

3 Engineering systems



Key words/ terminology

System	a set of things working together as parts of a mechanism or purpose
Sub- system	A system within a larger system
Motion	Movement
Component	A part that is used to make something
Mechanical	Moving parts/ physical materials

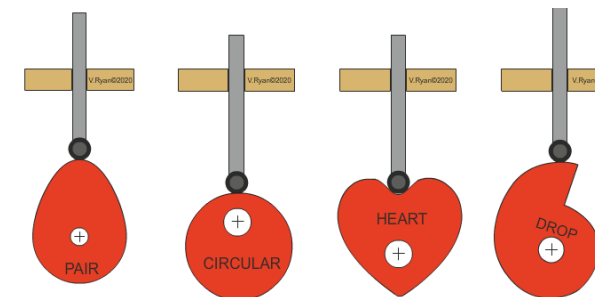
Non-negotiable Knowledge (What you need to know)

Mechanical systems

Cams and Followers

Cams and followers turn rotary motion into reciprocating motion.

- The follower moves up and down as the cam rotates.
- The cam can be turned manually via a handle or automatically using a motor.
- Eccentric cams are circular but have an off-centre rotating shaft. With this type, the rise and fall produced is symmetrical.



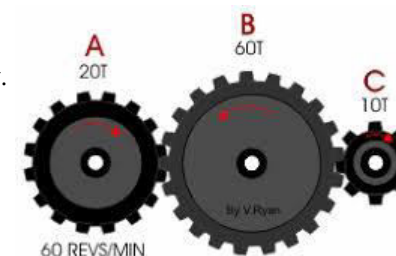
Types of Motion

Type	Description	Example
Linear motion – 	motion in a straight line. For example, a train moving across a straight track.	
Rotary motion – 	motion that turns in a circle. For example, a wheel turning.	
Oscillating motion 	– a swinging motion from side to side. For example, a pendulum in a clock.	
Reciprocating motion – 	motion that goes back and forth in a straight line. For example, a hand cutting tool being moved backwards and forwards.	

Gears/ Gear trains

Gear trains transmit rotary motion and torque. They are made up of two or more spur gears that mesh together.

- On two-spur gear trains a larger gear driving a smaller gear results in increased speed but decreased torque.
- A smaller gear driving a larger gear has the opposite effect.
- The driven gear will rotate in the opposite direction to the driver gear.
- Gear ratio = Number of teeth on driver gear / number of teeth on driven gear



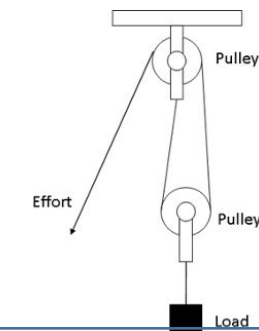
Pulleys

Pulley systems are used to reduce effort when lifting loads and to transfer power within a system. •A larger pulley wheel driving a smaller wheel will result in increased speed but decreased torque.

- A smaller wheel driving a larger wheel results in the opposite effect.
- The direction of rotation remains the same from the driver to the driven pulley.
- Velocity ratio = Diameter of the driven pulley / diameter of the driver pulley

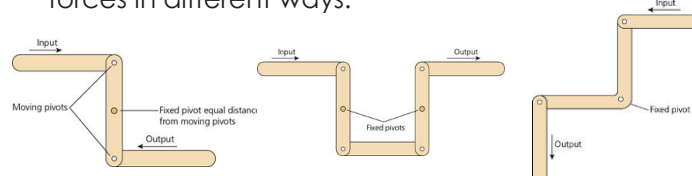
Lifting loads with pulleys

- Pulley systems are commonly used to aid the lifting of heavy objects by increasing the mechanical advantage.
- This is the ability of a mechanism to move a large load with a small effort force. It is usually written as a number with no units.
- Mechanical advantage (MA) = Load (F_b) / Effort (F_a)



Linkages

- Linkages are used to change the size of a force, the direction of motion and/or the type of motion.
- They are constructed by joining together links, rods or levers. These are connected via pivots that either allow or restrict their movement.
- A pivot can be fixed or moveable.
- Different types of linkages affect movement and forces in different ways.



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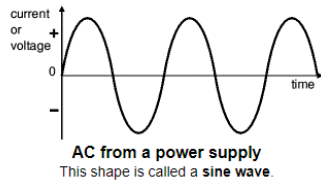
Non-negotiable Knowledge (What you need to know)

- AC/DC- Alternating current/ Direct current
- Electric/ Electronic components

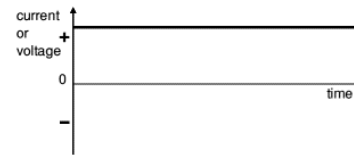
AC and DC
Electrical current

- An electric current is a flow of electric charge through a conductive medium, such as a wire.
- The SI unit of current is the ampere, or amp. Ohm's Law states that the current flowing through a resistor is directly proportional to the voltage across the resistor. This is represented using the formula:
• Current (I) = Voltage (V) / Resistance (R)
- There are two types of electrical current that are used:-Alternating current (AC) -Direct current (DC)

Alternating current (AC) changes direction periodically. The voltage level reverses along with the current.



Direct current (DC) flows in one direction only.



Powering products – mains electricity and batteries

- Mains electricity:-Supplied at 230 V AC in the United Kingdom. -Electrical outlets, or sockets, allow devices to make use of the electricity provided using a three-prong (live, neutral, earth) plug.
- Batteries:-Consist of two terminals (an anode and a cathode) and an electrolyte. -Convert chemical energy into electrical energy.



Interface components

- Transistor switching circuits
- Field effect transistors (FETs)- These are voltage amplifiers. Normal transistors are analogue, where as FET's are operated digitally. Similar to standard transistors, they have three legs, however they have different names (gate, drain, source). FET's provide an output signal high enough for motors and solenoids to operate.

Logic Gates

Logic gates are the basic building blocks of any digital system. It is an electronic **circuit** having one or more than one input and only one output. The relationship between the input and the output is based on a certain **logic**. Based on this, **logic gates** are named as **AND gate**, **OR gate**, **NOT gate**

Inputs and Outputs

- An input device takes a signal from the real world and converts it into an electronic signal. For example, converting light, sound or movement into a current or voltage.
- An output device turns the electronic signal back into a real world signal.



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Input components

	Slide switch (SPST) Allows current to flow through it when the internal contacts are touching, i.e. when it is switched 'on'.
	Light dependent resistor (LDR) Changes the light level that is detected into a resistance. Its resistance decreases as the brightness increases.
	Thermistor Changes the temperature level that is detected into a resistance. Usually the resistance decreases as the temperature increases.

Output components

	Light emitting diode (LED) Produces light when current flows from the anode to the cathode.
	Buzzer Uses an internal oscillator to produce sound when current flows through it.
	7-segment display Consists of a package of LEDs arranged so that numbers from 0 to 9 can be displayed.

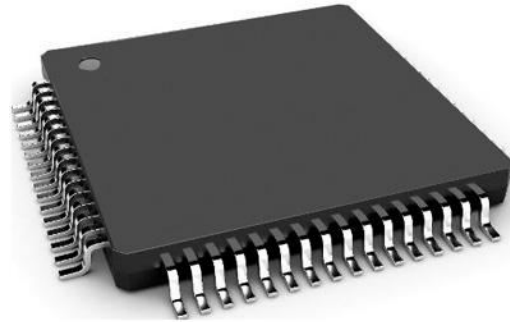


Non-negotiable Knowledge (What you need to know)

Electric/ Electronic components

What is a microcontroller?

- A small computer on an integrated circuit (IC).
- Has different pins for the connection of input and output devices.
- A peripheral interface controller (PIC) is a widely used example.
- Different sizes available (8- text-based programming languages, block editors pin all the way to 40 and beyond).
- Can be programmed using or flowchart software.



What are microcontrollers used for?

- Microcontrollers can be used to replace discrete components in circuits. This reduces the size of complex circuits, as software replaces hardware.
- Microcontrollers can be programmed to perform a wide range of tasks, including:- Timing-Counting-Generating sequences-Comparing values



Discrete components- resistors, capacitors and diodes

- Discrete components are electronic components made up of a single unit.
- They differ from integrated circuits (ICs), which are whole circuits on a small chip.
- Before the invention of ICs, all components were discrete, and they are still widely used in systems today.
- Examples of discrete components include:-resistors-capacitors-diodes



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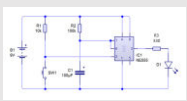
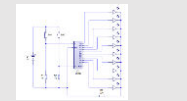
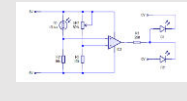


Process devices

Process devices take the signal provided by the input stage of a system and change it in some way. For example:

- Timing
- Counting
- Comparing values
- Logic functions

Process devices can be programmable or non-programmable.

	555 monostable timer- used for timing e.g. egg timer
	Decade counter- used for counting- e.g. lap counter
	Comparator- compares voltage-

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Non-negotiable Knowledge (What you need to know)

Structural systems

- The purpose of a structural system is to resist loads and forces that could otherwise cause the main structure to deform or fail.



- An example is the steel frame 'grid' design that made the development of the skyscraper possible.

Loads and stresses

- Static loads- **Static loading** is a **load** that doesn't change over time
- Dynamic loads- **Dynamic** loads or forces are loads that have change in either size, position or direction
- Tensile stresses- **Tensile stress** is the resistance of an object to a force tending to tear it apart.
- Compressive stresses- **Compressive stress** is the **stress** on materials that leads to a smaller volume. By **compressive stress** the material is under **compression**.

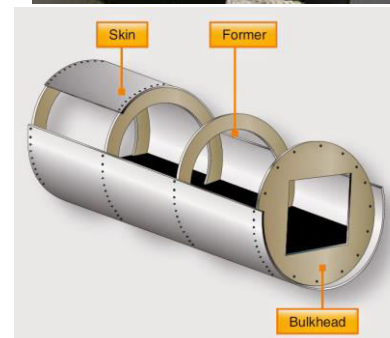
Space frame and monocoque structures

Monocoque

Monocoque, also called **structural skin**, is a structural system in which loads are supported by an object's external skin, similar to an egg shell. The word *monocoque* is a **French** term for "single shell"

Applications-

- Formula one cars
- Boats
- Aircraft shell



<https://www.aircraftsystemstech.com/p/fixed-wing-aircraft-fuselage-fuselage.html>

Space frame

In **architecture** and **structural engineering**, a **space frame** or **space structure** (3D truss) is a rigid, lightweight, **truss**-like structure constructed from interlocking **struts** in a **geometric pattern**. Space frames can be used to span large areas with few interior supports.



Space frame structure used in the roof structure at King's Cross railway station

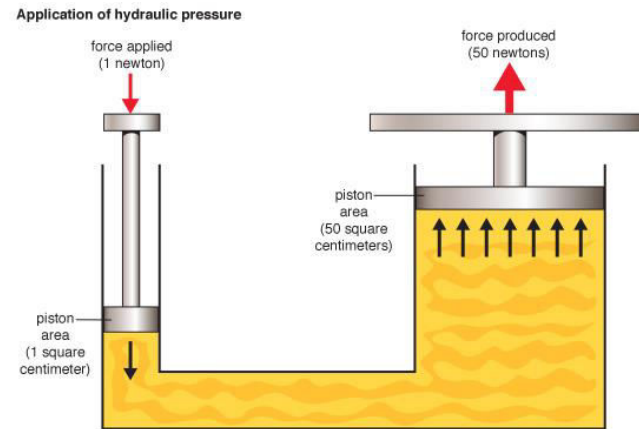
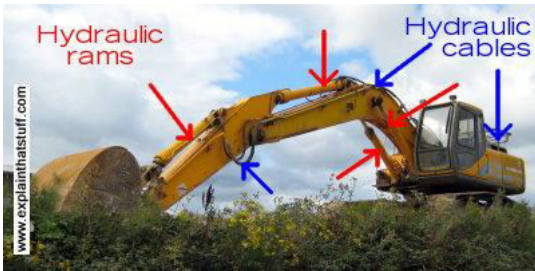
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Non-negotiable Knowledge (What you need to know)

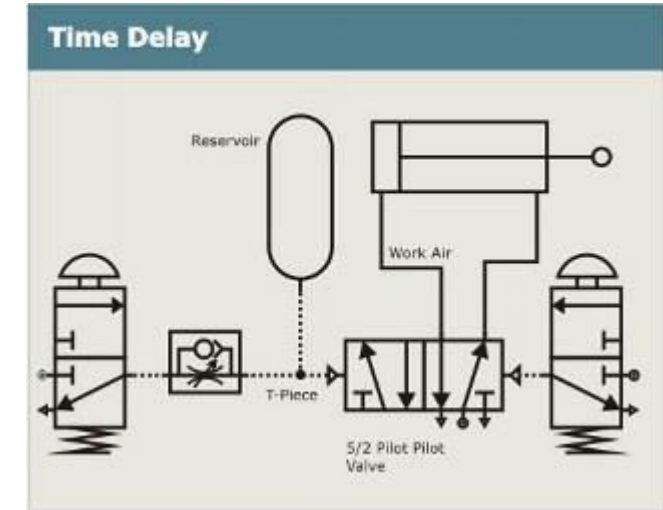
- Hydraulics and Pneumatics

Pneumatic and Hydraulic systems are widely used in engineering applications ranging from simple hand tools to complex robots and production systems, for example, the systems that mass produce our favourite foods, games and consoles

- Hydraulics- Liquids (usually oil)
- Pneumatics- Gas

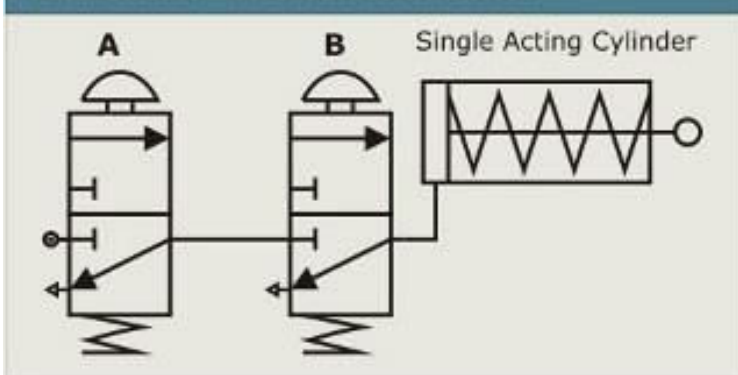


1 newton=3.6 ounces. 1 square centimeter=0.16 square inch.
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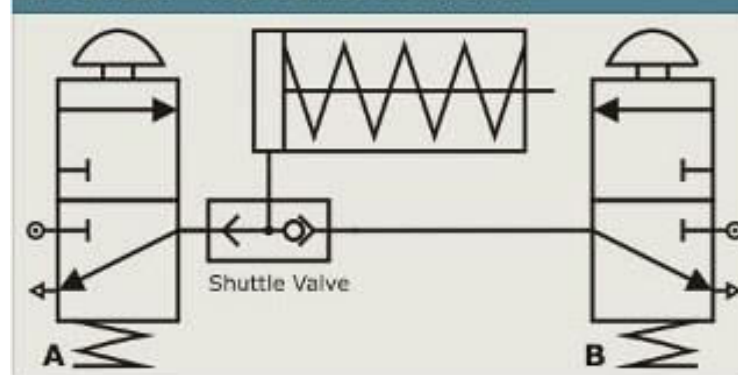


- A time delay circuit can be created by using an unidirectional-flow control valve and a reservoir connected in series.
- The valve restricts the flow of air into the reservoir. This causes the reservoir to fill up slowly, resulting in a time delay.

And Circuit - Two Valves in Series



Or Circuit - Two Valves in Parallel



- Valves placed in series or in parallel can be used to create simple logic circuits.
- An AND circuit consists of two valves connected in a series. The button on each of both valves must be pressed for the cylinder to operate.
- An OR circuit consists of two valves connected in parallel. The cylinder will operate if any of the two buttons (one on each valve) are pressed.

<https://www.explainthatstuff.com/hydraulics.html>