

INVESTIGATING CONTROL

<p>CONTENTS</p> <p>Investigation 1 - <i>Heating a House</i></p> <p>Investigation 2 - <i>Temperature Control</i></p> <p>Investigation 3 - <i>Light Control</i></p> <p>Investigation 4 - <i>Sequential Control</i></p>
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INVESTIGATION 1 - HEATING A HOUSE

You are going to investigate the temperature control in a model house.

Equipment needed:

- A 12 V 24 W lamp (this gives out a lot of heat) and power supply.
- A model house. This is a simple container with approximate dimensions 20 cm x 20 cm x 20 cm.
- A temperature sensor linked to a computer; alternatively a thermometer.

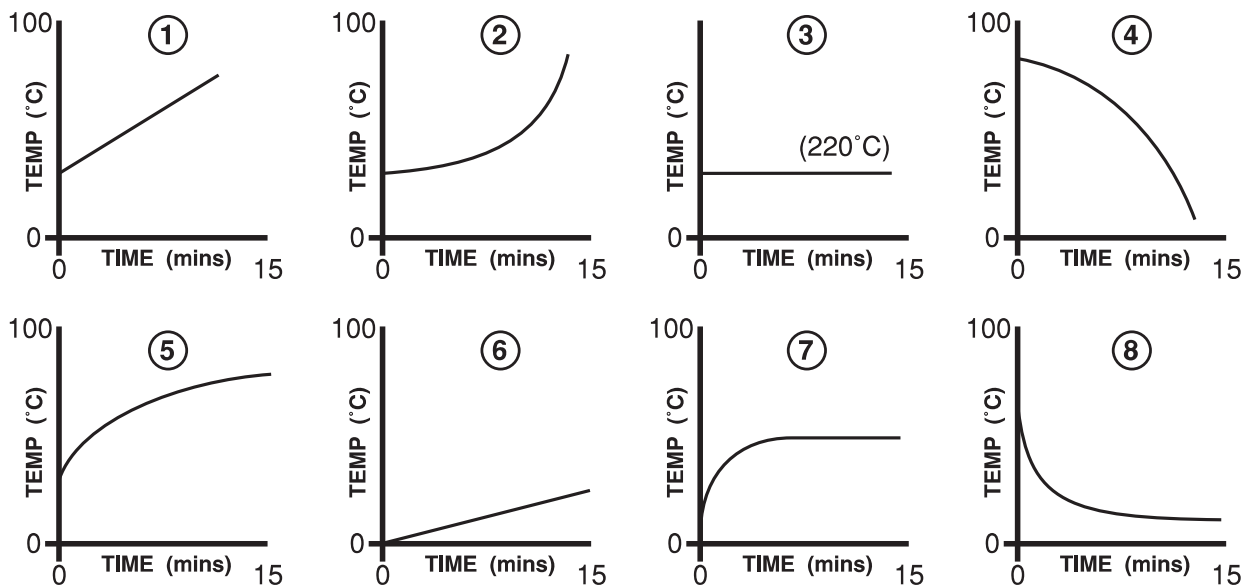
Make a prediction

You are going to turn on the heater in the model of a house, and record what happens to the temperature in the model.

Examine the model house. Write a short description explaining what you are going to do.

Describe what you think will happen to the temperature in the house when the heater is switched on.

Examine the graphs drawn below. Say which graph you think shows best how the temperature in the model will change over 15 minutes or so. Explain your choice of graph.



Collecting data

- Place the lamp in the model of the house.
- Switch the lamp on.
- Measure the temperature inside and outside the house frequently. You need to keep measuring until the temperatures are steady. This could take about 15 minutes. Make sure you keep a clear record of your data.

Time (mins)	Outside Temp (°C)	Inside Temp (°C)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Examine the data

- Plot your data as a graph. Use the Graph Quality Checklist to help you.
- Examine your graph. Write a description of how the inside temperature has changed while you were measuring it. Has the outside temperature changed?
- Is the graph of the inside temperature the same shape as you expected when you made your prediction? Describe any differences.
- What controls the heating in the house?
- If this were your house, would you be satisfied with the control of the heating system? Explain your answer.

GRAPH QUALITY CHECKLIST

The following provides a quality checklist for your graph:

Horizontal axis:

1. Is the axis labelled? (e.g. time)
2. Are the units correct? (e.g. seconds, mins)

Horizontal scale:

3. Is the scale uniform? (e.g. 2 mins per cm)
4. Is the available space used sensibly ?
(e.g. range of plotted points covers most of the space on the axis)
5. Is the scale easy to read? (e.g. 1:2, 1:5 or 1:10, not 1:3.)

Vertical Axis:

6. Is it labelled?
7. Are the units correct?

Vertical scale:

8. Is the scale uniform? (e.g. 5 degrees per cm)
9. Is the available space used sensibly?
10. Is the scale easy to read? (e.g. 1:2, 1:5 or 1:10, not 1:3.)
11. Are the points correctly plotted?
Are they in the correct place?
12. Is the title of graph clear and correct?

EXERCISE

The table below shows temperature changes for the decades from 1860-1990 obtained by the Climatic Research Unit, University of East Anglia.

- Use this data to plot a graph of temperature change against time.
- What does the graph tell you about global warming?
- Why do you think the temperature has risen so much since the 1930s?

Date (Year)	Temp change relative to 1860 (°C)
1860	--
1870	0.58
1880	0.54
1890	0.38
1900	1.08
1910	0.22
1920	0.62
1930	1.18
1940	2.77
1950	3.73
1960	3.71
1970	3.84
1980	3.71
1990	5.98

INVESTIGATION 2: TEMPERATURE CONTROL

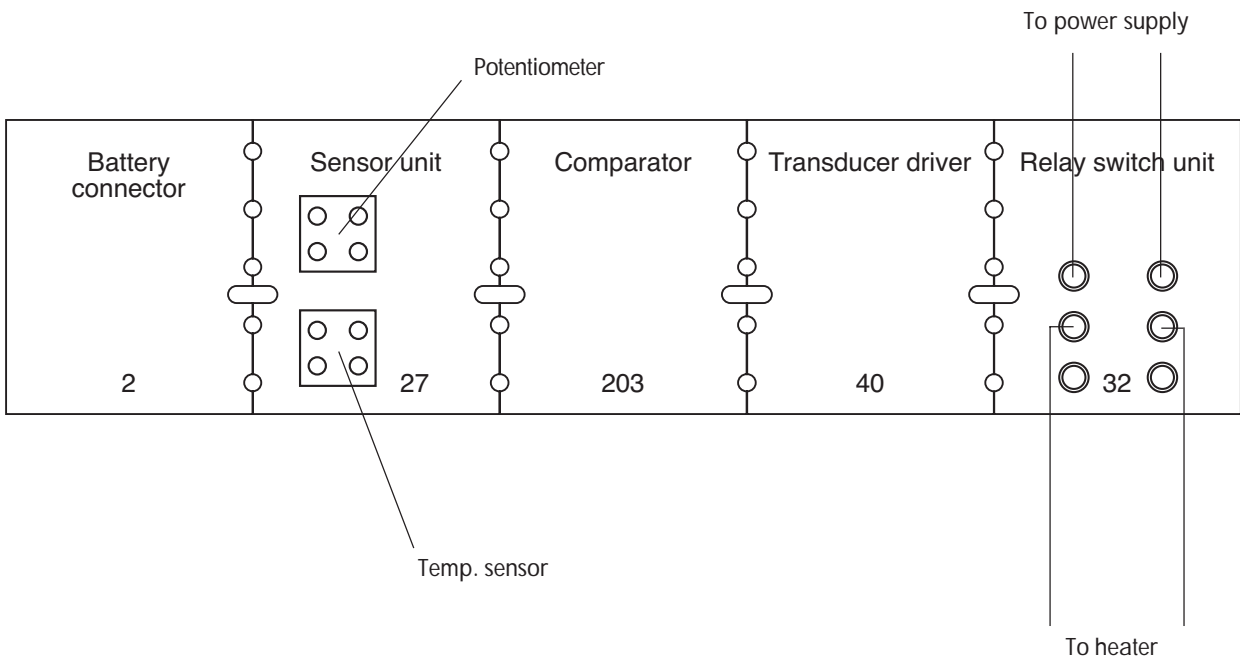
Equipment needed:

- A 12 V 24 W lamp (this gives out a lot of heat) and power supply.
- Systems electronics boards (power supply, remote temperature sensor and sensor unit, comparator, transistor driver, relay switch).
- A model house.
- A temperature sensor linked to a computer, or alternatively a thermometer.
- A light sensor linked to a computer.

Make a prediction

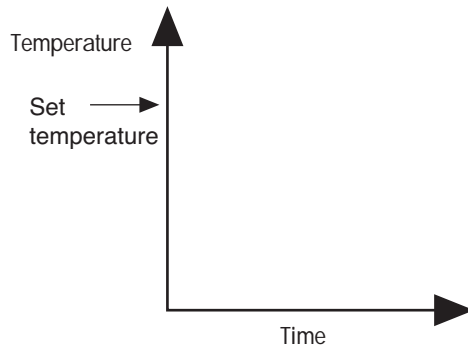
You are going to use a control system to set the temperature you want in your model house. When you turn on the control system, you will record what happens to the temperature and when the heater is on.

The control system is built from the electronics boards as below. Write a short description explaining what you are going to do.



Describe what you think will happen to the temperature in the house and the heater when the control system is switched on.

Draw a set of axes like these shown:



Sketch a graph showing how you think the temperature in the model will change over 15 minutes or so.

Show on the same graph when you think the heater will be on and when off.

Collect the data

- Set up the control system as shown in the previous section. Turn the thumbwheel on the comparator and make sure that the lamp switches on and off.
- Turn the remote potentiometer to its centre position.
- Adjust the comparator thumbwheel until the heater relay switches in.
- The remote potentiometer is now used to set the desired temperature; use it to set the control system so that the 'heater' is just on (the further past this point the potentiometer is turned, the higher the set temperature).
- Place the lamp and the sensor in the model of the house.
- Switch on the control system.
- Measure the temperature inside and outside the house frequently for about 30 minutes. Make sure you keep a clear record of your data.
- Record when the lamp switches on and off.

Time heater switches on (mins - secs)	Time heater switches off (mins - secs)

Use the data

- Plot your temperature data as a graph using axes like those shown. Use the Graph Quality Checklist at the beginning of this study file.
- Add to the graph information showing when the heater was on and when it was off.
- Examine your graph. Write a description of how the inside temperature changed while you were measuring it.
- In what ways is this graph different from the graph in the first investigation?
- Explain what you think the link is between the shape of the temperature graph and the times the heater is on.
- If this were your house, would you be satisfied with the control of the heating system? Explain your answer.

Analyse the control system

- Draw a block diagram of the control system you have just been using:

What is the input part?

The process?

The output?

Is it open or closed loop (is there feedback)?

What information is flowing between the blocks?

- Can you think of any things that could be done to improve the system?

Write your ideas down and explain why they would make the system better.

Digital and analogue outputs

In the heating system you have just investigated the heater is simply switched ON (1) if the room is too cold or OFF (0) if it is too warm.

This is called an on/off or digital output control system.

An improvement might be to adjust the amount of heat that the heater gives out depending on how cool the house is.

This would mean that, if the house was very cold, the heater would be fully on, but if it was nearly warm enough the heater would only be slightly on.

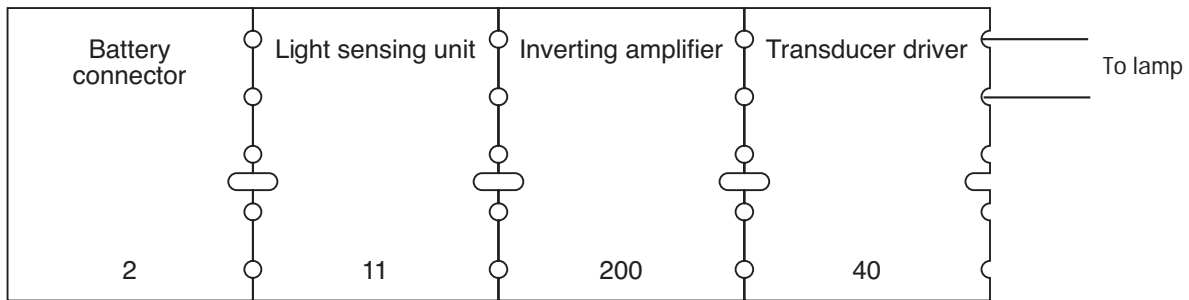
This kind of control system is called an analogue output system

INVESTIGATION 3: LIGHT CONTROL

You are going to find out a bit about analogue output systems by comparing digital and analogue control of light levels.

Equipment needed:

- Systems electronics boards (power supply, light sensor unit, comparator, transistor switch, relay switch).
- A 6 V 12 W lamp and power supply.



Investigating the system

- Set up the control system as shown above. Set the two thumbwheels to their centre positions.
- Gradually reduce the amount of light reaching the light sensor. Observe what happens to the lamp.
- You will need to work in a darkened room for this part. You should find that in the dark your lamp is on quite brightly.
- Slowly bring the lamp close to the light sensor. Observe carefully what happens.

Examine the control system

- Draw a block diagram of the control system you have just been using:

What is the input part?
 The process?
 The output?
 Is it open or closed loop (is there feedback)?
 What information is flowing between the blocks?

- Describe what happens when the amount of light on the light sensor falls.

Use the diagram you have drawn to help you explain why you think this happens.

- Describe what happens when the lamp is slowly brought closer to the light sensor.

Use the diagram you have drawn to help you explain why you think this happens.

Describe what you think the difference is between an analogue and a digital output. Use your experience of controlling a lamp as an example.

CONTINUOUS OR SEQUENTIAL CONTROL

In the lighting systems you have just investigated the light level is being monitored all the time and the lamp is being controlled all the time.

This is called a continuous control system.

Many control systems do not work in this way. Instead, they are designed to perform a sequence of actions one after the other.

This is called a sequential control system.

INVESTIGATION 4: SEQUENTIAL CONTROL

You are going to find out a bit about sequential control systems by investigating the way that a washing machine is controlled.

To do this investigation, you will need to observe a real washing machine, for instance in a Laundrette, going through its cycle.

List the basic stages that the washing machine goes through and describe what happens at each stage. Copy and complete the table below for each stage you identify.

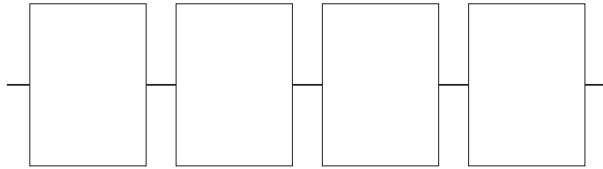
Stage	What happens
Select wash required Switch on	
Wash	
Rinse	
Spin	

What does the washing machine need to sense during its operation? (i.e. What are the **inputs** to the control system?)

What does the machine need to control? (i.e. What are the **outputs** from the control system?)

- Your teacher will give you a sheet of cards.
Cut out the cards.
- Place the cards in front of you.
Take those cards that represent a single wash stage and put them into an order to show all the control activities in this stage.
- Now add the other cards so that you have all the basic stages of the complete washing cycle.
You should be able to use all the cards.
There are some blank cards which you can write on and include if your machine has extra stages.

- Arrange the cards in order onto a blank sheet of paper and leave a small gap between the cards and join them with a straight line like this:

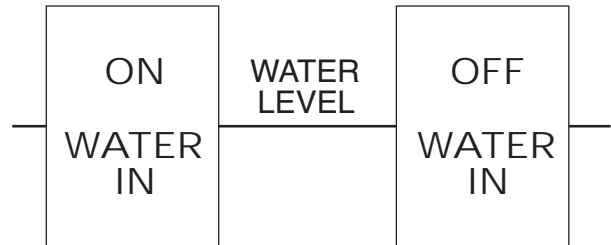


You now have a diagram of the washing machine control system showing the sequence of the actions.

Each action in the sequence is started by something:

- Sometimes, **one action starts when the one before it is complete**. For example, at the start the machine only starts to fill up once the door lock is on.
- At other times, **an action happens when a certain amount of time has gone by**. For example, the drum rotation carries on for a fixed time and then stops.
- In some cases, **an action happens when a sensor starts it off**. For example, the water filling the machine is switched off when the water reaches the correct level.

On your diagram, write next to each action the thing that makes it start. Here is an example:



- List the actions controlled by feedback
- List the actions not controlled by feedback

You can make complex diagrams easier to follow by using colour. Use this colour code on your diagram :

WATER IN	blue
HEATING	red
WATER OUT	brown
ROTATING	green.

Choose one of the parts of the system controlled by feedback.

- Draw a control system block diagram of this part of the system:

Label the input stage.
Label the process.
Label the output.

- After labelling the block diagram, write down what information is flowing between each stage.

ON	WATER IN (wash)	OFF	WATER IN (wash)	ON	WATER IN first rinse	OFF	WATER IN first rinse	ON	WATER IN final rinse	OFF	WATER IN final rinse	ON	WATER OUT wash	OFF	WATER OUT wash	ON	WATER OUT rinse
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OFF	WATER OUT rinse	ON	WATER OUT final rinse	ON	HEATER	OFF	HEATER	OFF	HEATER	ON	ROTATION wash	OFF	ROTATION wash	ON	ROTATION rinse	OFF	ROTATION rinse
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ON	ROTATION final rinse	OFF	ROTATION final rinse	ON	SLOW SPIN rinse	OFF	SLOW SPIN rinse	ON	SLOW SPIN final rinse	OFF	SLOW SPIN final rinse	ON	FAST SPIN	OFF	FAST SPIN	ON	DOOR LOCK
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OFF	DOOR LOCK	ON		OFF		OFF		OFF		ON	POWDER RELEASED		ON	CONDITIONER RELEASED	ON		OFF
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ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
WATER IN	WATER IN	WATER IN	WATER IN	WATER IN	WATER IN	WATER IN	WATER IN	WATER OUT

OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
WATER OUT	HEATER	HEATER	ROTATION	ROTATION	ROTATION	ROTATION	ROTATION	ROTATION

ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
SLOW SPIN	SLOW SPIN	SLOW SPIN	SLOW SPIN	FAST SPIN	FAST SPIN	DOOR LOCK	DOOR LOCK	ON

OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
			POWDER RELEASED	CONDITIONER RELEASED	WATER OUT	WATER OUT		