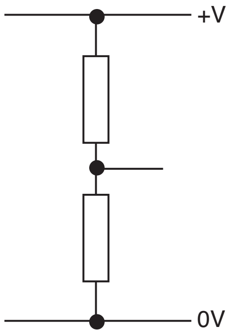
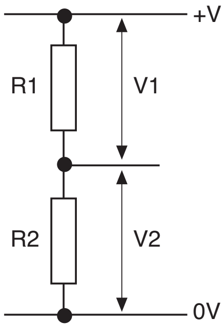
THE POTENTIAL DIVIDER AND LDR

THE POTENTIAL DIVIDER

A simple potential divider is two resistors joined in series across a supply. The purpose of a potential divider is to produce a voltage at the point between the two resistors which is lower than the supply voltage. It can be said to 'divide' the supply voltage.



To think about a potential divider, use the letters shown here for voltage and resistance. Voltage V is the power supply voltage, V1 is the voltage across the resistor R1 and V2 the voltage across resistor R2.

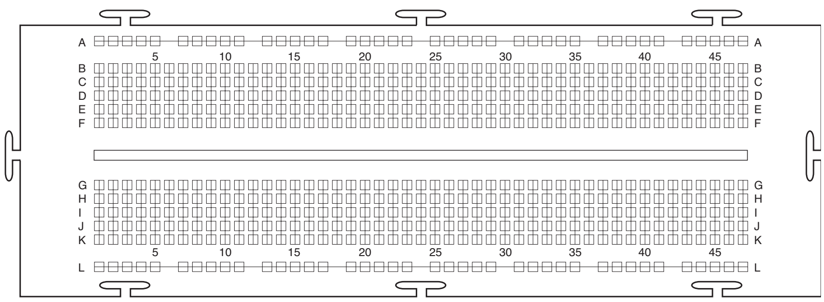


If the resistors R1 and R2 are of equal value - e.g. 1 kΩ each - the voltage at the centre is half the supply voltage - i.e. the voltage is ‘divided’ in half. The voltage at the centre depends on the values of R1 and R2 and can be calculated as follows:

$$V_2 = \frac{R_2}{R_1 + R_2} \times V$$

INVESTIGATION 1

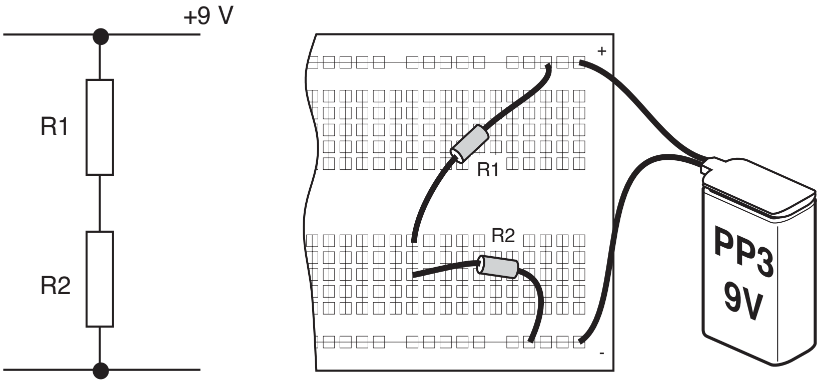
There are a number of ways to mount resistors for a practical investigation of the potential divider. For this activity, you can use **prototype board**. This is sometimes known as **breadboard**. It allows you to build circuits and change components quickly.



To complete the investigation, you need:

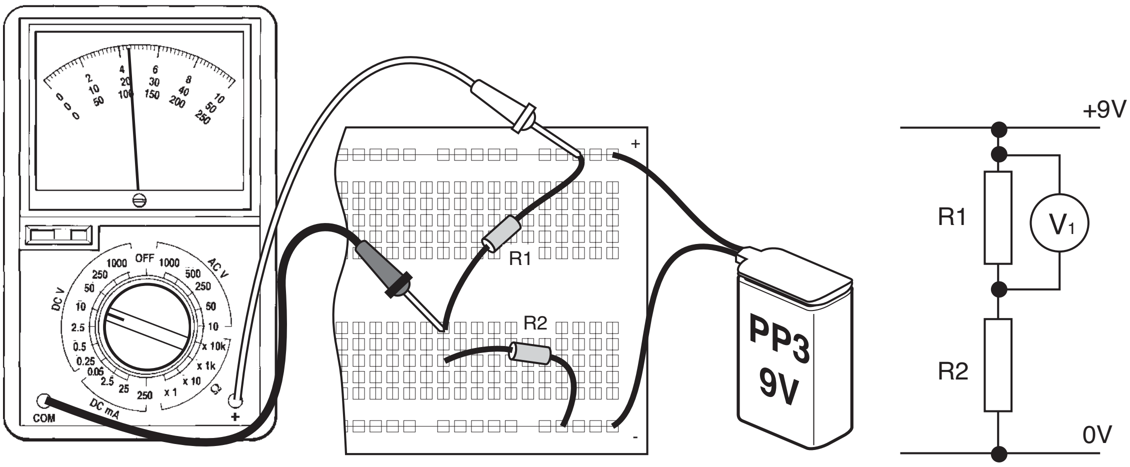
- A breadboard.
- A multimeter - set on a voltage range to measure a maximum of 9 V.
- Some short pieces of insulated single conductor wire with the ends stripped.
- A 9 V battery and battery holder OR a power supply.
- A range of resistors - between 1 kΩ and 10 kΩ.

This is how you connect your circuit on the breadboard:

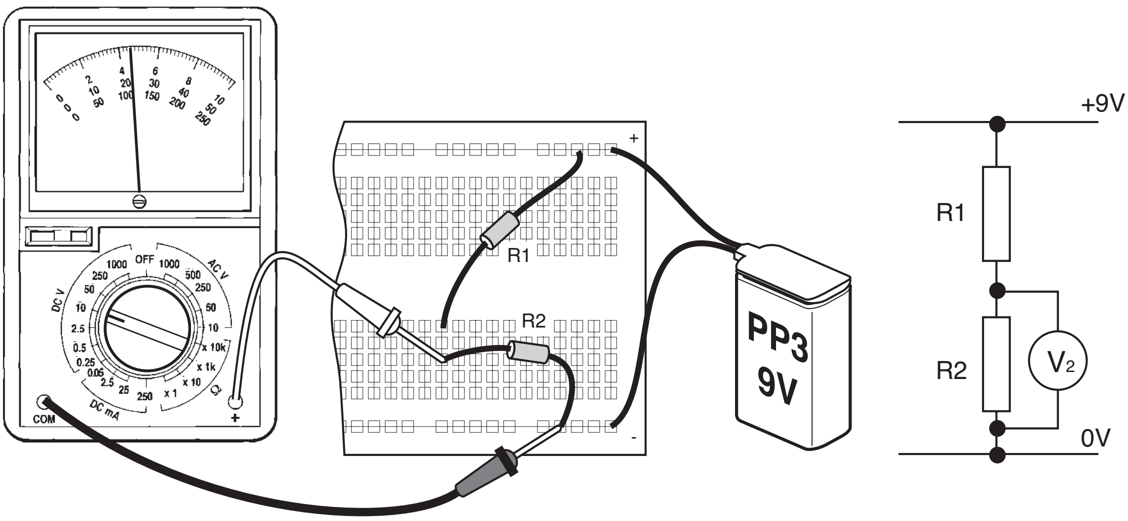


First, insert two 1 kΩ resistors for R1 and R2 and then measure the voltage across them as shown. In both cases, the reading should be 4.5 V. This will also be true for other resistor values providing they are of equal values.

To measure the voltage V1, connect the multimeter across R1:



To measure the voltage V2, connect the multimeter across R2:



Now try a 1 kΩ resistor for R1 and a 2 kΩ resistor for R2.
What is the result?

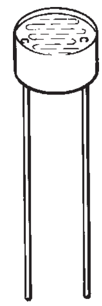
- Try other values.
- Draw a table to record your results.
- Measure and record the supply voltage.

Remember...

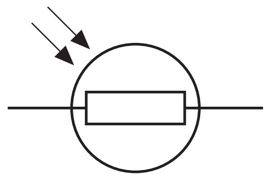
- Never forget to write down your results.
- It is easier to see what is going on if you put your results into a table.
- Be systematic, for example, by increasing R1 by the same amount each time.
- Keep things simple (to start with), leave R2 alone and just change R1.

THE LDR

In industry, light sensors are used to measure levels of light so people can work safely and without eye strain. Another use is in photography, where it is necessary to measure accurately the level of light needed to take correctly exposed photographs. The sensor often used in these applications is the light dependent resistor (LDR). This is a special resistor whose resistance changes with the level of light.



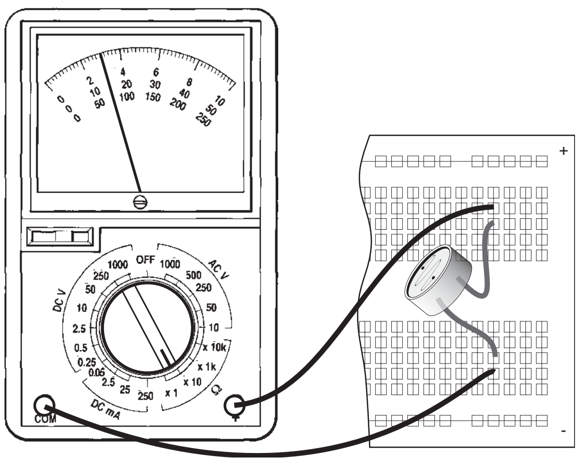
LDR type ORP 12



LDR symbol

INVESTIGATION 2

Connect a multimeter to the LDR on the prototyping board as shown:



Switch the multimeter to the resistance range you want. This will be either the Ω x 1 range which gives a direct reading from the resistance scale or the Ω x 1 k range which gives 1000 times the scale reading. Other meters can have other resistance ranges.

Cover the LDR completely with your finger and then read the value of the resistance from your multimeter.

Write the value in Table 1 in the correct place. Now copy and complete the table by measuring the LDR's resistance in other situations.

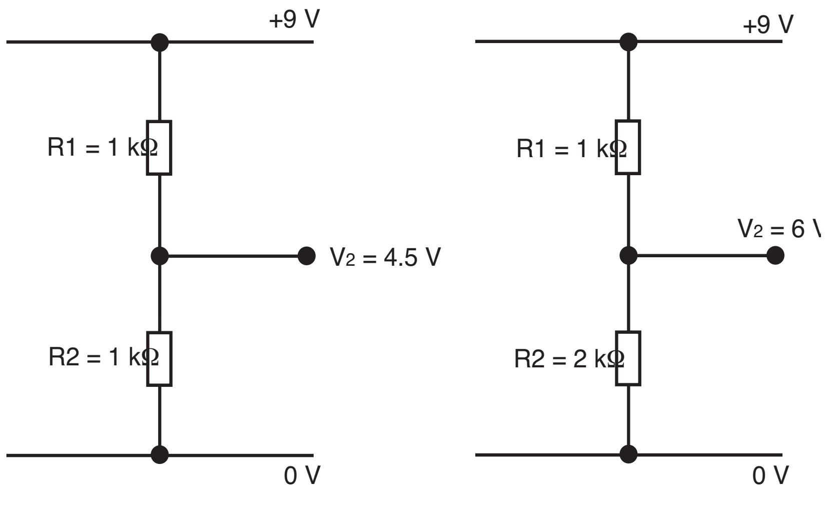
INDOORS		**OUTDOORS**	
Situation	**Resistance**	**Situation**	**Resistance**
LDR completely covered		Dull or overcast	
Fluorescent lit room		Cloudy or bright	
60 W lamp at 1 m		Hazy sun	
6 V 0.06 A lamp at 10 cm		Bright sunlight	

Table 1

It is more convenient for electronic circuits to detect changes in voltage rather than changes in resistance. Sensors such as the LDR are connected in series with a resistor to form a potential divider.

THE LDR AS PART OF A POTENTIAL DIVIDER

You will have realised from investigation 1 that the voltage at the centre of a potential divider depends on the ratio of the values of the two resistors that make up the potential divider. Two of the results you obtained should have been similar to the ones shown below



Changing R2 from 1 kΩ to 2 kΩ caused the value of V_2 to change from 4.5V to 6V.

A formula may be used to perform a calculation to predict the voltage V_2 measured in each case. This formula is known as the potential divider formula.

$$V_2 = \frac{R_2}{R_1 + R_2} \times \text{supply voltage}$$

Substituting the values from the right hand circuit into the formula we get:

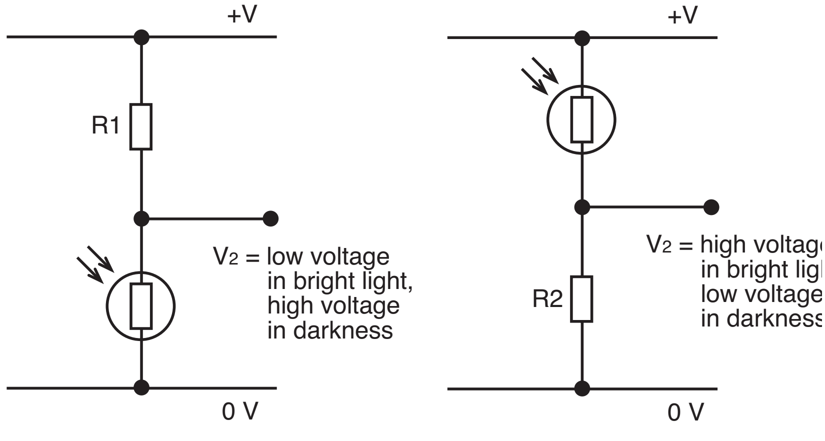
$$V_2 = \frac{2k\Omega}{2k\Omega + 1k\Omega} \times 9v$$

$$= \frac{2}{3} \times 9$$

= 6 volts

Use the formula to confirm the value of V_2 obtained in the left hand circuit.

This effect of different values of resistance producing different voltages can be applied to input sensing circuits. The sensor is connected in series with a resistor to form a potential divider. A change in the ambient conditions will cause a change in the resistance of the sensor which in turn produces a change in V_2. This change in V_2 can be detected by an electronic processing circuit.



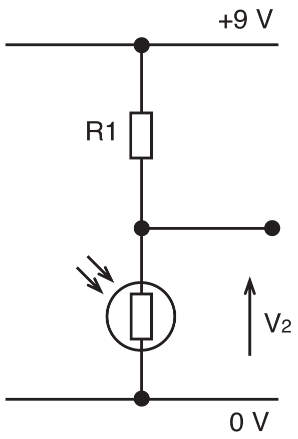
From investigation 2 you should have realised that the LDR has a high resistance in the dark and a low resistance in bright light.

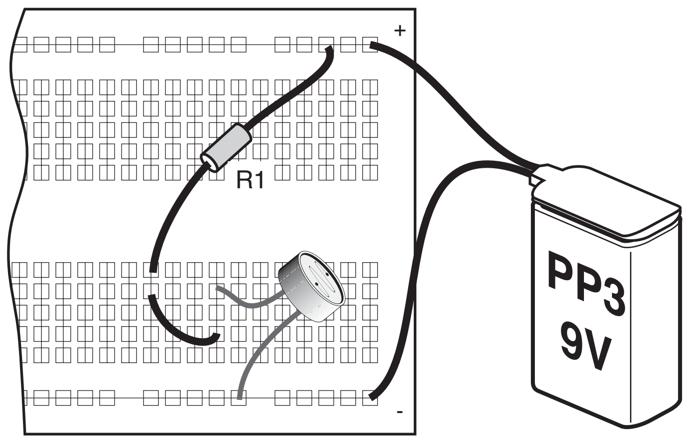
Two possible light sensing circuits are shown below.

As a rule of thumb the value of the series resistor used with a sensor should be approximately half the maximum value of sensor resistance that could be encountered in the environment in which it is being used.

INVESTIGATION 3

Use a voltmeter to measure the voltage V2 in darkness and in bright light. You will have to refer to table 1 of investigation 1 and use the rule of thumb given above to enable you to determine a suitable value for R1. A table of resistor preferred values is provided on the next page.





PREFERRED VALUES

Manufacturers of resistors cannot supply every possible value of resistor, so they make available preferred values only.

The E12 and E24 series of preferred values start as follows:

E12	E24
10R	10R
	11R
12R	12R
	13R
15R	15R
	16R
18R	18R
	20R
22R	22R
	24R
27R	27R
	30R
33R	33R
	36R
39R	39R
	43R
47R	47R
	51R
56R	56R
	62R
68R	68R
	75R
82R	82R
	91R
100R	100R
	110R
120R	120R
	130R
150R	150R
	160R
180R	180R
	200R
220R	220R
	240R
270R	270R
	300R
330R	330R
	360R
390R	390R
	430R
470R	470R
	510R

E12	E24
560R	560R
	620R
680R	680R
	750R
820R	820R
	910R
1K	1K
	1K1
1K2	1K2
	1K3
1K5	1K5
	1K6
1K8	1K8
	2K0
2K2	2K2
	2K4
2K7	2K7
	3K0
3K3	3K3
	3K6
3K9	3K9
	4K3
4K7	4K7
	5K1
5K6	5K6
	6K2
6K8	6K8
	7K5
8K2	8K2
	9K1
etc	etc