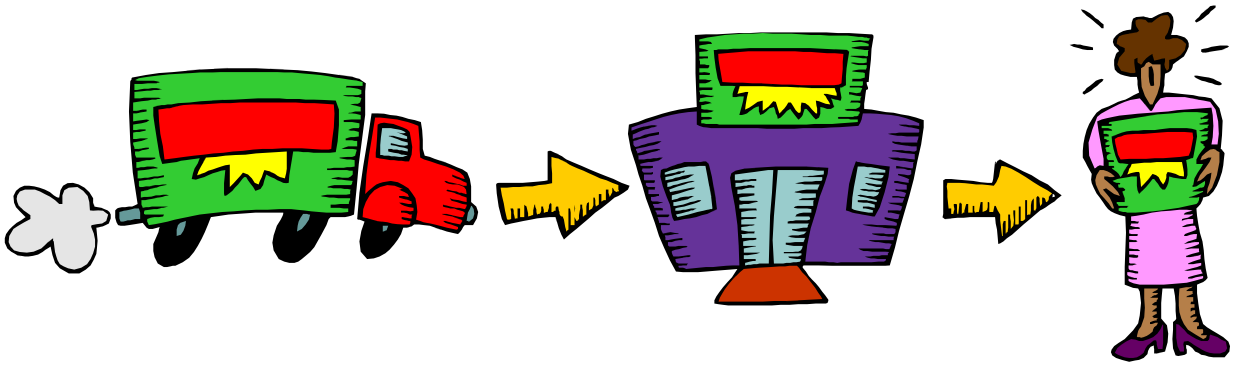
ENGINEERING SCIENCE

Engineering Systems and Control



Name _____

Class _____

Teacher _____

Ellon Academy
Technical Faculty

Learning Intentions

- To learn about the different roles of engineering
- To learn about the varied role of Engineers in designing, implementing, testing and controlling complex systems
- To learn the effects that engineering has on the world
- To know about control diagrams for simple control systems
- To learn about what the systems approach is
- To learn about subsystems
- To learn about energy forms
- To learn about basic energy transformations
- To know about open loop & closed loop control
- To know what a feedback loop is
- To learn what an error detector is and how its used in a control system

Success Criteria

- I can identify and describe different branches of engineering
- I can explain how emerging technologies can provide improves solutions to engineering challenges
- I can describe examples of social, environmental and economic impacts of engineering
- I can draw and understand a system diagram, showing inputs and outputs
- I can describe, using the systems approach, how some simple engineered objects work
- I can identify basic energy transformations
- I can identify the main sub-systems of an object
- I can draw and understand sub-system diagrams
- I can understand and create diagrams for simple control systems
- I can understand the difference between automatic and manual control
- I can understand how an error detector is used within control systems

To access video clips that will help on this course
go to www.youtube.com/MacBeathsTech

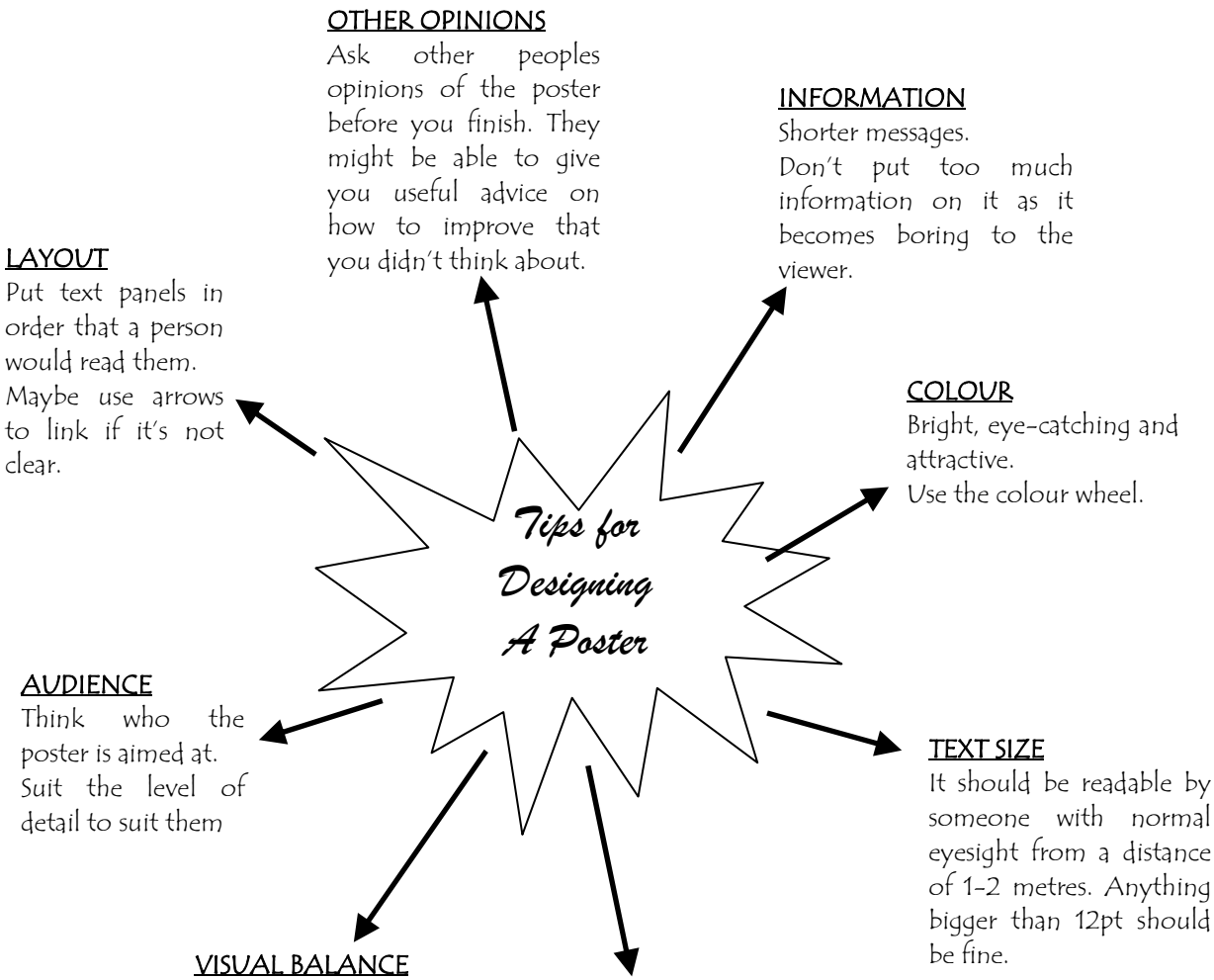
What is Engineering?

You have chosen to do Engineering Science, but what exactly is an engineer? What does an engineer do?

Task 1

Working in groups, use the internet to research Engineering.
What exactly does an engineer do? Is there just the one type? Is it just working in the oil industry?
Using your IT skills Make up a poster to show everyone about Engineering and what career paths you can follow by taking this course.

WWW.TOMORROWSENGINEERS.ORG.UK



Task 2

Choose an engineering challenge from the list below

- New Forth Road Crossing
- Aberdeen Bypass
- Virgin Galactic
- Google Car
- Offshore Wind Farms

You are to produce a PowerPoint on the engineering challenge, by completing the following tasks.

(a) Describe how several different branches of engineering all contribute to the successful completion of this project. You should refer to civil, mechanical, electrical, chemical and at least 1 more form of engineering.

(b) Describe some example tasks that engineers would do while working on this project. These should include:

- design tasks
- implementation tasks
- testing
- the controlling of the complex systems

(c) Describe how two recent or current technological developments are making it possible to improve solutions to this engineering challenge.

Your teacher will give you tips on how to do a successful PowerPoint

Task 3

Review the engineering challenge that you have been investigating.

You are going to produce a report entitled 'The Impacts of Engineering', by completing the following tasks.

(a) Describe **one positive and one negative social impact** resulting from an engineering project or challenge

(b) Describe **one positive and one negative economic impact** resulting from an engineering project or challenge

(c) Describe **one positive and one negative environmental impact** resulting from an engineering project or challenge

(d) Describe **at least two examples** of how engineering solutions are contributing to tackling climate change.

Task 4

A prototype solar panel is being tested.
Describe the role of the following engineers in the development of the Panels

(a) An Electronic Engineer

(b) A Mechanical Engineer

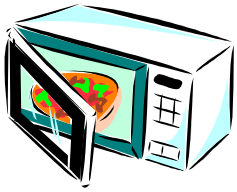
What is Technology?

Task 5

Working in groups use the paper provided by your teacher to note down what your group think is meant by technology?

Can you imagine a world without technology?

There would be no cars or planes or TV, no computers or microwaves or many of the things that we take for granted in our daily lives.



You would have to get up every morning in a cold cave. Wash in cold water that has been collected from the stream using a bucket made from skins and cook breakfast on an open fire.

Task 6

Workings in your groups again, make 2 lists using the headings NEEDS and WANTS. A zombie apolocalypse has just happened and you are hiding in an underground bunker that the zombies can never get access to– under the NEED side write down what you to survive and anything you think is a luxury (WANT).

Technology is used by us in an attempt to make the world we live in a much more comfortable place.

All this depends on technology. The design of the bus or car depends on knowledge of MECHANISMS – the construction of a house requires knowledge of STRUCTURES – the heating system is controlled using ELECTRONICS – the factories where the cars are made probably use COMPUTER CONTROL and PNEUMATIC SYSTEMS, and this all needs to be powered by ENERGY. All of these areas of technology are going to be studied during you Engineering Science course.

Task 7

Read the following statements. After each one put a T or F to say whether you think it is TRUE or FALSE.

Technology is only about electronics.

Women cannot understand technology.

Technology is about solving problems.

Cars use technology but windmills don't.

People have always used some form of technology.

The world would be a better place without technology.

Everybody is affected by technology.

Only scientists use technology.

Cavemen did not use technology.

Task 8

Copy and complete the sentence below putting each of the 5 words listed in an appropriate place in order to reach a definition of technology that we will use for this course.

LIVES; MAKING; RESOURCES; PROBLEMS; KNOWLEDGE.

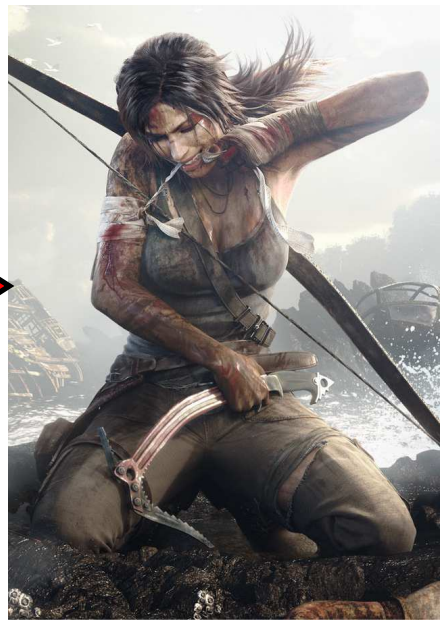
Technology is about ..... things by using ..... and ..... to solve ..... in an attempt to make our ..... better.

Task 9

In your lifetime Technology has advanced tenfold. If you even think of the advancements that have been made in computer games since you first played them.

Tomb Raider

1997-2013



Your task is to pick an everyday piece of technology and create a timeline poster. The poster must show how it started and it has progressed throughout the years.

http://www.youtube.com/watch?v=1rPAO_kzirc

THE SYSTEMS APPROACH

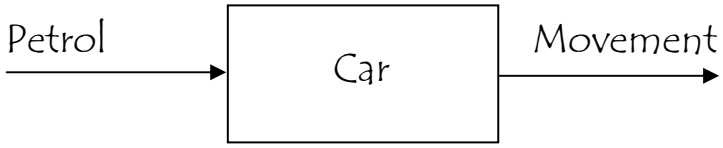
Solving problems in technology can be made simpler if we use something called the SYSTEMS APPROACH. Most things can be analysed using this method.

For most things we want it to do something for us. – This is called the **OUTPUT.**
To get it to do this we need to put something in. – this is called the **INPUT.**
How this is done is called the **PROCESS.** We do not need to know how it is done so the process is usually put inside a 'Black Box.'

This block diagram is called the UNIVERSAL SYSTEM and can be applied to any system.

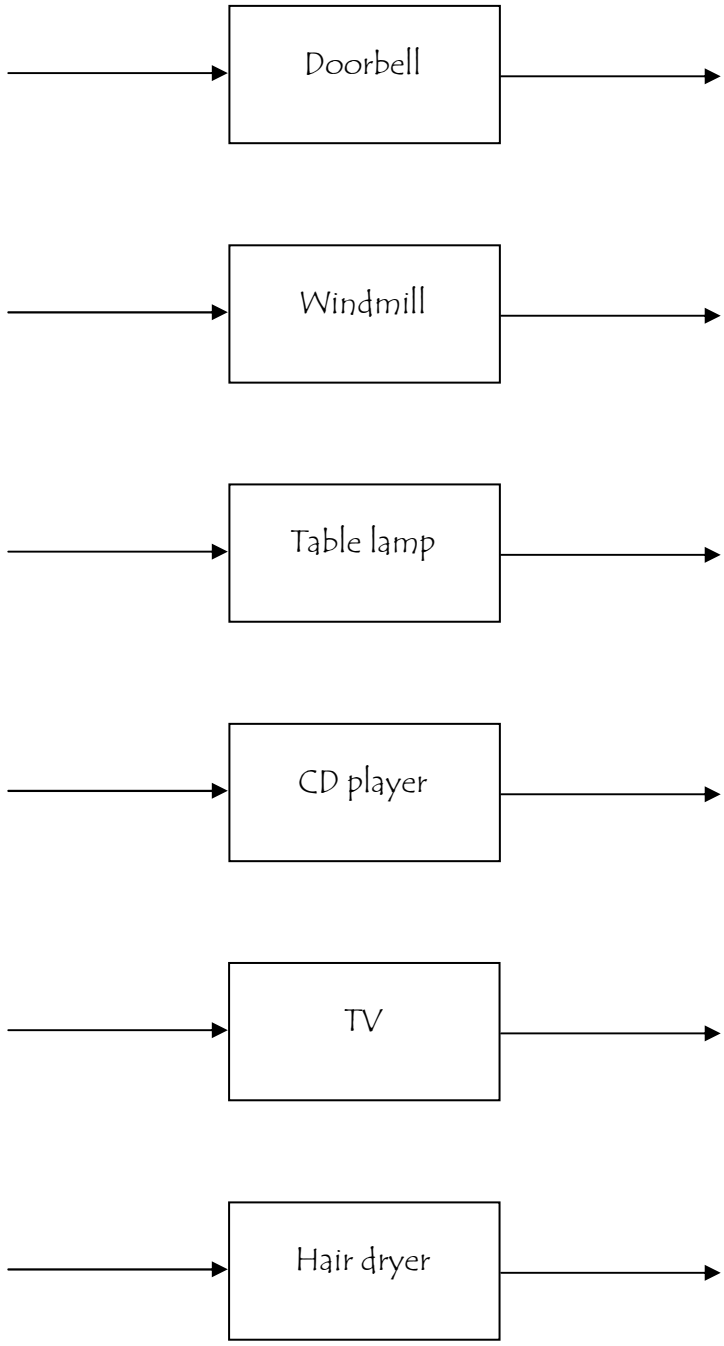
It might help you to understand the idea of a system if you think about some of the systems that are at work in your own body. For example: if you pick up a hot plate by mistake, you quickly put it down. Your fingers sense the heat and pass a signal to your brain, your brain processes (decides what to do) this signal and sends its own signal to the muscles in your arm, then your muscles pull your hands away from the plate.

When going to work in the morning a person can use a car to get there. He or she only needs to know how to drive and to put petrol into it. How it all works can be left to the mechanics in the garage.



Task 10

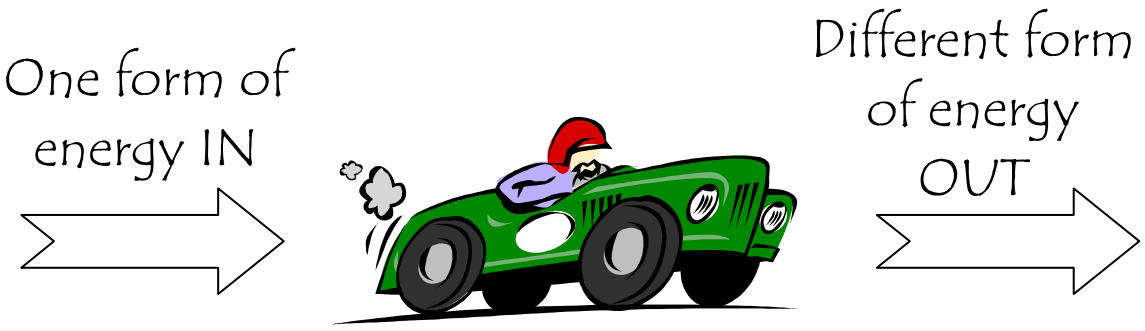
Copy and complete the block diagrams below by adding the correct inputs and outputs.



Extension

Some of these systems can have more than 1 input or more than 1 output. Add anymore you can think of to your block diagrams.

Energy



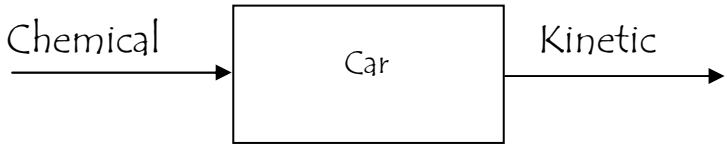
Energy is needed to make things work.

ENERGY can be CONVERTED from one form into another by a suitable PROCESS.

Listed below are the main forms of energy:

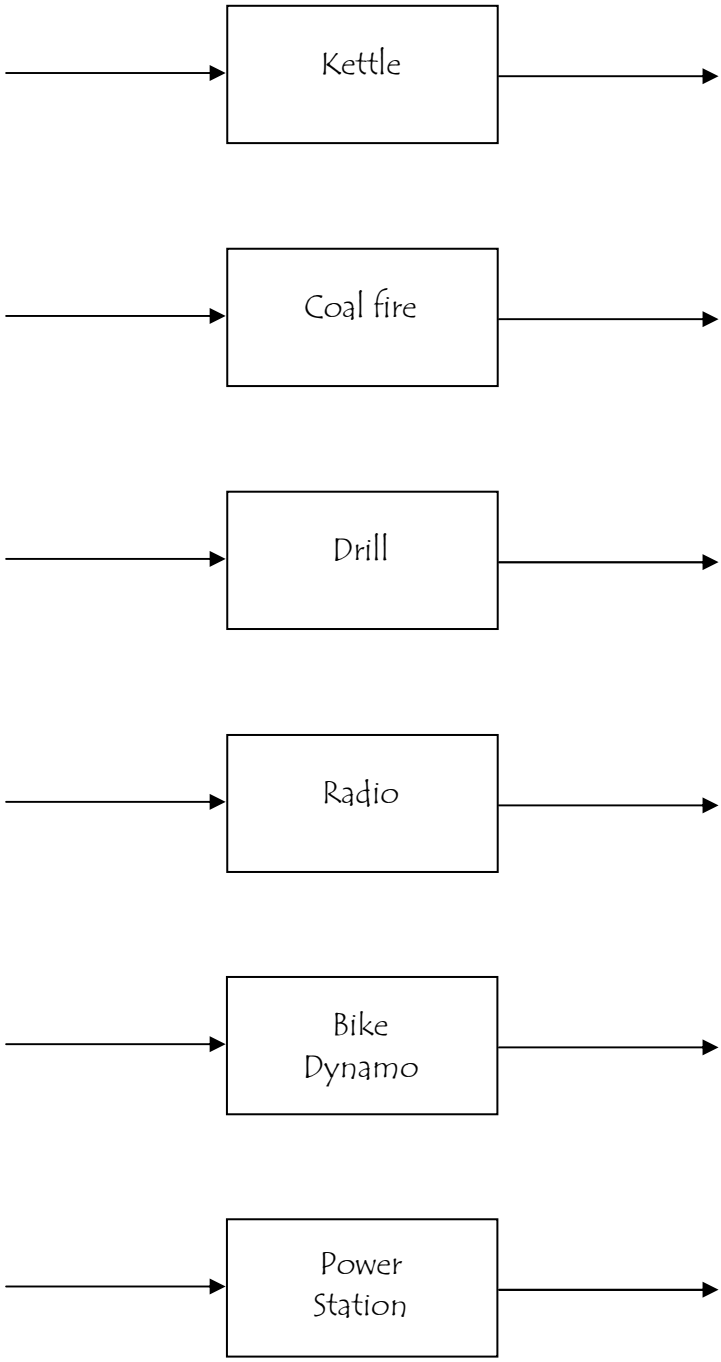
Sound	Heat	Light
Electrical	Chemical	Nuclear
Magnetic(field)	Kinetic (movement)	Potential (stored)

Take our example of the car from before its input is petrol which is a type of CHEMICAL ENERGY. Its output is movement which is KINETIC ENERGY.



Task 11

Copy and complete the block diagrams below by adding the correct forms of energy inputs and outputs.

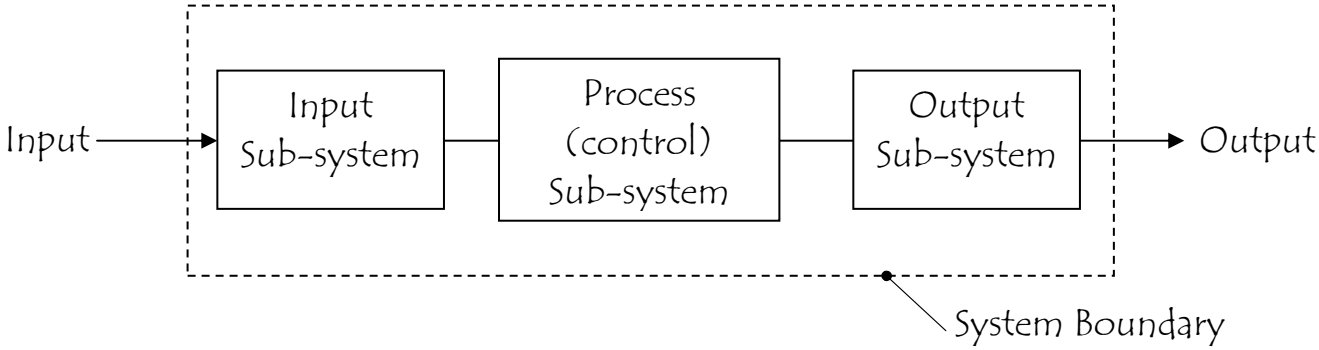


Extension

Some systems do not convert energy from one form into another. These systems TRANSFER the same form of energy from one place to another. Try to think of some systems that do this and draw block diagrams for them.

Sub-Systems

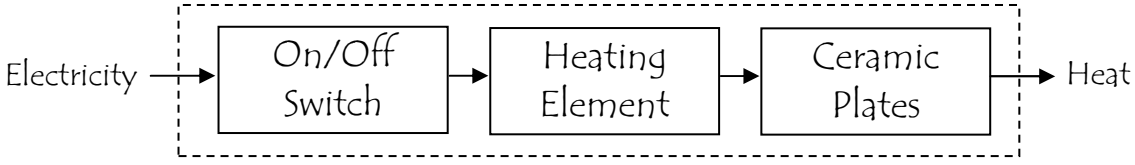
The Universal System is OK for working out how technology works, but to use technology to solve problems we must break it down even further to get a greater understanding of it. To do this, we use a **sub-system** diagram as shown below.



The sub-system diagram shows the *internal* detail of the system. Each box, called a **sub-system**, can be thought of as a system within a system and has its own input and output. The dashed line around the sub-system is called a **system boundary** and this marks the area of interest to us. The 'real world' input and output are shown as arrows entering and leaving the sub-system diagram.

By using a sub-system diagram it shows more detail of how a system works. For example A set of Hair Straighteners

By doing a universal diagram not much information can be gathered on how the system actually works.
By breaking it down into a sub-system diagram, it is clearer how the technology works.



Task 12

1. Draw a sub-system diagram for the following:

   (a) Torch

   (b) Vacuum cleaner

   (c) Kettle

   (d) Toaster

2. Draw a sub-system diagram for a house alarm with a door sensor, panic button, keypad arm, control unit, siren and strobe-light alarm.

Control Systems

For any system to be effective, it must be adequately controlled.

Imagine the problems that might arise in your school if there was nobody

- In charge
- Taking responsibility for day-to-day activities
- Ensuring that teachers were present and teaching their classes
- Checking that pupils actually went to classes.

All types of system require some form of control to make the system work properly. Control is absolutely central to the effective functioning of our society, from the streetlight that switches on automatically at night, through the air-conditioning in shops and offices and the autopilot in aeroplanes, to international electronic banking and the internet.

There are 2 types of control systems – **Manual Control Systems** and **Automatic Control Systems**

- *Manual control* is performed by the actions of humans.

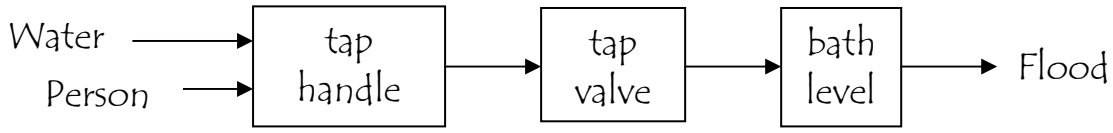
- *Automatic control* is performed by technological devices

Types of Control

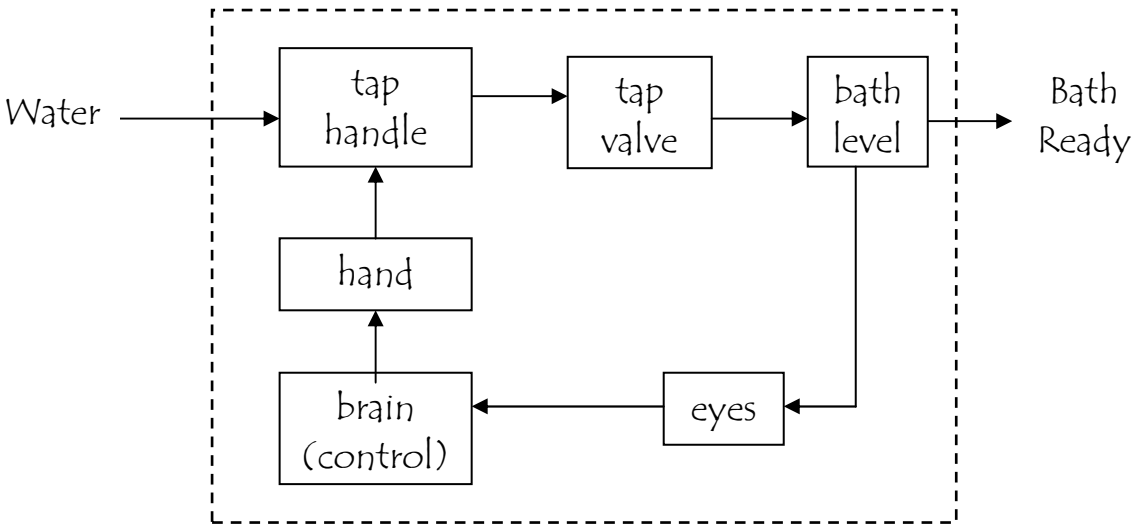
Along with Automatic and Manual control, we also normally consider the type of control the system provides. There are two types of control:

- open-loop control
- closed-loop control

This is an example of **manual open-loop control** for running a bath. The bath continues to fill, and will eventually overflow, because nobody is there to check the system turn off the tap.



This is an example of a **manual closed loop control** for running a bath. The baths runs, but because someone is there to check the system ensuring nothing goes wrong, the bath will not overflow.

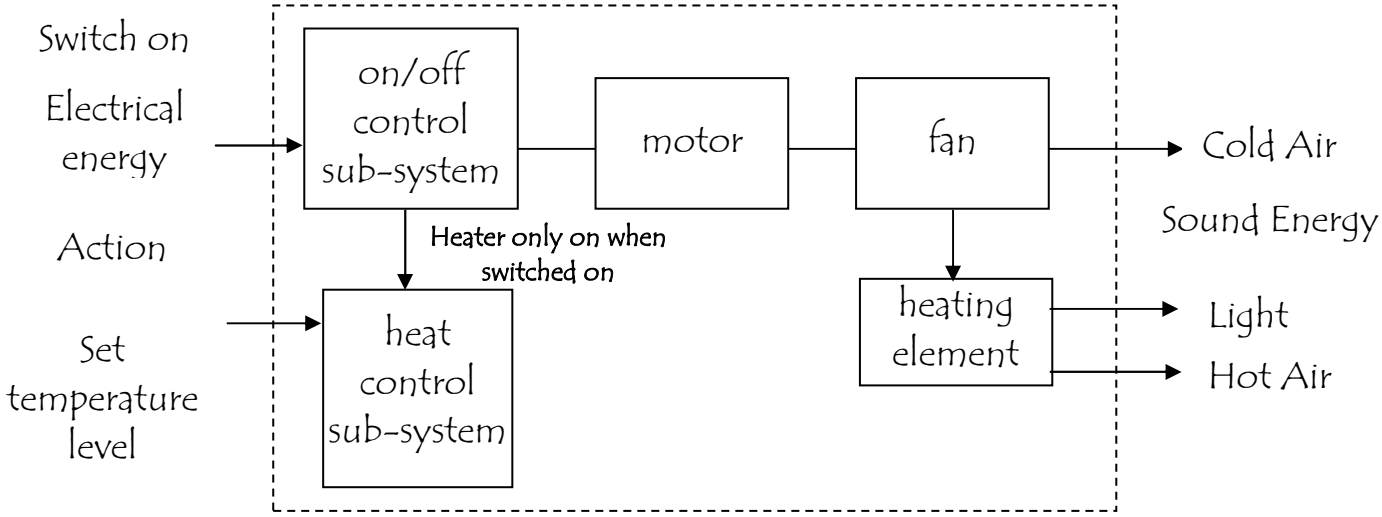


Open Loop Control

At the simplest level a control system can process an input condition to produce a specified output. This is the simplest acceptable level of control. It is also the most common form of control system, used widely in domestic and industrial systems because it is cheap to install and simple to operate.

An example is a hair dryer. The input is the action of pressing the button and the output is the hot air.

A system diagram for a hair dryer is shown below.



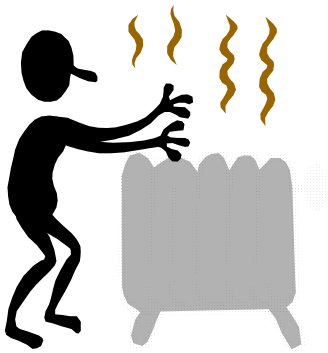
Here the input signal from the on/off and temperature switch is processed to produce the output. The output air is not monitored or adjusted in any way and it is just blown out at whatever temperature the heater warms it to.

An *open-loop control system* is the simplest and cheapest form of control. However, although open-loop control has many uses, its basic weakness lies in its inability to adjust the output to suit the requirements.

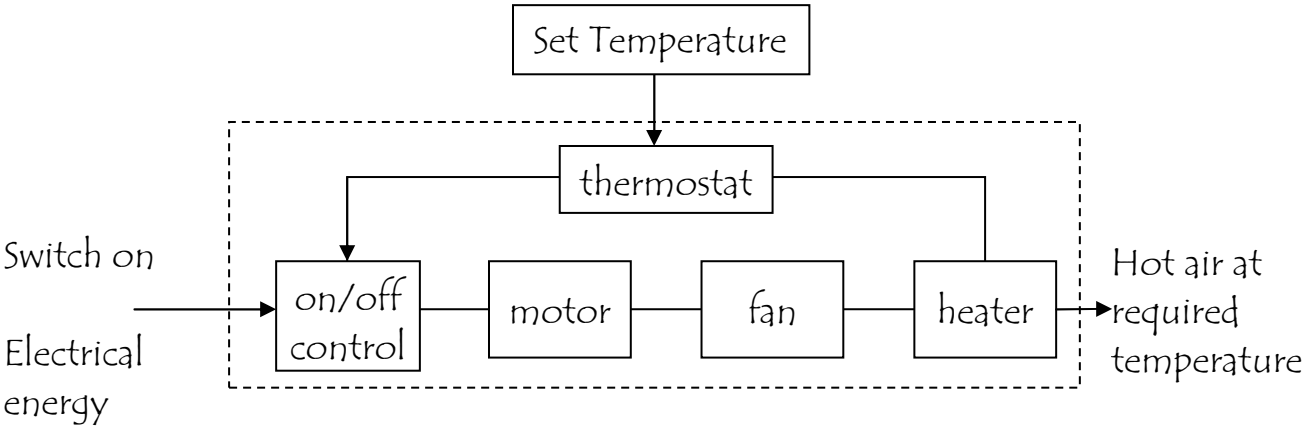
Closed Loop Control

This is the most sophisticated form of control.

In closed-loop control *the value* of the *output* is constantly monitored as the system operates and this value is *compared* with the set (or reference) value. If there is any *difference* between the actual value and the set value (an *error*), then the *input* to the system is varied in order to *reduce* the *output error* to zero.



Closed-loop control systems are therefore capable of making decisions and adjusting their performance to suit changing output conditions. An example is a thermostatically controlled fan heater
The sub-systems diagram for the heater is shown below.



All closed-loop control systems include a sensing sub-system that feedbacks information to the control sub-system. The control sub-system will process this feedback signal and make a 'decision' on whether to alter the output

In the system diagram you should note that the *diagram* now forms a continuous loop that can be followed round repeatedly as the system operates.

Task 13

Draw a sub-systems diagram for a fridge with a thermostat, control unit, coolant pump, door switch and light.

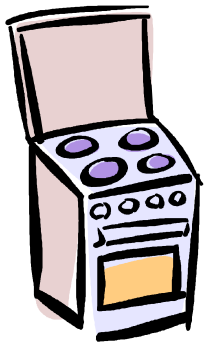
Task 14

1. State three examples of manual open-loop control. Draw a system diagram for each one and show the system boundary.

2. State three examples of manual closed-loop control. Draw a system diagram and show the system boundary.

3. State three examples of automatic closed-loop control. Draw a system diagram and show the system boundary.

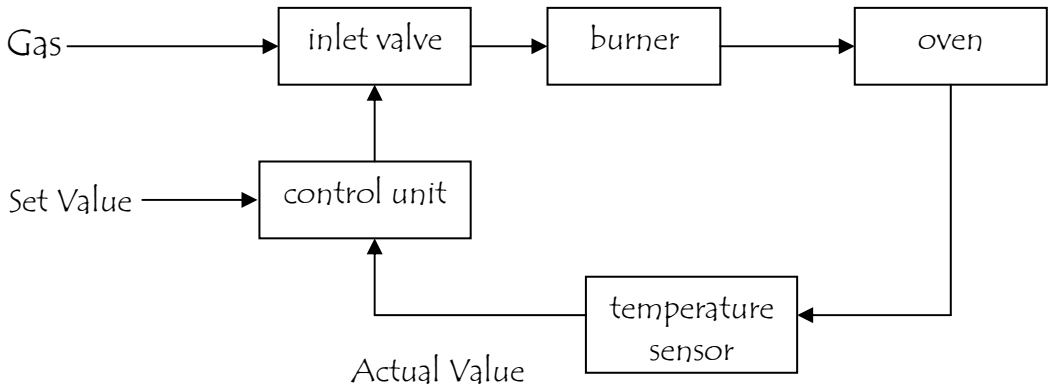
Control Diagrams



The purpose of closed-loop control is to ensure that the output is maintained at, or as closely as possible to, the desired level. For example, the temperature is set on a dial on the control panel of a cooker will be a closed loop control.

A temperature sensor constantly monitors the output (oven temperature) and produces a signal representing the *actual* temperature.

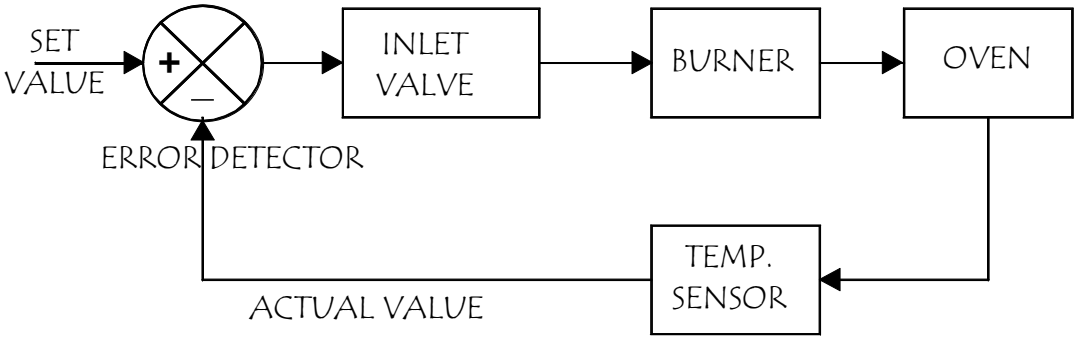
The *actual* signal is fed back to a control element, which compares it with the *set* signal. Any difference between *set* and *actual* signals produces an *error signal.* This causes the control element to either decrease or increase the input (gas flow) in order to reduce the temperature error to zero.



The control unit shown in the system diagram above performs two functions.

- The set and actual values are compared.
- Any resulting error is used to vary the input sub-system as required.

A more detailed diagram, sometimes called a control diagram, may be drawn. This shows the control unit in more detail.

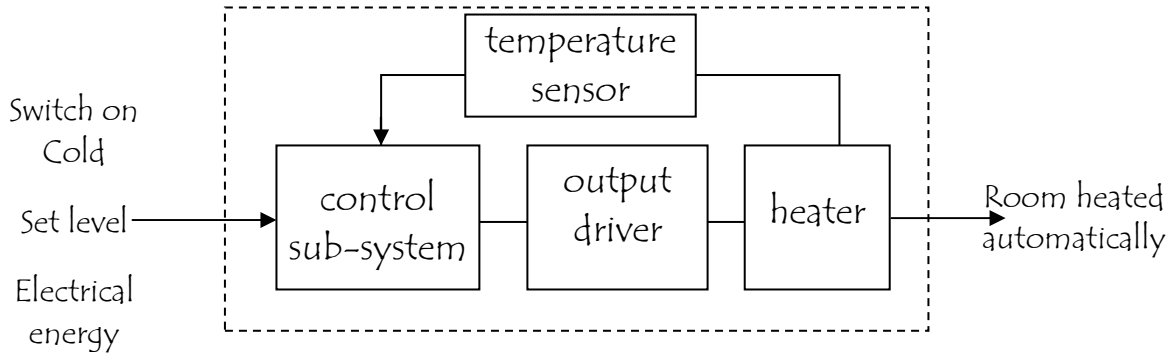


The control diagram includes an *error detector*. It compares the actual value to the set value. If it differs, it changes the input to compensate.

http://www.youtube.com/watch?v=f0obr3HZaDo

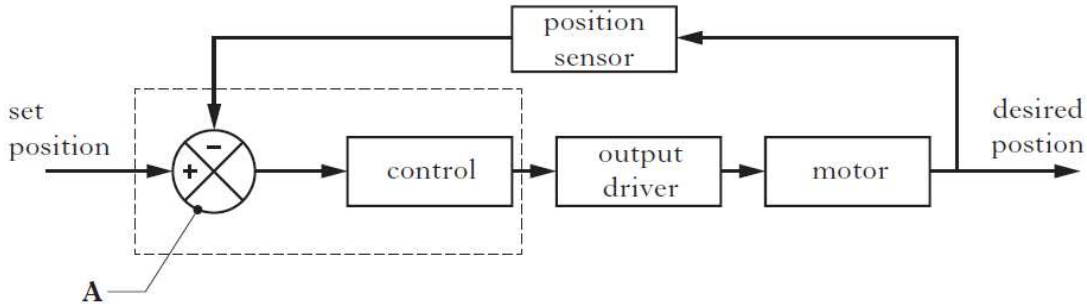
Task 15

A sub-systems diagram for an automatic heater is shown below. Redraw the system to include an error detector.



Task 16

A control diagram for the automatic positioning of a telescope is shown



(a) State the name of part A,

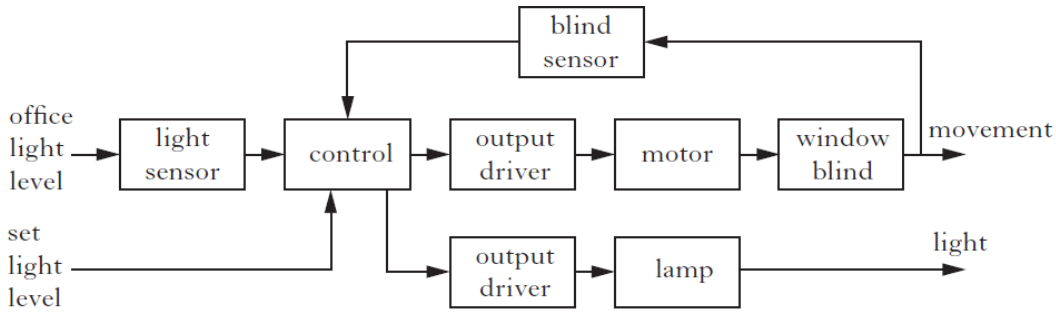
(b) (i) State the type of feedback used in the telescope system.

(ii) Describe why this feedback is used.

(c) Describe, with reference to the diagram the operation of the telescope system.

Task 17

The diagram below shows a simplified sub-system diagram for the control of the light level in an office. A light will turn on if the office is too dark or a window blind will close if it is too bright.



(a) (i) Complete the sub-system diagram shown by adding the system boundary.

(ii) Describe why a system boundary should be included in a sub-system diagram.

(b) Describe, with reference to the diagram, the operation of the **window blind**.

The system uses both open and closed loop control.

(c) (i) State the difference between open and closed loop control.

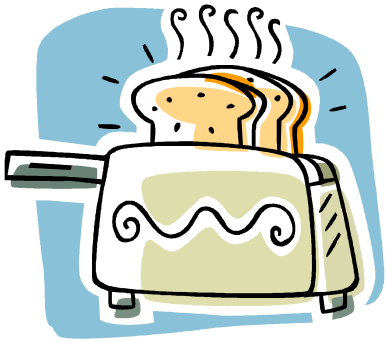
(ii) State which of the output transducers is operated using closed loop control.

Task 18

1. The systems approach is often used to help understand engineering problems.

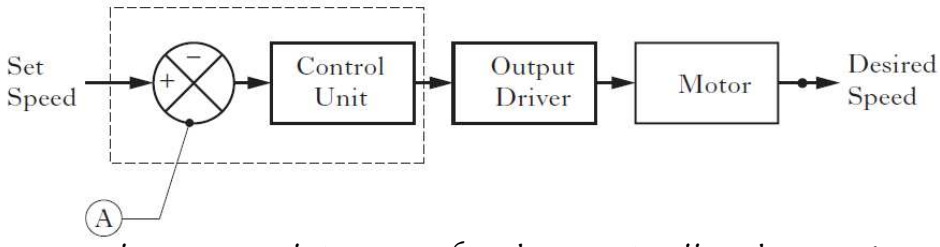
(*a*) Draw the Universal Systems diagram.

(*b*) Draw a **system diagram** for a toaster. Show the **main energy** input and the **main energy** output.



2.

(a) A treadmill uses closed loop control to maintain a constant speed. Describe closed loop control.



An incomplete control diagram for the treadmill is shown above.

(*b*) (i) State the name of symbol A

(ii) Complete the control diagram above.