Mechanisms

A mechanism is any device capable of changing the size, direction or type of movement of force or artefact

Mechanical Systems

- Mechanisms require energy in order to operate - this energy required is called the effort
- The mechanism will then do the job it is designed to do - this result is called the output

e.g. Bike Brakes

- **Input**: force pulling the brake lever
- **Process**: bell crank mechanism pressing against wheel of bike
- **Output**: bike comes to a stop

Examples of Mechanisms:

- Gears
- Worm & Worm Wheel
- Cams
- Ratchets

Advantages of Mechanisms:

- Reduce effort required to complete a task
- Efficiently carry out work if well designed
- Reduce load and strain on the body of the user

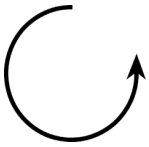
Disadvantages of Mechanisms:

- Can be dangerous if not properly guarded
- Some mechanisms require very accurate assembly
- Can be expensive
- Many mechanisms require lubricant to prevent seizure

Types of Motion

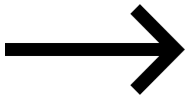
Rotary

- Turns around in a circle
  - Eg: wheel



Linear

- Moves in a straight line
  - Train on a track



Oscillating

- Swinging over and back from side to side in an arc
  - Pendulum on a clock

Reciprocating

- Moves forwards and backwards along a straight line
  - A saw cutting through wood

Mass refers to the amount of material in an object - measured in kg

Weight refers to the mass of a material as it is acted on by earths gravity - measured in newtons (N)

Work refers to a force exerted on an object that causes it to move, requiring energy - measured in joules (J)

Power refers to the amount of work done per unit of time - measured in watts

Levers

A lever is a mechanism made up of a rigid bar that can turn, or pivot around a fixed point called a fulcrum.

- Levers allow us to move heavy loads with relatively small efforts

The Law of the Lever states that if a lever is balanced, the clockwise moment must equal the anticlockwise moment.

clockwise moment = anticlockwise moment

$$F1 \times D1 = F2 \times D2$$

Classes of lever:

- Class 1
    - Load located at one end, the fulcrum is in the centre and the effort is located at the other end
        - Eg: seesaw, pliers, crowbar
- Class 2
    - Load located in the centre with the effort and fulcrum at either end
        - Eg: wheelbarrow, can crusher
- Class 3
    - Load and fulcrum located as either end with the effort in the middle
        - Eg: tweezers, cooking tongs

Mechanical Advantage

Mechanical advantage refers to the ratio of the load and effort - there are no units for mechanical advantage

Moment of a force

This can also be referred to as the turning effect or can be shortened to just “the moment” is defined as the product of the force and the perpendicular distance between it’s line of action and the fulcrum - measured in newton metres (Nm)

Linkages

Allows a force or motion to be directed in a desired direction. They consist of a number of levers connected by pivots

Types of Linkages:

- Bell crank linkage
- Push-pull linkage
- Reverse motion linkage
- Treadle linkage
- Parallel linkage

Everyday uses for linkages:

- Bicycle brakes (bell crank)
- Scissor lift (parallel)
- Windscreen wipers (treadle)

Springs

A spring is an elastic object, usually made from steel coils in the shape of a helix that are used to store mechanical energy.

Types of Springs:

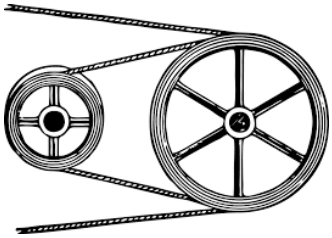
- Tension spring - stretches when pulled by a load
- Compression spring - retracts as a load pushes on it
- Torsion spring - twists as torque acts on it

Everyday uses for springs:

- Watches
- Shock-absorbers in cars
- Trampolines
- Mattresses
- Notebooks
- Pens

Pulleys

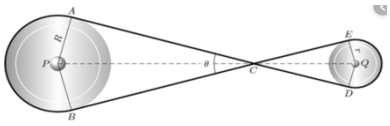
A pulley mechanism consists of a rope running through one or more wheels. As you pull down on one end of the rope the other end rises and lifts whatever it is attached to. Two or more pulley wheels can be used together to create a pulley system.



The driver pulley is the pulley which provides the rotational speed - it drives the driven pulley.

If there are pulley wheels of different sizes then the smaller wheels will spin faster than the larger ones.

- This ratio is known as the velocity ratio



The direction of the driven pulley can be changed by

crossing over the drive belt between the driver and driven pulleys.

Belt Drives

Flat Belts:

Simplest of belt drives and were widely used in early machines and during the industrial revolution in steam powered factory machines. They are prone to slipping and must be carefully aligned.

Round Belts

This belt drive has a circular cross section and are used in situations that require low torque. They are designed to work with a pulley with a corresponding circular groove

Vee Belts/Wedge Belts

These belts are less prone to slippage and alignment issues than the flat or round belt pulleys. They have a v-shaped cross section and provide excellent grip and are very unlikely to slip off.

Toothed/Noth/Cog Belts:

These belts have teeth that fit into a corresponding pulley. They provide excellent grip, will almost never slip and are used in high torque situations. The timing belt in cars are an example of a toothed belt system.

Pulley belts need to be kept under tension in order to ensure efficient operation. This can be achieved by using a tensioning device which is a spring loaded wheel that is pushed against the belt or pushes the pulleys further apart to create tension.

Advantages of Belt Drives:

- No rusting
- No need for lubricant
- Relatively inexpensive
- Reduced wear on metal parts that are not in direct contact

Disadvantages of Belt Drives:

- Can be noisy
- Belts can be easily damaged
- Can be inefficient due to friction

Gears

A gear refers to a wheel with notches or teeth cut out of it and that will mesh with the teeth of a similar gear to transmit rotary motion. Gears produce precise and efficient motion.

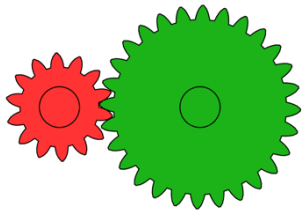
One major advantage of gears over belt drives is that gears cannot slip whereas belt drives can.

A gear train refers to several gears meshed together.

Types of Gears:

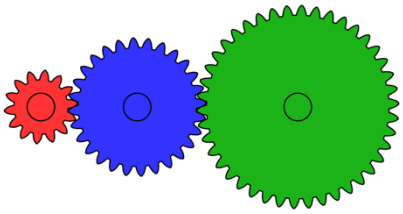
Spur Gears:

Gears that are meshed together in a parallel configuration



Idler Gears

A gear placed between the driver gear and driven gear that allows them to rotate in the same direction as each other.

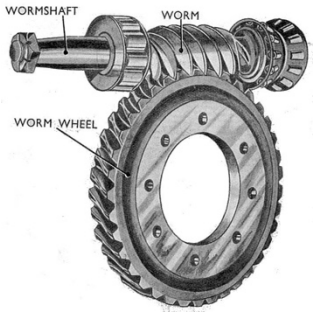


Compound Gears

Two or more gears fixed to the same shaft. This configuration can all for an increase or decrease in the gear ration of a system and thus alter the speed of the final output.

Worm and Worm Wheel Gears

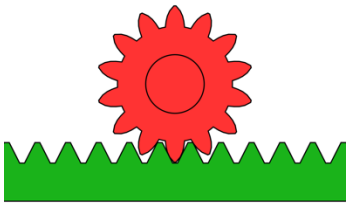
The “worm” section is a gear that has one long continuous tooth thread wrapped around a shaft. The “wheel” is a large gear wheel. This type of gear can provide large speed reductions and can transfer motion through 90 degrees. This gear system is compact and has good torque. Worm and Worm Wheel gears are used in guitar tuning pegs.



Bevel Gears

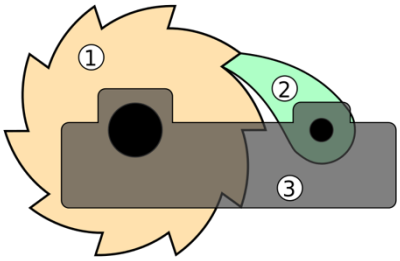
These gears also transfer motion through 90 degrees. The teeth are cut out on a cone instead of a disc to allow them mesh accurately together.

Rack and Pinion



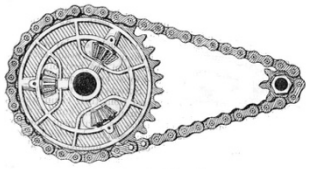
This system changes rotary motion into linear motion. The “rack” is a flat bar with teeth while the “pinion” is a small gear wheel. The pinion moves along the rack. This type of system has been adapted to work to be a component of the steering mechanism found in cars.

Ratchet and Pawl



The rather is a wheel with saw-like teeth cut out of it and the pawl is a piece that falls into the dip of the wheel as it rotates. This type of gear is unidirectional.

Chain and Sprocket



The chain meshes into the sprocket and are used to transmit rotary motion. An example of this type of gear system can be found on peddle bicycles.

Cams

Cams are another mechanism that can be used to turn rotary motion into reciprocating motion. The cam consists of an irregular shaped disk on a shaft which rotates. As it rotates the follower rests of the cam and moves up and down as the cam rotates.

Cam and follower mechanisms are used in car engines to control the exhaust and inlet valves as well as in the camshaft of a car which converts the linear motion of the pistons into the rotary motion of the driveshaft.

Types of Cams:

- Circular Shaped Cam
- Pear Shaped Cam
- Heart Shaped Cam
- Linear/flat plate Cam
- Cylindrical/barrel Cam

Crank and Slider

The crank is a rotating disk that is connected to the slider via the connecting rod. The slider is guided by a tunnel or a channel. This mechanism converts rotary motion into linear motion. Steam trains are an example of this mechanism.

Friction

Friction is the resistance to motion of one object moving in relation to another. Friction exists wherever two surfaces come into contact. Friction causes wear on parts and wastes energy as well as reduces speed. Brakes work by creating friction on the wheel, forcing it to slow down and stop.

How to reduce friction:

- Lubricants
- Bearings
- Ensure smooth surfaces
- Design streamlines body shape

How to maximise friction:

- Brake pads in a car braking system
- Tyre Threads
- Create rougher surfaces

Bearings

A bearing system is generally used to reduce friction, heat build-up, wear and tear and to provide smoother motion

Equations To Remember

Property/Principle	Equation/Formula	SI Units
Weight	Weight = mass x gravity	Newton (N)
Work	Work = force x distance	Joule (J) or Newton Metre (Nm)
Power	Power = work/time	Watt (W)
Mechanical Advantage	MA = load/effort	
Torque	Torque = force x radius	Newton Metre (Nm)
% Efficiency	output/input x100	%
Moment	Moment = force x distance from fulcrum	Newton Metre (Nm)