8. a) How much energy is used lighting a 60. W bulb for 4.5 hours? Answer in joules and kilowatt-hours.

$E = P \cdot t \qquad 60.\frac{J}{s} \times 4.5\,hr \times \frac{3{,}600\,s}{hr} = 9.7 \times 10^5\,J$ (energy)

$0.060\,Kw\,(4.5\,hr) = .27\,Kwhr$ (energy)

9. A DC power charger is marked as "5.0 V 3.5 VA."

VA = volt amp

a) What quantity is being measured as 3.5 VA? $V \times I = P$

$= 3.5$ watts measure of power $\left[\frac{J}{C}\right]\left[\frac{C}{s}\right] = \left[\frac{J}{s}\right] = watt$

b) How much current does the charger use?

$I = \frac{P}{V} \qquad \frac{3.5\,W}{5.0\,V} = 0.70\,A$

10. A resistor is marked as 270 Ω with a power rating of 0.50 W.

R P

$P = IV$

$P = I^2R$

$P = \frac{V^2}{R}$

a) What is the maximum current this resistor can safely handle?

$I = ?$ $\quad I = \sqrt{P/R} = \sqrt{\frac{0.50\,W}{270\,\Omega}} = 0.043\,A$

b) What will happen if there is more current than this maximum amount in the resistor?

short circuit = melting, smoking, heating, fire!

$I \gg R$

11. A cell-phone battery is marked as "90 mA h 12 V 1.08 Wh".

a) What quantity is being measured as 90 mAh?

mA h

$\left[\frac{C}{s}\right][s] = C$

measure of charge

$0.090\frac{C}{s} \times 3{,}600\,s = 324\,C$

Capacity:

a quantity used to measure the ability of a cell to release charge

A battery whose capacity is 90 mA h means that before it "dies" and needs recharging you can run it:

at 90 mA for 1 hour or

at 45 mA for 2 hours or

at 9 mA for 10 hours, etc.

$E = qV$

b) Determine how much energy is stored in the battery.

$E = 324\,C \times 12\,V = 3{,}888\,J$ (energy) $= .00108\,Kwh$ (energy)

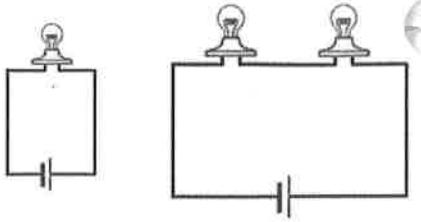
12. A cell has a capacity of 1400 mA h. Calculate the number of hours for which it can supply 1.8 mA.

$\frac{1400\,mAh}{1.8\,mA} = 780$ hours

(777.78 hrs) → 2 s.f.

Series and Parallel Circuits

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 . . power

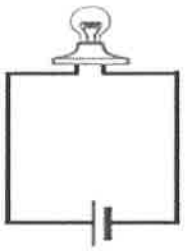
2. Add a second bulb in series. Observe or infer what happens to the:

	PREDICTION	RESULT
Power of an individual bulb		↓
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		↓
Total current in the circuit		↓
Current through an individual bulb		↓

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

bulb goes out breaks the circuit

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



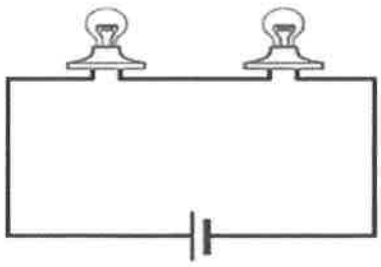
3 V

$V = IR$

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

$P = IV$

R	10Ω
V	3V
I	0.3A
P	0.9W

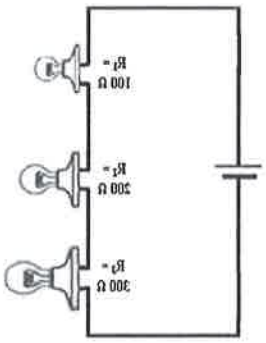


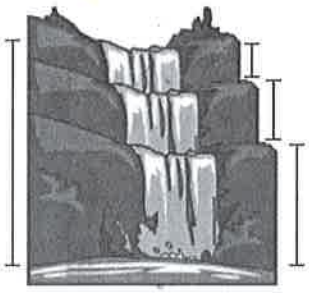
3 V

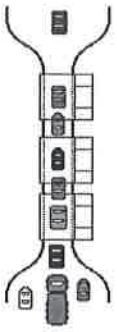
	Bulb #1	Bulb #2	Circuit Total
R	10Ω	10Ω	20Ω
V	1.5V	1.5V	3V
I	0.15A	0.15A	0.15A
P	.225W	.225W	.45W

$I = \frac{3V}{20\Omega}$

Analyzing Series Circuits







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

$I_T = I_1 = I_2 = I_3$

NOTE: Current is the same if circuit is the same.

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

$V_T = V_1 + V_2 + V_3$

NOTE: conservation of energy

Gustav Robert Kirchhoff
(1824-1887)

Kirchhoff's Second Law (Voltage Law, Loop Rule):
Around any closed loop, the voltage rise is equal to the voltage drop.

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

$R_T = R_1 + R_2 + R_3$ $\quad R_T = R_{eq}$

Equivalent resistance – Single resistance that could replace all resistance in the circuit

NOTE: R_T is always greater than any individual resistance.

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

$P_T = P_1 + P_2 + P_3$

NOTE: conservation of energy

Series relationships

$V = IR$ $\quad P = IV$

$\frac{V_1}{V_2} = \frac{I_1 R_1}{I_2 R_2}$ $\quad \frac{P_1}{P_2} = \frac{I_1 V_1}{I_2 V_2}$

5. In a series circuit, which resistor, if any, will . . .

a) have the greatest potential difference across it?
largest resistance

b) have the most current running through it?
same

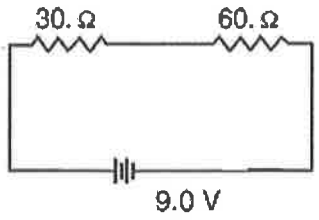
c) dissipate the most power?
largest resistance

d) shine brightest (if it is a light bulb)?
largest resistance - one that draws the most power

I=? V=?

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

P=?

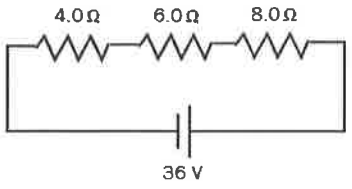


R	I	V	P
30Ω	.1A	3V	.3W
60Ω	.1A	6V	.6W

$I_T = \frac{V}{R_T} = \frac{9V}{90\Omega} = .1A$

$V = IR$ $P = IV$

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



R	I	V	P
4Ω	2A	8V	16W
6Ω	2A	12V	24W
8Ω	2A	16V	32W

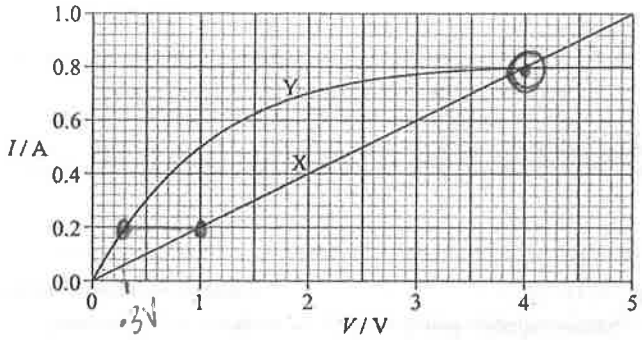
$R_T = 18\Omega$ $I_T = \frac{V}{R_T}$

$I_T = \frac{36V}{18\Omega} = 2A$

$P = IV$

I-V Characteristics

1. The graph below shows the I-V characteristics of two conductors, X and Y. The 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.

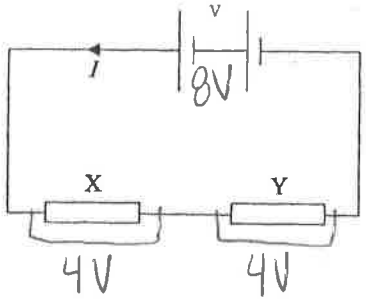


a) Determine the resistance of each resistor.

$R = \frac{V}{I} = \frac{4V}{0.8A} = 5\Omega$

$\frac{I}{V} = \frac{1}{R}$ (slope)

$V = IR$



b) Determine the total voltage of the battery.

4V + 4V = 8V

c) Determine the total power dissipated in the circuit.

$P_T = IV_T$ (0.8A X 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.

"X" + "Y"

1.0V + .3V = 1.3V