Lesson 4 Series and Parallel Circuits

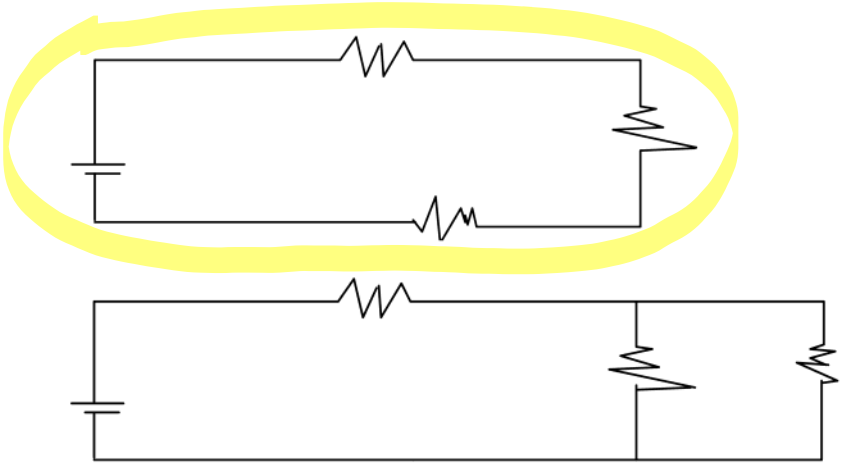
May 9, 2020 12:00 PM

$V = IR$ $P = VI$

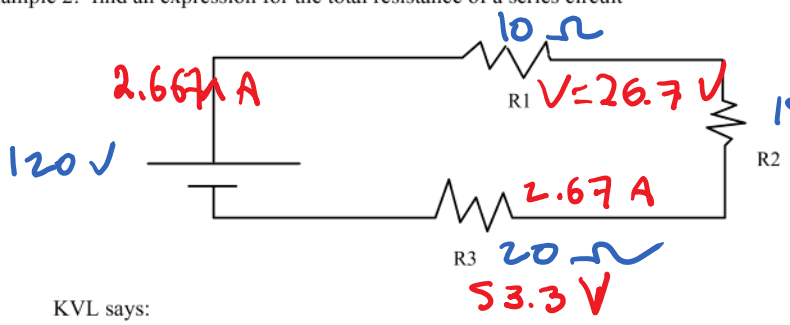
Lesson 4: Series and Parallel Circuits

•a series circuit is a circuit where resistors are connected in a row with no junctions in between them

•example 1: which circuits show resistors in (simple) series?



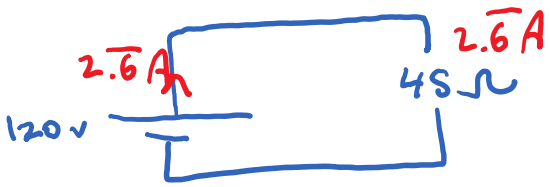
•example 2: find an expression for the total resistance of a series circuit



$R_t = 10 + 15 + 20$

KVL says:

KCL says:



$I_T = \frac{V_T}{R_T} = \frac{120}{45}$

$I_T = 2.6\ A$

total resistance R_t=

=

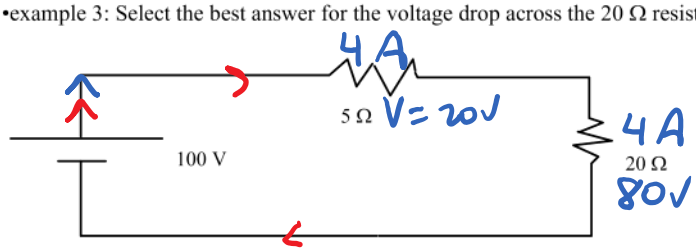
=

=

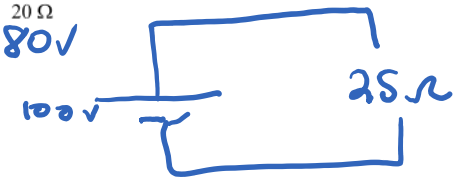
series R_t = $R_1 + R_2 + R_3 + \ldots$

R = Ω = ohm

•example 3: Select the best answer for the voltage drop across the 20 Ω resistor



$R_T = 5 + 20 = 25\ \Omega$



a) 100 volts

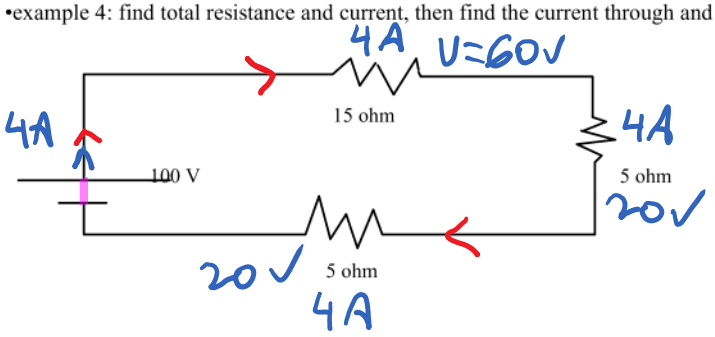
b) more than 50 volts

c) ~~less than 50 volts~~

$I_T = \frac{V_T}{R_T} = \frac{100}{25} = 4.0\ A$

explain your answer using relevant physics principles

•example 4: find total resistance and current, then find the current through and voltage drop across each resistor



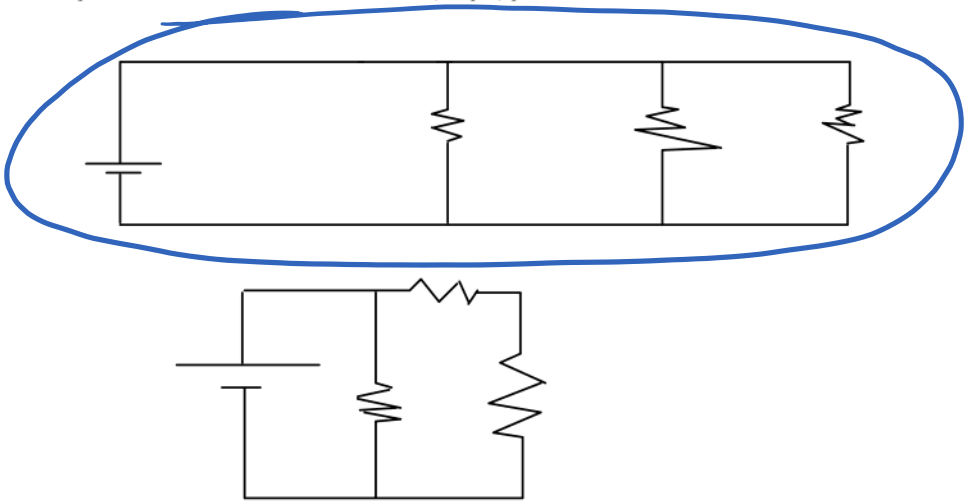
$R_T = 15 + 5 + 5$

$R_T = 25\ \Omega$

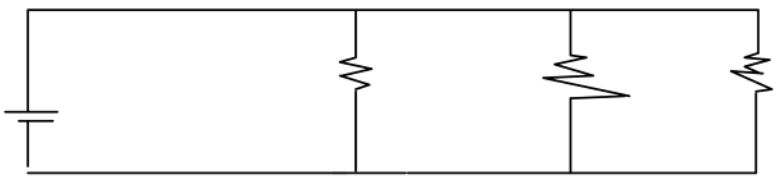
$I_T = \frac{100}{25} = 4\ A$

•a parallel circuit is a circuit where resistors start and end at the same voltage (height)...i.e. the resistors are directly connected at the top and at the bottom with no other resistors in between

•example 5: which circuit shows resistors in (simple) parallel?



•example 6: find an expression for the total resistance of a parallel circuit



KVL says:

KCL says:

total resistance $\frac{1}{R_t}$ =

=

=

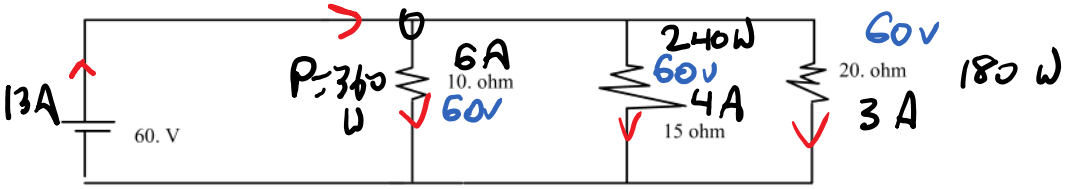
=

$$\frac{1}{R_{//}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \cdots$$

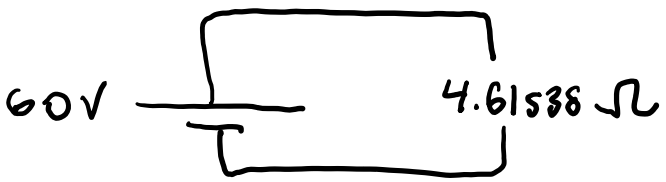
parallel R_t =

R = Ω = ohm

•example 7: find R_t and I_t, then find V, I for all resistors, P



$$\frac{1}{R_{//}} = \frac{1}{10} + \frac{1}{15} + \frac{1}{20} \rightarrow R_T = 4.61538\ \Omega$$

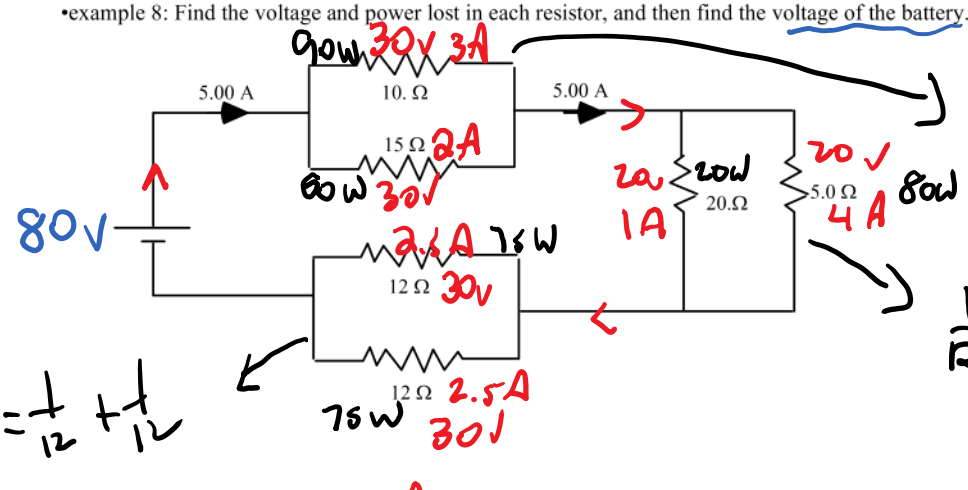


$$I_T = \frac{V_T}{R_T} = \frac{60}{4.61538}$$

$$I_T = 13\ A$$

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

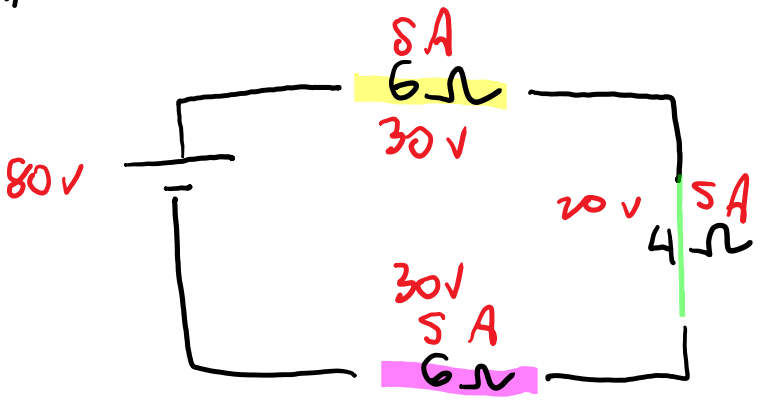
•example 8: Find the voltage and power lost in each resistor, and then find the voltage of the battery.



$\frac{1}{R_{//}} = \frac{1}{10} + \frac{1}{15}$

$\frac{1}{R_{//}} = \frac{1}{20} + \frac{1}{5}$

$\frac{1}{R_{//}} = \frac{1}{12} + \frac{1}{12}$



$R_T = 6 + 4 + 6$

$R_T = 16\,\Omega$

$I_T = 5\ A$

$V_T = I_T R_T = 5(16) = 80V$

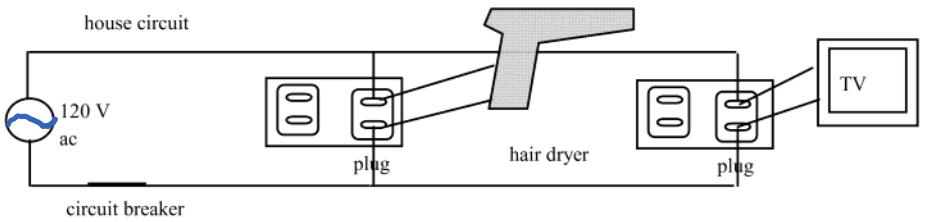
• example 8 illustrates an important point. It shows us that the voltage drop across parallel resistors is the same as the drop across the equivalent resistor in the equivalent circuit.

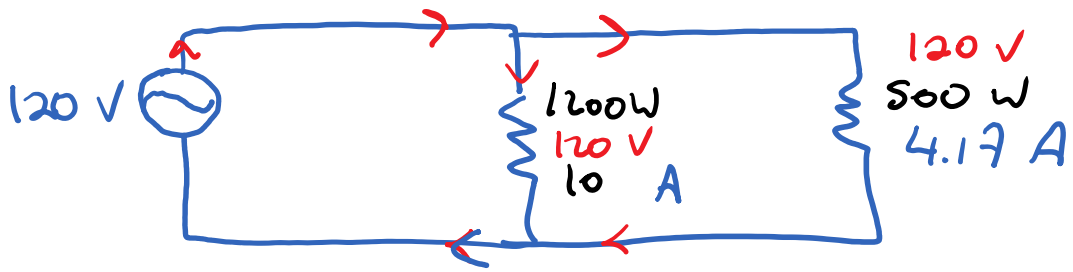
•In a household circuit, plugs and lights are wired in parallel to 120 volts AC. Each circuit has a circuit breaker in the circuit. The circuit breaker is an automatic switch that opens when the current exceeds a set value(15 Amp usually). When the switch is opened, no more current flows through the circuit.

•example 9: If we connect a 1200 Watt hairdryer and a 500 Watt TV to the same circuit, will we cause the 15 A breaker to trip?

$P = VI$

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



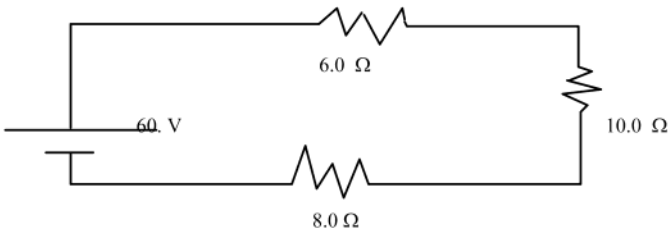


$I_T \approx 10 + 4.17 \approx 14.17\ A$

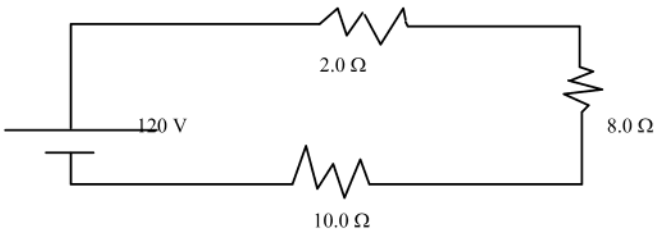
The breaker will not trip. (barely)

Exercises

1. Find all unknown voltages and currents(2.5 A,15V; 2.5A, 25V; 2.5 A, 20. V)

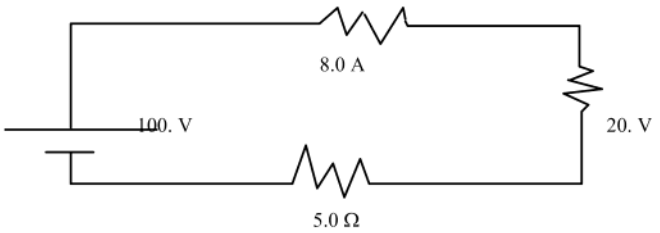


2. Find all unknown voltages and currents (6.0 A,12 V; 6.0 A, 48 V; 6.0 A,60. V)

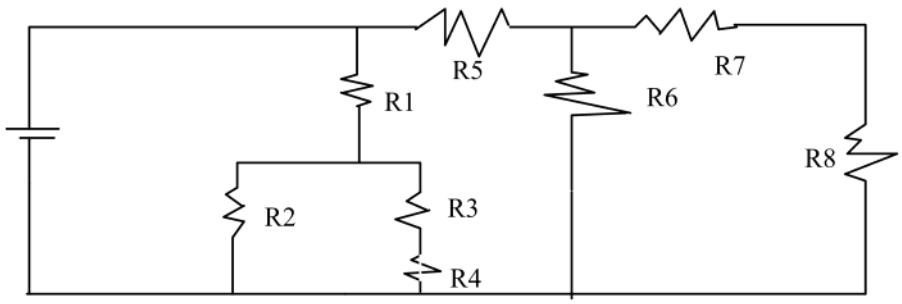


3. Find all unknown voltages, currents and resistances

(5.0 Ω, 40. V; 8.0 A, 2.5 Ω; 8.0 A, 40 V)

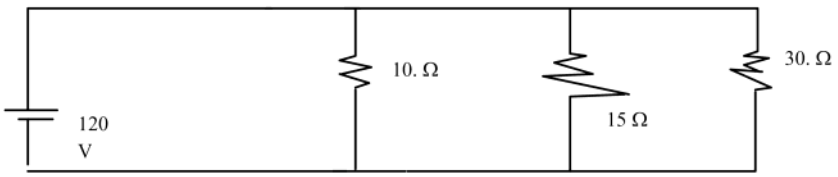


4. Which resistors are in series?



Ans: (R7 and R8), (R3 and R4)

6. Find all voltage drops and currents (120 V, 12A; 120V,8.0A;120V,4.0A)



7. Find the total current in #6 if we

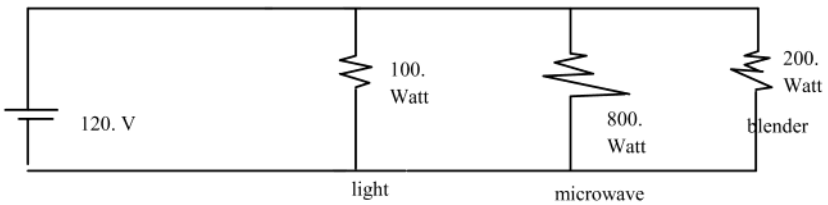
a) remove the 15 ohm (16A)

b) remove the 30. ohm (20. A)

c) add another 10. ohm in parallel (36 A)

d) add a 120 ohm in parallel (25 A)

8. Find all voltage drops and currents (120. V,0.833 A;120.V, 6.67 A; 120. V,1.67 A)



9. i) In household circuit #8, find the total current if we make the following changes to the circuit.

ii) Indicate (yes or no) if these changes would cause the circuit breaker to trip (this happens when the total current exceeds 15.0 A)

a) adding another 100. W light (in parallel) (no, I_t=10.0 A)

b) removing the 800. W microwave (no I_t=2.50 A)

c) adding a 1400. W hair dryer (in parallel) (yes I_t= 20.8 A)

d) adding a 300. W computer (in parallel) (no I_t = 11.7 A)

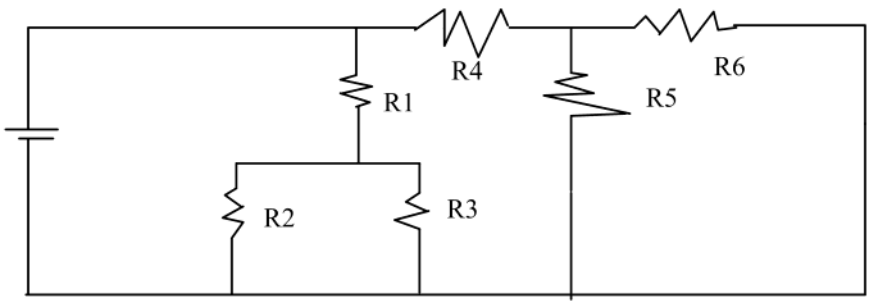
10. What is the maximum number of the following in a house circuit (note: an outlet has V=120 V, and max current is 15 A)

a) 100 W light bulbs b) 250 W TV's

b) 10 W toothbrushes d) 800 W toasters

(18; 7;180; 2)

11. Which resistors are in parallel?



Ans: (R1 and R4), (R2 and R3), (R5 and R6)

14. If we add a resistor in parallel to a parallel circuit, what happens to the total resistance?

a) it increases

b) it decreases

c) it may increase or decrease depending on the value of the resistance we add.

Ans: (b) Bonus: Can you prove it?

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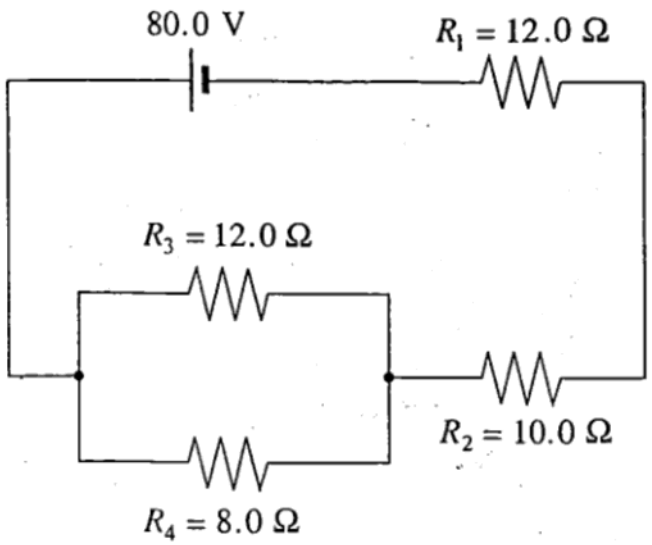
What is the power dissipated in the 8.0 Ω resistor in the circuit as shown?



Ans: 26 W