CIRCUIT CALCULATIONS

(ENGINEERING ONLY)

Learning objectives

- ❑ Which terms will we have to use when we design circuits?
- ❑ What are SI units/prefixes?
- ❑ How can we apply Ohms Law?
- ❑ How do we calculate power, battery capacity and component values?

Key words:

Resistance,

Voltage,

Power,

capacitance,

SI units,

prefixes

Explanation

What can we remember…

Which SI prefixes are commonly used in circuit design?

Prefixes	Value	Standard form	Symbol
Tera	1 000 000 000 000	10^{12}	T
Giga	1 000 000 000	10^{9}	G
Mega	1 000 000	10^{6}	M
Kilo	1 000	10^{3}	k
Deci	0.1	10^{-1}	d
Centi	0.01	10^{-2}	c
Milli	0.001	10^{-3}	m
Micro	0.000 001	10^{-6}	μ
Nano	0.000 000 001	10^{-9}	n
Pico	0.000 000 000 001	10^{-12}	p

e.g. $10M\Omega$

e.g. $100K\Omega$

e.g. $200mA$

e.g. $200\mu F$

Learning objectives:

- ❑ Which terms are used in circuit design and construction?
- ❑ What are the types of electronic component?

Explanation

What can we remember…

Which terms are used in circuit design and manufacture?

		Which units are used?...	
Current (I)	The flow of electrical charge in a circuit	**Ampere (Amp)**	**A**
Resistance (R)	The measure of the difficulty of passing an electrical current.	**Ohms**	**Ω**
Voltage (V)	The difference in charge between two points in a circuit.	**Volts**	**V**
Power (P)	The rate at which electrical energy is transferred.	**Watts**	**W**
Capacitance (C)	The amount of electrical energy stored.	**Farad**	**F**

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Explanation

What can we remember…

What are "SI" units?

International System of Units

Amps

1A
1 mA = 0.001 A
1000 mA = 1 A

Volts

1V
1mV = 0.001 V
1KV = 1000V

Ohms

1Ω
1KΩ = 1000Ω
1MΩ = 1,000,000Ω

Watts

1W
1mW = 0.001 W
1KW = 1000W

Farad

1F 1µF = 0.000,001 F

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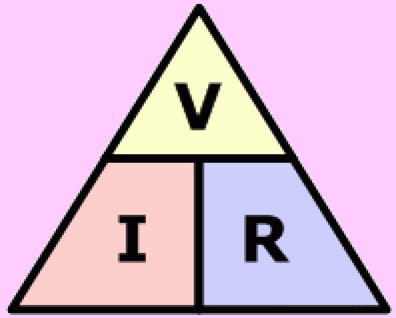
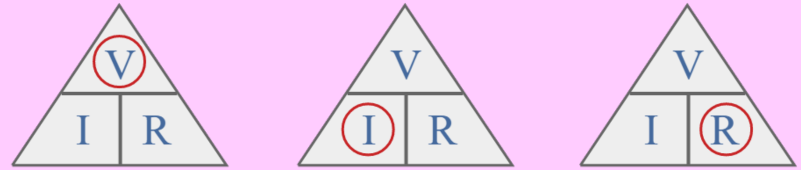
Explanation

What is Ohm's law

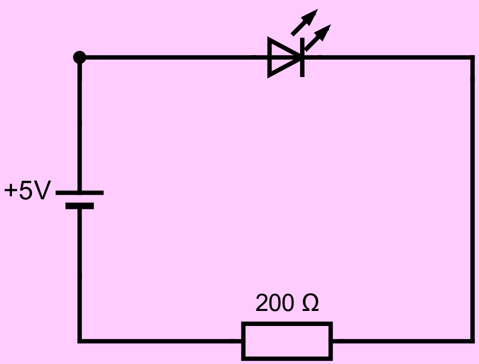
States that electric current is proportional to voltage and inversely proportional to resistance.





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

How do we apply Ohm's law?



$$V = 5V$$
$$R = 200\Omega$$
$$I = ?$$

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

$$I = 0.025A$$

$$I = \frac{5}{200}$$

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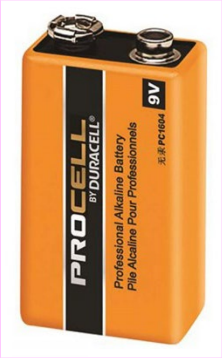
Explanation

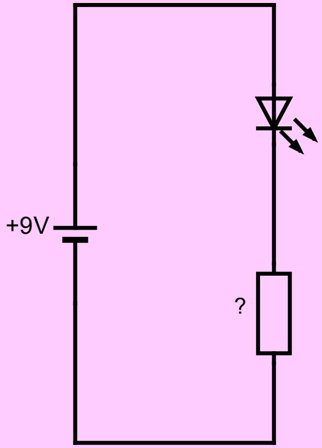
What is a typical application of Ohm's law?

Description
Our Colour Changing 5mm Diffused LEDs slowly cycle through various colours, making it ideal for mood lighting, toys or ornaments. They have a forward voltage drop of 4.5V at a 20mA output

Calculate the value of the current limiting resistor required if a 9V battery is used.



$$Resistance = \frac{supply\ voltage - LED\ voltage\ drop}{current}$$



$R = ?$

$V_{supply} = 9\text{V}$

$V_{LED} = 4.5\text{V}$

$I = 20mA \quad I = 0.02A$

$$R = \frac{9 - 4.5}{0.02}$$

$$R = 225\Omega$$

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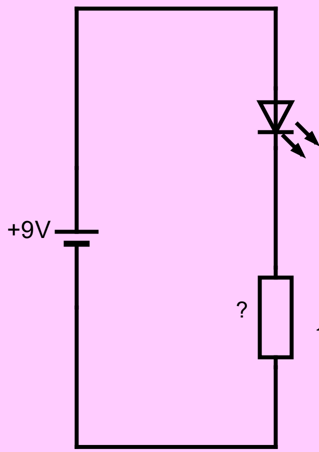
Explanation

What are the common resistor values?



$R = 225\Omega$

3.9	43	470	5.1 k	56 k	620 k
4.3	47	510	5.6 k	62 k	680 k
4.7	51	560	6.2 k	68 k	750 k
5.1	56	620	6.8 k	75 k	820 k
5.6	62	680	7.5 k	82 k	910 k
6.2	68	750	8.2 k	91 k	1.0 M
6.8	75	820	9.1 k	100 k	1.2 M
7.5	82	910	10 k	110 k	1.5 M
8.2	91	1.0 k	11 k	120 k	1.8 M
9.1	100	1.1 k	12 k	130 k	2.2 M
10	110	1.2 k	13 k	150 k	2.4 M
11	120	1.3 k	15 k	160 k	2.7 M
12	130	1.5 k	16 k	180 k	3.3 M
13	150	1.6 k	18 k	200 k	3.6 M
15	160	1.8 k	20 k	220 k	3.9 M
16	180	2.0 k	22 k	240 k	4.7 M
18	200	2.2 k	24 k	270 k	5.6 M
20	220	2.4 k	27 k	300 k	6.8 M
22	$\boxed{240}$	2.7 k	30 k	330 k	8.2 M

Which resistor would we select?

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Explanation

What are the power limitations of resistors?

Most common resistors have a power rating between 0.125W and 1 watt . Resistors with higher power ratings are usually referred to as power resistors and used specifically to dissipate power.

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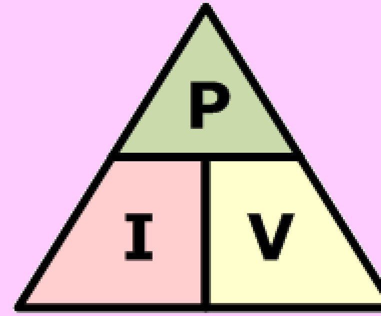
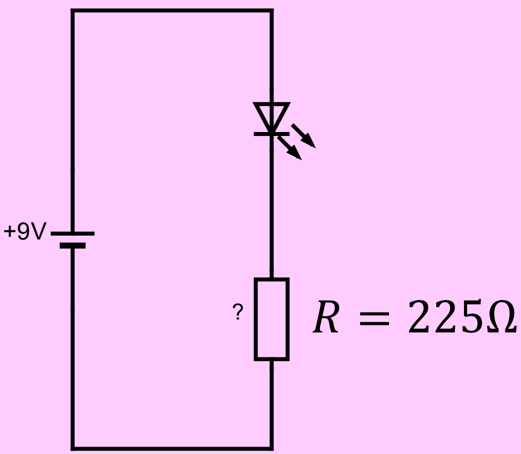
Explanation

What would the power requirements of the resistor be?

$$V = 4.5V$$

$$I = 0.02A$$





$$P = IV$$

$$P = 0.02 \times 4.5$$

$$P = 0.09W$$

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Explanation

How can we combine Ohms law and the power formula?

Ohms law

$$V = IR$$

Power formula

$$P = IV$$

How do we calculate power with only voltage and resistance readings?

$$P = IV \Rightarrow P = \left(\frac{V}{R}\right)V \Rightarrow P = \frac{V^2}{\mathrm{R}}$$

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

How do we calculate power with only current and resistance readings?

$$P = IV \Rightarrow P = I(\mathrm{I} \times R) \Rightarrow P = I^2\mathrm{R}$$

$$V = IR$$

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Explanation

How do we calculate battery capacity?

What is battery capacity measured in?

Ah $\quad$ $\mathrm{m}Ah$

How can we calculate battery capacity?

$$Battery\ capacity\ (mAh) = current(mA) \times time(h)$$

How long could we run a typical LED which draws 20mA from this battery?

$$time(h) = \frac{capacity(mAh)}{current(mA)} \qquad time(h) = \frac{3500}{20}$$

$$time(h) = 175h$$

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Explanation

How do we calculate battery capacity?

How long could we run the same LED from this car battery?

$$capacity = 100Ah$$

$$current = 20mA$$

$$current = \frac{20}{1000} \qquad current = 0.02A$$

$$time(h) = \frac{capacity(mAh)}{current(mA)} \qquad time(h) = \frac{100}{0.02}$$

$$time(h) = 5000h$$

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