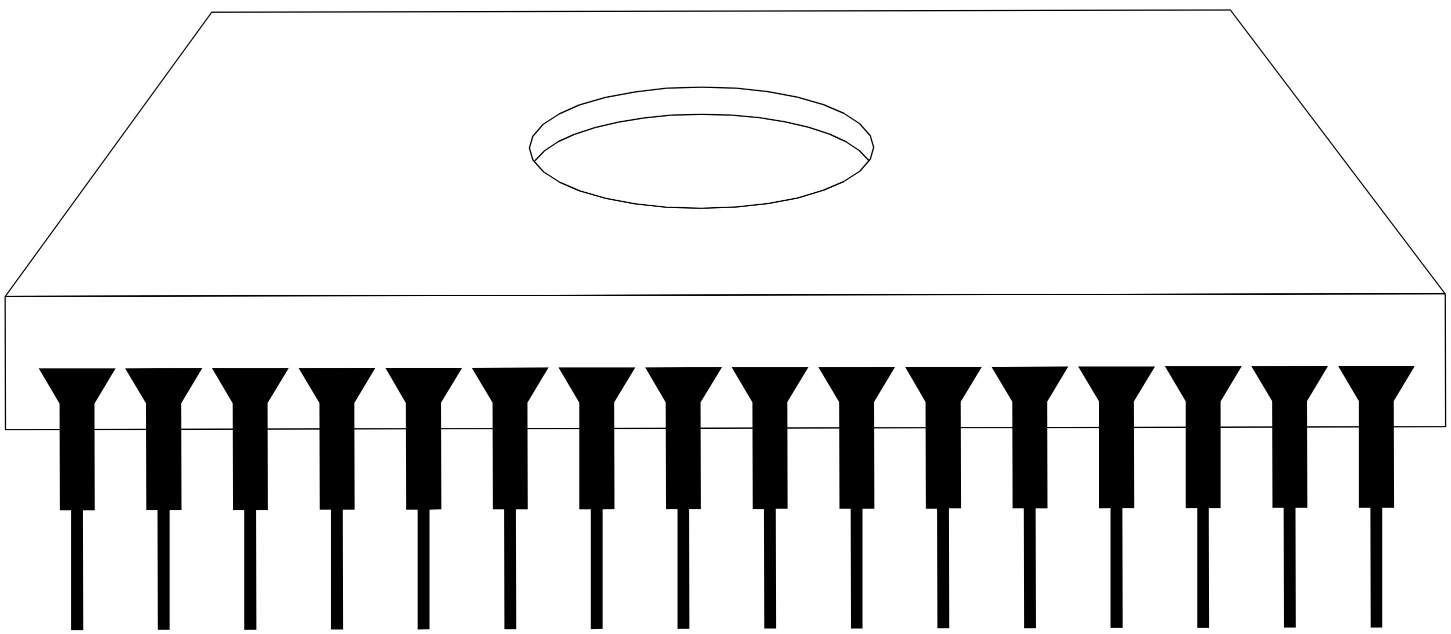
Standard Grade Physics

"ELECTRONICS"

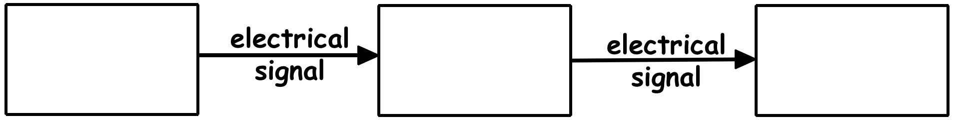


Name: ______________________________ **Class:** ______ **Teacher:** ______________________

NOTES

1) ELECTRONIC SYSTEMS OVERVIEW

Any **electronic system** consists of **3 parts**:



Information is passed along the system by

__________ ________.

The table shows examples of **electronic systems** and their **input**, **process** and **output** parts:

system	input	process	output
CD player			
electronic calculator			
electronic stopwatch			
computer			
radio			

The Electrical Signals

The **electrical signals** are either **analogue** or **digital**.

Analogue Signals

These can have many ___________ values.

Often, their value keeps ___________.

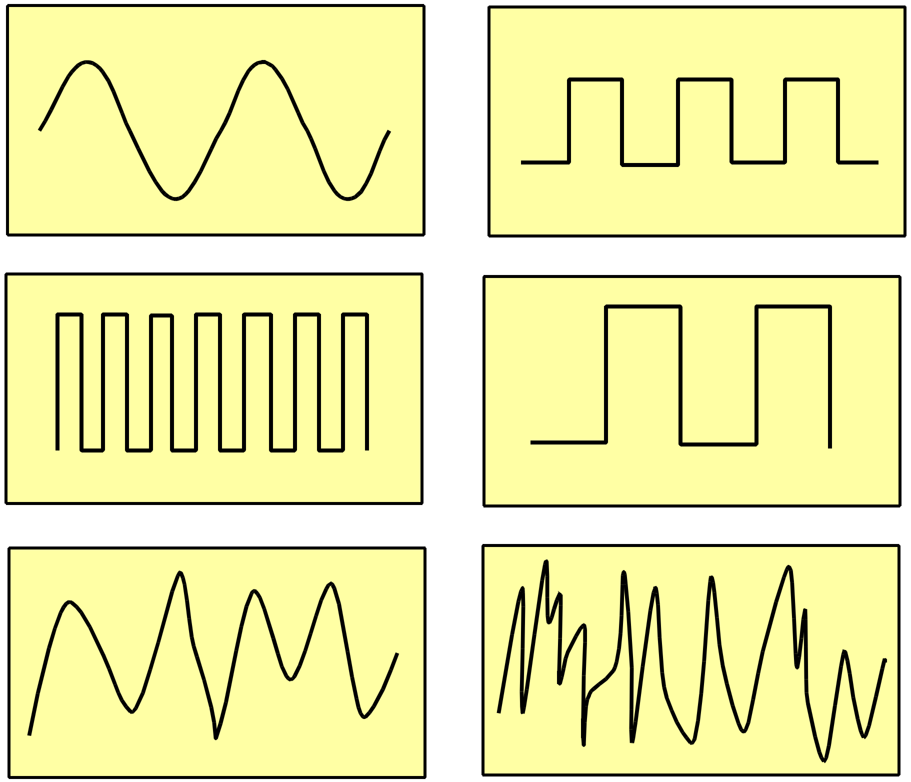
Digital Signals

These have only **2** values.

We describe these values in different ways:

_____/_____ or _____/_____ or _____/_____

*Are these signals on an oscilloscope **analogue** or **digital**?*

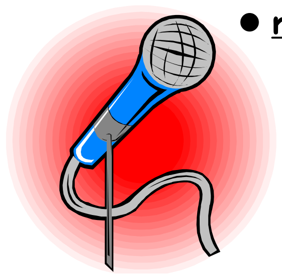


2) INPUT DEVICES

Input devices measure the **energy** surrounding them and change it into **electrical energy**.

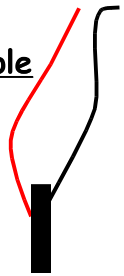
For example:

- **microphone**



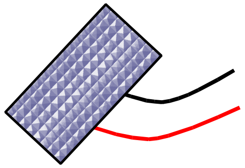
________ → ____________

- **thermocouple**



________ → ____________

- **solar cell**



________ → ____________

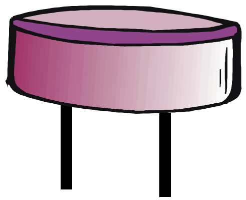
The **electrical energy** is in the form of a **changing voltage**.

The **resistance** of some **input devices** changes as the **energy** they measure changes.

For example:

- **thermistor**

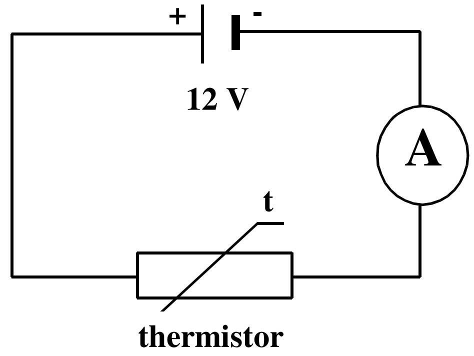
- **light dependent resistor (LDR)**



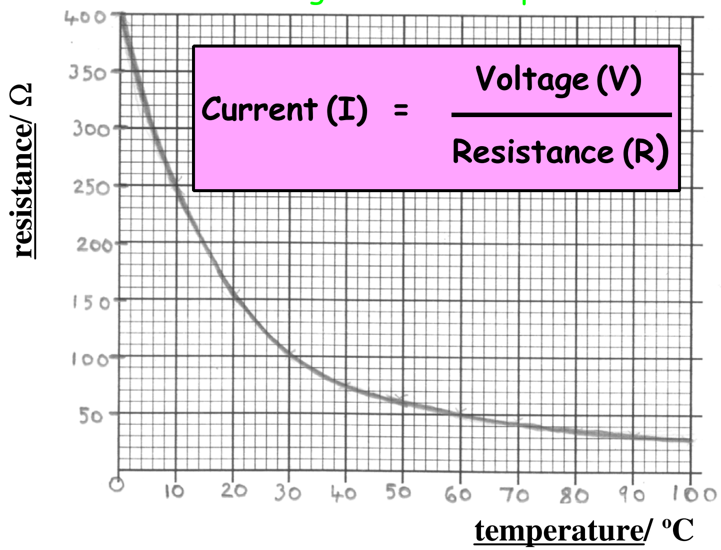
The **resistance** of a **thermistor** changes as its ____________ changes.

The **resistance** of a **LDR** ____________ as the **light level** ____________ (and vice versa).

The **thermistor** in this circuit controls the size of the **current** flowing around the circuit. As the **temperature** changes, the **resistance** of the **thermistor** changes, so the size of the **current** changes.



This graph shows how the resistance of the thermistor in the above circuit changes as its temperature changes.



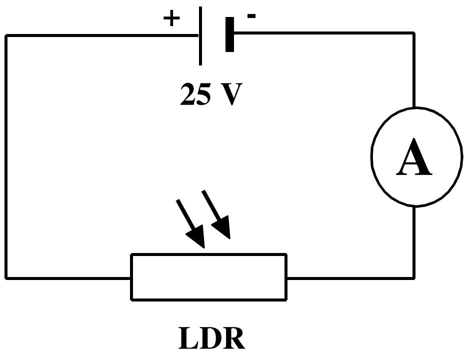
Determine the **current** flowing through the circuit when the temperature of the surroundings is:

(a) 10 °C

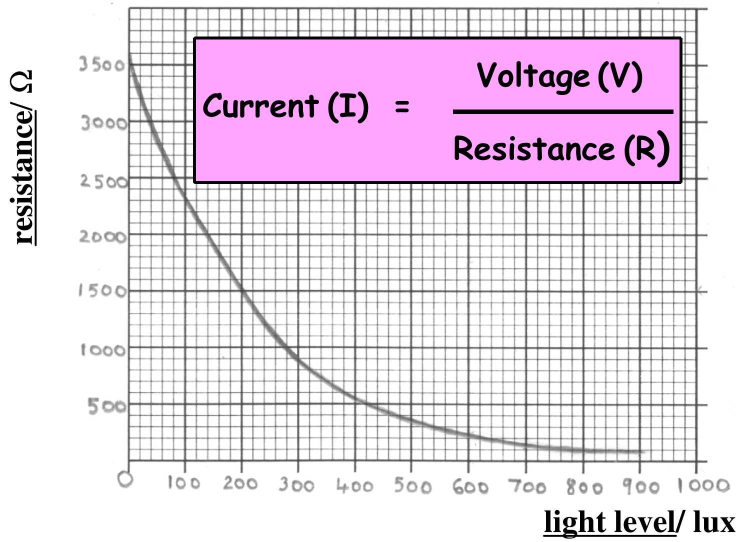
(b) 30 °C

(c) 60 °C

The LDR in this circuit controls the size of the current flowing around the circuit. As the light level changes, the resistance of the LDR changes, so the size of the current changes.



This graph shows how the resistance of the LDR in the above circuit changes as the light level changes.



$$\text{Current (I)} = \frac{\text{Voltage (V)}}{\text{Resistance (R)}}$$

Determine the **current** flowing through the circuit when the light level of the surroundings is:

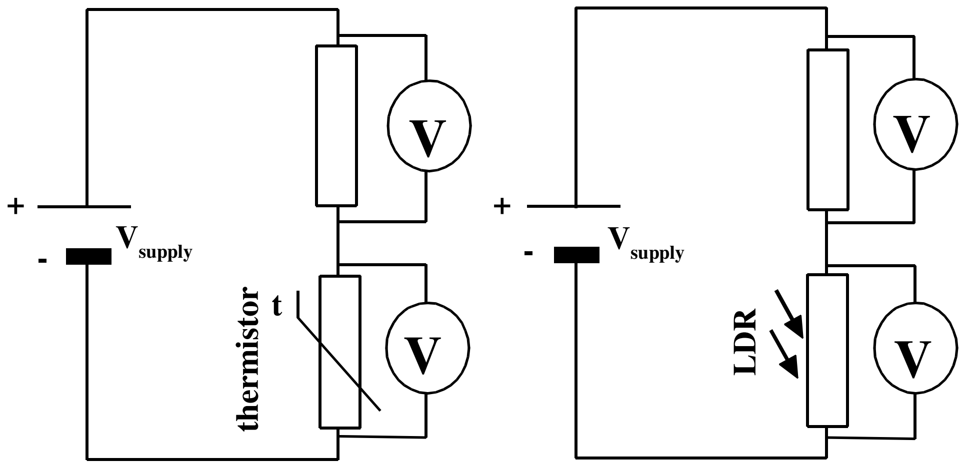
(a) 100 lux

(b) 400 lux

(c) 800 lux

Voltage Divider Circuits

To obtain a **voltage** from a **thermistor** or **LDR**, we connect them in a **voltage divider** circuit:



As the **resistance** (**R**) of the **thermistor** or **LDR** changes, the **voltage** (**V**) across it changes.

To calculate the **voltage** (**V**) across the **top** or **bottom** **resistor** in a **voltage divider**, we use the **"voltage divider equation"** :

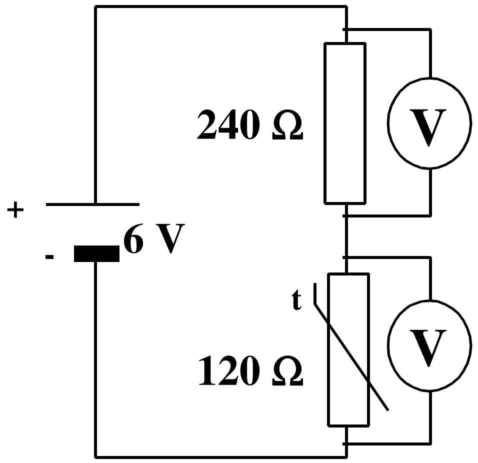
$$V_{top} = \frac{R_{top}}{R_{top} + R_{bottom}} \times V_{supply}$$

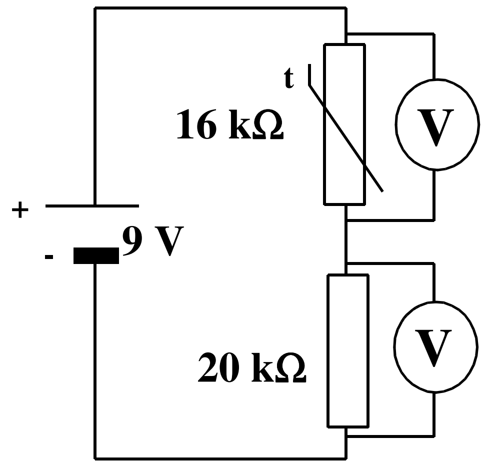
or

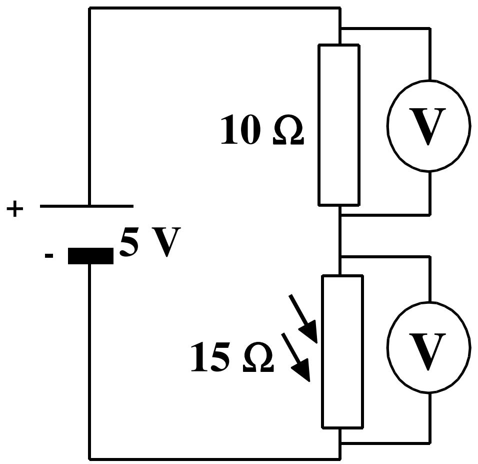
$$V_{bottom} = \frac{R_{bottom}}{R_{top} + R_{bottom}} \times V_{supply}$$

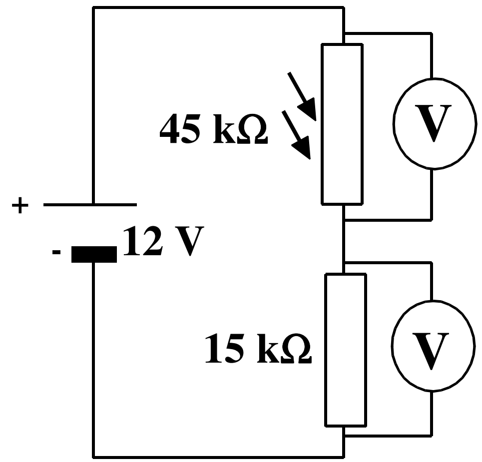
voltage across top resistor + voltage across bottom resistor = supply voltage

For each voltage divider circuit, calculate the **voltage** across the **bottom resistor** and the **voltage** across the **top resistor**:





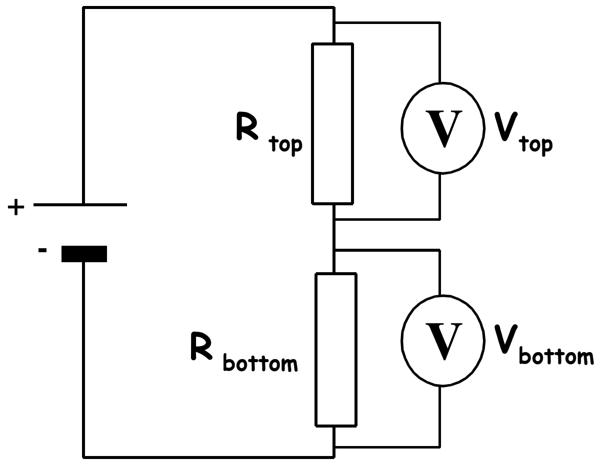




In a **voltage divider circuit**, the **voltage** across a resistor is related to its **resistance**.
The **h______** the **resistance** of a resistor, the **h______** the **voltage** across it.

This equation applies:

$$\frac{V_{top}}{V_{bottom}} = \frac{R_{top}}{R_{bottom}}$$



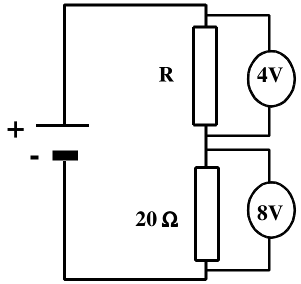
Because a **voltage divider circuit** is a **series circuit**, the **current** passing through both resistors is the **s___**.

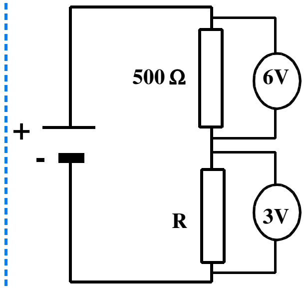
$$\text{Current (I)} = \frac{\text{Voltage (V)}}{\text{Resistance (R)}}$$

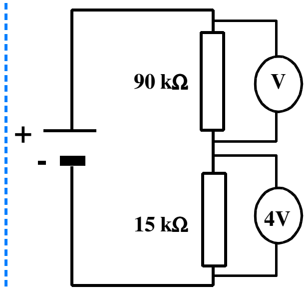
For each voltage divider circuit below:

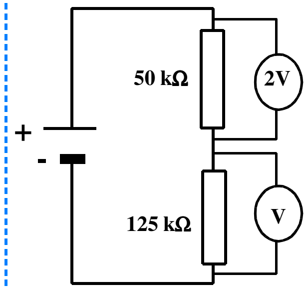
(a) Determine the **missing quantity**;

(b) Calculate the **current** passing through both resistors.



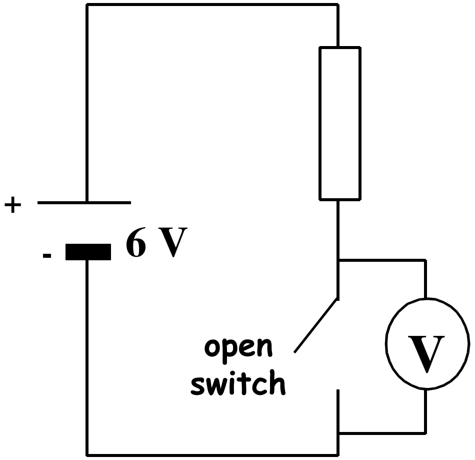






Two other **input devices** which can be placed in a **voltage divider circuit** are a **switch** and a **capacitor**:

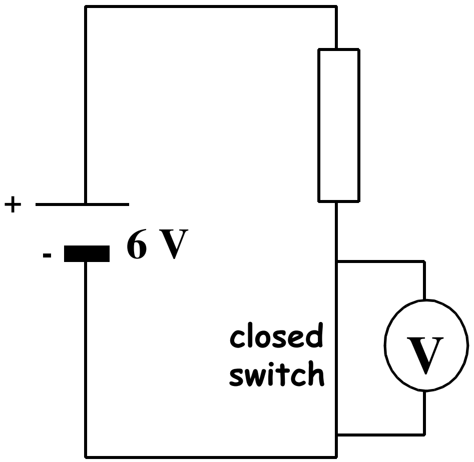
switch



When the **switch** is **open**, the **voltmeter** reads ______ (which is the _________ **voltage**).

The supply voltage splits between the **top resistor** and the **switch** depending on the **resistance** of each.

Because the **open switch** has an **infinitely high** (_____________) **resistance** compared to the **top resistor**, ______ of the **voltage** is found across the **open switch**.



When the **switch** is **closed**, the **voltmeter** reads _____.

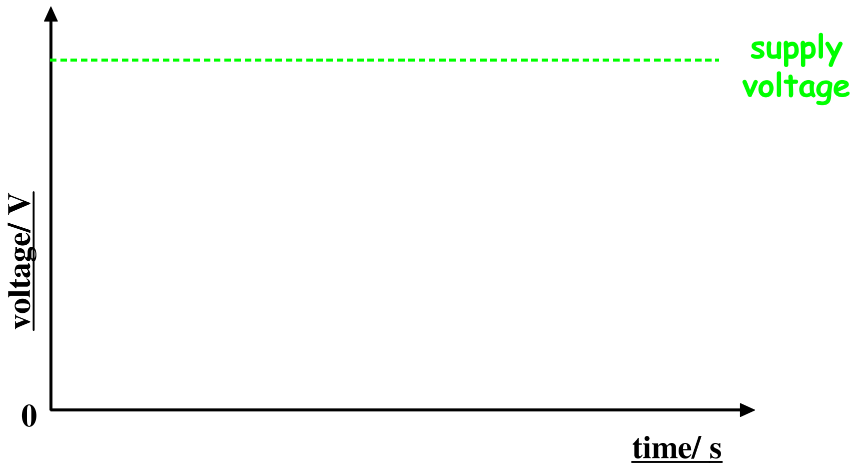
The **supply voltage** splits between the **top resistor** and the **switch** depending on the **resistance** of each.

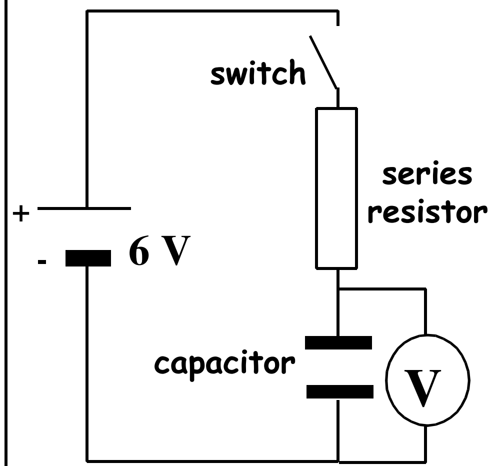
Because the **top resistor** has a much _________ **resistance** compared to the **closed switch**, ______ of the **voltage** is found across the **top resistor** and ______ is found across the **closed switch**.

capacitor

A **capacitor** is a device which stores **electric charge**.

As a **capacitor charges up**, the **voltage across it** increases from ______ up to the ____________ **voltage**:





When the **switch** is **closed**, the **capacitor** starts to **charge up** and the **voltage across it** increases.

The **time** taken for the capacitor to **charge up fully** to the **supply voltage** depends on the **value of the** ___________ and the value of the **series** ______________.

By drawing lines, match each **input device** with the **input job** it does for a particular **electronic system**:

- The "singing input" for a karaoke machine.

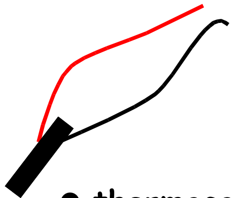
- The "temperature sensor" for a small electronic thermometer.

- The "light input" for an electronic calculator's power supply.

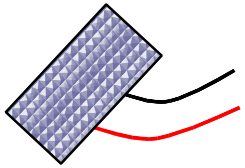
- The "light detector" for the flash system of a camera.

Input devices

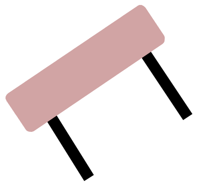
- microphone



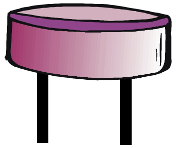
- thermocouple



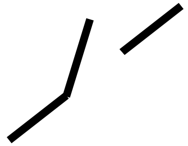
- solar cell



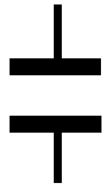
- thermistor



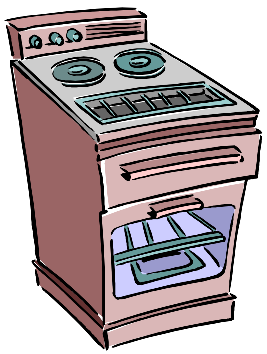
- light dependent resistor (LDR)



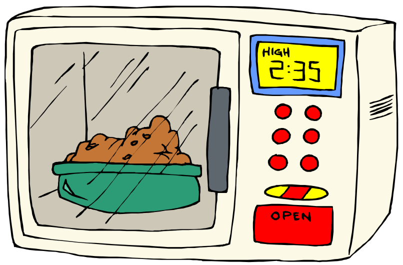
- switch



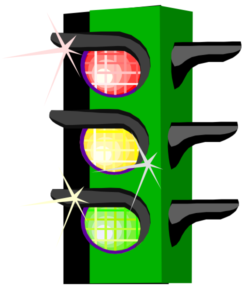
- capacitor



- The "temperature sensor" for a very hot electric oven.



- The "on/off input" for a microwave oven.



- The "time delay input" for a pedestrian-controlled crossing. (The red light switches on when someone has pressed the "wish to cross" button and the voltage has built up from zero to a high enough value).

3) OUTPUT DEVICES

Output devices take the **electrical signal** (**electrical energy**) from the **process part** of an electronic system and change it into **a useful form of energy**.

For example:

• Analogue Output Devices

The output can have many ___________ values.

Often, the value keeps ___________.

• **loudspeaker**

__________ → ___________

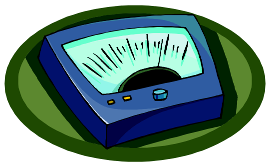
The **v** _ _ _ _ _ _ and **f** _ _ _ _ _ _ _ _ _ _ of the sound keep changing.

• **electric motor**

__________ → ___________

The **s** _ _ _ _ of the turning motor can be changed to many different values.

• **moving coil meter**



__________ → ___________

The **p** _ _ _ _ _ _ _ _ of the pointer on the scale can change from anywhere between the **far l** _ _ _ and **far r** _ _ _ _.

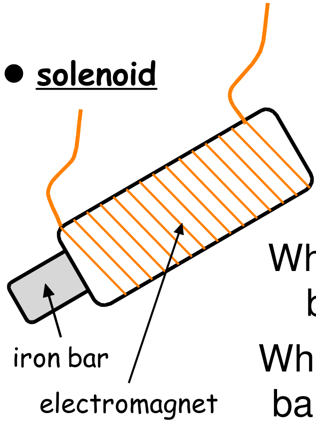
• Digital Output Devices

These have only ___ values.

We describe these values in different ways:

_____/_____ or _____/_____ or _____/_____

• **solenoid**

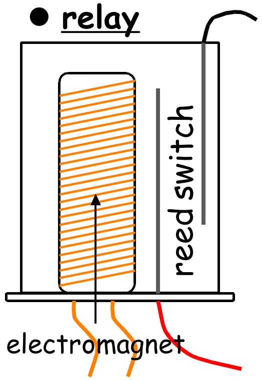


__________ → ___________

When the solenoid is **ON**, the iron bar in the centre is pulled **i** _.

When the solenoid is **OFF**, the iron bar in the centre is pushed **o** _ _.

• **relay**

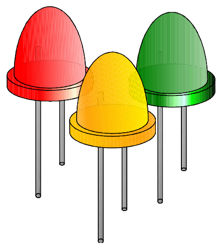


__________ → ___________

When the relay is **ON**, the reed switch is **c** _ _ _ _ _.

When the relay is **OFF**, the reed switch is **o** _ _ _.

• **light emitting diode (LED)**

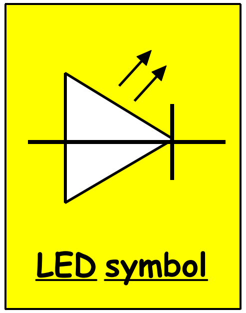


__________ → ___________

The **LED** is either **o** _ or **o** _ _.

Its **b** _ _ _ _ _ _ _ _ _ does not change.

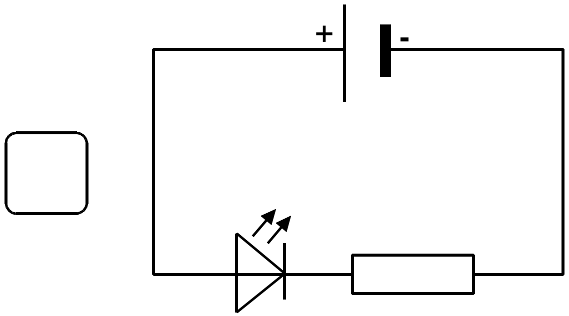
Connecting LED's in a Circuit

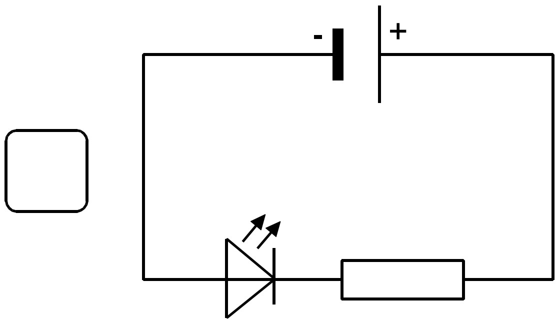


An **LED** will only light if it is connected **one way round**:

Put a **tick** or **cross** in each box below to show the circuit in which the LED will light.

For the circuit in which the LED lights, draw **arrows** to show the direction in which electrons flow.





A **r** _ _ _ _ _ _ _ _ is connected beside (in **s** _ _ _ _ _ _ with) the **LED**.

This is needed to ____

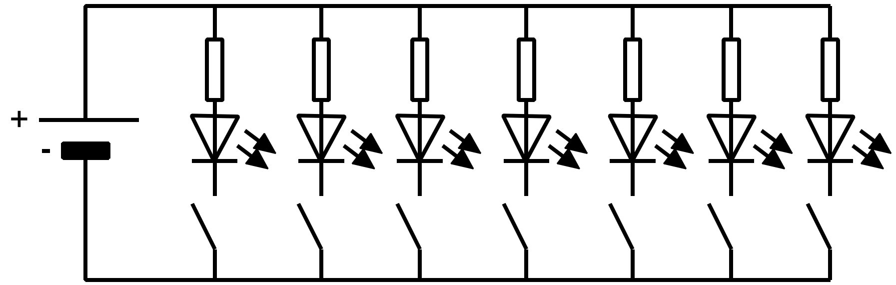
____

____

The Seven-Segment Display

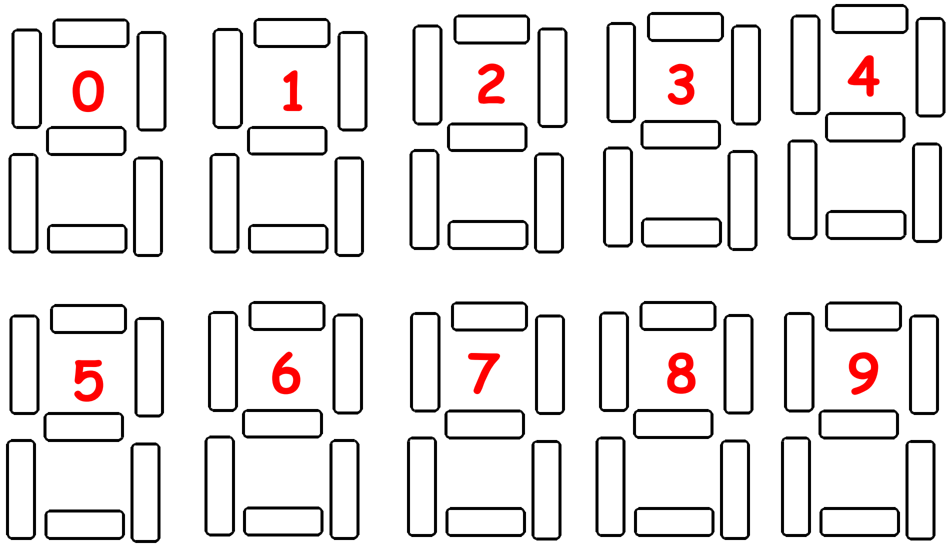
Seven separate **LED's** can be arranged to form the shape of a **number e** _ _ _ _ - This is called a **7- s** _ _ _ _ _ _ _ **d** _ _ _ _ _ _ _.

Each **LED** can be switched **on** or **off** **s** _ _ _ _ _ _ _ _ _ _ using the electric circuit below:



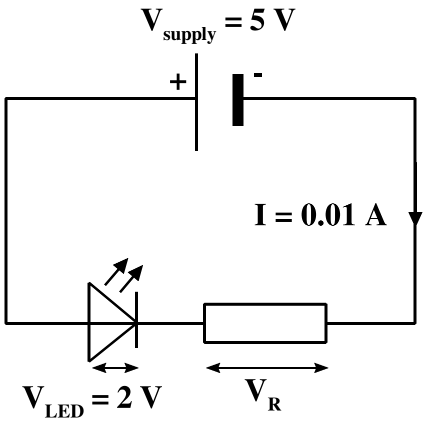
This allows **any number** from __ to __ to be displayed.

Colour in the **LED's** which must be lit to produce these numbers:



Calculating the Resistance of the Series Resistor Protecting an LED

For the electric circuit shown below, the maximum voltage the **LED** can safely take is 2 V. The current is 0.01 A.



Voltage across resistor (V_R) = $V_{supply} - V_{LED}$

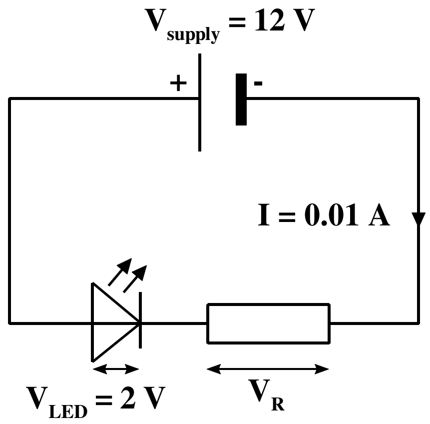
$= 5\ V - 2\ V$

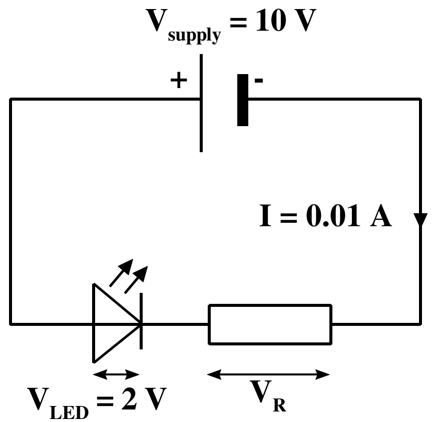
$= 3\ V$

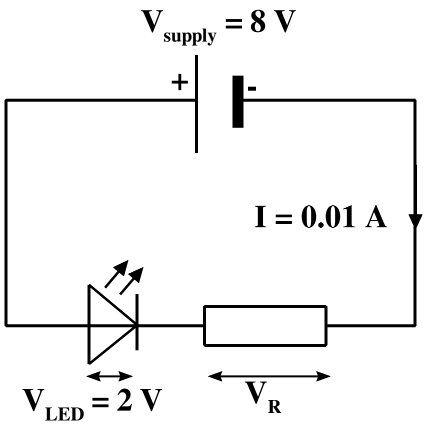
Resistance of resistor (R) = $\frac{V_R}{I}$

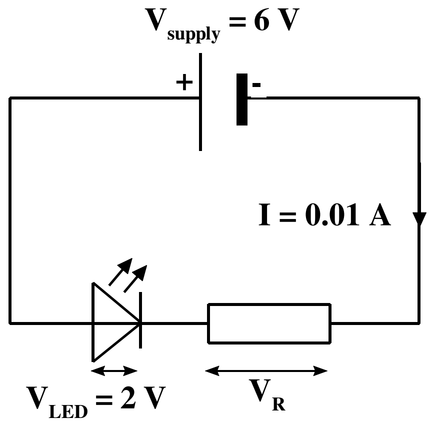
$= \frac{3\ V}{0.01\ A} = \underline{300\,\Omega}$

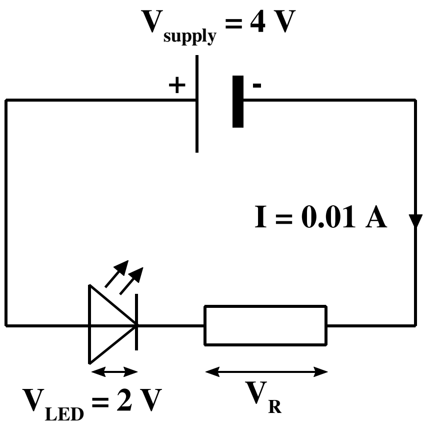
Calculate the **resistance** of the protective resistor in each of the following LED circuits:

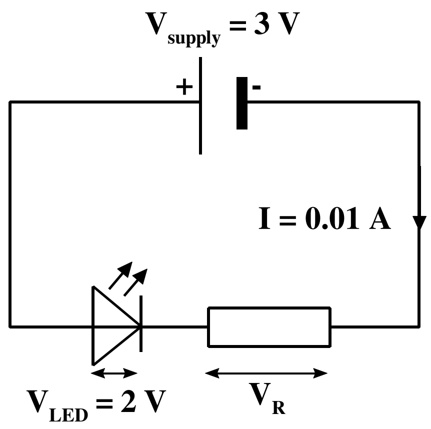





V_{supply} = 8 V
+
-
I = 0.01 A
V_{LED} = 2 V
V_R


V_{supply} = 6 V
+
-
I = 0.01 A
V_{LED} = 2 V
V_R

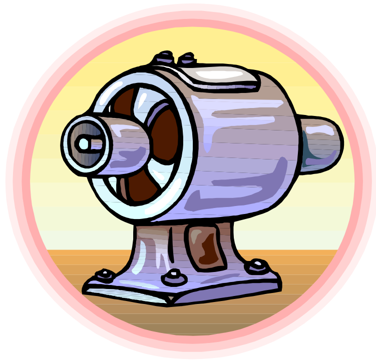

V_{supply} = 4 V
+
-
I = 0.01 A
V_{LED} = 2 V
V_R


V_{supply} = 3 V
+
-
I = 0.01 A
V_{LED} = 2 V
V_R

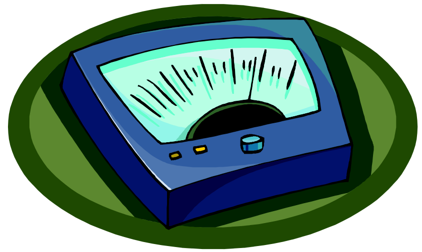
By drawing lines, match each **output device** with the **job** it does in **2** different **electronic systems**:

- loudspeaker

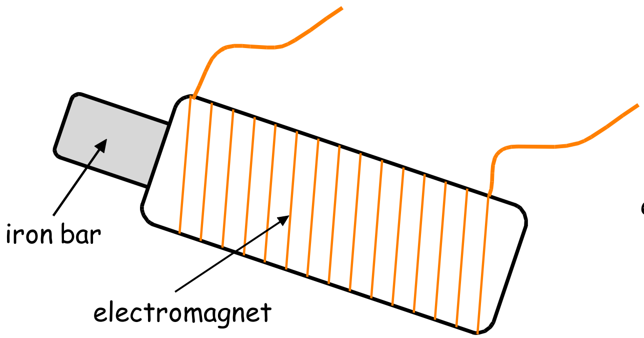
- electric motor



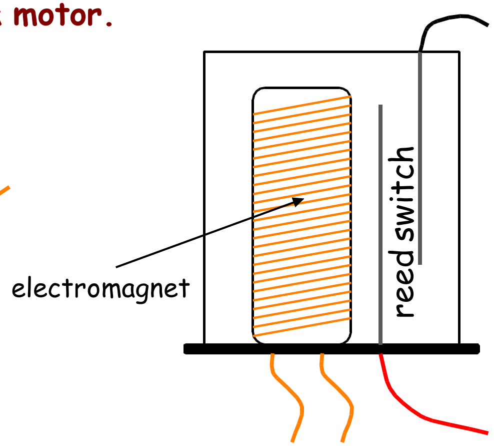
- moving coil meter



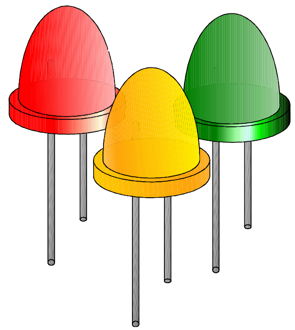
- Giving out sound from a telephone earpiece.
- Displaying numbers in a seven segment display.
- Showing a voltage reading.
- An electrically-operated door bolt.
- Turning the chuck of an electric drill.
- Switching on a device in a nuclear reactor.
- Pushing boxes off a conveyor belt.
- Turning the blades of a fan.
- Giving out sound from a radio.
- Showing a current reading.
- Switching on a motor.
- Showing that a radio is switched on.



- solenoid



- relay



- light emitting diode

4) DIGITAL PROCESS DEVICES

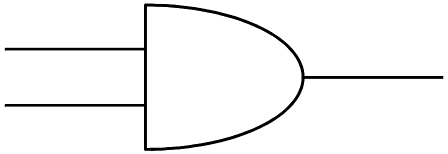
Process devices take information from **input devices**, **process the information**, then **send it to** an **output device**.

Logic Gate Circuits

A **logic gate outputs** a signal
(______/______ or ______/______ or ______/______)
depending on the signal(s) **input** to it.

Logic gates may have one or more **inputs**.

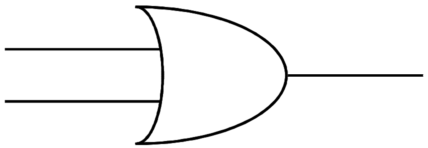
A **t _ _ _ _ _ t _ _ _ _ _** shows the **output** for all possible **input** combinations.



_ _ _ **gate**

truth table

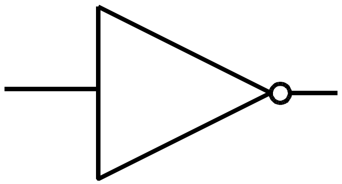
INPUT A	INPUT B	OUTPUT C



_ _ **gate**

truth table

INPUT A	INPUT B	OUTPUT C



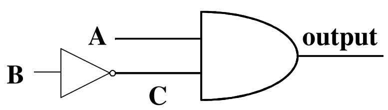
_ _ _ **gate (_ _ _ _ _ _ _ _ _)**

truth table

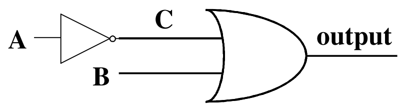
INPUT A	OUTPUT B

Control circuits in **electronic devices** use a **combination of logic gates.**

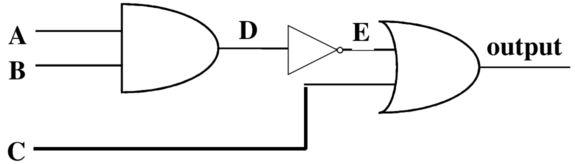
For the **combinations of logic gates** shown, complete the **truth tables**:



A	B	C	output
0	0		
0	1		
1	0		
1	1		

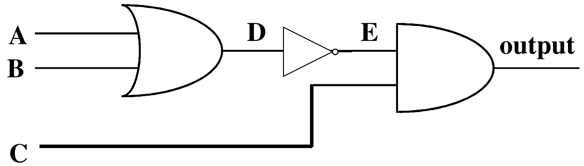


A	B	C	output
0	0		
0	1		
1	0		
1	1		

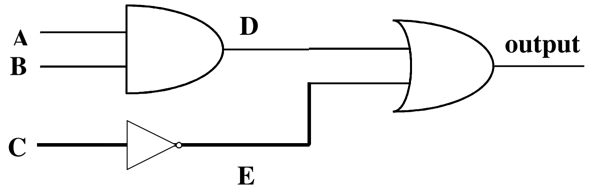


A	B	C	D	E	output
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

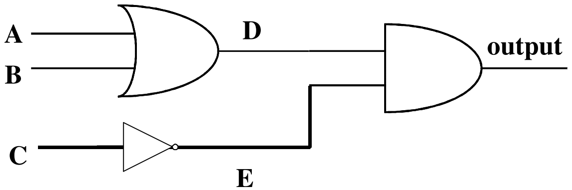
A	B	C	D	E	output
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			



A	B	C	D	E	output
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			



A	B	C	D	E	output
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

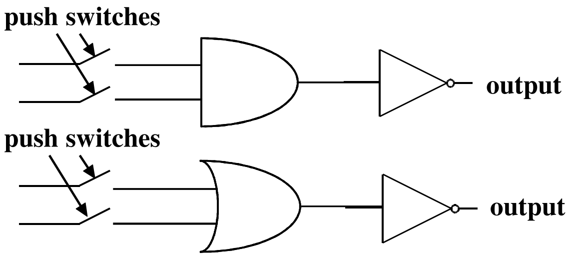


Simple Logic Gate Control

Two simple **logic gate control circuits** are shown:

circuit A

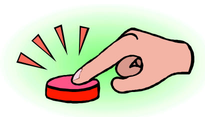
circuit B



Explain which circuit is used:

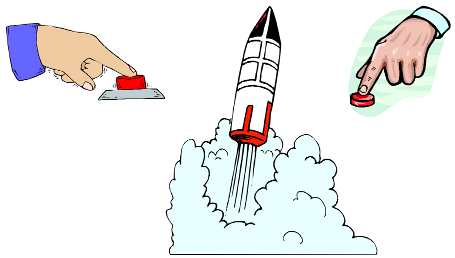
By staff in a bank if there is a robbery.

When **either** of the 2 push switches is closed, the output becomes **0**. An electromagnet which holds up a security screen in front of the bank worker is switched off, so the screen falls.



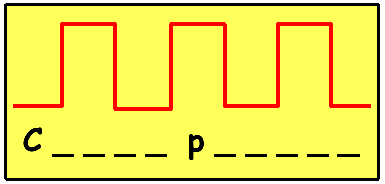
By soldiers preparing to fire a missile.

When **both** of the 2 push switches are closed, the output becomes **0** and the safety lock on the firing mechanism is switched off - the missile is launched.

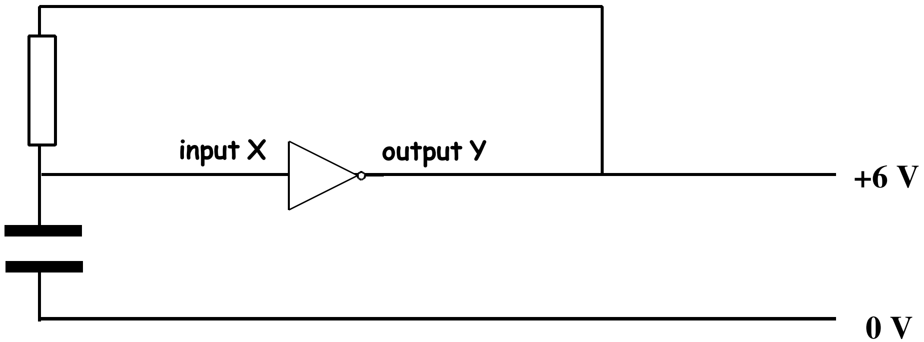


Clock Pulses

C _ _ _ _ **p** _ _ _ _ _ _ are a continuous series of **d** _ _ _ _ _ _ _ **p** _ _ _ _ _ produced at regular time intervals.



They are produced in a **digital circuit** by a **s** _ _ _ _ _ **o** _ _ _ _ _ _ _ _ _ (**c** _ _ _ _ **p** _ _ _ _ **g** _ _ _ _ _ _ _ _ _).



1) Capacitor is **uncharged**.
Input X = __ , so output Y = __ .

2) Capacitor **charges up**.
Input X = __ , so output Y = __ .

3) Capacitor **discharges**, so is **uncharged** again.

4) This process keeps **r** _ _ _ _ _ _ _ _ at **r** _ _ _ _ _ _ **i** _ _ _ _ _ _ _ _ _ , so produces **c** _ _ _ _ **p** _ _ _ _ _.

To get **more clock pulses** every second (increased frequency), we ___________ the **resistance** of the **resistor** or ___________ the **capacitance** of the **capacitor** - And vice versa.

(a) On the oscilloscope screen on the right, draw the shape of **clock pulses** output from a **simple oscillator.**

(b) Is a **simple oscillator** circuit **analogue** or **digital**?

____

(c) Sketch a **simple oscillator** circuit. Label the **resistor**, **capacitor** and **inverter**.

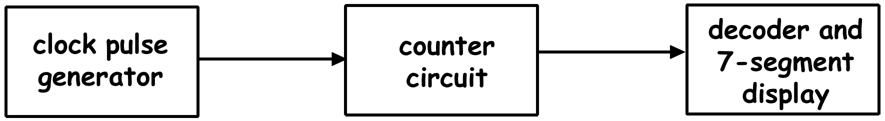
(d) Explain how the **simple oscillator** operates.

(e) Describe how to **decrease** the **frequency** of the **clock pulses** produced by the **simple oscillator**.

Simple oscillator (**clock pulse generator**) **circuits** produce **digital clock pulses** for **digital w _ _ _ _ _ _ _** and **digital c _ _ _ _ _ _**.

The **digital clock pulses** are counted by a **c _ _ _ _ _ _ _ circuit** - This circuit outputs **b _ _ _ _ _ _ numbers**.

The **b _ _ _ _ _ _ numbers** are then fed to a **d _ _ _ _ _ _ _** which changes them to a **d _ _ _ _ _ _ _ number** for display on a **7-s _ _ _ _ _ _ _ d _ _ _ _ _ _ _**.



Changing Binary Numbers to Decimal

Binary numbers are used by electronic devices such as computers and calculators.

Binary numbers are made up of only **ones** and **zeros** - For example: **1010**.

This is how to convert a **binary number** into a **decimal number**:

1	0	1	0
×	×	×	×
8	4	2	1
↓	↓	↓	↓

8 + 0 + 2 + 0 = 10

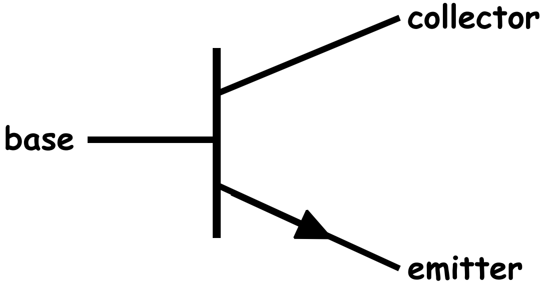
Convert these **binary numbers** into **decimal numbers**:

1001	**0101**
0010	**0111**
0100	**0110**
0011	**1000**

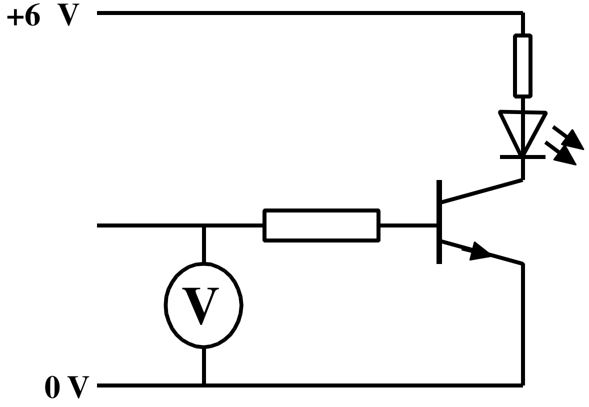
The Transistor as an Electronic Switch

A **transistor** can be used in a circuit as an **electronic s _ _ _ _ _ _**.

The **circuit symbol** for an **NPN transistor** is shown:



A **transistor switching circuit** is shown:

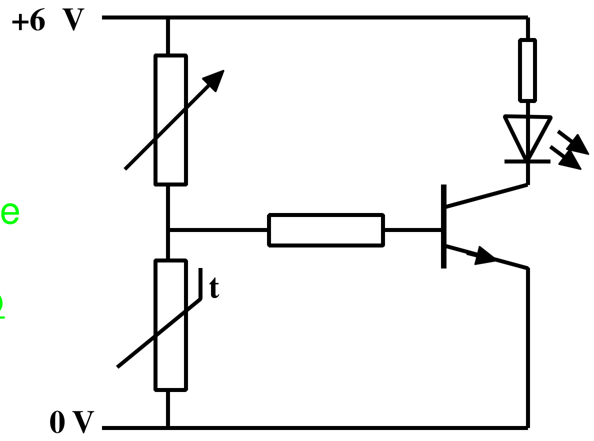


The **transistor** may be **conducting** (**ON**) or **non-conducting** (**OFF**).

When a **h _ _ _ voltage** (**___ V or more**) is applied across the voltmeter, the **transistor** is switched ___. The **transistor** then switches the **LED** ___.

When a **l _ _ voltage** (**less than ___ V**) is applied across the voltmeter, the **transistor** is switched ___. The **transistor** then switches the **LED** ___.

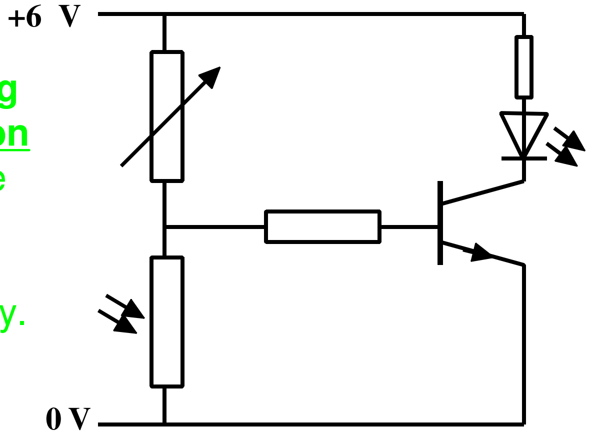
This **transistor switching circuit** is used to switch **on** a warning **LED** when the **temperature** in a greenhouse gets **too low**. Explain how it works:



Redraw the circuit with the **variable resistor** and **thermistor** swapped about. Explain what happens this time when the **temperature** **falls**.

What is the purpose of the **variable resistor**?

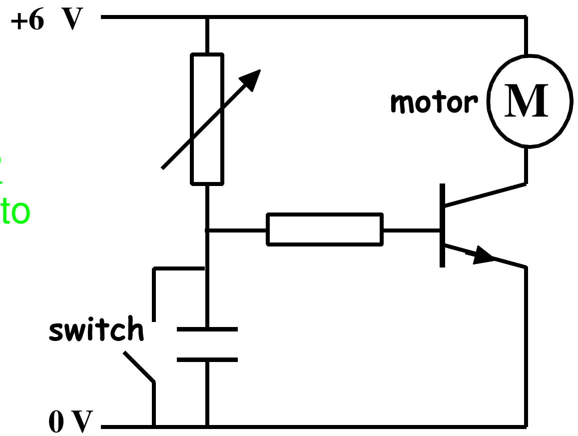
This **transistor switching circuit** is used to switch **<u>on</u>** a warning **LED** when the **light level** in a school library gets **<u>too</u> <u>low</u>** for people to read comfortably. Explain how it works:



Redraw the circuit with the **variable resistor** and **LDR** swapped about. Explain what happens this time when the **light level <u>falls</u>**.

What is the purpose of the **variable resistor**?

This **transistor switching circuit** contains a **<u>capacitor</u>** and **<u>switch</u>**. It is used to **<u>delay</u>** the **motor switching on**.



WHEN SWITCH S IS <u>OPEN</u>, THE MOTOR IS <u>ON</u>.

Explain what happens when the **switch** is **<u>closed</u>:**

Explain what happens when the **switch** is **<u>opened</u>** again:

What is the purpose of the **variable resistor**?

5) ANALOGUE PROCESS DEVICES-AMPLIFIERS

Amplifiers play an important part in electronic devices which have a **loudspeaker output** - For example:

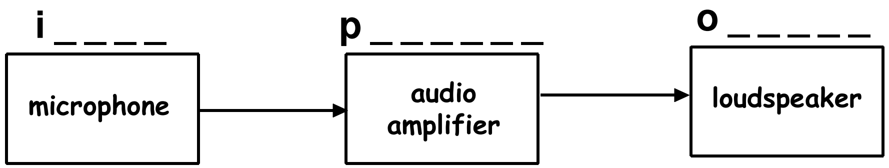
____

____

The **amplifier** increases the **a** _ _ _ _ _ _ _ _ _ of the electrical **i** _ _ _ _ **signal**.

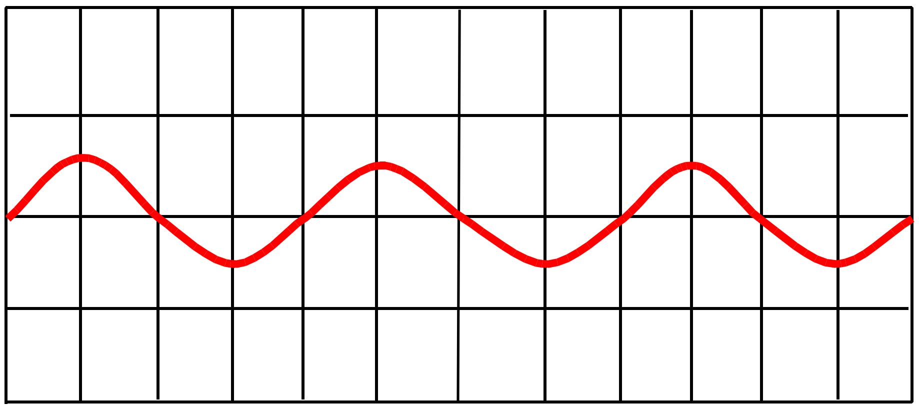
As a result, the **o** _ _ _ _ _ **signal** has a greater **amplitude** than the **input signal** - It now has enough **e** _ _ _ _ _ to power the **loudspeaker**.

For example, a karaoke machine:



The **audio amplifier** does not change the **f** _ _ _ _ _ _ _ _ of the **input signal** - If the **input signal** has a **frequency** of **1 000 Hz**, the **output signal** has a **frequency** of _______ **Hz**.

The trace below shows the **electrical signal** from a **microphone** which is being input to an **amplifier**. On the same trace, draw the **possible shape** of the **output signal**.



Voltage Gain of an Amplifier

In an **electronic system**, the **electrical signals** are usually **voltages**. The number of times an **amplifier** increases the **amplitude** of an **input voltage** by is known as the **v** _ _ _ _ _ _ **g** _ _ _ of the **amplifier** - This does not have a **u** _ _ _.

$$\text{voltage gain} = \frac{\text{output voltage}}{\text{input voltage}}$$

In each case below, calculate the **voltage gain** of the **amplifier**:

input voltage = 12 V, output voltage = 36 V

input voltage = 2.5 V, output voltage = 75 V

input voltage = 1.2 V, output voltage = 24 V

input voltage = 0.15 V, output voltage = 45 V

input voltage = 0.25 mV, output voltage = 12.5 mV

input voltage = 100 mV, output voltage = 2 000 mV

In each case below, calculate the **output voltage** from the **amplifier**:

input voltage = 0.15 V,
voltage gain of amplifier = 200

input voltage = 0.15 V,
voltage gain of amplifier = 80

input voltage = 18 mV,
voltage gain of amplifier = 30

input voltage = 12.5 mV,
voltage gain of amplifier = 20

In each case below, calculate the **input voltage** to the **amplifier**:

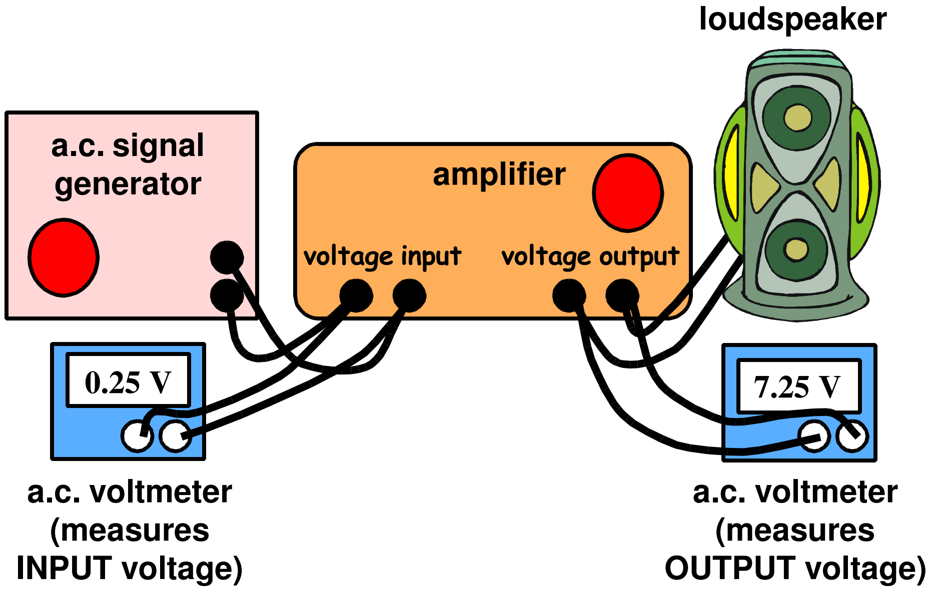
voltage gain of amplifier = 250,
output voltage = 90 V

voltage gain of amplifier = 15,
output voltage = 25.5 V

voltage gain of amplifier = 120,
output voltage = 36 mV

voltage gain of amplifier = 75,
output voltage = 210 mV

Experiment to Measure the Voltage Gain of an Amplifier



Describe how you would use this apparatus to measure the **voltage gain** of the amplifier.

Amplifier Power

The electrical **power input** to and **power output** from an **amplifier** can be calculated using the formula:

$$\text{power} = \frac{\text{voltage}^2}{\text{resistance}}$$

Note - In amplifier problems, the word "**impedance**" is sometimes used instead of the word "**resistance**".

In each case, calculate the **power input** or **power output** of the amplifier:

input voltage = 12 V, resistance = 6 Ω

output voltage = 12 V, resistance = 3 Ω

input voltage = 6 V, resistance = 9 Ω

output voltage = 2 V, resistance = 8 Ω

input voltage = 5 V, resistance = 2.5 Ω

output voltage = 9 V, resistance = 18 Ω

input voltage = 8 V, resistance = 8 Ω

output voltage = 100 V, resistance = 25 Ω

input voltage = 2.5 V, resistance = 6.25 Ω

output voltage = 5.5 V, resistance = 1.25 Ω

input voltage = 13 V, resistance = 26 Ω

output voltage = 100 V, resistance = 500 Ω

input voltage = 5.5 V, resistance = 0.25 Ω

output voltage = 7.5 V, resistance = 1.25 Ω

Power Gain of an Amplifier

The number of times an **amplifier** increases the **amplitude** of an **input power** by is known as the **p _ _ _ _ g _ _ _** of the **amplifier**
- This does not have a **u _ _ _**.

$$\text{power gain} = \frac{\text{output power}}{\text{input power}}$$

In each case below, calculate the **power gain** of the **amplifier** which has **amplified** the **input power**:

input power = 10 W, output power = 300 W

input power = 3 W, output power = 180 W

input power = 2.5 W, output power = 15 W

input power = 0.15 W, output power = 36 W

input power = 0.25 mW, output power = 525 mW

input power = 10mW, output power = 350 mW

A loudspeaker of resistance 8 Ω has 6 volts across it.

(a) Calculate the **power output** of the loudspeaker.

(b) Find the **power gain** of the amplifier to which the loudspeaker is connected if the input power to the amplifier is 0.05 W.

(a) Calculate the **power output** of a loudspeaker of resistance 12 Ω which has 24 V across it.

(b) Find the **power gain** of the amplifier to which the loudspeaker is connected if the input power to the amplifier is 0.02 W.

(a) Calculate the **power output** of a loudspeaker of resistance 24 Ω which has 8 V across it.

(b) Find the **power gain** of the amplifier to which the loudspeaker is connected if the input power to the amplifier is 0.12 W.

LEARNING OUTCOMES

blue = General red = Credit

	1) Electronic Systems Overview						
1.	I can state that an electronic system consists of three parts - input, process and output.						
2.	I can distinguish between analogue and digital signals.						
3.	I can identify analogue and digital signals from waveforms viewed on an oscilloscope.						

	2) Input Devices						
1.	I can describe the energy transformations involved in a microphone, thermocouple and solar cell.						
2.	I can state that the resistance of a thermistor changes with temperature and the resistance of an LDR decreases with increasing light intensity (and vice versa).						
3.	I can carry out calculations using voltage, current and resistance for a thermistor and LDR.						
4.	I can carry out calculations involving voltages and resistances in a voltage divider.						
5.	I can state that during charging, the voltage across a capacitor increases with time.						
6.	I can state that the time to charge a capacitor depends on the values of the capacitance and series resistance.						
7.	I can identify, from a list, an appropriate input device for a given application.						
8.	I can identify, without a list, appropriate input devices for a given application.						

	3) Output Devices						
1.	I can give examples of output devices and the energy conversions involved.						
2.	I can give examples of analogue output devices and digital output devices.						
3.	I can draw and identify the symbol for an LED.						
4.	I can state that an LED will light only if connected one way round.						
5.	I can explain the need for a series resistor with an LED.						
6.	I can describe, by means of a diagram, a circuit which will allow an LED to light.						
7.	I can state that different numbers can be produced by lighting appropriate segments (LED's) of a 7-segment display.						
8.	I can calculate the value of the series resistor for an LED.						
9.	I can identify appropriate output devices for a given application.						

	4) Digital Process Devices						
1.	I can state that logic gates may have one or more inputs and that a truth table shows the output for all possible input combinations.						
2.	I can draw and identify the symbols for two input AND and OR gates, and a NOT gate (inverter).						
3.	I can state that: ● high voltage = logic '1' ● low voltage = logic '0'.						
4.	I can draw the truth tables for two input AND and OR gates, and a NOT gate (inverter).						
5.	I can identify the following logic gates from truth tables: ● two-input AND ● two-input OR ● NOT (inverter)						
6.	I can complete a truth table for a simple combinational logic circuit.						
7.	I can explain how to use combinations of digital logic gates for control in simple situations.						
8.	I can state that a digital circuit can produce a series of clock pulses.						
9.	I can explain how a simple oscillator (clock pulse generator) built from a resistor, capacitor and inverter works.						
10.	I can describe how to change the frequency of the clock pulses produced by a simple oscillator (clock pulse generator).						
11.	I can state that there are circuits which can count digital pulses.						
12.	I can give an example of a device containing a counter circuit.						
13.	I can state that the output of the counter circuit is in binary.						
14.	I can state that the output of a binary counter circuit can be converted to decimal.						
15.	I can calculate the decimal equivalent of a binary number in the range 0000 - 1001.						
16.	I can draw and identify the circuit symbol for an NPN transistor.						
17.	I can state that a transistor may be conducting (ON) or non-conducting (OFF).						
18.	I can state that a transistor can be used as a switch.						
19.	I can identify, from a circuit diagram, the purpose of a simple transistor switching circuit.						
20.	I can explain the operation of a simple transistor switching circuit.						

	5) Analogue Process Devices - Amplifiers						
1.	I can identify, from a list, devices in which amplifiers play an important part.						
2.	I can state the function of the amplifier in devices such as radios, intercoms and music centres.						
3.	I can state that the output signal of an audio amplifier has the same frequency as the input signal, but has a larger amplitude.						
4.	I can carry out calculations involving input voltage, output voltage and voltage gain of an amplifier.						
5.	I can describe how to measure the voltage gain of an amplifier.						
6.	I can carry out calculations involving power, voltage and resistance (impedance).						
7.	I can carry out calculations involving input power, output power and power gain of an amplifier.						

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