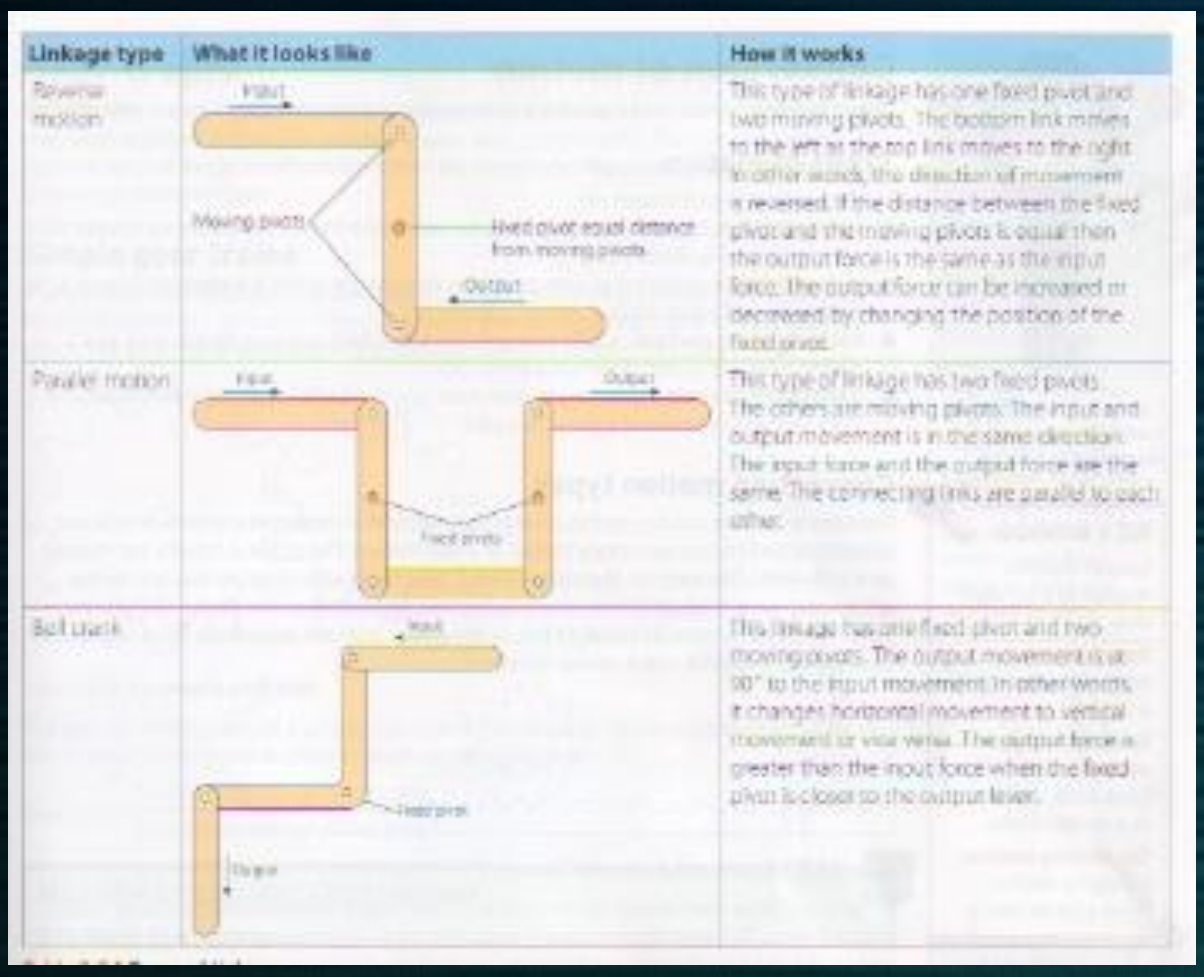
Mechanical systems

SECTION 3.2

Linkage mechanisms

Linkages are used to change the direction of movement, and the size of the force.
The are constructed by joining together links, rods or levers and are connected via pivot points (a pivot point is something that balances or turns and can be either fixed or moveable) that either allow or restrict movement.

The three types of linkages you need to be aware of are below:



Mechanical advantage

Linkages can be used to create a mechanical advantage buy moving the fixed pivot point closer or further away from the input or output.

The equation used is: Mechanical advantage MA = Load / Effort

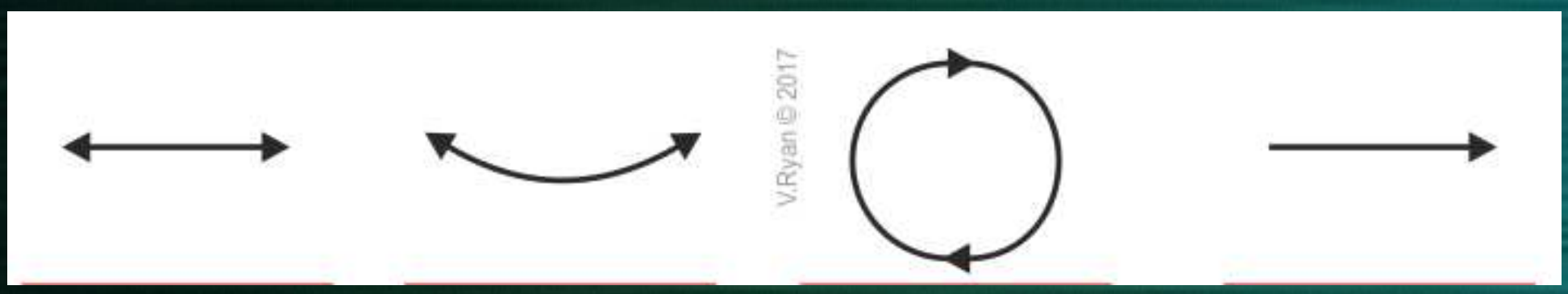
In a Linkage the effort is the force at the input and the load is the force at the output.
The units used is Newtons (N).

Types of movement

One of the main functions of a mechanical system is to change one type of motion for another.

There are four types of motion or movement:

Reciprocating – Motion travels back and fourth in a straight line
Oscillating – Motion swings from side to side
Rotary – Motion travels round in a continuous circle
Linear – Motion travels in a straight line



Mechanical systems

SECTION 3.2

Linkages

In the table below Name, draw and label the three linkage mechanism naming the fixed and movable pivot points.

Linkage name	Image	Description

Below write down the equation for Mechanical advantage

Using this equation work out the MA (Mechanical advantage) of the following linkage mechanisms (show all working) Remember the saying “You have to INPUT the EFFORT”, to convert the words effort and load to input and output)

1, Input force = 5N, Output force = 40N

2, Input force = 8N, Output force = 64N

3, Input force = 6N, Output force =

In the table below name, draw and cite examples of the four types of movement

Movement 1:	Movement 2:	Movement 3:	Movement 4:
Example	Example	Example	Example

Mechanical systems

SECTION 3.2

Converting types of movement
Rack and Pinion

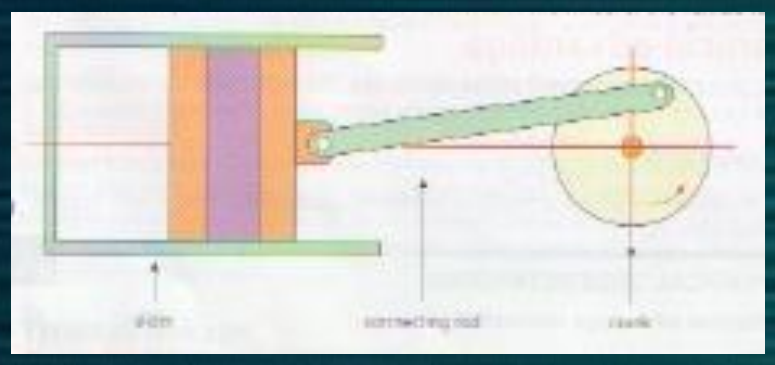
Mechanical systems are used to convert rotary motions from one to another.

A rack and pinion mechanism converts rotary movement into reciprocating or vise versa. The rack is a straight bar with teeth along it which is meshed with a pinion which is a gear so as the pinion rotates the rack is made to slide / move.

Crank and slider

This type of mechanism is used to convert rotary motion into reciprocating or vice a versa.

To create reciprocating motion the crank rotates and the connecting rod pushes the slider moves back and forth.
A piston engine in a car works like this but in reverse, the slider is the piston which reciprocates making the crank or axial rotate turning the wheels.



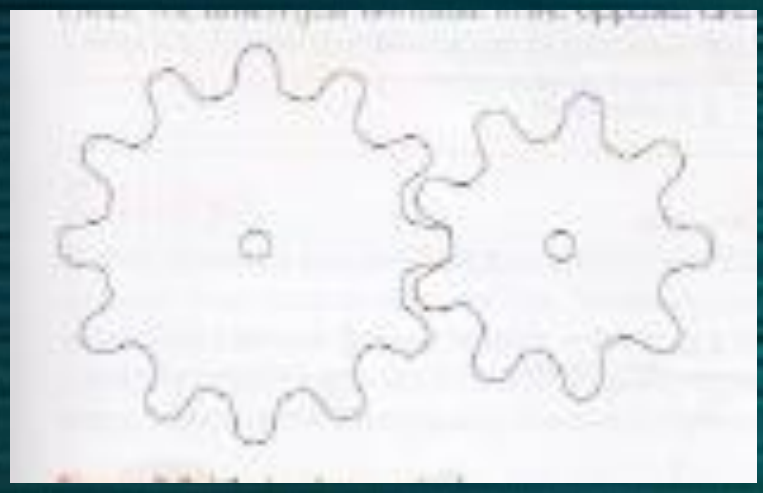
Gear train

This mechanism transmits rotary motion and torque, they are made up of two or more gears that are meshed together, the size and number of teeth on each gear can affect the speed of the gearing system and the torque applied.

A simple gear train is where two gears are meshed together so that when one rotates the other also rotates but at an increase speed but decreased torque or lower speed but increase torque.
One issue with the gearing system is that the gears will rotate in opposite directions so an idle gear can be added to make them rotate in the same direction.

The Velocity ratio of a gear train can be calculated by dividing the number of teeth on the driven by the number of the teeth on the driver.

Velocity ratio = no. of Driven teeth / no. of Driver teeth.



Chain and Sprocket

An alternative to using gear trains is to use a chain and sprocket mechanism. This involves using two gears known as sprockets that are connected via a chain which is made up of a series of links held together via pins.

As the Driver sprocket rotates so does the chain which then in tern makes the Driven Sprocket also rotate.

The advantage over complex gear trains as only two Sprockets are needed saving money. However, the chain can jump or break if not maintained properly.
So the chain needs to be tensioned with additional additional spring loaded mechanisms used.

The most common application of this mechanism is on a bicycle pedal system.
The Velocity ratio of this mechanism can be calculate the same way as a gear train, VR = Driven / Driver.

Mechanical systems

SECTION 3.2

Rack and Pinion

Below draw down what a rack and pinion mechanism looks like.

On the diagram use arrows to show the types of movement, name the types of movement to.

Find two examples of where a rack and pinion mechanism would be used

.

.

Crank and slider

Below draw down what a Crank and slider mechanism looks like.

On the diagram use arrows to show the types of movement, name the types of movement to.

Find two examples of where a Crank and slider mechanism would be used

.

.

Gear trains

Below draw down what a Gear train mechanism looks like.

On the diagram use arrows to show the type of movement, name the type of movement.

Find two examples of where a gear train mechanism would be used

.

.

Chain and sprocket

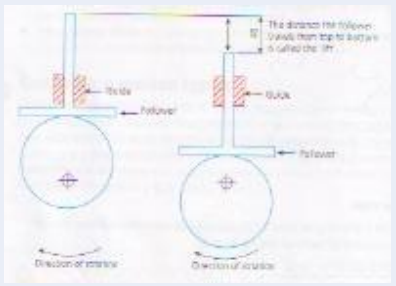
Below draw down what a chain and sprocket mechanism looks like.

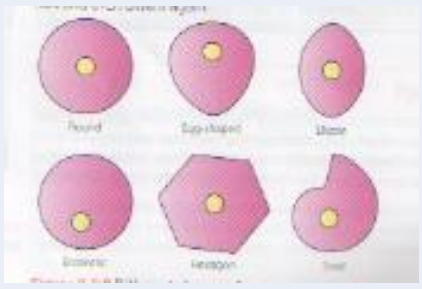
Mechanical systems

SECTION 3.2

Cams

Cams and followers are designed to turn rotary motion into reciprocating motion. As the follower moves up and down the cam rotates which can e done manually via a handle or via a motor.





The pattern of movement is determined by the design / shape of the cam, i.e. if the cam is round with the shaft in the centre the follower will remain stationary, however if the cam is round but the shaft is off centre then the follower will continually rise and fall.
There are many shapes of cams:

- Eccentric – With this type of cam there is continual movement up and down of the follower as it rotates
- Snail – With this type of cam the follower will rise and then have a sudden fall due to the straight edge on the cam.
- Ellipse – With this type of cam you get two rises as the cam rotates
- Hexagonal – with this type of cam you get several small rises and falls.
- Egg shaped – with this cam the follower doesn't move for half a rotation as the shaft is in the centre but as the shape of the cam changes the follower begins to rise and then fall once again.

Pulleys

These are systems that are used to reduce effort when lifting loads and to transfer power. They transmit rotary motion and use wheels that are placed a set distance apart that can include grooves or teeth to increase grip as they can slip. As the wheel (Driver) rotate this makes the belt made from rubber rotates and moves the connecting wheel (Driven) forming a pulley system.

The direction of rotation remains the same but speed and torque can be increased by using different sized pulley wheels
A larger pulley wheel driving a small wheel will result in a speed increase.
However, a small pulley wheel driving a larger wheel will result in increased torque

The Velocity ratio can be calculated by: Velocity ratio = Driven diameter / Driver diameter.

The reason Pulley systems are used over gear and chain is cost, they have less sophisticated parts.

Pulleys are used to lift weight, Figure 3.2.10 show a pulley system with no Mechanical advantage (MA). Effort in = same effort out, the pulley is attached to a high point and then lifted from the ground via the pulley rope.

To increase the MA the pulley needs to be moveable and inverted (figure 3.2.11) the rope is fixed above the pulley so the effort to lift is halved but the user would have to be above the pulley which might not be achievable.

This can be modified (figure 3.2.12) a fixed pulley is attached on the ceiling, a rope attached to this pulley wheel, wrapped around a second moveable pulley and then around the fixed ending up on the ground for the user to pull. MA of 2 and from the ground.

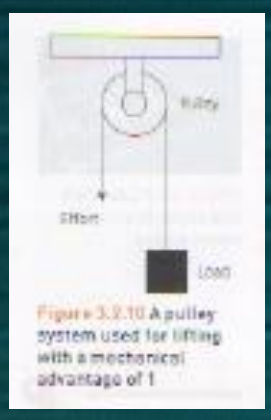
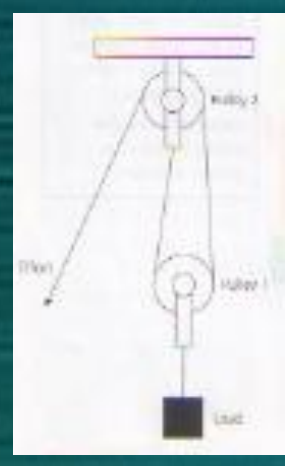


Figure 3.2.10 A pulley system used for lifting with a mechanical advantage of 1

Figure 3.2.11 A pulley system with a mechanical advantage of 2



Bearings

These are machine parts who's role is to control movement and reduce friction between moving parts.

Plain bearings

These are the simplest form , they provide a sliding contact with the other parts of the machine. There are several sub-types of plain bearings including radial bearing, linear and thrust bearings – Example of a radial bearing is a shaft rotating in a hole (car axial).

Rolling element bearings

These bearing consist of a rolling element placed between two bearings known as races. They have been designed to prevent sliding friction, two common types are Roller bearings and Ball bearings.

Figure 3.2.13 A radial plain bearing

Figure 3.2.14 A ball bearing

Mechanical systems

SECTION 3.2

Cams and Followers

Below draw down what a Cam and follower mechanism looks like.

State what types of movement the cams and Followers have

.

.

What determines the pattern of movement of the follower?

_____

_____

Below drawn down three shapes of Cams

For each describe their pattern of movement

1

_____

_____

2

_____

_____

3

_____

_____

Pulleys

What type of movement does the Pulley mechanism transfer

_____

On the Pulley wheels what can they have to help grip and attach the belt?

.

.

What advantage do you think these grooves or teeth have on the belt when the wheel is turning at high speed or carrying a large load.

_____

_____

The belt is made from Rubber, why is this a suitable material?

_____

_____

Mechanical systems

SECTION 3.2

With this type of mechanism, how can the speed be adjusted?

_____
_____

_____
_____

What is meant by the term Torque

_____
_____

_____
_____

Use the equation on the photocopied sheet to calculate the VR (Velocity ratio)

A driver pulley has a diameter of 30mm and the driven pulley has a diameter of 150mm what is the velocity ratio? (show all working)
The answer needs to be in the form of a ratio i.e. 1:2 etc.

A driver pulley has a diameter of 50mm and the driven pulley has a diameter of 200mm what is the velocity ratio? (show all working)
The answer needs to be in the form of a ratio i.e. 1:2 etc.

A driver pulley has a diameter of 20mm and the driven pulley has a diameter of 240mm what is the velocity ratio? (show all working)
The answer needs to be in the form of a ratio i.e. 1:2 etc.

Mechanical systems

SECTION 3.2

With this type of mechanism, how can the speed be adjusted?

_____
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What is meant by the term Torque

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Use the equation on the photocopied sheet to calculate the VR (Velocity ratio)

A driver pulley has a diameter of 30mm and the driven pulley has a diameter of 150mm what is the velocity ratio? (show all working)
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A driver pulley has a diameter of 50mm and the driven pulley has a diameter of 200mm what is the velocity ratio? (show all working)
The answer needs to be in the form of a ratio i.e. 1:2 etc.

A driver pulley has a diameter of 20mm and the driven pulley has a diameter of 240mm what is the velocity ratio? (show all working)
The answer needs to be in the form of a ratio i.e. 1:2 etc.

Mechanical systems

SECTION 3.2

Bearings

Below draw down what a plain bearing looks like

Describe what a plain bearing does

_____
_____

Explain why you would need to use a Plain Bearing

_____
_____

_____
_____

Below draw down what a rolling element bearing looks like

Describe what a rolling element bearing does

_____
_____

_____
_____

Name a couple of examples

.

.

Mechanical systems

SECTION 3.2

Complete the ‘Check your knowledge and understanding section

1, State the function of a reverse motion Linkage

_____
_____

_____
_____

2, A Mechanical system has an input force of 35N and an Output force of 140N.
Calculate the Mechanical advantage of the system.
Show all working

3, The Driven gear in a gear train has 45 teeth and the driver gear has 135 teeth.
Calculate the gear ratio of the system
Show all working

4, State the main purpose of a cam and follower mechanism
_____
_____

_____
_____

5, Describe the two main functions of a pulley system.

1,
_____
_____

2,
_____
_____