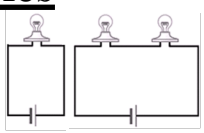
Combining Light Bulbs in Series

1. Build a circuit with one light bulb and observe its brightness. The brightness of a bulb is a measure of...



2. Then add a second bulb in series. Observe or infer what happens to the: *Increase, Decrease, or Remain the same*

Power of an individual bulb (= brightness)		↓ ×4
Total power of the circuit		↓
Resistance of an individual bulb		same
Total resistance of the circuit		↑
Total potential difference across the circuit		same
Potential difference across an individual bulb		↓ ×2
Total current in the circuit		↓
Current through an individual bulb		↓ ×2

3. Unscrew one light bulb from its base (but leave the base in the circuit). What happens to the other light bulb? Why?

goes out - incomplete circuit

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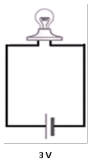
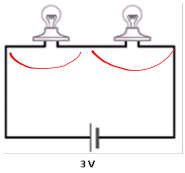
4. Assume each light bulb has a resistance of 10Ω. Analyze each circuit.



R	10Ω
V	3v
I	.3A
P	.9w

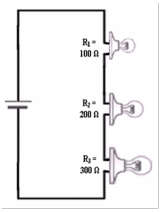
$I = V/R$

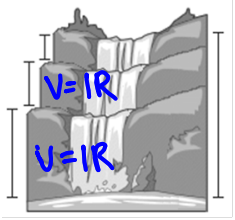
$P = IV$

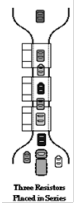


	Bulb #1	Bulb #2	Circuit Total
R	10Ω	10Ω	20Ω
V	1.5v	1.5v	3v
I	.15A	.15A	.15A
P	.225w	.225w	.45w

Analyzing Series Circuits







1. **Current:** Current is the same at all points in a series circuit. Current is the same through each resistor.

$I_T = I_1 = I_2 = I_3 = \ldots$

NOTE: this does NOT mean the current stays the same if you change the circuit

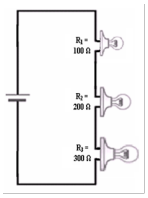
2. **Voltage:** The increase in potential provided by the battery is equal to the sum of the potential drops across each resistor.

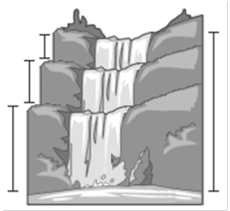
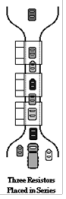
$V_T = V_1 + V_2 + V_3 + \ldots$

NOTE: conservation of energy

Kirchhoff's Second Law (Voltage law, Loop Rule)- Around any closed loop, the sum of the emf's (voltage rises) equals the sum of the potential differences (voltage drops).

Analyzing Series Circuits



3. **Resistance:** The total resistance of the circuit is the sum of the individual resistances.

$R_T = R_1 + R_2 + R_3 + \ldots$

Equivalent resistance – the single resistance that could replace the several resistors in a circuit

NOTE: The total resistance is higher than any of the individual resistances.

4. **Power:** The total power used in the circuit is the sum of the power used by the individual resistors.

$P_T = P_1 + P_2 + P_3 + \ldots$

NOTE: Conservation of energy principle

Analyzing Series Circuits

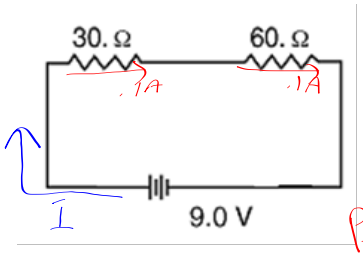
Series relationships

$\frac{V_1}{V_2} = \frac{R_1}{R_2} = \frac{P_1}{P_2}$

$P = IV$

5. In a series circuit, which resistor, if any, will . . .
   a) have the greatest potential difference across it?
      highest
   b) have the most current running through it?
      all the same
   c) dissipate the most power?
      highest
   d) shine brightest (if it is a light bulb)?
      highest

6. Determine the current through each resistor, the potential drop across each resistor, and the power dissipated by each resistor in the circuit below.



$R_T = R_1 + R_2 = 90\Omega$

$I_T = V_T / R_T = 9V / 90\Omega = .1A$

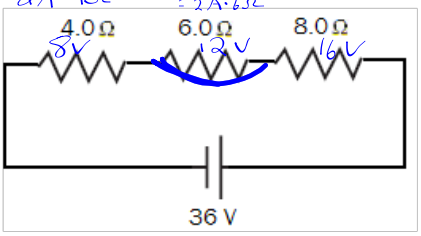
$V_{30} = IR_{30} = .1A \cdot 30\Omega = 3V$

$V_{60} = IR_{60} = .1A \cdot 60\Omega = 6V$

$P_{30} = IV_{30} = .1A\ 3V = .3W$

$P_{60} = IV_{60} = .1A \cdot 6V = .9W$

7. Find the potential difference across each resistor, the current through each resistor, and the power used by each resistor.



R_T = 18 ohms

2A

$I_T = V_T / R_T = 36v / 18\Omega = 2A$

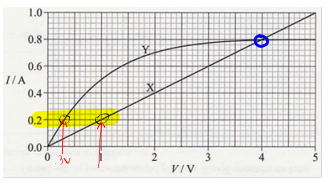
$V_4 = IR = 2A \cdot 4\Omega = 8v$

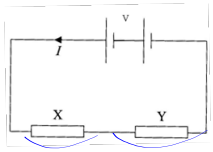
$V_6 = IR = 2A \cdot 6\Omega = 12v$

$V_8 = IR = 2A \cdot 8\Omega = 16v$

I-V Characteristics

1. The graph below shows the I-V characteristics of two conductors, conductors are connected in series to a battery whose voltage is such that the power dissipated in each of the two resistors is the same.





a) Determine the resistance of each resistor.

$R = V/I = 4v/.8A = 5\Omega$

b) Determine the total voltage of the battery.

8v

c) Determine the total power dissipated in the circuit.

$I_T \cdot V_T$

$(8A)(8V) = 6.4w$

d) The battery is replaced by another one such that the current through X is 0.2 amps. Determine the voltage of this battery.

$V_T = 1.3v$