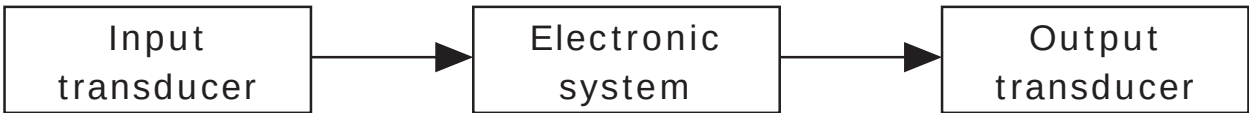
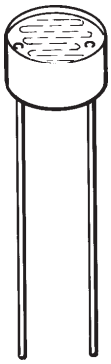
TRANSDUCERS

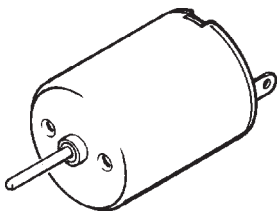
Transducers change energy from one form to another. Because of this, they can be used to link electronic systems to the 'outside world'.



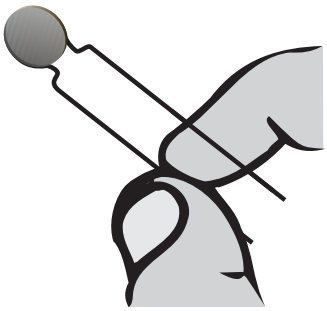
EXAMPLES



Light sensor

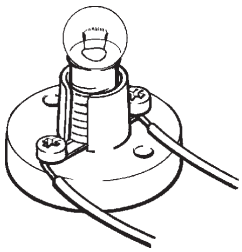


Dynamo

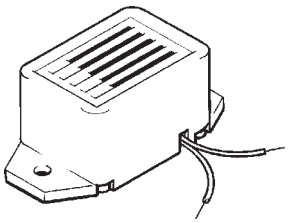


Temperature sensor

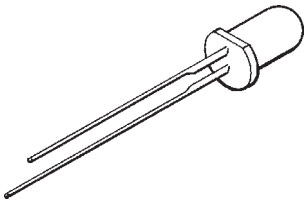
EXAMPLES



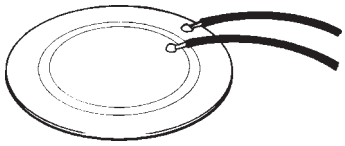
Lamp



Loudspeaker or buzzer



Light emitting diode



Piezo transducer

TEMPERATURE SENSORS AND CONTROLLING TEMPERATURE

There are three types of temperature sensor that are readily available and easy to use. These are:

- thermistors
- thermocouples
- LM35 IC (integrated circuit).

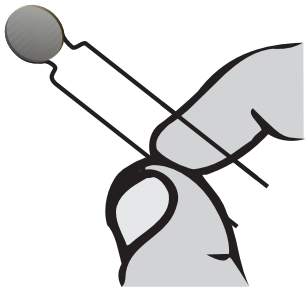
When you select a temperature sensor, you should consider:

• Its characteristics	How does the value change with temperature? Is the relationship linear?
• Ease of use	What circuit do you need? Are there limitations? Are there any special precautions?
• Cost	
• Response time	How quickly does it react?

THERMISTORS

These are devices that change their resistance as the temperature changes.

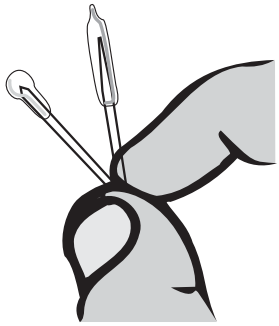
You can use either a **general purpose disc thermistor** or a **bead thermistor**:



Disc thermistor

THERMOCOUPLES

These consist of a junction of two different metals which produces a small voltage when heated. The value of this voltage changes with temperature.



Bead thermistor

LM35

This is an integrated circuit (IC). The output voltage changes with temperature.

INVESTIGATING THERMISTORS

You will need:

- 10 kΩ disc thermistor
  (temperature range -30 to +125^0 C) RS 256-073.
- 10 kΩ bead thermistor
  (temperature range +10 to +100^0 C) RS 256-045.
- Multimeter to measure resistance.
- Water bath and heater.
- A -10 to +110^0 C thermometer.

There are two things to investigate:

- The way the resistance changes with temperature.
- How quickly the value of resistance settles down.

To investigate the second of these, you need to be able to keep the temperature in the water bath constant.

Plan your investigation carefully.
Think about:

- What you will change and what you will keep the same.
- What you need to measure.
- How you will record your data.
- How you will present your data.

INVESTIGATING A THERMOCOUPLE

You will need:

- General purpose thermocouple
  RS 159-001 (-50 to + 200^0 C).
- Multimeter to measure mV.
- Water bath and heater.
- -10 to +110^0 C thermometer.

You need to find out:

- The way the voltage produced changes with temperature.
- How quickly the value settles down.

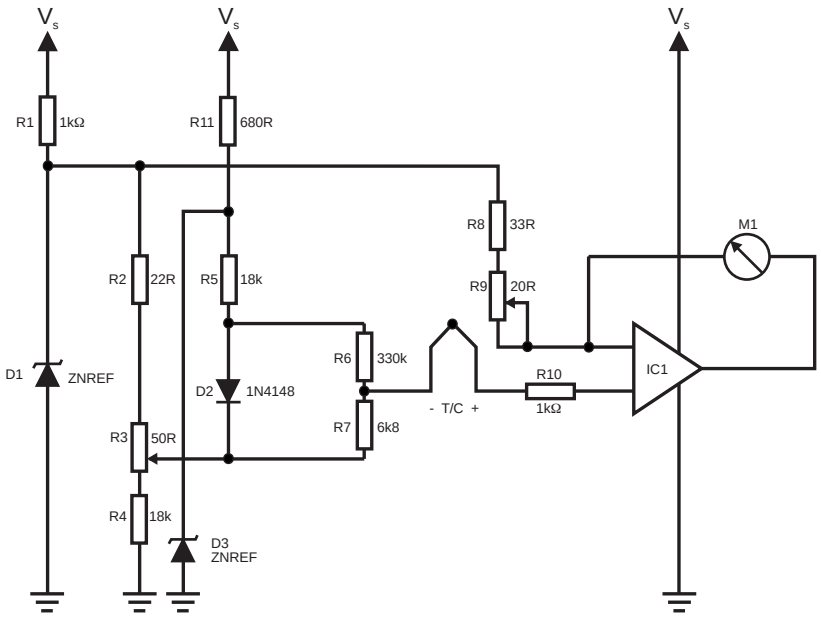
Plan your investigation carefully.
Think about:

- What you will change and what you will keep the same.
- What you need to measure.
- How you will record your data.
- How you will present your data.

The circuit you need to use for a thermocouple is quite complicated.

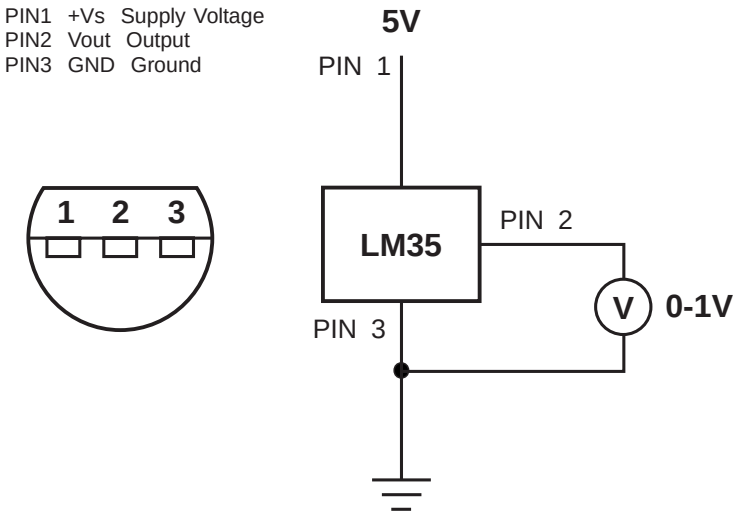
Here is a typical circuit:

Temperature measurement circuit



INVESTIGATING AN LM35

The LM35 is an integrated circuit. It contains the temperature sensor and the circuit needed to process the signal. To use it to measure temperature, connect it like this:



You will need:

- An LM35 DZ - this can be used for the range 0^{o} C to 100^{o} C.
- 0 - 1 V voltmeter (you may need a 0 - 100 mV meter for lower temperatures).
- A 5 V DC power supply.
- A heater in a container (the 12 V 24 W lamp and model house you used before is ideal).
- A 12 V power supply for the lamps.
- A -10 to 100^{0} C thermometer.

In this investigation, you want to find the characteristics of the LM35.

What do you need to measure?

- the temperature in the room?
- the output of the LM35?
- time?

How will you change the temperature?
Do you need to let the temperature become constant before taking a reading?

Plot a graph of your results.

What are the advantages of an LM35?

SELECTING A TEMPERATURE SENSOR

Copy and complete the table on the next page for each sensor.
Use this information to help you select the sensor you need.
You will find additional information in catalogues.
e.g. RS, Rapid Electronics, Maplin.

Factor	Questions	Your findings:		
		Thermistors	*Thermocouple*	*LM35*
Its characteristics	How does the value change with temperature?			
Ease of use	What circuit do you need? Are there limitations? Are there any special precautions?			
Cost				
Response time	How quickly does it react?			

CONTROLLING TEMPERATURE

To control the temperature, you need to think about all of the stages in the system. This means the input, the process and the output.

Input: Selecting a sensor
The sensor you select depends on the situation.

Things to think about:

- Do you need a linear relationship? In other words, do you need the output to change uniformly with temperature?
- Do you need a fast response?
- What is the reliability like?
- What is the cost?
- When you have selected your sensor, what else do you need? For example, the thermistor needs to be connected as part of a potential divider.

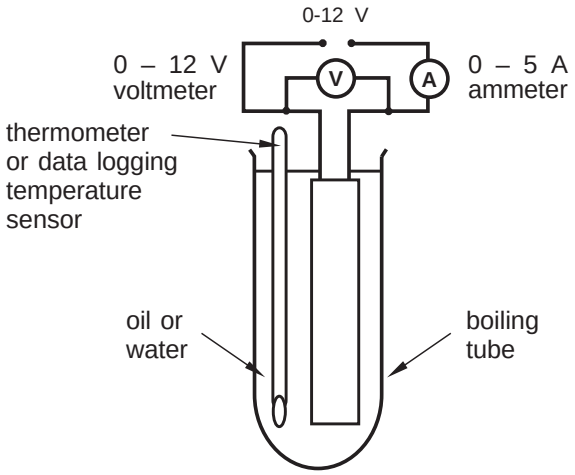
Output
Suitable heaters for a given situation might be:

- A 12 V aquarium heater.
- A 12 V immersion heater.

Investigate how the heat output depends on supply voltage and current.

You will need:

- 0 - 12 V variable power supply.
- 0 - 12 V or 0 - 25 V voltmeter.
- 0 - 5 A ammeter.
- Heater.
- Boiling tube and oil if required.



Why do you think oil might be used?

You need to measure and record

- Voltage and current.
- Temperature.
- Time.

Do you need to let the temperature become constant before taking a reading?

Process

- Do you need to control the temperature continuously or control the heater ON and OFF?
- What are the minimum and maximum temperatures?
- Do you need to be able to set the temperature at different takeover levels?

LIGHT SENSORS AND CONTROLLING LIGHT LEVELS

There are two light sensors that are readily available and can easily be used. These are:

- The LDR - light dependent resistor.
- The photodiode.

In this investigation, you will compare these two devices. This should help you to select the best one for you to use. The features to compare are:

- Characteristics - are they linear or not?
- Ease of use - this includes external circuit required.
- Speed of response - this is difficult to investigate; you can look it up in the catalogue.

THE LDR

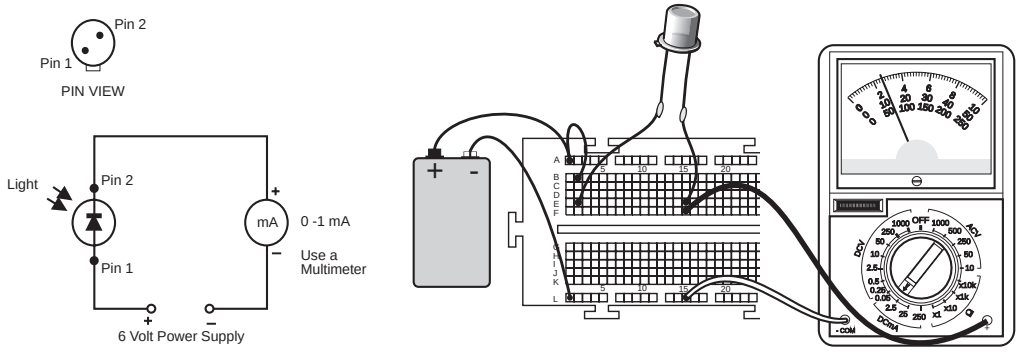
This changes its resistance as the light level changes.
The resistance can be measured with a multimeter without connecting the LDR into a circuit.

You need to plot a graph of resistance against light level.

THE PHOTODIODE

This needs to be connected into a circuit.
The current through the photodiode changes with the light level.

This is the circuit you need.



You need to plot a graph of current against light level.

CHANGING THE LIGHT LEVEL

You will need a light source:

This could be a 12 V lamp in a holder.

You can change the light level by moving further away from the lamp.

If you have a light meter, you can measure and record the light level.

If you do not have a light meter, use the following information:

Start 100 mm from the centre of the lamp. Call this light level 1.

If you now move twice as far away, that is 200 mm, the light level will be 1/4.

Use the distances in this table to give the light levels indicated:

Distance from the centre of the lamp	**Light level (no units)**
100 mm	1
115 mm	0.75 (3/4)
141 mm	0.5 (1/2)
200 mm	0.25 (1/4)
283 mm	0.125 (1/8)

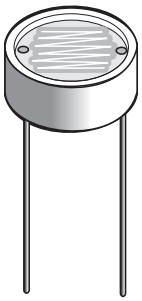
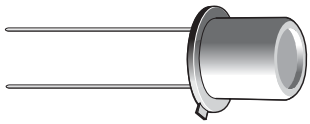
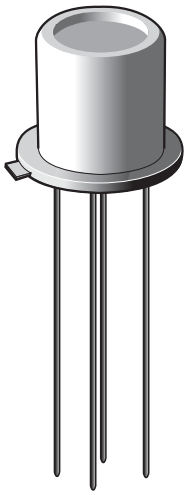
- You will need to do this in a darkened room. Why is this?

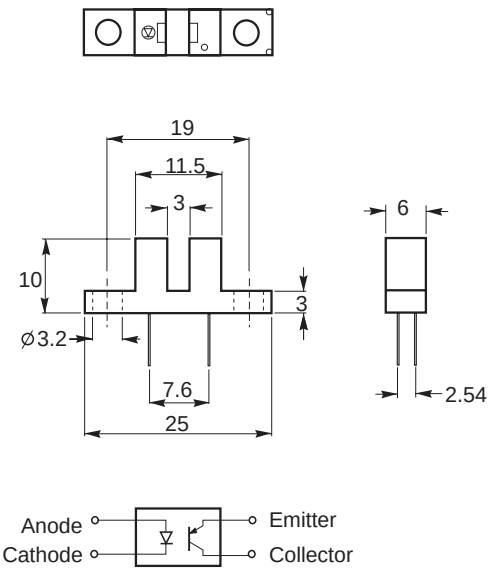
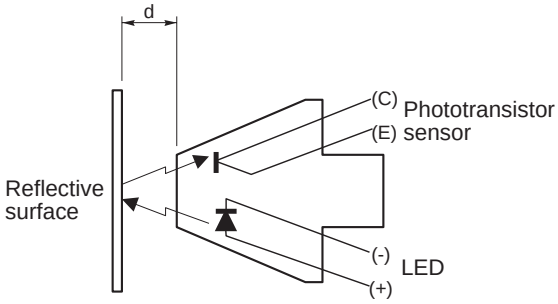
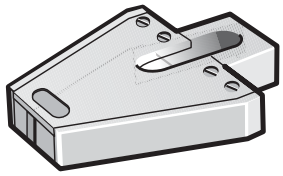
SELECTING A LIGHT SENSOR

Optical sensors are designed to make them more useful.

Some of these use infra red (IR) rather than visible light. This does not affect the way they work.

Here is a summary of these devices:

Device	Typical specification *(See catalogues for more information)*		Notes
LDR (ORP 12) 	**Light intensity (lux)** 10 100 1000	**Resistance (Ω)** 3 M 1.3 k 270	Needs to be put into a 'sensing' circuit, e.g. as part of potential divider with an op-amp and transistor. (See TEP Electronics module.) Needs a light source.
Photodiode 	Dark current 1.4 mA Max. current 100 mA		Needs a separate light source Needs circuit, e.g. reverse biased and connected to op-amp. Fast response.
Light activated switch 			This contains a photodiode and the associated circuit on one chip. An external resistor and capacitor are needed to set the light level required. When the light level exceeds this, it switches from logic 0 to logic 1. It operates on IR including sunlight. It can be used to drive logic circuits or a reed relay. Needs a light source.

Device	Typical specification *(See catalogues for more information)*	Notes
Slotted opto		This contains an IR emitter and sensor switch in a plastic body. Contains all required circuits on chip. Needs to be connected to logic circuit. Typical current 2 mA.
Reflective opto	 White dot indicatesLED d, optimum distance 4.6mm 	As above but arranged to receive reflected switch-beam.

Sensor	Characteristics	Ease of use	Speed of response	Other useful features

CONTROLLING LIGHT LEVELS

To control light levels, you need to think about all of the stages in a system. This means the input, process and output.

Input
Selecting a sensor
The sensor you select depends on the situation.

Things to think about:

- Do you need a linear relationship? In other words, do you need the output to change uniformly with light levels?
- Do you need a fast response?
- What is the reliability like?
- What is the cost?
- Do you need a light source as well as a sensor?

When you have selected your sensor, make sure you know what else you need. For example, the LDR needs to be connected as part of a potential divider.

Output
The output will be a light bulb or lamp.

- What power do you need?
- What voltage should it be?

Process
- Do you need to control the light level continuously or switch the lamp ON and OFF?
- Do you need to be able to set the light level?