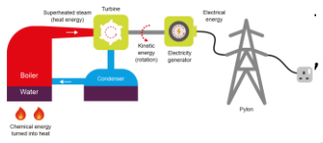
UNIT 2: ENERGY, MATERIALS, SYSTEMS AND DEVICES PT1

ENERGY GENERATION

Fossil Fuels
Fossil fuels are formed from the fossilised remains of plants and animals over millions of years
Coal, oil and gas are extracted through mining and drilling

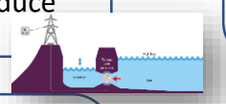
Energy Generation Fossil fuels can be burned to



Fracking
Fracking involves drilling into layers of shale rock deep in the earth to release pockets of gas
Water, sand and chemicals are injected into a well in order to force gas back up

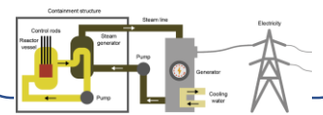
Photovoltaic cells
Light photons hit the PV cell which allows electrons to flow, creating an electric current

Tidal energy
The rise and fall of the tide forces water through turbines which drive generators to produce electricity



Hydroelectric power (HEP)
Hydroelectric power is a very reliable and controllable energy source. The set-up costs are financially and environmentally expensive

Nuclear Power
Nuclear power provides an abundant, reliable supply of clean energy



ENERGY STORAGE

Potential Energy
Potential energy is stored in objects not in motion, that will move once released

Kinetic Energy
Kinetic energy involves motion and movement, for example: Electricity when travelling throughout a circuit, Heat radiating from a fire, Sound coming from a speaker

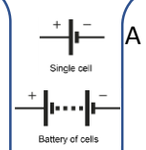
Chemical/Mechanical Storage
Mechanical storage:
Compression, Tension, Motion
Chemical storage:
Batteries, Gases, Solid fuel, Food

Pneumatics
Compressed air or gas is used to create movement. Pneumatic systems are very accurate and low maintenance

Hydraulics
Pumped and compressed liquid is used instead of air which creates a more powerful system

Flywheel
Flywheels rotate in a near frictionless environment They use surplus energy to reach optimum speed Momentum is stored until it is required

Cells and Batteries
A battery stores chemical energy in a series of cells
Each cell is usually 1.5V (rechargeable cells are 1.2V)
Each battery has a positive and negative terminal



MODERN MATERIALS

Modern materials
New and improved materials are constantly being discovered and developed. Modern materials can help to solve: design issues, technical constraints, environmental issues

Biodegradable polymers
Biodegradable polymers are made from vegetable starches, often corn-starch. Common varieties include: Polylactic acid (PLA) commonly used in 3D printing filament

Polymorph and Coolmorph
Both biodegradable, non-toxic and can be coloured. Ideal for modelling as they can be shaped using only hand pressure. They can be reused and remoulded multiple times

Titanium
Although a chemical element, titanium is commonly alloyed with other metals It is relatively lightweight, tough and stiff with low density

Fibre optics
Fibre optic cables carry light down a thin glass core
Uses include: Cable TV and broadband infrastructure

Graphene
Research into the uses of graphene is currently active in many areas including: flexible electronics, biomedicine, energy storage and composite materials

Metal foam
Metal foams are very lightweight compared to solid metals. As little as 25% of the mass of the solid metal is used.

SMART MATERIALS

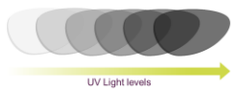
Smart materials
A material that makes changes depending on what stimulus is applied.
Touch, Light, Heat, Sound etc

Self-healing polymer
Self-healing polymers react to stress fractures by releasing a resin into the new crack
Microcapsules of liquid resin are ruptured

Self-healing concrete
Designed to avoid cracks filling with water. Spheres of bacteria are added to the mixture. When wet the bacteria produce calcium carbonate which fills the crack.

Thermochromic pigments
Hot and cold temperatures trigger a change of colour in special thermochromic dyes
Applications include: Fever scan strips used on infants, Room thermometers.

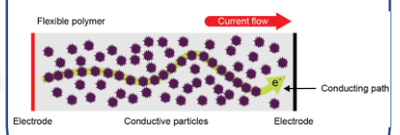
Photochromic particles
Ultraviolet light reacts with photosensitive silver halide particles within the lenses



Photochromic pigments
UV light stimulates particles in a special pigment. The effect only lasts as long as strong UV light is present. These pigments are mainly used for novelty goods and colour changing paints

Shape memory alloy (SMA)
Nitinol is an SMA of nickel and titanium. Once set, the alloy can be deformed into a different shape Heat or electricity is used to trigger a response in its shape

Quantum Tunnelling Composite
QTC is a polymer that contains billions of metal particles that don't actually touch each other. It is an unusual material being both an insulator and a semi-conductor



Acid or alkali?
PH levels can be detected using litmus paper It uses compounds found in different varieties of lichen Different colours and shades appear depending on the PH

Piezoelectric material
Piezoelectric material works in two ways: Subject it to movement or stress and it produces electricity. Attach an electrical signal to it and it moves

Piezo transducer
Using a thin layer of piezoelectric material, small transducers vibrate when an electrical signal is sent through the contacts. Used in mobile phones and other electronics

UNIT 2: ENERGY, MATERIALS, SYSTEMS AND DEVICES PT2

COMPOSITE MATERIALS AND TECHNICAL TEXTILES

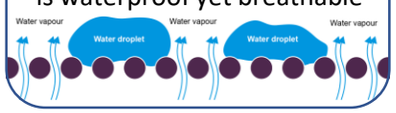
Composite material
A materials properties can be enhanced by combining two or more materials = A composite

Reinforced plastic
Glass reinforced plastic (GRP)

Carbon fiber reinforced plastic (CRP)

Technical textiles
The increased functionality of a technical textile can include: Weatherproofing, Strengthening, Adding conductivity and insulation, both thermally and electrically

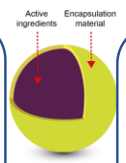
Gore-Tex®
Gore-Tex® is a special fabric membrane that is waterproof yet breathable



Aramids
Aramids are particularly tough fibers made from modified polyamide They offer: Cut and tear resistance Flame proofing Thermal insulation. Nomex® and Kevlar® are both types of aramid

Conductive fabrics and threads
E-textiles allow electricity to travel along special threads which are either woven or sewn into fabrics

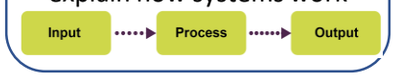
Microencapsulation
Solids, liquids or gasses are sealed in tiny capsules. These active ingredients can be released at controlled rates and under controlled conditions



SYSTEMS APPROACH TO DESIGNING

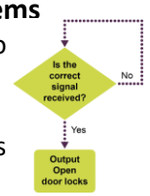
Electronic Systems
An electronic system is a series of parts or components that control a task or activity. Many products contain electronic systems

Systems diagram
Separate inputs, processes, decisions and outputs are placed in individual boxes to help explain how systems work

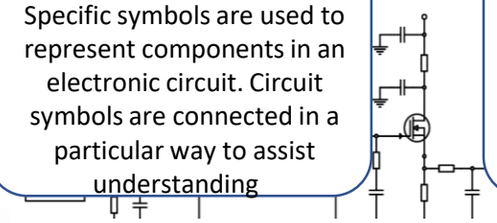


Open loop systems
Open loop systems **do not** make decisions based on feedback

Closed loop systems
Feedback is used to make a decision. Diamond boxes represent decisions



Circuits and symbols
Specific symbols are used to represent components in an electronic circuit. Circuit symbols are connected in a particular way to assist understanding

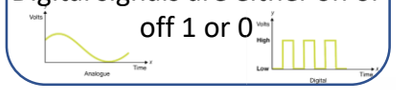


Input components
Systems and devices are triggered either manually or automatically using switches and sensors. Switches are a common form of input also heat, light, movement and sound .

Output components
Output components change electrical energy into light, sound, heat, movement and so on.

ELECTRONIC SYSTEMS PROCESSING

Digital vs Analogue
Analogue signals have an infinite range of values Digital signals are either on or off 1 or 0



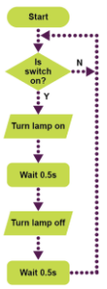
Integrated Circuit (IC)
Also known as microchips, ICs are capable of performing specific tasks

Digital or analogue inputs?
Switches are input components that give a digital signal Components such as thermistors, LDRs and microphones require an analogue input.

Output components
Buzzers, speakers produce sound Monitors, Lights, Projectors produce light/images Heat, Movement are also outputs

Monostable device
The single pulse produced is usually triggered by a switch or sensor. The length of the pulse can be varied by changing the delay time

Astable device
The stream of pulses produced are oscillating and constant. One **cycle** is the time (t) a single pulse takes to go from **0** (off) to **1** (on) and back to **0**

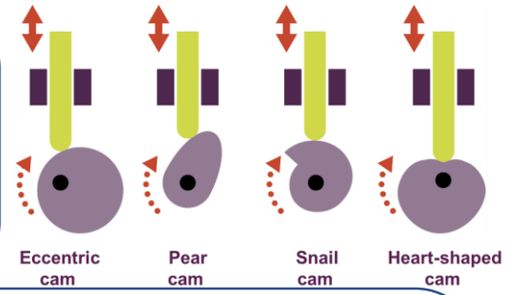


Counting
PICs can be programmed to count up and down, and can take over the roles of many traditional ICs

MECHANICAL DEVICES

Movement and motion
*Motion is the action of something being moved

*Motionless is something at rest.



Linear motion
Movement in one direction along a straight line

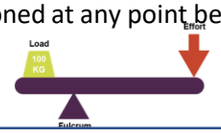
Reciprocating motion
A repetitive back-and-forth or up-and-down linear action

Oscillating Motion
A repetitive back and forth motion along a curved path

Rotary Motion
Objects moving in a circular motion usually around a fixed axis

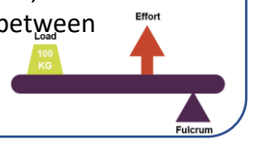
Levers
Levers help provide **mechanical advantage** (MA) They have **two** parts – a **bar** and a **pivot** also known as the **fulcrum**

First Order Lever (Class 1)
The load and effort are at opposite sides with the fulcrum positioned at any point between

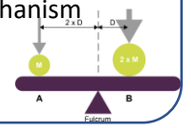


Second Order Lever (Class 2)
The effort is at the opposite end to the fulcrum, with the load positioned between

Third Order Lever (Class 3)
The load is at the opposite end to the fulcrum, with the effort positioned between



Equilibrium
When the effort and the load are equal, equilibrium can be created in a mechanism



Linkages
Linkages are mechanisms that use rigid parts to: Change the magnitude of a force Change the direction of a force, or Transform it into a different motion