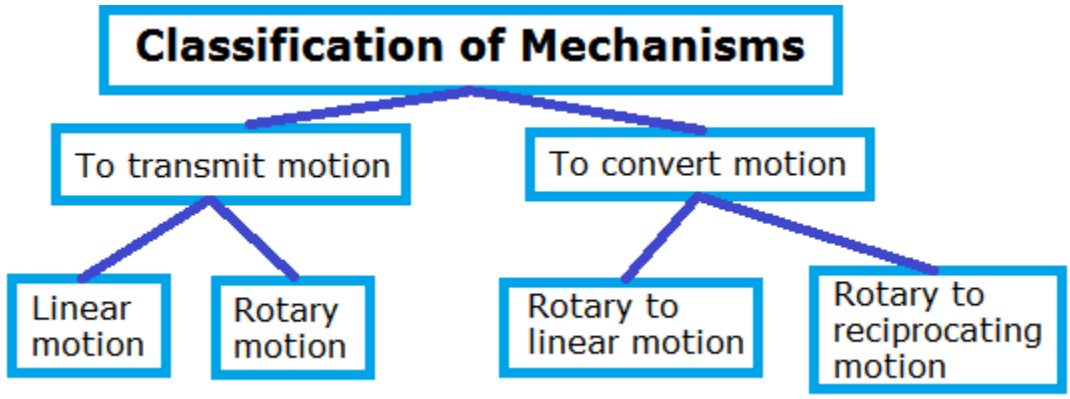
Unit 9 Mechanisms

1. Mechanisms

Mechanisms are devices that transmit and convert forces and motions from an input to an output element. They enable us to use less effort to carry out a task.

We can classify mechanisms in this way:

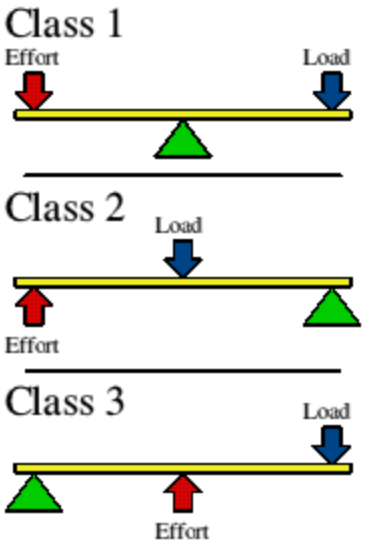


Linear motion mechanisms

These mechanisms transmit motion in a straight line from one point to another.

Levers

A lever is a rigid bar with a point of support called a fulcrum. The mechanical force or effort is put on one end of the lever, and the load is on the other end. A lever is balanced when it fulfills the Law of the Lever: F x d = R x r. Where F is the effort, d is the distance of the effort from the fulcrum, R is the load, and r is the distance of the load from the fulcrum.



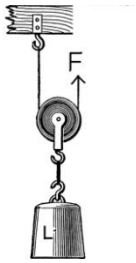
Types of levers

There are three types of levers, classified by the position of the load and effort to the fulcrum.

Type 1 levers – the load and the effort are on opposite sides of the fulcrum. Common examples include the prongs of a hammer, scissors, and a seesaw.

Type 2 levers – the load is between the effort and the fulcrum. Common examples include drawbridges, bottle openers, and bellows.

Type 3 levers – the effort is between the fulcrum and the load. Common examples include tweezers, fishing poles, and your arm.



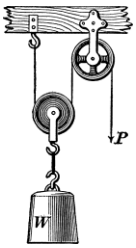
Fixed pulleys

This is a wheel that has a groove for a rope, chain, or belt to go around it. It rotates around an axle that is fixed (does not move).

A fixed pulley is balanced when the effort is equal to the load: F = R.

Fixed pulleys are used to raise and lower loads easily. Common examples: wells, gym equipment.

Movable pulleys



A movable pulley has two pulleys – one that is fixed and one that can move in a linear direction. A moveable pulley requires half the effort of a fixed pulley to life the same load.

A moveable pulley is balanced with this equation: F = R/2

Compound pulleys (block and tackle)

This is a set of fixed pulleys and movable pulleys. If we use more pulleys, it becomes more complex, but also easier to lift a load.

This type of mechanism is used in elevators (for people and goods) as well as in cranes.

2. Rotary motion mechanisms

These types of mechanisms transmit motion and effort in a circular way.

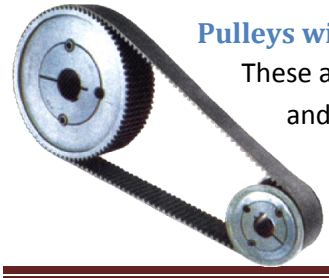
Friction drive

Made up of two or more wheels that are in contact. The motion of the first wheel makes the other wheel turn, transmitting the motion. The ration between the rotation velocities of the wheels depends on the sizes of the wheels.

We use this equation: $N_1 \times D_1 = N_2 \times D_2$ or $D_1/D_2 = N_2/N_1$

Where N_1 and N_2 are the velocities of the wheels and D_1 and D_2 are the corresponding diameters of the wheels.

We use friction drives in industry, as well as in film reels.



Pulleys with belts

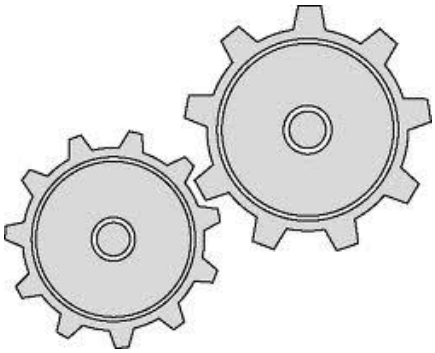
These are two pulleys or wheels a certain distance apart. They have parallel axles and they rotate simultaneously at the same speed. The two wheels rotate in the same direction.

Used in industrial machines, car engines, washing machines, drills, and

many other places.

Gear mechanisms and cogwheels

Cogwheels are sets of wheels that have teeth called cogs. These teeth mesh together so that one wheel moves the other.



The cogwheels rotate in opposite directions.

The ratio between the rotation velocities of the wheels depends on the number of teeth on each wheel.

We use this equation: $N_1 \times Z_1 = N_2 \times Z_2$ or $Z_1/Z_2 = N_2/N_1$

N represents the velocities of the wheels, and Z is the number of teeth.

We use cogwheels in industrial machinery, automobiles, domestic machines.

Worm gear

A worm gear is a screw that moves a cogwheel that is perpendicular to the screw. When the screw rotates, the cogwheel moves as many teeth forward as there are grooves in the screw.

This mechanism is used to reduce velocity or serve as a braking system.

With a worm drive the velocity of the wheel (N_{wheel}) is equal to the velocity of the screw (N_{screw}) multiplied by the number of grooves in the screw ($Z_{grooves}$) and divided by the number of teeth in the wheel (Z_{wheel})

$N_{wheel} = (N_{screw} \times Z_{grooves}) / Z_{wheel}$

Uses: lap counter mechanisms, gear reduction systems, guitar tuning keys, windshield wipers.

Gear mechanisms with a chain

These are two cogwheels with parallel axles connected with a chain. They rotate simultaneously at the same speed.

The ratio between the rotation velocities of the wheels depends on the number of teeth on each gear:

$N_1 \times Z_1 = N_2 \times Z_2$ or $Z_1/Z_2 = N_2/N_1$

N represents the velocities of the wheels, and Z is the number of teeth.

Uses: industrial machinery and engines. Bicycles, motorbikes, and three-wheeled vehicles.

Pulley trains with belts

This is a system of pulleys or wheels with a belt. There are two or more pulleys, which cause all the pulleys or wheels to rotate at the same speed.

The gear ratio between the drive pulley and the driven pulley depends on the size of the pulleys in the system. It is expressed as a function of their diameters.

Gear train

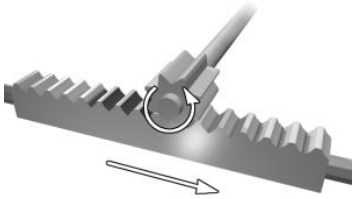
This is a system of more than two gears, connected together. The rotary motion of the first wheel turns the second, and so on. Wheels in contact with each other rotate in opposite directions.

Used in machine tools, robotics, motor vehicles, and some kitchen appliances.

3. Mechanisms that transform motion

These mechanisms transform motion in one of two ways.

From rotary into linear motion



Rack and pinion

Uses a pinion mounted on a rack. When the pinion rotates, the rack advances in a linear motion.

The mechanism can also transform the linear motion of the rack into a rotary motion of the pinion. It's a reversible mechanism.

Used in bench drills, corkscrews, automobile steering.

Nut and bolt

Consists of a bolt or threaded bar and a nut that has the same interior diameter as the diameter of the bolt.

Used in taps, car jacks, screw tops for bottles.

Winch (and crank handle)

A crank handle is attached to the axle of a cylindrical drum. The crank is used to turn the winch. The winch is a drum that rotates on its axle. We use this mechanism to lift loads.

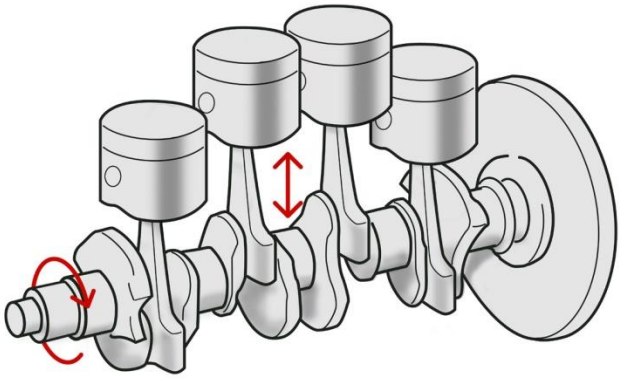
Uses: roller blinds, coffee grinders, crushing machines, cranes.

From rotary into reciprocating motion

Crank-link-slider

This is composed of a crank and a rod (called a connecting rod or a link). As the wheel rotates, the crank transmits the rotary motion to the connecting rod.

Uses: trains, internal combustion engines, windshield wipers, machine tools.



Crankshaft

This is a set of connecting rods attached to a jointed axle. Each of the joints acts as a crank.

Uses: combustion engines.

Cam

A rotating shape that pushes a "follower" as it moves. We can change the shape and the outside edge of the piece to produce complex movements.

Uses: combustion engines.

Eccentric cam

Has a wheel with an off-center rotation axle. This transforms the rotary motion of the wheel into motion in the connecting rod.

Uses: sewing machines, windshield wipers.