

Technology

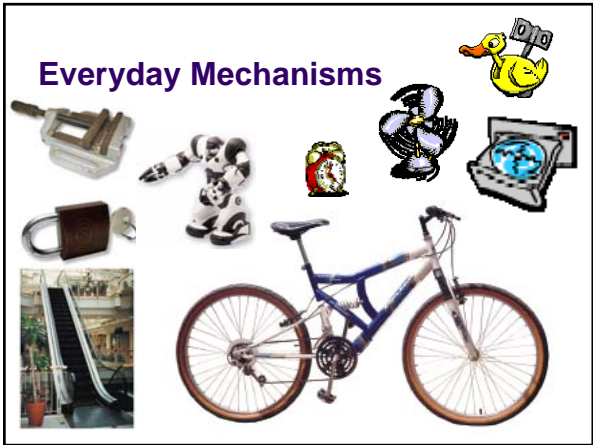
Mechanism: An Overview



The IronMan Challenge



Everyday Mechanisms



Everyday Mechanisms

- Observe the products passed around
- Identify the parts that make the product a mechanism
- Can you name other products in your everyday life?



O Level Syllabus

- understand and sketch simple examples of levers and linkages in use
- explain the function of a simple pulley system, the relationship between speed of rotation of pulley, diameter of pulley and velocity ratio of a pulley system
- explain simple gear ratios, transmission speeds and their effects on transmission of motion
- give examples of types of motion: rotary, linear, oscillating, reciprocating
- describe the use of crank, cam, follower, rack and pinion, bevel gearing, worm and wheel gearing, the screw in converting linear motion to rotary motion and vice versa
- understand and explain the concept of cable control, pneumatic control, hydraulic control
- analyse and describe mechanisms in terms of input, process, output and feedback; recognise the difference between open and closed loop systems



N Level Syllabus

- understand and sketch simple examples of levers and linkages in use
- explain the function of a simple pulley system, the relationship between speed of rotation of pulley, diameter of pulley and velocity ratio of a pulley system
- explain simple gear ratios, transmission speeds and their effects on transmission of motion
- give examples of types of motion: rotary, linear, oscillating, reciprocating
- describe the use of crank, cam, follower, rack and pinion, bevel gearing, worm and wheel gearing, the screw in converting linear motion to rotary motion and vice versa



INTRODUCTION

- Mechanisms are used as a means of controlling movement and force.
- Products that use electronic components in the operation of their mechanisms are called **electromechanical** products.



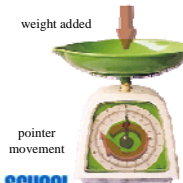
MECHANICAL SYSTEMS

- A mechanism is usually considered as a 'system' which produces an **OUTPUT** movement or force, from a given **INPUT** movement or force. The arrangement of components for converting the movement is called the **PROCESS** stage of the system.



O Level Syllabus: Analyse & describe mechanisms

MECHANICAL SYSTEMS



Open Loop System



O Level Syllabus: Analyse & describe mechanisms

MECHANICAL SYSTEMS



Lowering Water Level, Opens Supply Valve, Rising Water Level, Closes Valve

Closed Loop System




FUNCTIONS OF MECHANISMS

- Six basic tasks performed by mechanical systems include:
 - type of movement
 - place of movement
 - speed of movement
 - direction of movement
 - distance of movement
 - amount of force a movement provides
- Some mechanical systems perform two or more of these tasks at the same time.



FUNCTIONS OF MECHANISMS

- Changing the type of movement.
- The four main types of movement are:
 - linear: straight line motion
 - rotary: circular motion
 - reciprocating: forward and backward motion along a straight line
 - oscillating: forward and backward motion along an arc



glue extrudes

rotary knob

INPUT

→

PROCESS

→

OUTPUT





rotary knob

screw thread

glue stick movement

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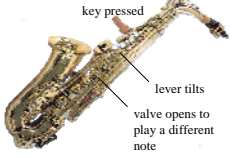
4 Basic Types of Motion

<h3 style="text-align: center; color: blue;">Rotary Motion</h3>  <p style="text-align: center;">Movement in a circle Eg. pedals on bicycle, earth, fan merry-go-round</p>	<h3 style="text-align: center; color: blue;">Oscillating Motion</h3>  <p style="text-align: center;">Movement backwards and forwards <u>in the arc of a circle</u> Eg. pendulum of a clock, swing</p>
<h3 style="text-align: center; color: blue;">Linear Motion</h3>  <p style="text-align: center;">Movement in a straight line Eg. car moving along a road, MRT, train</p>	<h3 style="text-align: center; color: blue;">Reciprocating Motion</h3>  <p style="text-align: center;">Movement backwards and forwards <u>along a straight line</u> Eg. Needle in sewing machine</p>

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FUNCTIONS OF MECHANISMS

- Changing the place of movement.
- It is necessary sometimes to produce an output movement which is some distance away from the input movement.



key pressed

lever tilts

valve opens to play a different note

INPUT

→

PROCESS

→

OUTPUT

press key

lever

valve movement

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FUNCTIONS OF MECHANISMS

- Changing the speed of movement.

INPUT

→

PROCESS

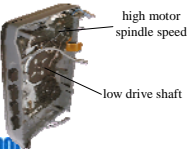
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OUTPUT

high spindle speed

pulley

low drive valve



high motor spindle speed

low drive shaft

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FUNCTIONS OF MECHANISMS

- Changing the direction of movement.
- By changing the direction of movement, mechanical systems can make things easier to use.

INPUT

→

PROCESS


→

OUTPUT

handle

lever

plunger raised



lever

plunger

handle

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FUNCTIONS OF MECHANISMS

- Changing the distance of movement.
- A small movement sometimes needs to be amplified to create a larger movement or vice versa.

INPUT

→

PROCESS

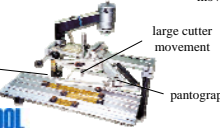
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OUTPUT

small pointer movement

pantograph

large cutter movement



large cutter movement

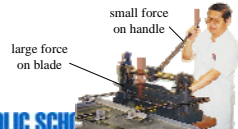
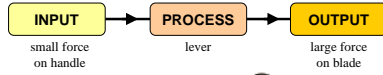
pantograph

small pointer movement

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FUNCTIONS OF MECHANISMS

- Changing the amount of force a movement provides.
- Mechanical systems are frequently used for increasing force.



TRANSMISSION RATIO

- The **transmission ratio** states the relationship between the input and output movements in a mechanical system.

$$\text{Transmission ratio} = \frac{\text{Output movement}}{\text{Input movement}}$$

- The ratio can be used to compare distances, angles or number of revolutions.



MECHANICAL ADVANTAGE

- The **mechanical advantage** is the ratio between the output force and the input force of the mechanical system.

$$\text{Mechanical advantage} = \frac{\text{Output force}}{\text{Input force}}$$

- The unit of force is the Newton (N).



MECHANICAL COMPONENTS

- The common components used in mechanical systems are:

- | | |
|----------------------|-------------------|
| - linkage | - wheel |
| - lever | - gears |
| - crank | - screw |
| - bell crank | - rack and pinion |
| - cam | - springs |
| - pulley | - bearings |
| - chain and sprocket | - cable |



A Summary

[Watch Video](#)

Note:

- Machine = Mechanism



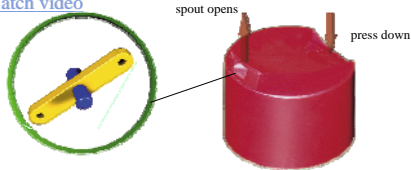
Technology

Mechanical Components 1



MECHANICAL COMPONENTS

- Levers provide a simple method of increasing force or movement as well as for changing the direction of movement.
- [Watch video](#)

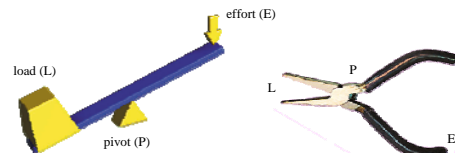


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MECHANICAL COMPONENTS

- There are three classes of levers.
- How to decrease or increase effort?

FIRST CLASS

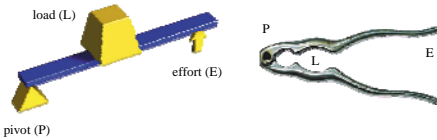


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MECHANICAL COMPONENTS

- There are three classes of levers.
- What is relationship between load and effort?

SECOND CLASS

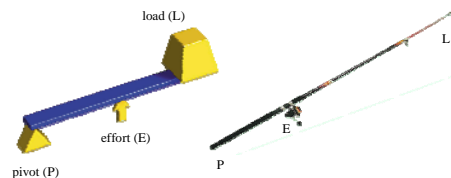


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MECHANICAL COMPONENTS

- There are three classes of levers.
- What is relationship between load and effort?

THIRD CLASS



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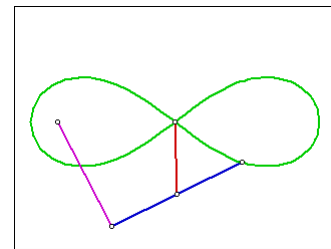
MECHANICAL COMPONENTS

- Levers are connected in different ways to create linkages.
- Uses:
 - Extension
 - Create paths



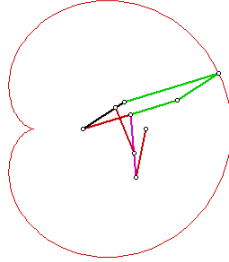
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MECHANICAL COMPONENTS



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MECHANICAL COMPONENTS



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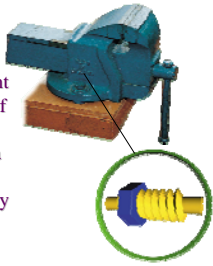
More Linkage Resources

- [http://en.wikipedia.org/wiki/Linkage_\(mechanical\)](http://en.wikipedia.org/wiki/Linkage_(mechanical))
- <http://www.flying-pig.co.uk/pages/link.htm>

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MECHANICAL COMPONENTS

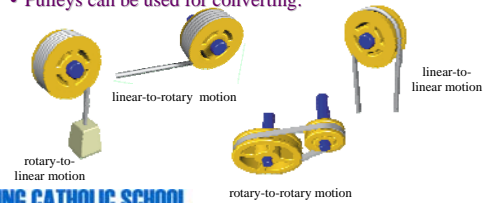
- The **screw** is used to convert rotary motion into linear motion. The finer the thread, the smaller the linear movement produced by a single rotation of the screw.
- The screw mechanism allows a very large force to be exerted.
- Linear actuators are powered by electric motors.
- [Watch video](#)



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MECHANICAL COMPONENTS

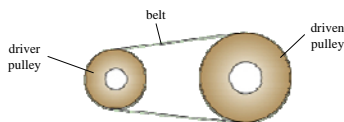
- A pulley is a wheel that is used with a belt or cable for transmitting movement or force.
- [Watch video](#)
- Pulleys can be used for converting:



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MECHANICAL COMPONENTS

- Pulleys can be used to increase or decrease force or movement.
- If the driver pulley has a smaller diameter than the driven pulley in a belt drive system, the driven pulley rotates more slowly than the driver.



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(Out of syllabus, good to know)

MECHANICAL COMPONENTS

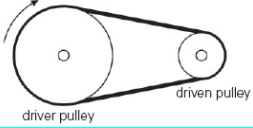
- Rotational force, called **torque**, is increased in a pulley drive system when the driven pulley has a larger diameter than the driver pulley.



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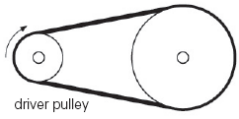
Speed vs Torque

If the **driver pulley** is bigger than the driven pulley, the driven pulley **turns faster** than the driver, but **less torque**.



driver pulley driven pulley

If the **driver pulley** is smaller than the driven pulley, the driven pulley **turns slower** than the driver, but **higher torque**.

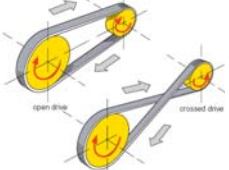


driver pulley

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MECHANICAL COMPONENTS


- In an **open drive** system, the pulleys rotate in the **same direction**.



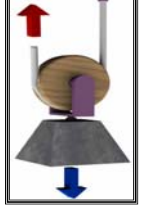
- In a **crossed drive** system, the pulleys rotate in **opposite directions**.

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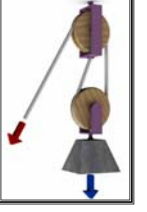
Different types of pulleys



Fixed Pulley



Movable Pulley

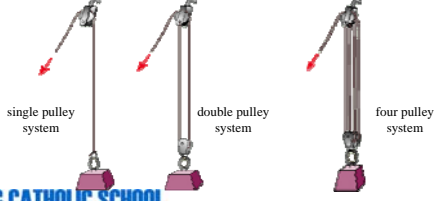


Compound Pulley
(Fixed + Movable)

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MECHANICAL COMPONENTS

- Simple and compound pulley systems can be used to reduce the effort needed to lift a load.

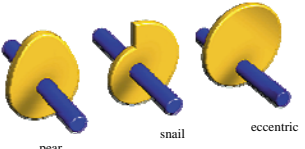


single pulley system double pulley system four pulley system

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MECHANICAL COMPONENTS

- A **cam** is a profiled piece of material fixed to a shaft. (wheel with a certain shape)
- It is normally used with a 'follower' to create a cam-and-lever or cam-and-slider mechanism.

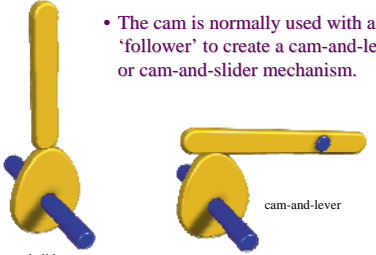


pear snail eccentric

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MECHANICAL COMPONENTS

- The cam is normally used with a 'follower' to create a cam-and-lever or cam-and-slider mechanism.



cam-and-lever

cam-and-slider

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Cam and Slider

- The cam-and-follower converts **rotary** motion to **reciprocating** motion.
- It **cannot** work the other way around.

Purpose of slider:

- To ensure that the follower will move in a straight reciprocating manner

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MECHANICAL COMPONENTS

- The cam is also used as a clamping device.

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MECHANICAL COMPONENTS

- Sequential timing devices make use of a series of cams along a shaft to operate levers in sequence.

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MECHANICAL COMPONENTS

- The graphs show the distance travelled by a follower against the rotation of three different cam profiles.

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Animated Toy (Pear Cam-Slider)

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More Resources on Cam-Follower

- <http://www.technologystudent.com/cams/camdex.htm>
- <http://en.wikipedia.org/wiki/Camshaft>
- <http://www.flying-pig.co.uk/mechanisms/pages/cam.html>

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Mechanical Components 2



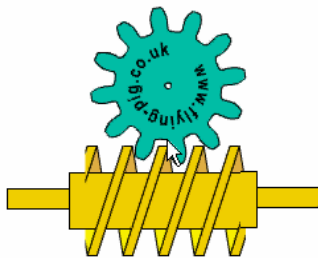
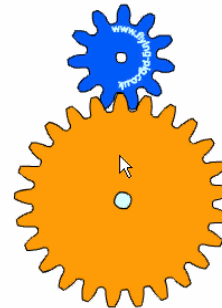
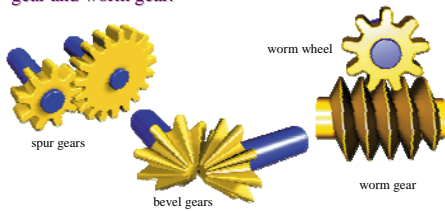
MECHANICAL COMPONENTS

- A **gear** is a circular wheel with a number of teeth around the circumference.
- Gears may be combined in different ways for controlling speed, increasing torque or changing the direction of motion.
- Trying this game
<http://www.shockwave.com/gamelanding/gears.jsp>



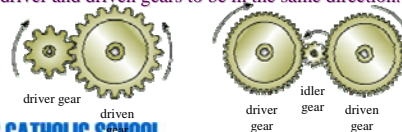
MECHANICAL COMPONENTS

- Three common types of gear are the spur gear, bevel gear and worm gear.



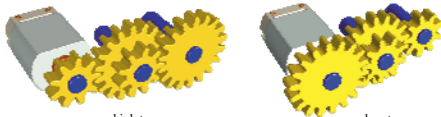
MECHANICAL COMPONENTS

- Two **spur gears** meshing together turn in opposite directions, converting a clockwise rotation into an anticlockwise rotation.
- Gear Ratio is **Number of Turns of Driver : Driven Gear**
- An **idler gear** between the two allows rotation of the driver and driven gears to be in the same direction.



MECHANICAL COMPONENTS

- If the spur gears are of different sizes, one gear turns faster than the other.



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MECHANICAL COMPONENTS

- A **gear train**, formed by several spur gears meshing together, can dramatically increase or decrease the speed or torque in a system.
- When the driven gear rotates more slowly than the driver gear, the output torque is increased.



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MECHANICAL COMPONENTS

- **Bevel gears** enable the axis of rotation to be converted through 90°.



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MECHANICAL COMPONENTS

- **Worm gears** is used to produce a considerable reduction in speed without the need for a gear train.
- One rotation of a worm gear causes the worm wheel to rotate by a single tooth.
- The worm wheel cannot be used to rotate the worm gear, therefore the input and output are not interchangeable.



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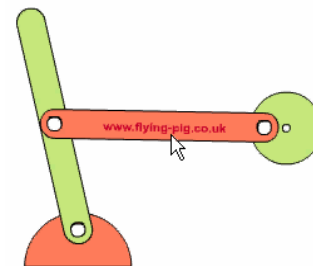


MECHANICAL COMPONENTS

- A **crank** consists of an arm with one end connected to a shaft, the other end having a handle or connecting point.
- Cranks are often used with a slider for converting reciprocating movement into rotary movement, or vice versa.

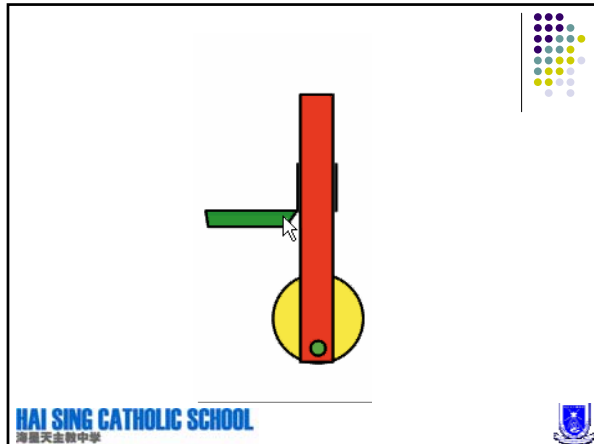


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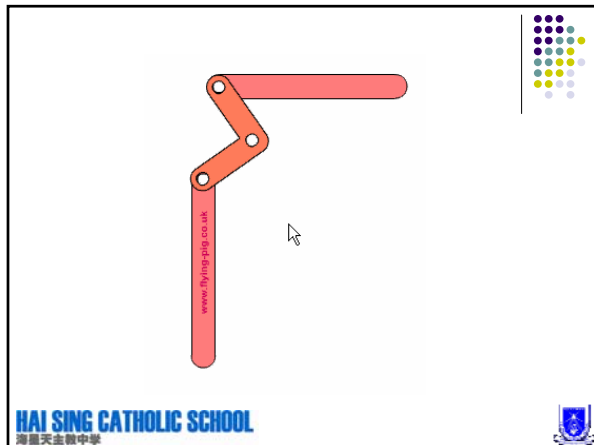


MECHANICAL COMPONENTS

- A **bell crank** is a special type of crank with two arms at 90° to each other connected at a common pivot point.
- Bell cranks allow the direction of movement or force to be converted through 90° and are often combined with a lever linkage.

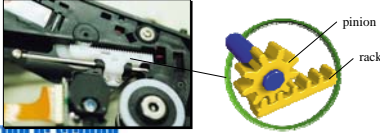


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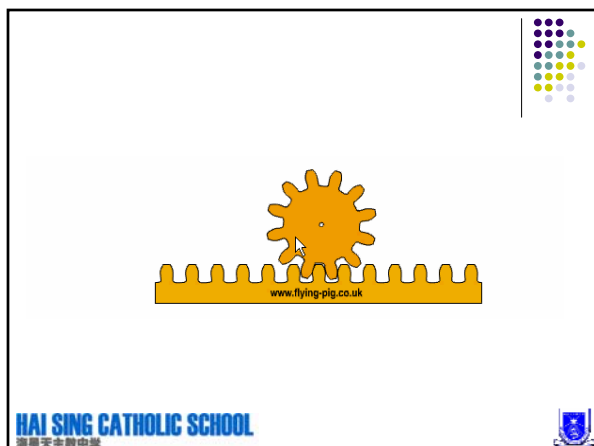


MECHANICAL COMPONENTS

- The **rack and pinion** mechanism consists of a straight rod (the rack) which has a number of gear teeth with a small gear wheel (the pinion).
- The rack and pinion is used to convert rotary-to-linear movement or linear-to-rotary movement.

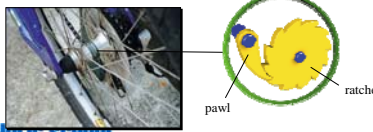


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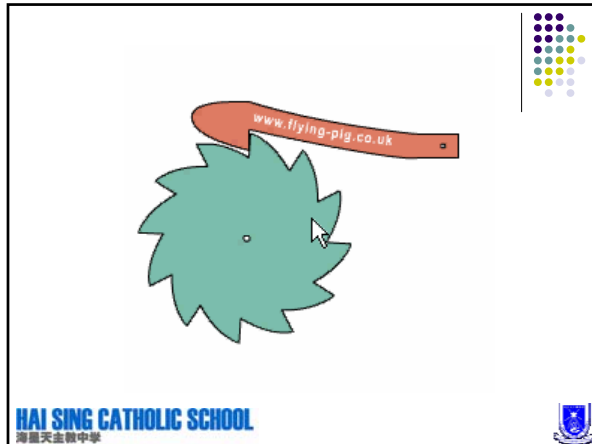


MECHANICAL COMPONENTS

- The **ratchet and pawl** is a mechanism used to allow motion in one direction only.
- The ratchet consists of a number of specially shaped teeth along the edge of a bar or wheel into which a pawl engages.



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MECHANICAL COMPONENTS

- Springs are used to provide a return movement in a mechanism and can be used in compression or tension.
- The energy stored in a spring is used as part of a return mechanism.

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MECHANICAL COMPONENTS

- A constant force spring is made from a curled strip of stainless steel or high carbon steel, such that when it is stretched out or reverse wound, it exerts a force as it attempts to unwind to its original shape.

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MECHANICAL COMPONENTS

- Cables allow an output movement to take place some distance away from the input movement.
- Usually made from multi-strand steel wire.
- Flexible and work well in tension.

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(Out of syllabus, but good to know)

MECHANICAL COMPONENTS

- The chain and sprocket mechanism is similar to the pulley drive except that a chain is used instead of a belt or cable.
- A chain is stronger than a belt and will not slip if it is kept in tension.

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(Out of syllabus, but good to know)

MECHANICAL COMPONENTS

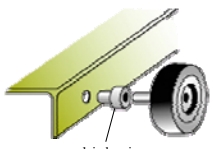
- Wheels often form the output of a mechanical system, but being driven via an axle by gears, pulleys or sprockets and chains.

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(Out of syllabus, but good to know)

MECHANICAL COMPONENTS

- Bearings are used to reduce friction between moving and fixed parts.
- The simplest type is the plain bearing which consists of a bush containing a rotating shaft. Lubricant can be applied to reduce friction.




plain bearing

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(Out of syllabus, but good to know)

MECHANICAL COMPONENTS

- Ball bearing races contain a number of hardened steel balls between an outer race and an inner race. They operate with minimal friction.
- For long, heavy shafts, roller bearings are used instead.




ball bearing roller bearing

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EXPLORING MECHANISMS

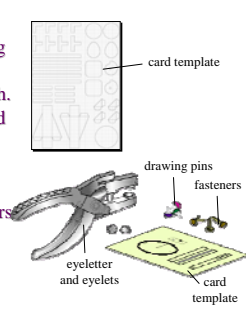
- Mechanisms can be explored using materials such as card, polystyrene sheet, corrugated plastics, plywood, plastics moulding and construction kits.
- Software is also available for testing mechanisms using a computer.



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EXPLORING MECHANISMS

- Card is ideal for prototyping mechanisms because it is cheap and easy to work with.
- Card templates may be hand drawn or designed with a CAD software. They can then be assembled using drawing pins, paper fasteners or eyelets for pivot points.



card template

drawing pins

fasteners

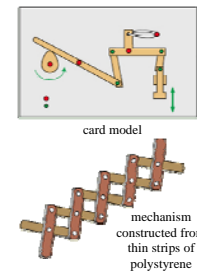
eyelet and eyelets

card template

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EXPLORING MECHANISMS

- To provide stability for card mechanisms, a wooden or plastics backing board should be used.
- If greater rigidity is needed, component parts may be cut from thin polystyrene sheet.



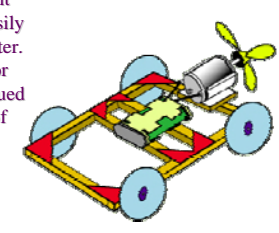
card model

mechanism constructed from thin strips of polystyrene

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EXPLORING MECHANISMS

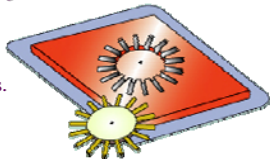
- Card wheels are suitable for use with very light structures and are easily cut using a circle cutter.
- Thin wooden strips or lolly sticks can be glued to triangular pieces of card to create a light framework.



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EXPLORING MECHANISMS

- Card is also suitable for making gear wheels, with matchsticks or wooden dowels forming the gear teeth.
- A vacuum-formed jig can speed up the manufacturing process.

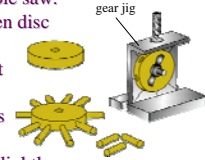


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EXPLORING MECHANISMS

- For heavier structures, wooden wheels and gears can be made using a hole saw.
- A gear is produced from a wooden disc by drilling holes around the circumference and inserting short lengths of wooden dowels.
- A jig is required for drilling holes accurately.
- Alternatively, panel pins may be lightly hammered around the circumference of a wooden disc to form the gear teeth.

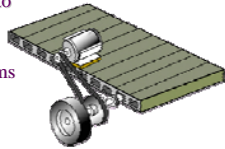


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EXPLORING MECHANISMS

- When constructing a chassis for a mechanism, the flutes in corrugated plastics sheet are ideal for the insertion of a shaft.
- Small bushes may be needed to keep the shaft steady.
- Other components such as wheels, gears, pulleys and cams may then be attached to the shaft.



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EXPLORING MECHANISMS

- A wide range of cheap plastics mouldings are available for mechanical project work including wheels, gears, cams and pulleys.

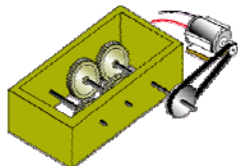


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EXPLORING MECHANISMS

- By combining gears of different sizes, a gearbox can be made to increase or to decrease the output speed in a mechanical system.
- When constructing a gearbox, accurate marking out of the gearshaft positions is essential to ensure that the gears mesh smoothly.



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Activities

- Simple Compound Machines
<http://www.edheads.org/activities/simple-machines/>

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