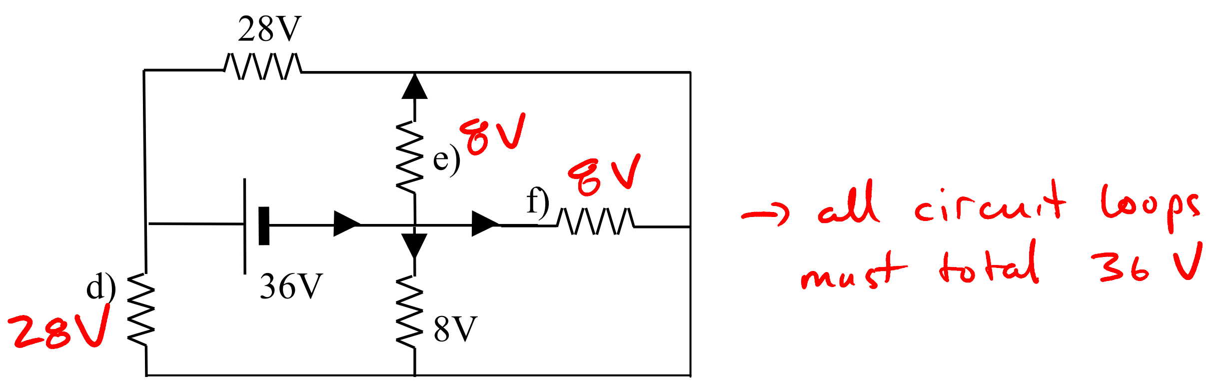
Example #4: If a chemical cell gives 600 J of energy to a charge of 50 C, what is the potential difference of this cell?

$$V = \frac{\Delta E_p}{q} = \frac{600}{50}$$

$$\boxed{V = 12\ V}$$

Example #5: Determine the unknown voltages for each of the following circuits.





Example #6: A small light bulb is connected to 3.0 V and will draw 150 mA.

(a) What is the net resistance of the bulb?

(b) If the voltage dropped to 2.0 V, how would the current change?

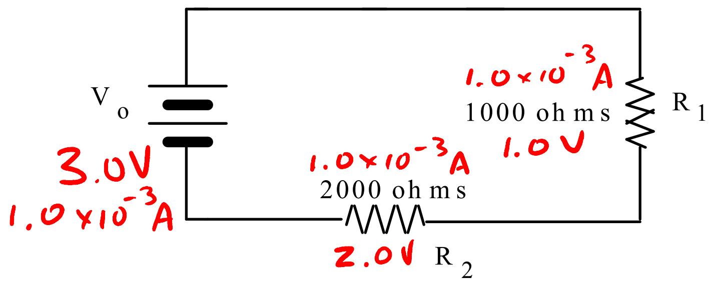
a) 150 mA = 0.150 A

$$R = \frac{V}{I} = \frac{3.0}{0.15} = \boxed{20\ \Omega}$$

b)

$$I = \frac{V}{R} = \frac{3.0}{20} = \boxed{1.2 \times 10^{2}\ V}$$

Example #7: Consider the following circuit diagram showing two resistors attached in series to a battery of two 1.5 V cells. Determine all unknown voltages, currents and resistances for each apparatus in the circuit.



V_o = p.d. of 2-1.5 cells in series

Since cells connected in series have their voltages added together, the total voltage,

$$V_o = 2 \times 1.5 \text{ V}$$
$$= 3.0 \text{ V}$$

→ in series, $R_o = 1000 + 2000$
$= 3000\ \Omega$

→ $I_o = \frac{V_o}{R_o} = \frac{3}{3000} = 1.0\times10^{-3}$ A

→ in series, I is constant, so

$$I_1 = I_2 = 1.0\times10^{-3}\text{ A}$$

Finally,

$$V_1 = I_1 R_1 = .001(1000)$$
$$= 1.0 \text{ A}$$

$$V_2 = I_2 R_2 = .001(2000)$$
$$= 2.0 \text{ A}$$

Example #8: Use your calculator to add these resistors in parallel:

(a) 25 Ω, 30 Ω, 50 Ω

(b) 50 Ω, 68 Ω, 270 Ω, 569 Ω

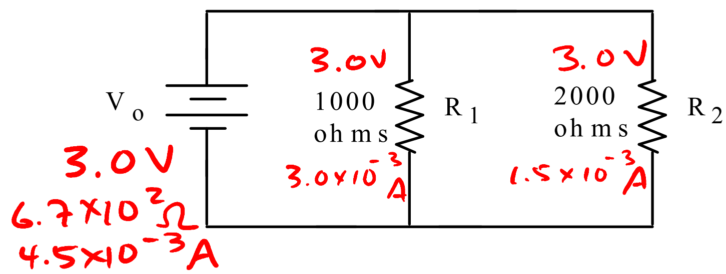
a) $\frac{1}{R_o} = \frac{1}{25} + \frac{1}{30} + \frac{1}{50}$

$$\boxed{R_o = 11\,\Omega}$$

b) $R_o = \left[\frac{1}{50} + \frac{1}{68} + \frac{1}{270} + \frac{1}{569}\right]^{-1}$

$$\boxed{R_o = 25\,\Omega}$$

Example #9: Consider the following circuit diagram showing two resistors attached in parallel to a battery of two 1.5 V cells. Determine all unknown currents, voltages and resistances.



→ $R_o = \left[\frac{1}{1000} + \frac{1}{2000}\right]^{-1} = 6.7 \times 10^{2}\ \Omega$ (667)

→ $I_o = \frac{V_o}{R_o} = \frac{3.0}{667} = 4.5 \times 10^{-3}\ A$

→ voltage drop across each resistor equals voltage gain by battery, so

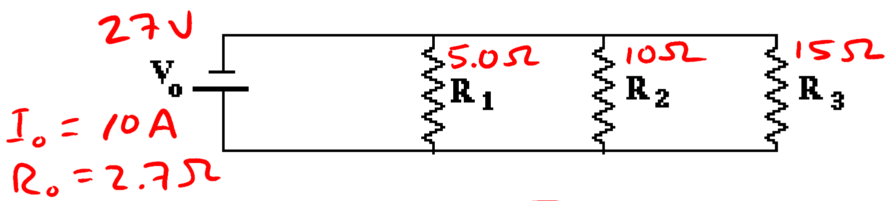
$V_1 = V_2 = 3.0\ V$

→ finally,

$I_1 = \frac{V_1}{R_1} = \frac{3.0}{1000} = 3.0 \times 10^{-3}\ A$

$I_2 = \frac{V_2}{R_2} = \frac{3.0}{2000} = 1.5 \times 10^{-3}\ A$

Example #10: In this example R_1= 5.0 Ω, R_2 =10 Ω and R_3 = 15 Ω and the total current is 10 A. Find the current in each branch.



→ first find $R_o = \left[\frac{1}{5} + \frac{1}{10} + \frac{1}{15}\right]^{-1}$

$= 2.7\,\Omega$

→ $V_o = I_o R_o = 10(2.7) = 27\text{ V}$ (27.3)

→ $V_1 = V_2 = V_3 = 27\text{ V}$

→ finally, $I_1 = \frac{27.3}{5} = 5.5\text{ A}$

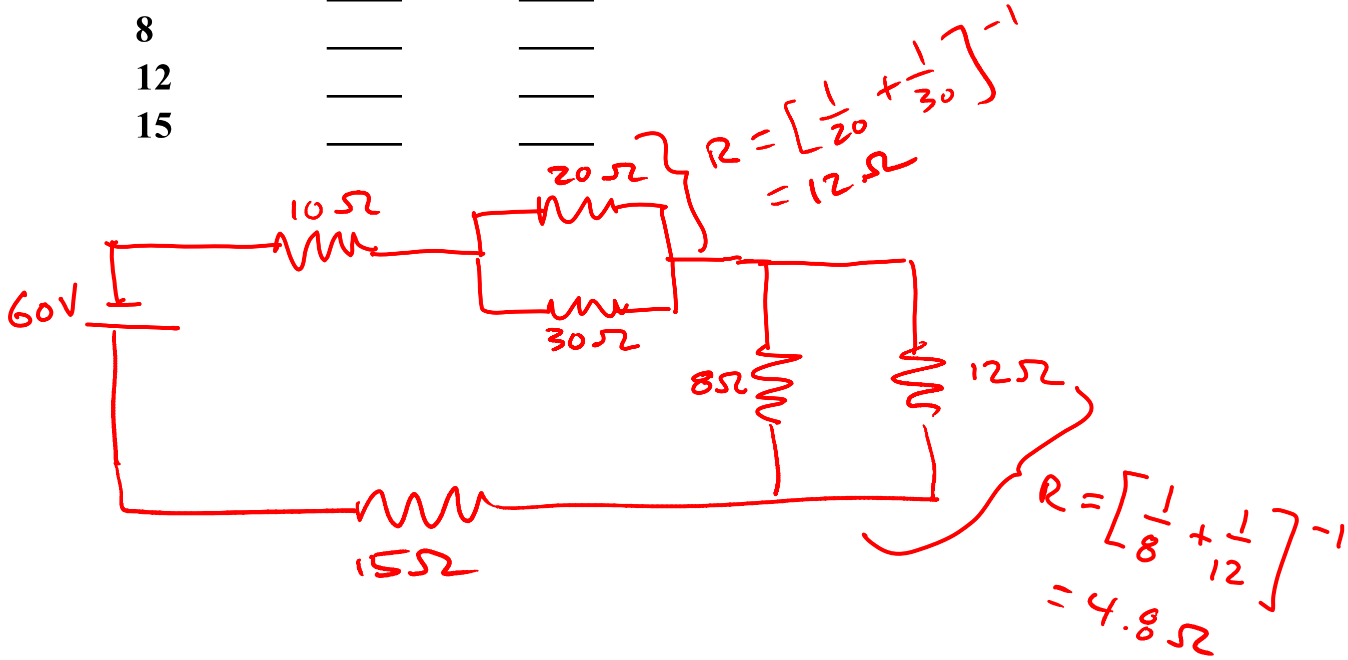
$I_2 = \frac{27.3}{10} = 2.7\text{ A}$

$I_3 = \frac{27.3}{15} = 1.8\text{ A}$

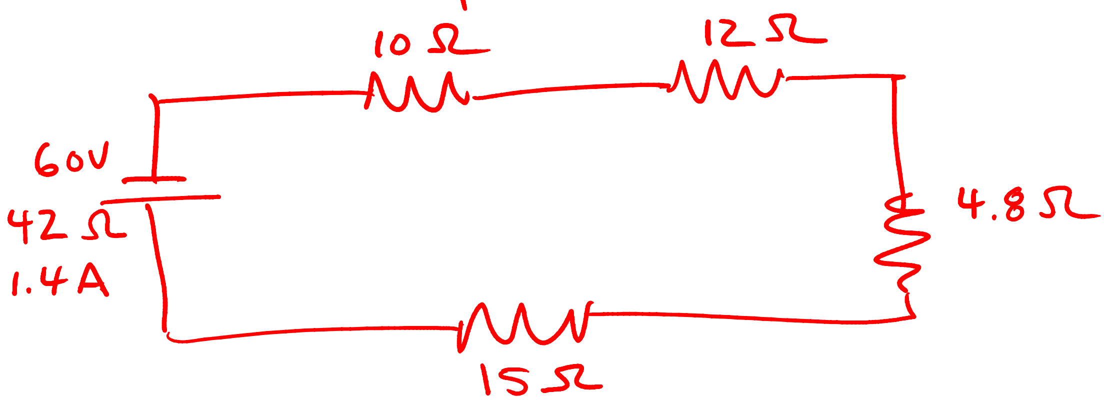
(check: $I_1 + I_2 + I_3 = 10\text{ A}$)

Example #11: Complete the table for the circuit on the previous page:

R (Ω)	V (V)	I (A)
10	____	____
20	____	____
30	____	____
8	____	____
12	____	____
15	____	____



→ Redraw a simplified circuit:



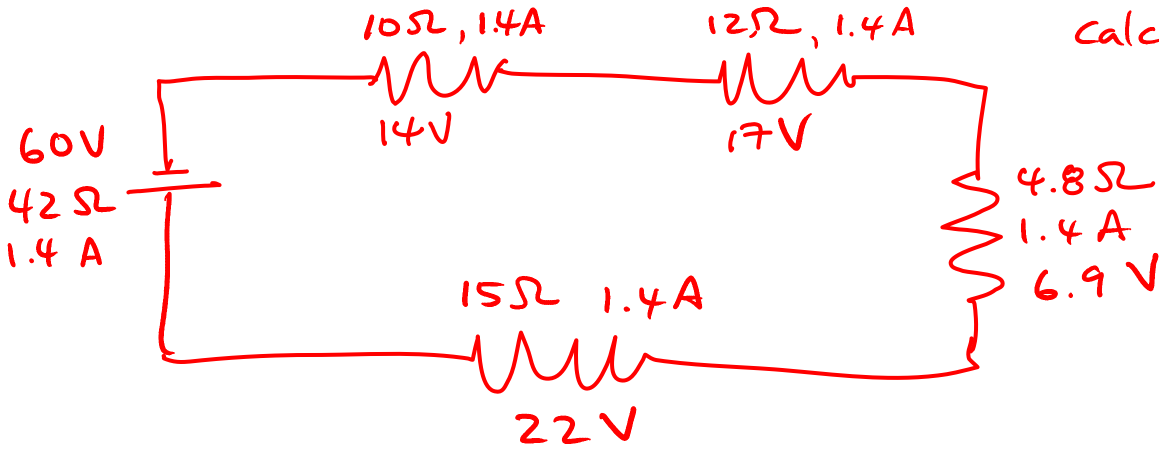
→ $R_o = 10 + 12 + 4.8 + 15 = 42\,\Omega$ (41.8)

→ $I_o = \frac{60}{41.8} = 1.4\text{ A}$ (1.44)

→ analyzing simplified diagram, current through each resistance = 1.44 A

(continued next page)

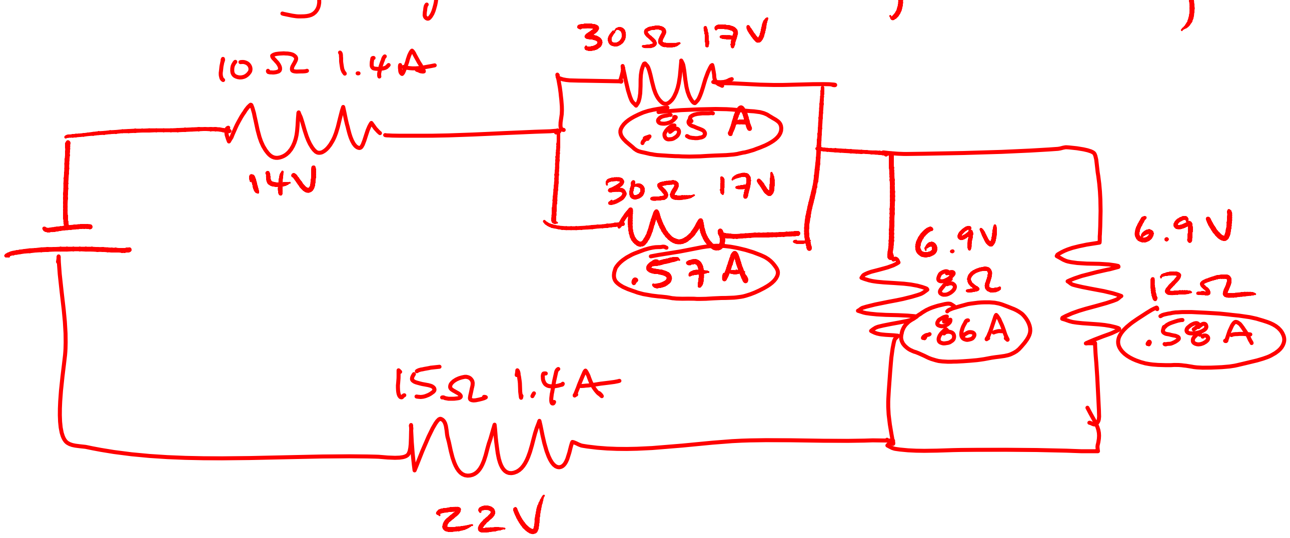
→ now find voltage drop for each resistance in simplified diagram, using $V = IR$ ($I = 1.44A$ for calculations)



→ at this point, check voltage:

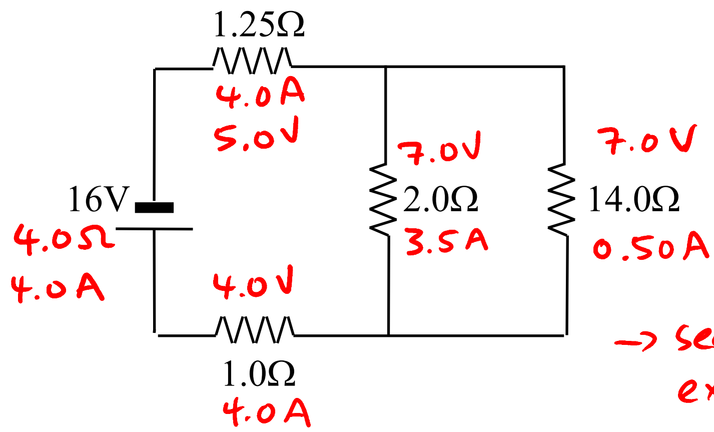
$14 + 17 + 6.9 + 22 = 59.9 \sim 60\,V$ ✓

→ finally, go back to original diagram:

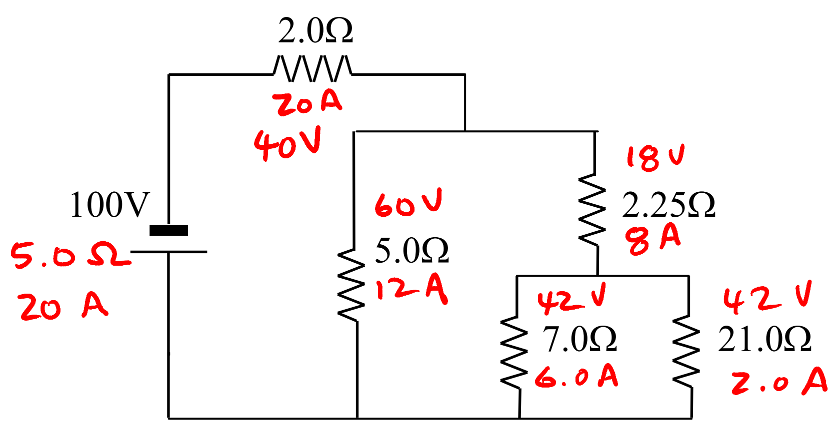


→ using voltage drops, and $I = \frac{V}{R}$, current through parallel resistors can be determined

Example #12: Calculate all unknown voltages, currents and resistances for the following circuits:



→ see below for explanation



→ see below for explanation

For circuit 1:

→ find R_o, then I_o

→ current through 1.25Ω, 1.0Ω resistors is the same as the battery, so use $V = IR$ to find voltage drops in those resistors

→ finally, use Kirchhoff's Voltage rule to find voltage drop across 2.0Ω, 14Ω resistors, then $I = \frac{V}{R}$ to find current flow in those resistors.

For circuit 2:

- → find R_o, then I_o
- → current across $2.0\,\Omega$ resistor = I_o for battery, so use $V = IR$ to find voltage drop in this resistor
- → use Kirchhoff Voltage rule to find drop in $5.0\,\Omega$ resistor, then find current in this resistor
- → use Kirchhoff Current rule to find current flow in $2.25\,\Omega$ resistor, then $V = IR$ to find voltage in this resistor
- → finally, use Kirchhoff Voltage rule to find missing drops in each of $7\,\Omega$, $21\,\Omega$ resistor, and Ohm's Law to find current in each resistor //

Example #13: From the circuit diagram for example 11, calculate the power used by each resistor connected in the circuit.

→ since all voltages + currents are known, use $P = IV$ to solve for each resistor:

$10\,\Omega \rightarrow 20\,W$

$20\,\Omega \rightarrow 15\,W$

$30\,\Omega \rightarrow 9.9\,W$

$8.0\,\Omega \rightarrow 5.9\,W$

$12\,\Omega \rightarrow 4.0\,W$

$15\,\Omega \rightarrow 30\,W$

Note: power provided by battery

$= 1.44 \times 60 = 86\ W$

→ this is equal (within error for rounding) to the total power used by the resistors.

Example #14: Find the cost of operating a kettle for 15 min if it draws 10 A from a standard 120 V outlet, and the cost is 5.5¢/kWh.

→ $15 \text{ min} \times \frac{1 \text{ hr}}{60 \text{ min}} = 0.25 \text{ hr}$

→ $P = IV = 10(120) = 1200 W$

→ $1200 W = 1.2 kW$

→ energy used: $P = \frac{\Delta E}{t}$

$\Delta E = 1.2(0.25) = 0.30 kW \cdot h$

→ cost = $0.30 \cancel{kW \cdot h} \times \frac{\$.055}{\cancel{kW \cdot h}}$

$= \boxed{\$.017}$

Example #15: An electric fan draws 2.0 A of current from a 120 V source. Determine the following:

(a) the power rating of the fan.

(b) its electrical resistance.

(c) the cost of operation of the fan during the month of August, assuming it is run continuously and electric energy costs 10 cents per kilowatt hour.

a) $P = IV = 2.0(120)$

$$\boxed{P = 2.4 \times 10^2 \text{ W}}$$

b) $R = \frac{V}{I} = \frac{120}{2.0} = \boxed{60\ \Omega}$

→ could also use $P = \frac{V^2}{R}$ to solve

c) $\#\text{hours} = 31 \text{ days} \times \frac{24 \text{ hr}}{1 \text{ day}}$

$= 744 \text{ hr.}$

power is 0.24 kW

$P = \frac{\Delta E}{t}$, $\Delta E = .24(744)$

$\Delta E = 178.56 \text{ kW} \cdot \text{h}$

$\text{Cost} = 178.56 \text{ kW} \cdot \text{h} \times \frac{\$.10}{\text{kW} \cdot \text{h}}$

$\boxed{= \$18}$ (17.86)

Example #16: A 6.0 volt motor is used to winch a 0.056 kg mass a vertical distance of 0.65 m in 5.62 sec. What current will the motor draw?

→ use $P = IV$

↳ must find power first

$$P = \frac{\Delta E}{t} = \frac{mg\Delta h}{t}$$

$$= \frac{.056(9.8)(.65)}{5.62}$$

$$= 6.35 \times 10^{-2}\ W$$

$$I = \frac{P}{V} = \frac{.35672}{6.0}$$

$$\boxed{I = 1.06 \times 10^{-2}\ A}$$

Example #17: When a 6.0 V EMF battery was connected to a 15 Ω resistance, a current of 375 mA occurred and the voltmeter reading was 5.625 V.

(a) Find the internal resistance r of this supply.

(b) If this battery is now connected to a 5.0 Ω resistor, what current will flow?

a) $V_T = \mathcal{E} - Ir$ where V_T = voltmeter reading

$5.625 = 6.0 - .375r$

$$\boxed{r = 1.0\,\Omega}$$

b) $R_o = 5.0\,\Omega$

$V_T = \mathcal{E} - Ir$ and $V_T = IR_o$

so $IR_o = \mathcal{E} - Ir \Rightarrow \mathcal{E} = IR_o + Ir$

$\rightarrow I = \dfrac{\mathcal{E}}{R_o + r} = \dfrac{6}{5+1}$

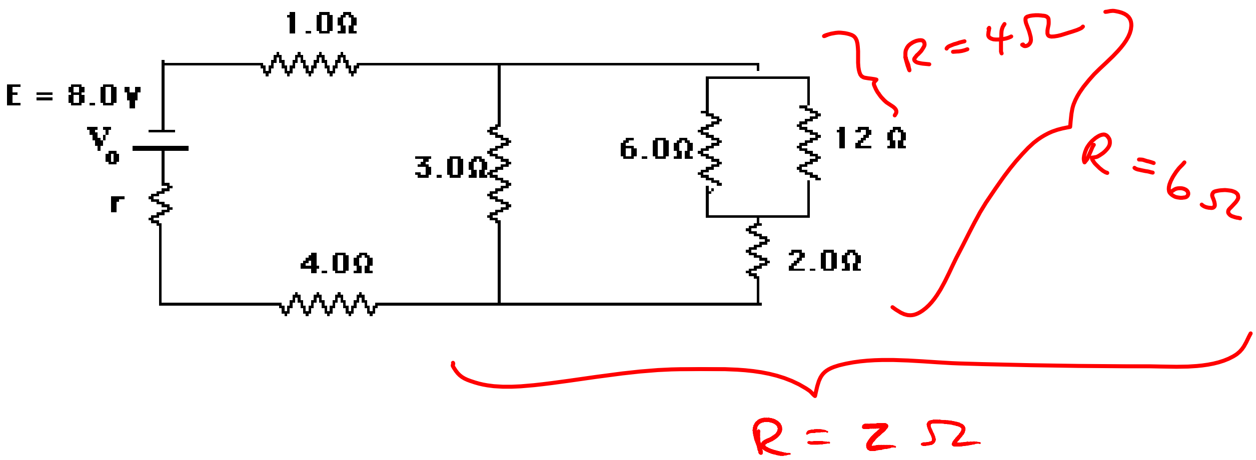
$$\boxed{I = 1.0\,A}$$

Example #18: A battery of EMF 8.0 V and internal resistance r = 1.0 Ω is connected to an external circuit as shown. Find:

(a) the equivalent resistance of the circuit.

(b) the total current leaving the battery.

(c) the potential difference between the terminals of the battery.



a) using appropriate techniques to simplify,

$$R_o = 1 + 2 + 4 = \boxed{7.0\,\Omega}$$

b) using $V_T = \mathcal{E} - Ir$ and $V_T = IR_o$,

$$I = \frac{\mathcal{E}}{R_o + r} = \frac{8.0}{7+1} = \boxed{1.0\text{ A}}$$

c) $V_T = IR_o = 1.0(7.0) = \boxed{7.0\text{ V}}$