Power transmission

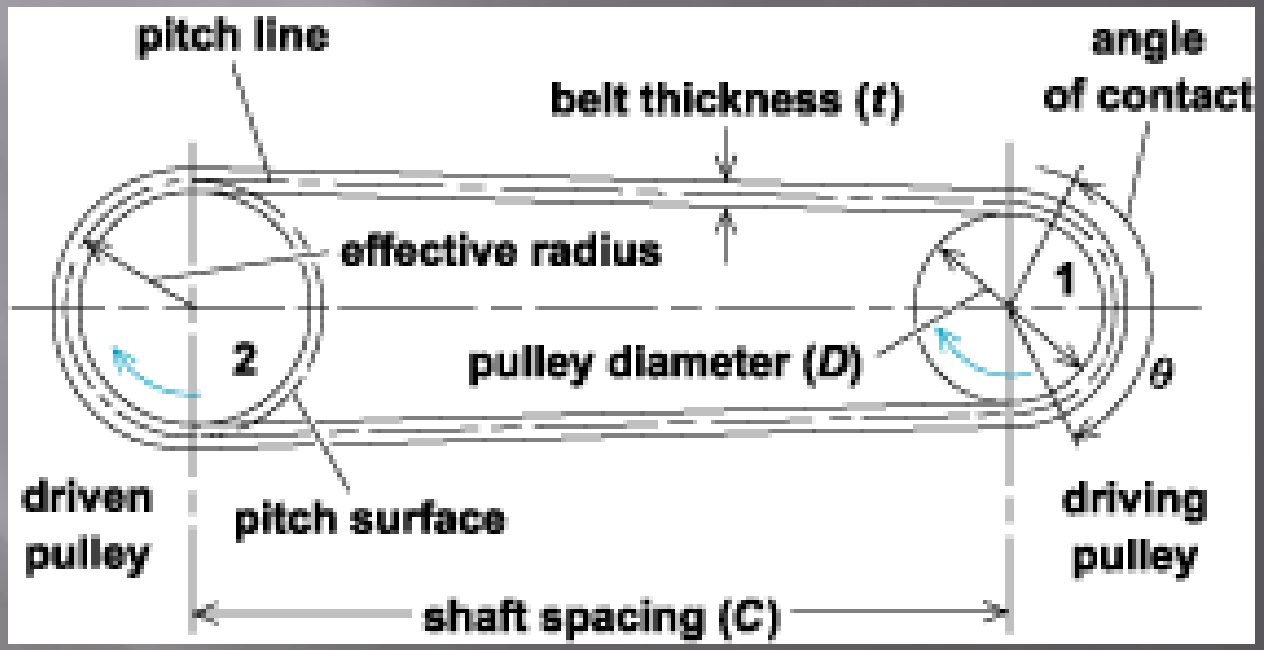
Power transmission is the movement of energy from its place of generation to a location where it is applied to performing useful work and can be done with

1) BELT DRIVE
2) CHAIN DRIVE
3) GEAR DRIVES
4) COUPLINGS
5) BEARINGS

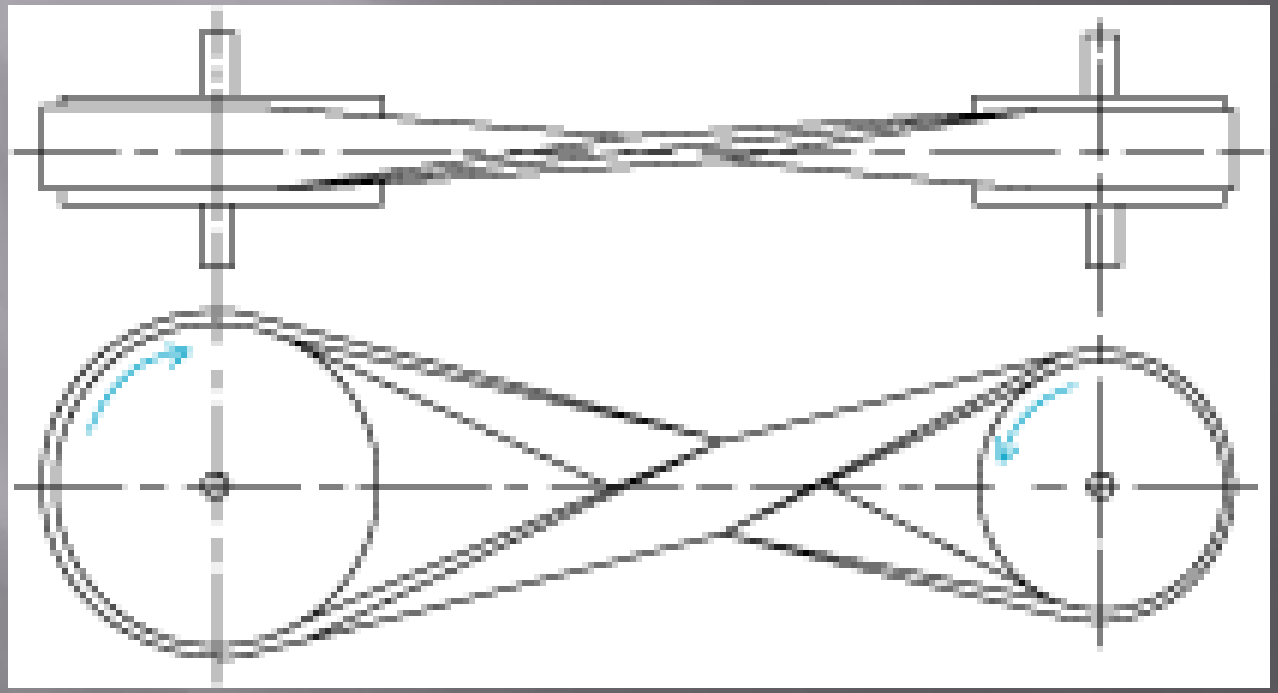
BELT DRIVE

1. A belt is a looped strip of flexible material, used to mechanically link two or more rotating shafts.
2. They may be used as a source of motion, to efficiently transmit power, or to track relative movement. Belts are looped over pulleys.
3. In a two pulley system, the belt can either drive the pulleys in the same direction, or the belt may be crossed, so that the direction of the shafts is opposite.

Open belt drive

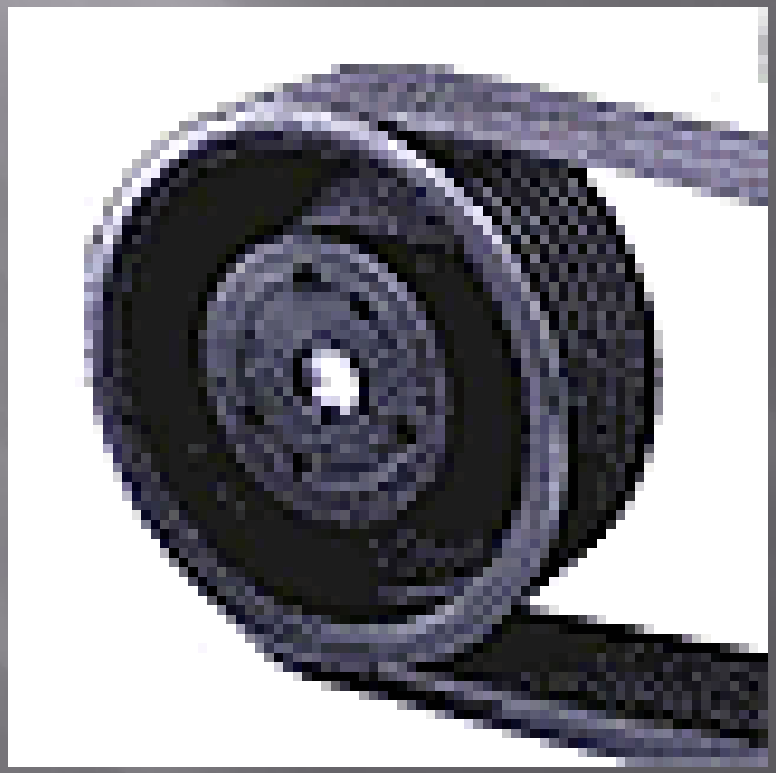


Cross belt drive.

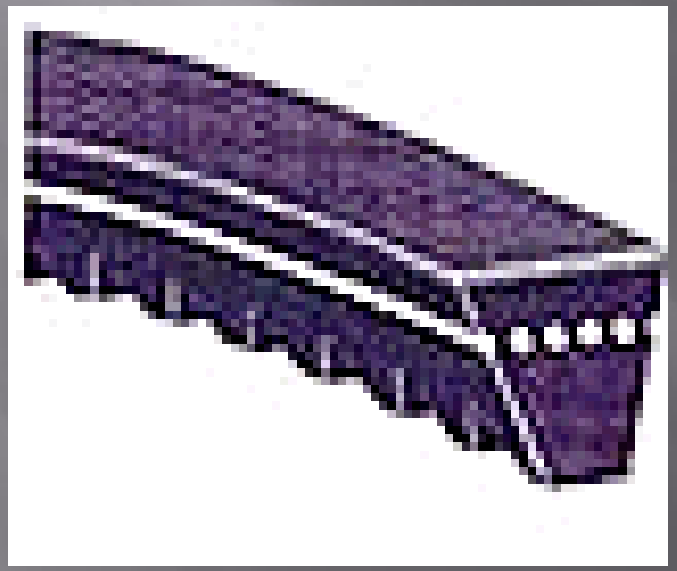


Belts on a Yanmar 2GM20 marine diesel engine

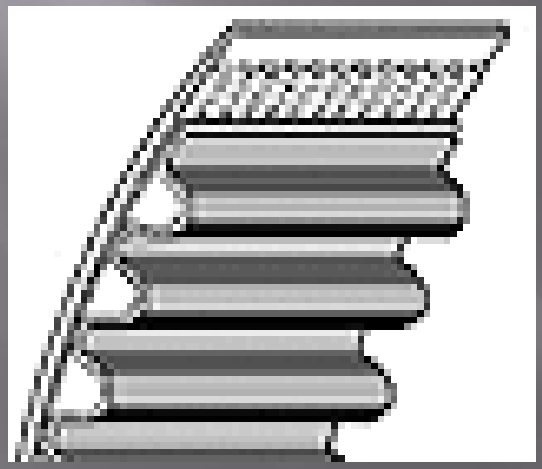
FLAT BELT



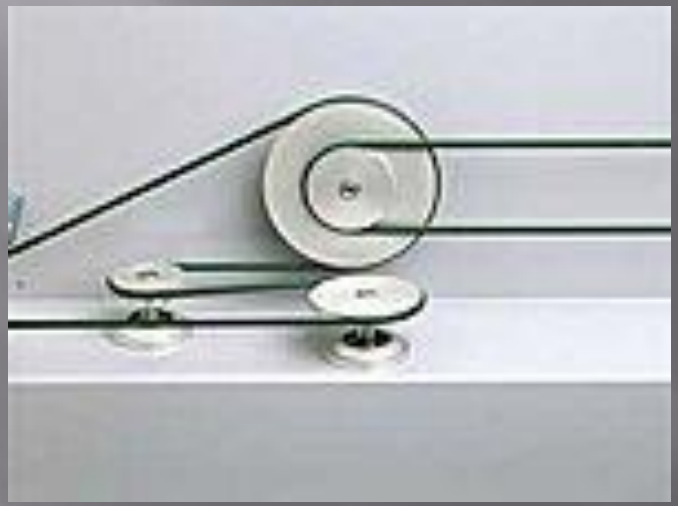
VEE BELT



TIMING BELT



ROUND BELT



Advantages of belt drive

- They are simple. They are economical.
- Parallel shafts are not required.
- Overload and jam protection are provided.
- Noise and vibration are damped out. Machinery life is prolonged because load fluctuations are cushioned (shock-absorbed).
- They are lubrication-free. They require only low maintenance.
- They are highly efficient (90–98%, usually 95%). Some misalignment is tolerable.
- They are very economical when shafts are separated by large distances.

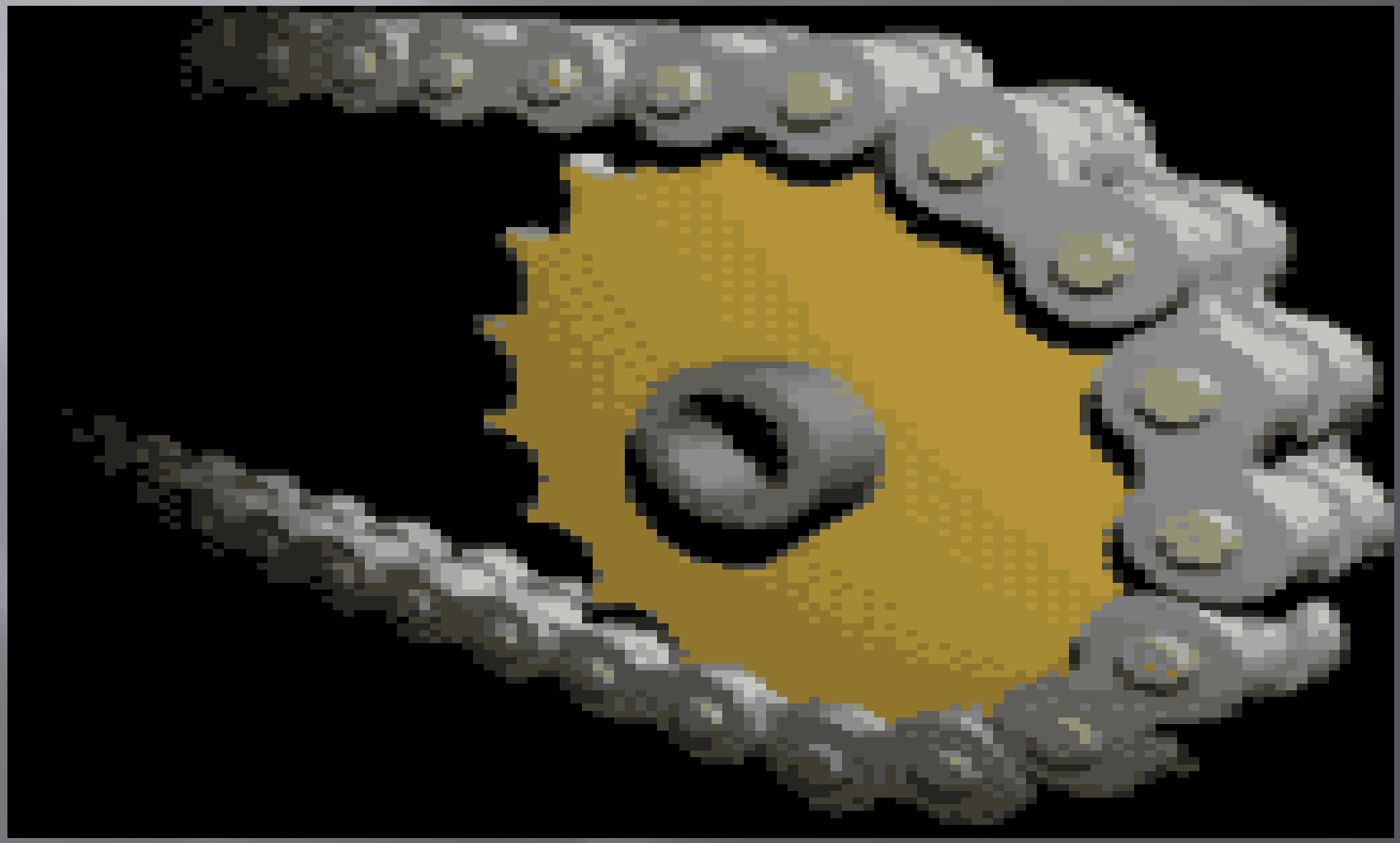
Disadvantages of belt drive

- The angular-velocity ratio is not necessarily constant or equal to the ratio of pulley diameters, because of belt slip and stretch.
- Heat buildup occurs. Speed is limited to usually 7000 feet per minute (35 meters per second). Power transmission is limited to 370 kilowatts (500 horsepower).
- Operating temperatures are usually restricted to –31 to 185°F (–35 to 85°C).
- Some adjustment of center distance or use of an idler pulley is necessary for wear and stretch compensation.
- A means of disassembly must be provided to install endless belts.

Chain drive

- Chain drive is a way of transmitting mechanical power from one place to another.
- It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles.
- It is also used in a wide variety of machines besides vehicles.
- Most often, the power is conveyed by a roller chain, known as the drive chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain.
- The gear is turned, and this pulls the chain putting mechanical force into the system..

Roller chain and sprocket



chain drives

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles

Why we need chain drivers?

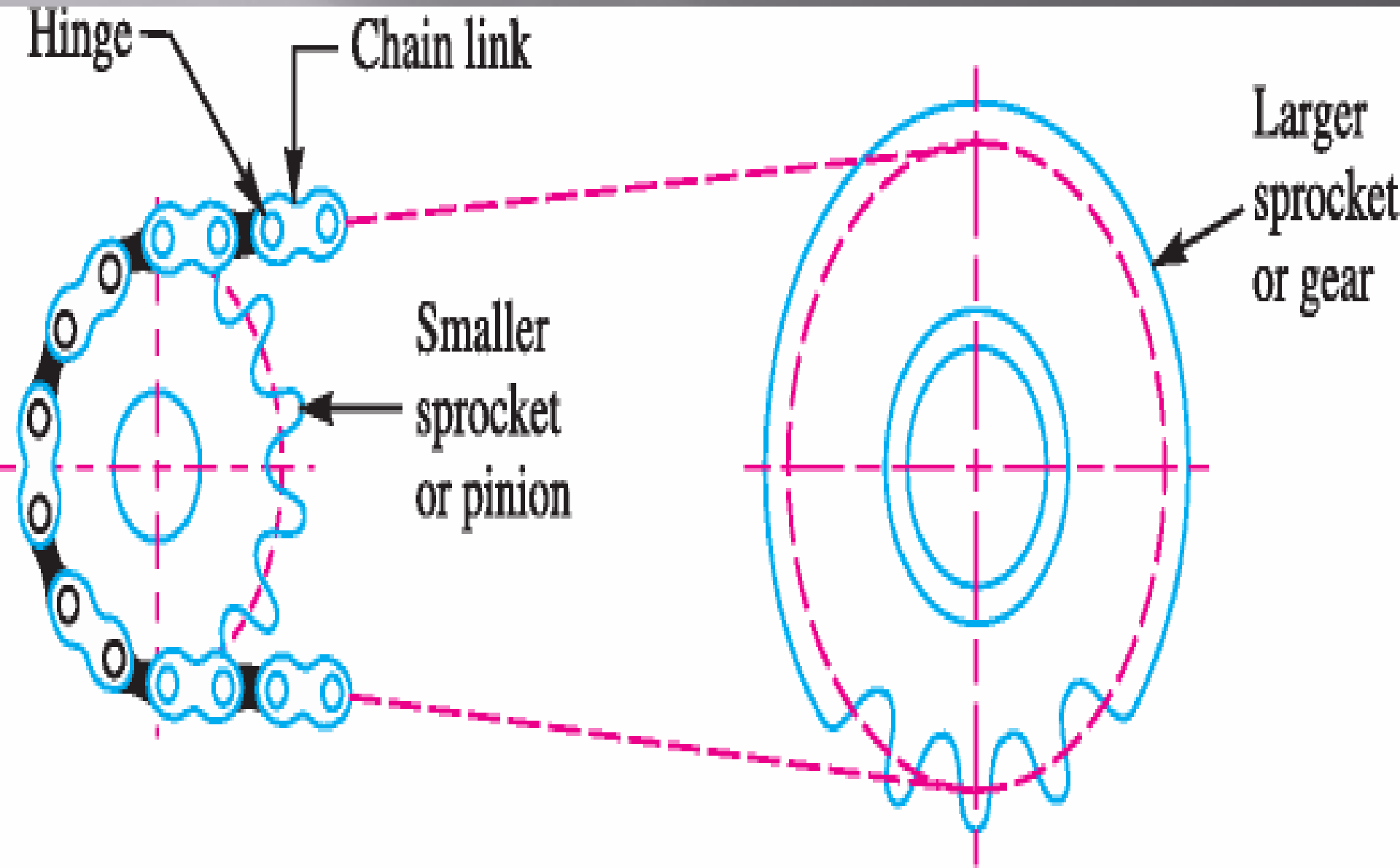
- **On belt and rope drives that slipping may occur. In order to avoid slipping, steel chains are used.**

INTRODUCTION

- DEFINITION

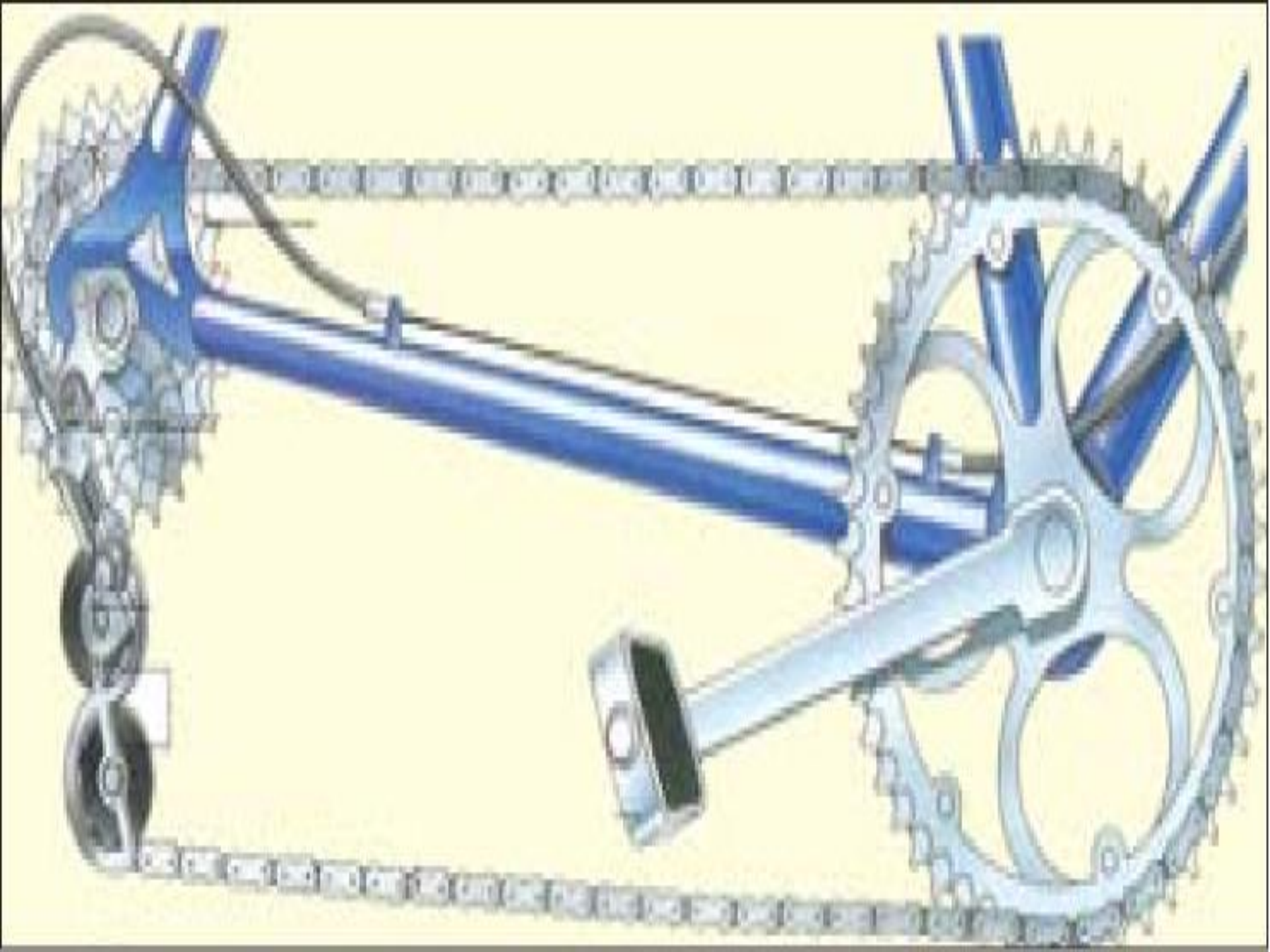
  - The chains are made up of number of rigid links which are hinged together by pin joints in order to provide the necessary flexibility for wrapping round the driving and driven wheels. These wheels have projecting teeth of special profile and fit into the corresponding recesses in the links of the chain as shown in Figure below

Explanation through diagram



Practical applications of chain drives

- The chains are mostly used to transmit motion and power from one shaft to another, when the centre distance between their shafts is short such as in bicycles, motor cycles, agricultural machinery, conveyors, rolling mills, road rollers etc.
- The chains may also be used for long centre distance of up to 8 meters.
- The chains are used for velocities up to 25 m / s and for power up to 110 kW. In some cases, higher power transmission is also possible.



Advantages and Disadvantages of Chain Drive over Belt or Rope Drive

Advantages

- As no slip takes place during chain drive, hence perfect velocity ratio is obtained.
- Since the chains are made of metal, therefore they occupy less space in width than a belt or rope drive
- It may be used for both long as well as short distances

.

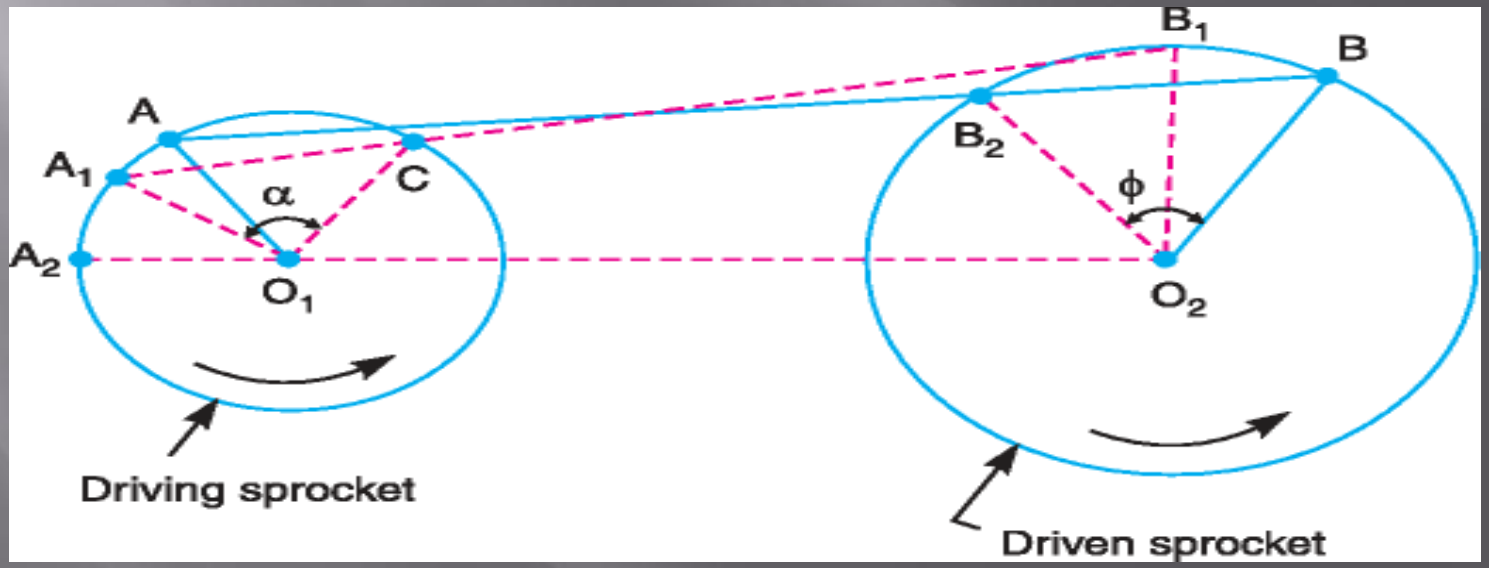
- It gives a high transmission efficiency (upto 98 percent).
- It gives less load on the shafts.
- It has the ability to transmit motion to several shafts by one chain only.
- It transmits more power than belts.
- It permits high speed ratio of 8 to 10 in one step.
- It can be operated under adverse temperature and atmospheric conditions.

Disadvantages

- The production cost of chains is relatively high.
- The chain drive needs accurate mounting and careful maintenance, particularly lubrication and slack adjustment.
- The chain drive has velocity fluctuations especially when unduly stretched.

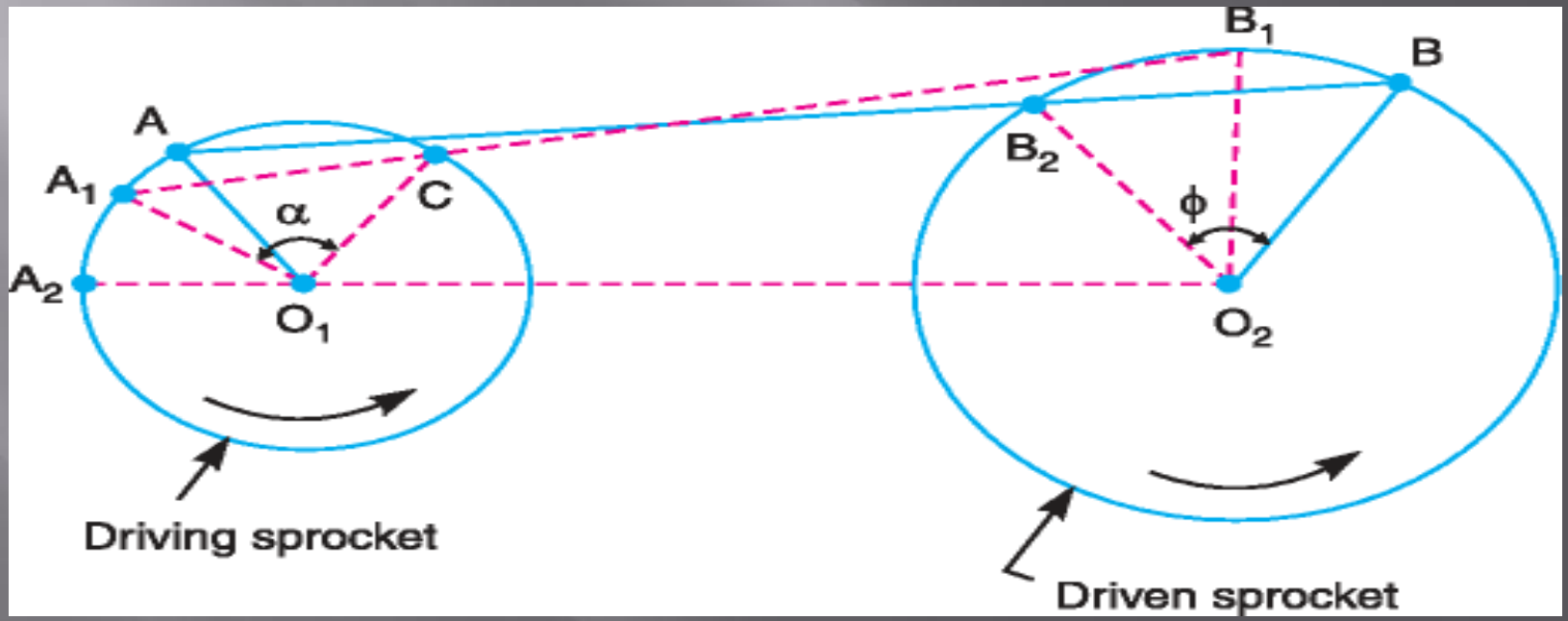
Kinematics of Chain Drive

- Let us consider two sprockets, in which driven sprocket is larger than the driver sprocket. AC is the pitch of driving sprocket, and BB_2 is the pitch of driven sprocket. We want to compare the angular velocities of two sprockets.



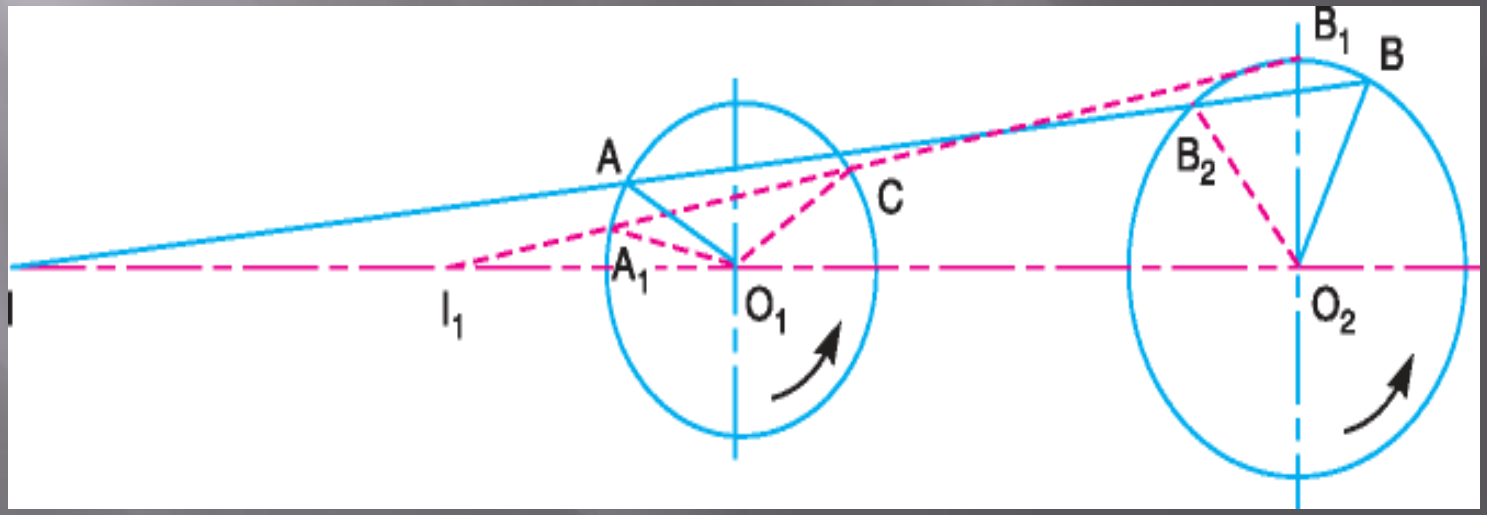
Kinematics of Chain Drive

- Initially when the driving sprocket was at A, the driven was at B, with the centers O_1 and O_2 respectively. To find the instantaneous centre, we produce O_1O_2 and AB to meet an point *I*.



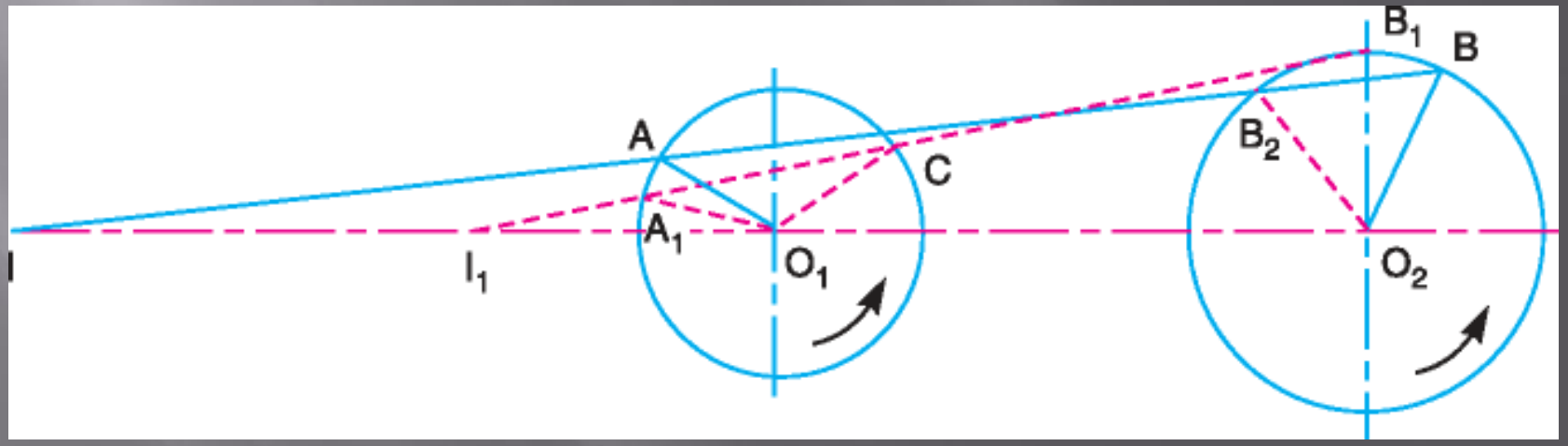
Kinematics of Chain Drive

- The instantaneous centre of rotation changes along with the rotation.
- The relation $\omega_1 / \omega_2 = 1+(O_2O_1 / O_1I)$ represents the minimum velocity ratio, as B is the lowest point of pitch and I is at the greatest distance from the driving sprocket.



Kinematics of Chain Drive

- When A moves to A_1, B moves to point B_1. So the instantaneous centre of rotation will be I_1.which as compared to I, is nearer from the driven sprocket. So velocity ratio will be maximum.



Kinematics of Chain Drive

- In actual practice, the smaller sprocket must have a minimum of 18 teeth and hence the variation of velocity ratio from the mean value is very small.

Classification of Chains

The Chains, on the basis of their use, are classified into the following three groups:

1. Hoisting or hauling (or crane) chains.
2. Conveyer (or tractive) chains.
3. Power transmitting (or driving) chains.

Hoisting or hauling (or crane) chains

- These chains are used for hoisting and hauling purposes. These are of two types:

1. Chains with oval links.
2. Chains with square links.

Hoisting or hauling (or crane) chains

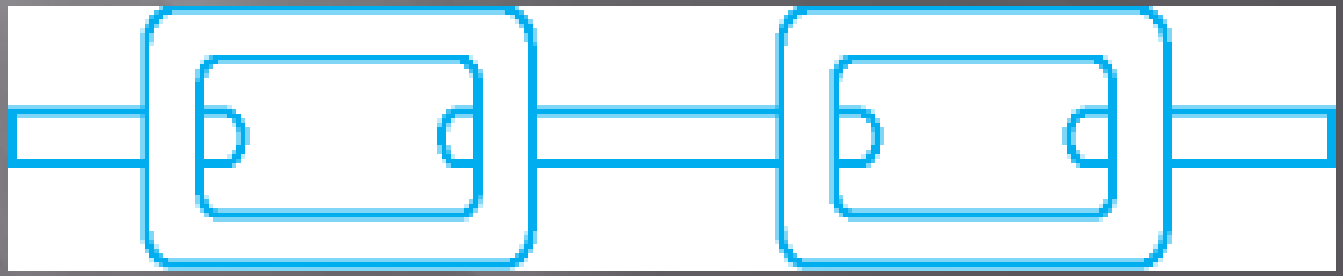
1. Chains with oval links:

   The links are of oval shape. The joint of each link is welded. Such type of chains are used only at low speeds such as chain hoists and in anchors of marine work.

Hoisting or hauling (or crane) chains

- Chains with square links:

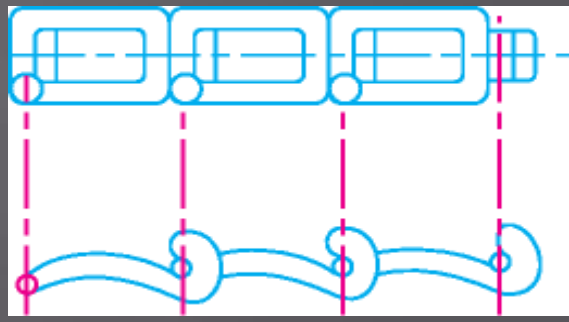
The links are of square shape. Such type of chains are used in hoists, cranes, dredges. These are cheaper than oval link chains, but the kinking occurs easily on overloading.



Conveyer Chains

- These chains are used for elevating and conveying the material continuously. These are of two types:

1. Detachable or hook joint type chain.
2. Closed joint type chain.



Conveyer Chains

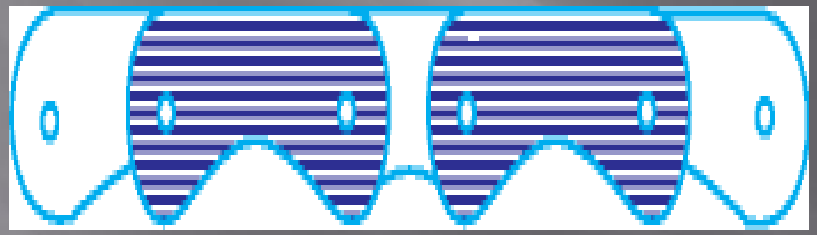
- Properties:

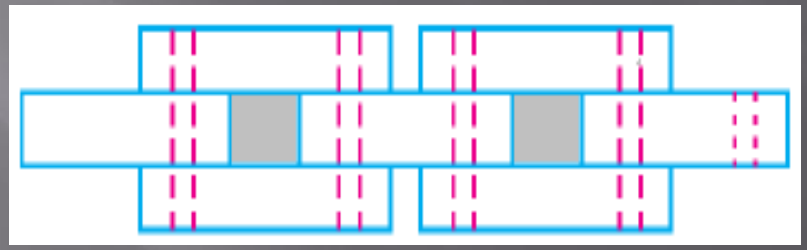
1. Usually manufactured by cast iron.
2. Do not have smooth running qualities.
3. Run at low speeds of about 3 to 12 Km/h.

Power transmittin chains

1. Block chain

- It is also known as bush chain.
- Produce noise because of rubbing between teeth and links.





GEAR

CONTENTS

- POWER TRANSMISSION
- GEAR
- TYPES OF GEARS
- NOMENCLATURE
- APPLICATIONS OF GEARS
- VELOCITY RATIO
- GEAR TRAINS
- EXAMPLE PROBLEMS AND QUESTIONS

GEAR…..

- Power transmission is the movement of energy from its place of generation to a location where it is applied to performing useful work

- A gear is a component within a transmission device that transmits rotational force to another gear or device

TYPES OF GEARS

1. According to the position of axes of the shafts.

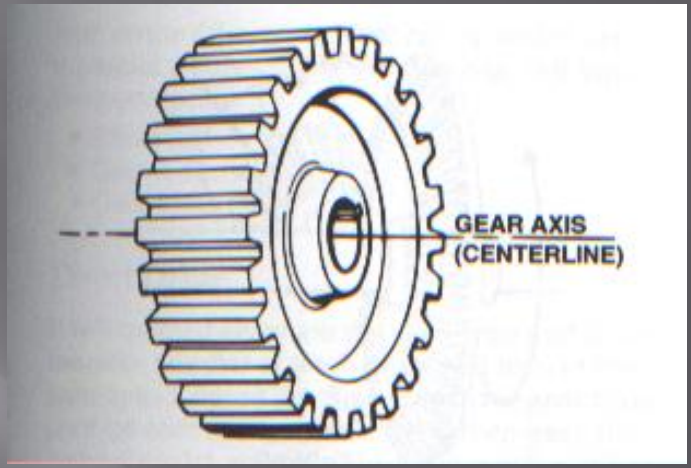
a. Parallel
   1. Spur Gear
   2. Helical Gear
   3. Rack and Pinion

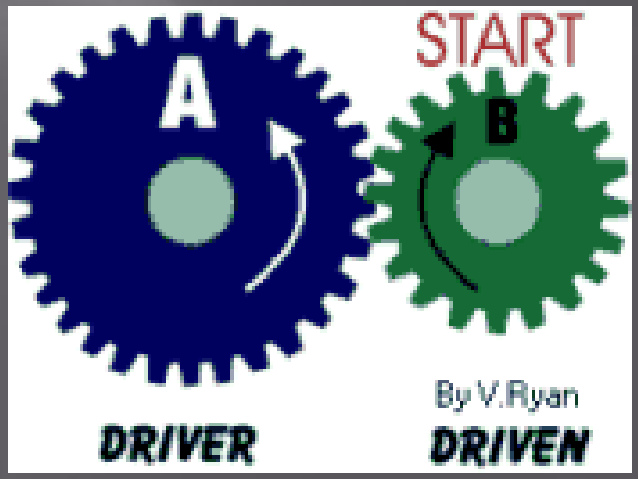
b. Intersecting
   Bevel Gear

c. Non-intersecting and Non-parallel
   worm and worm gears

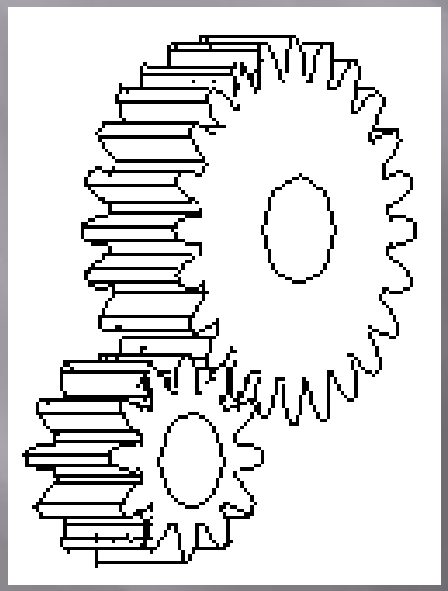
SPUR GEAR

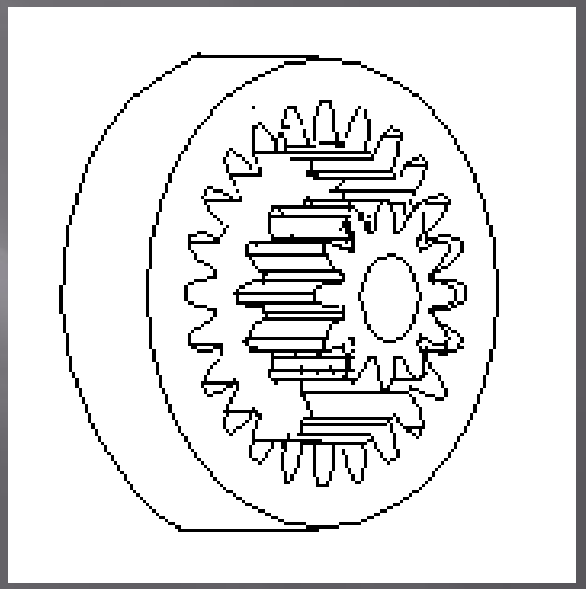
- Teeth is parallel to axis of rotation
- Transmit power from one shaft to another parallel shaft
- Used in Electric screwdriver, oscillating sprinkler, windup alarm clock, washing machine and clothes dryer





External and Internal spur Gear…





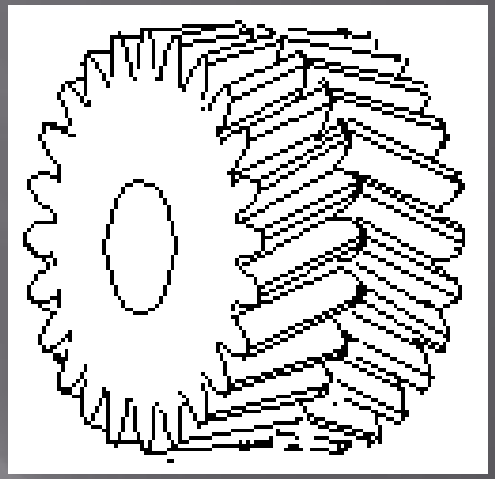
Helical Gear

- The teeth on helical gears are cut at an angle to the face of the gear
- This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears
- One interesting thing about helical gears is that if the angles of the gear teeth are correct, they can be mounted on perpendicular shafts, adjusting the rotation angle by 90 degrees

Helical Gear…

Herringbone gears

- To avoid axial thrust, two helical gears of opposite hand can be mounted side by side, to cancel resulting thrust forces



- Herringbone gears are mostly used on heavy machinery.

Rack and pinion

- **Rack and pinion gears** are used to convert rotation (From the pinion) into linear motion (of the rack)

- A perfect example of this is the steering system on many cars

Bevel gears

- **Bevel gears** are useful when the direction of a shaft's rotation needs to be changed
- They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well
- The teeth on bevel gears can be **straight**, **spiral** or **hypoid**
- locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

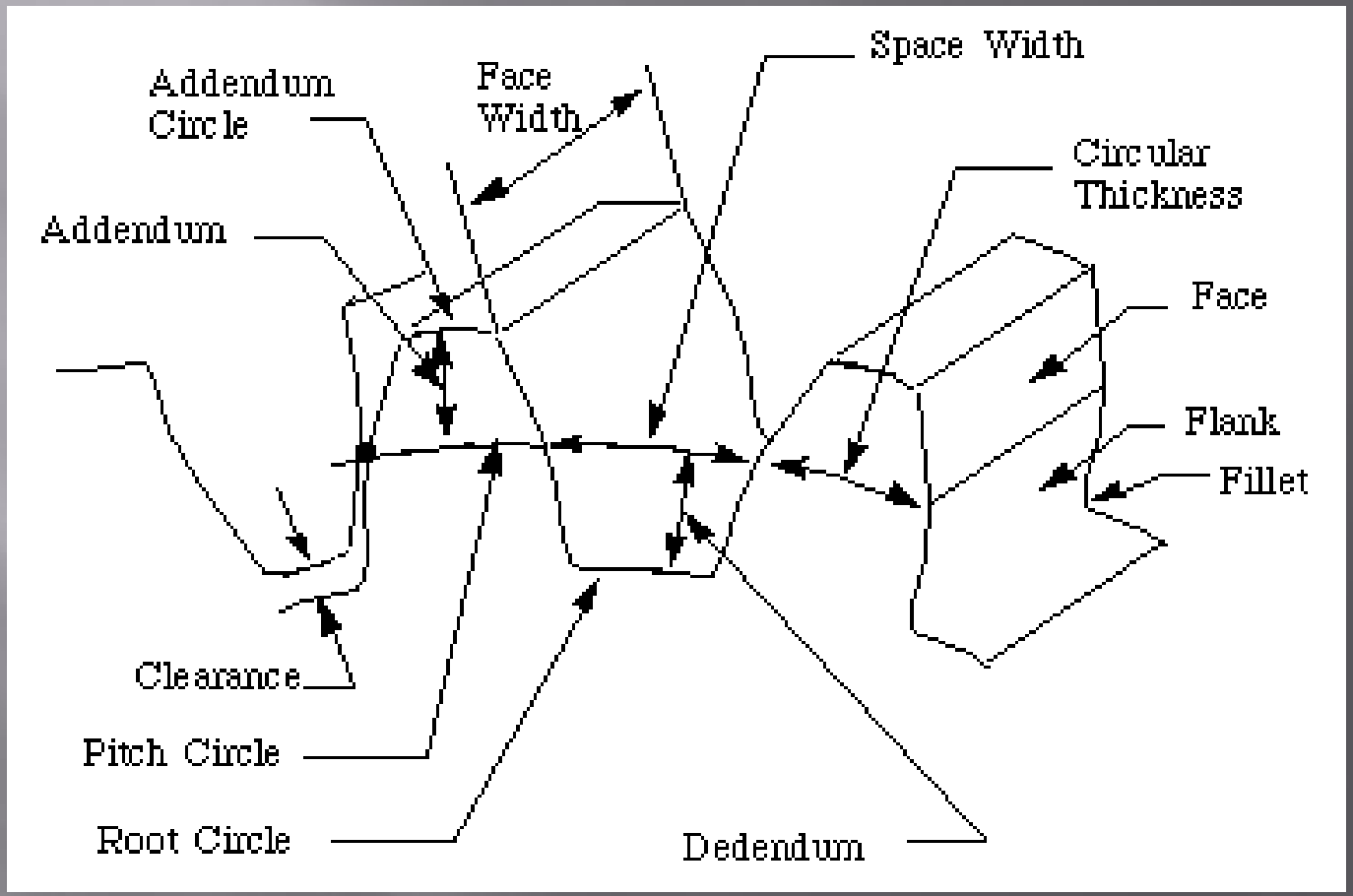
Straight and Spiral Bevel Gears

WORM AND WORM GEAR

- **Worm gears** are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater
- Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm
- Worm gears are used widely in material handling and transportation machinery, machine tools, automobiles etc

WORM AND WORM GEAR

NOMENCLATURE OF SPUR GEARS



NOMENCLATURE….

- **Pitch surface**: The surface of the imaginary rolling cylinder (cone, etc.) that the toothed gear may be considered to replace.
- **Pitch circle**: A right section of the pitch surface.
- **Addendum circle**: A circle bounding the ends of the teeth, in a right section of the gear.
- **Root (or dedendum) circle**: The circle bounding the spaces between the teeth, in a right section of the gear.
- **Addendum**: The radial distance between the pitch circle and the addendum circle.
- **Dedendum**: The radial distance between the pitch circle and the root circle.
- **Clearance**: The difference between the dedendum of one gear and the addendum of the mating gear.

NOMENCLATURE….

- **Face of a tooth**: That part of the tooth surface lying outside the pitch surface.
- **Flank of a tooth**: The part of the tooth surface lying inside the pitch surface.
- **Circular thickness** (also called the **tooth thickness**): The thickness of the tooth measured on the pitch circle. It is the length of an arc and not the length of a straight line.
- **Tooth space**: pitch diameter The distance between adjacent teeth measured on the pitch circle.
- **Backlash**: The difference between the circle thickness of one gear and the tooth space of the mating gear.
- **Circular pitch** (Pc) : The width of a tooth and a space, measured on the pitch circle.

$$P_c = \frac{\pi D}{N}$$

NOMENCLATURE….

- **Diametral pitch (**Pd): The number of teeth of a gear unit pitch diameter. The diametral pitch is, by definition, the number of teeth divided by the pitch diameter. That is,

Where

Pd = diametral pitch

N = number of teeth

D = pitch diameter

$$P_d = \frac{N}{D}$$

- **Module** (m): Pitch diameter divided by number of teeth. The pitch diameter is usually specified in inches or millimeters; in the former case the module is the inverse of diametral pitch.

$$m = D/N$$

VELOCITY RATIO OF GEAR DRIVE

d = Diameter of the wheel

N =Speed of the wheel

ω = Angular speed

velocity ratio(n) =

$$\frac{\omega_2}{\omega_1} = \frac{N_2}{N_1} = \frac{d_1}{d_2}$$

GEAR TRAINS

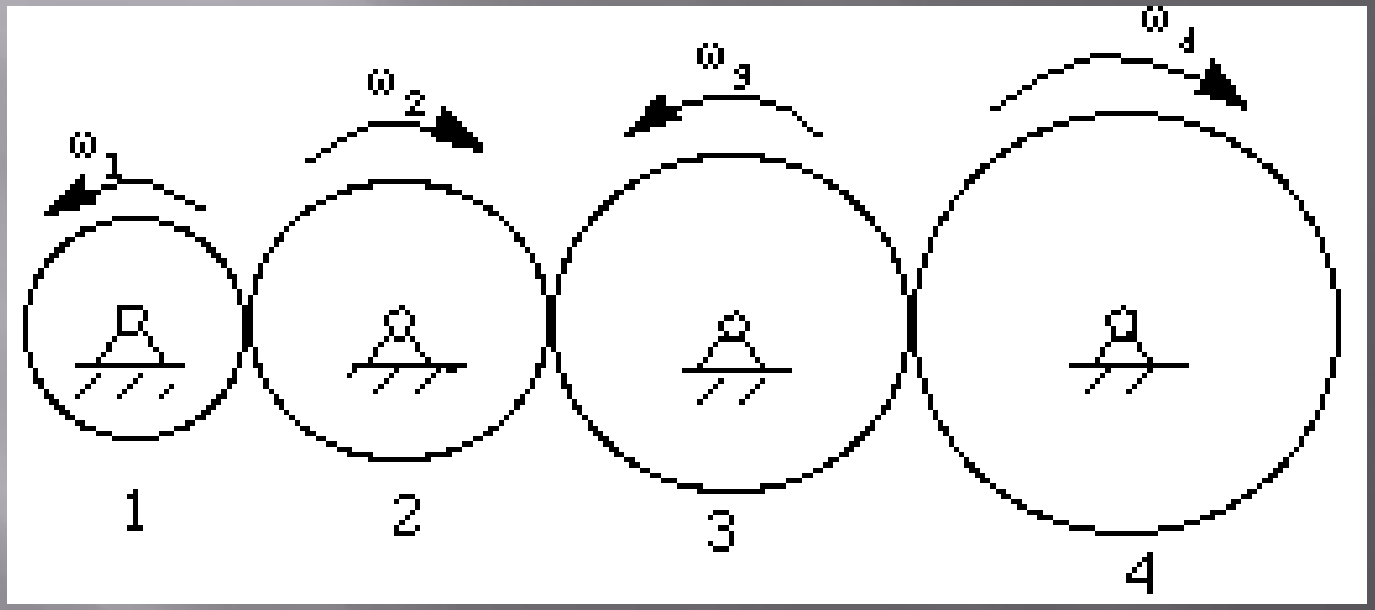
- A gear train is two or more gear working together by meshing their teeth and turning each other in a system to generate power and speed
- It reduces speed and increases torque
- Electric motors are used with the gear systems to reduce the speed and increase the torque

Types of Gear Trains

- Simple gear train
- Compound gear train
- Planetary gear train

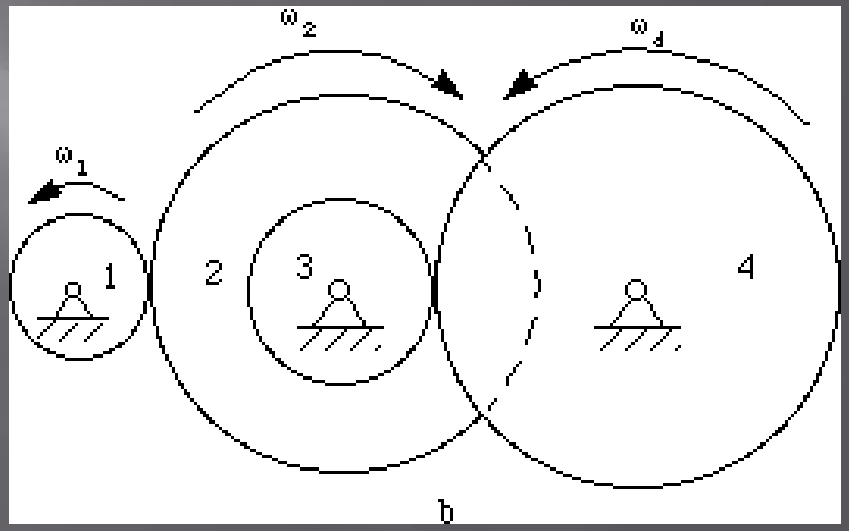
  Simple Gear Train
- The most common of the gear train is the gear pair connecting parallel shafts. The teeth of this type can be spur, helical or herringbone.
- Only one gear may rotate about a single axis

Simple Gear Train

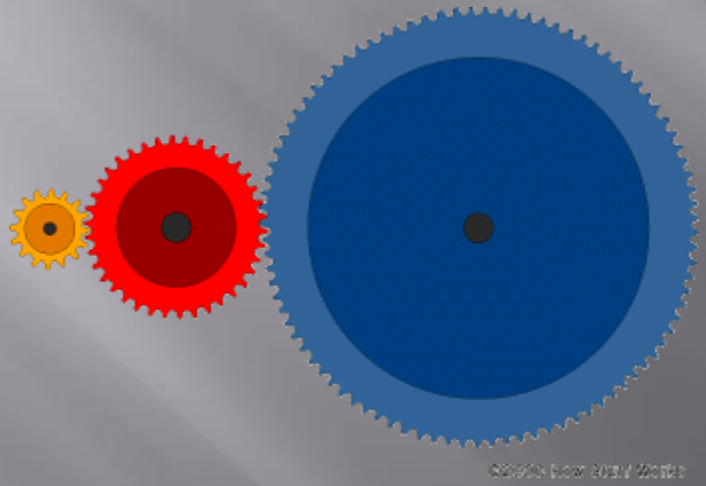


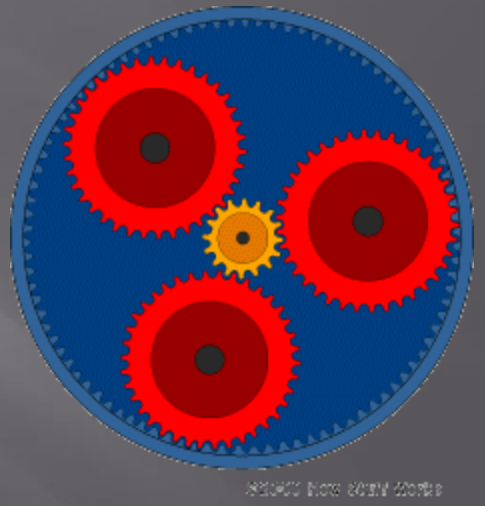
Compound Gear Train

- For large velocities, compound arrangement is preferred
- Two or more gears may rotate about a single axis



Planetary Gear Train (Epicyclic Gear Train)





Planetary Gear Train…

- In this train, the blue gear has six times the diameter of the yellow gear
- The size of the red gear is not important because it is just there to reverse the direction of rotation
- In this gear system, the yellow gear (the sun) engages all three red gears (the planets) simultaneously
- All three are attached to a plate (the planet carrier), and they engage the inside of the blue gear (the ring) instead of the outside.

Planetary Gear Train…

- Because there are three red gears instead of one, this gear train is extremely rugged.
- planetary gear sets is that they can produce different gear ratios depending on which gear you use as the input, which gear you use as the output, and which one you hold still.

Planetary Gear Train…

- They have higher gear ratios.
- They are popular for automatic transmissions in automobiles.
- They are also used in bicycles for controlling power of pedaling automatically or manually.
- They are also used for power train between internal combustion engine and an electric motor

Short Quetions

- What is power transmission?
- Why gear drives are called positively driven?
- What is backlash in gears?
- What are the types of gears available?
- What is gear train? Why gear trains are used?
- Why intermediate gear in simple gear train is called idler?
- What is the advantage of using helical gear over spur gear?
- List out the applications of gears
- Define the term ‘module’ in gear tooth
- What is herringbone gear?

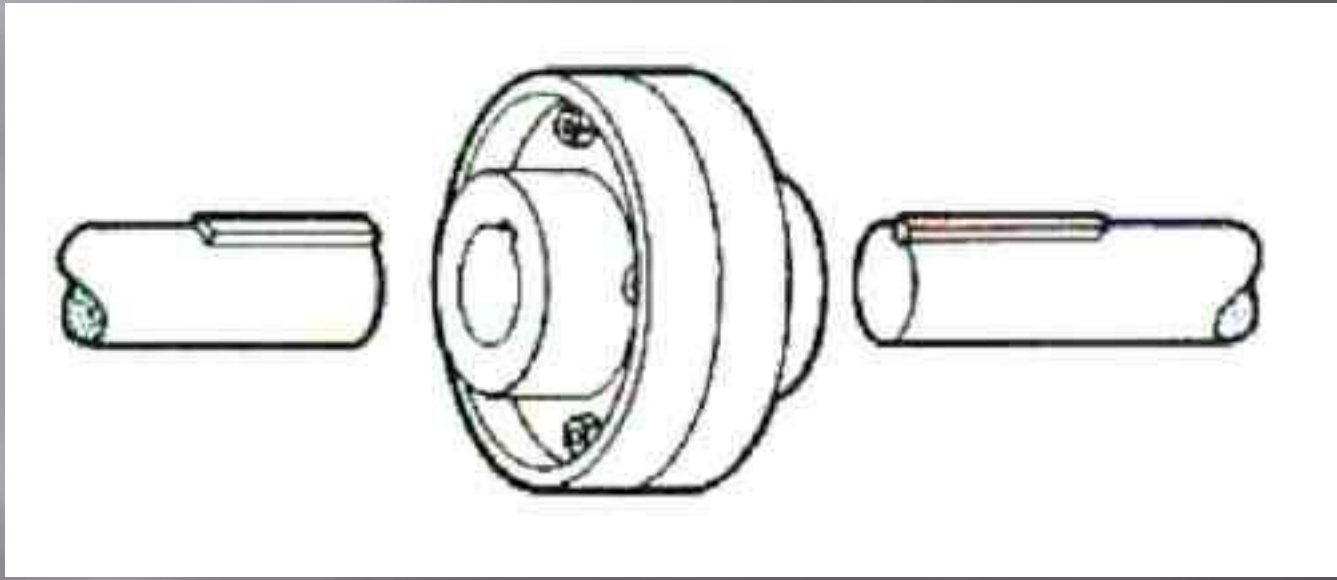
Couplings

- A device that is used to connect two shafts together for the purpose of power transmission.
- General types of couplings are:
  - rigid: for aligned shafts
  - flexible: for non-aligned shafts

Aligned Shaft Couplings

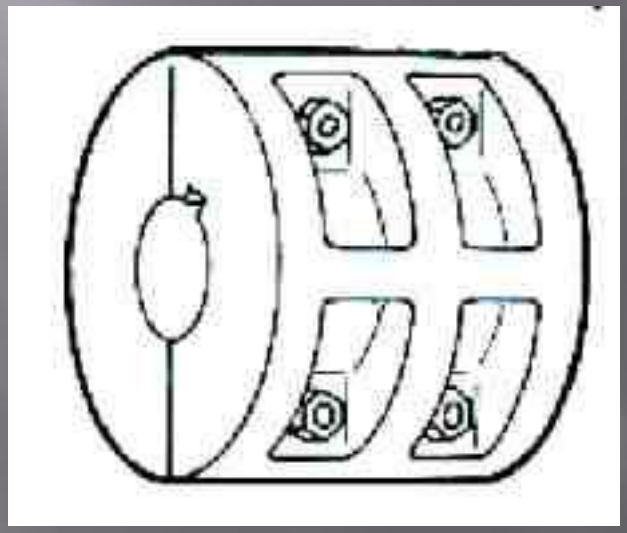
- Aligned shaft couplings are rigid couplings that are designed to draw two shafts together so that no motion can occur between them.
- Types
  - Flanged
  - Split Coupler
  - Keyed
  - Friction

Flanged Coupling



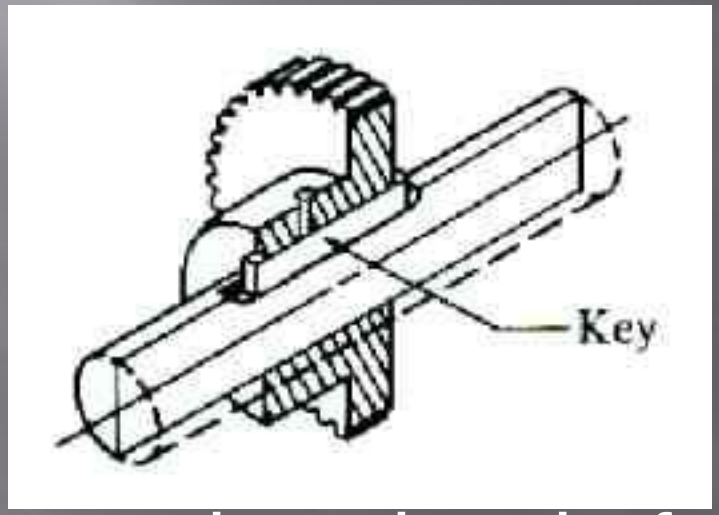
A key is used to to fix the coupling to the shaft, and then couplings are bolted together.

Split Coupler



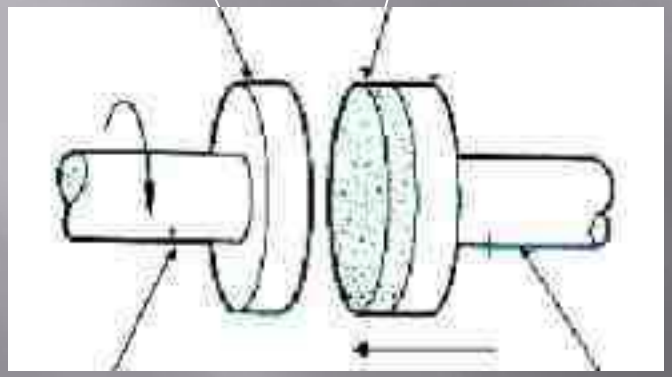
Again, a key is used to fix the coupling and the shaft and the two halves of the coupling are bolted together.

Keyed Coupler

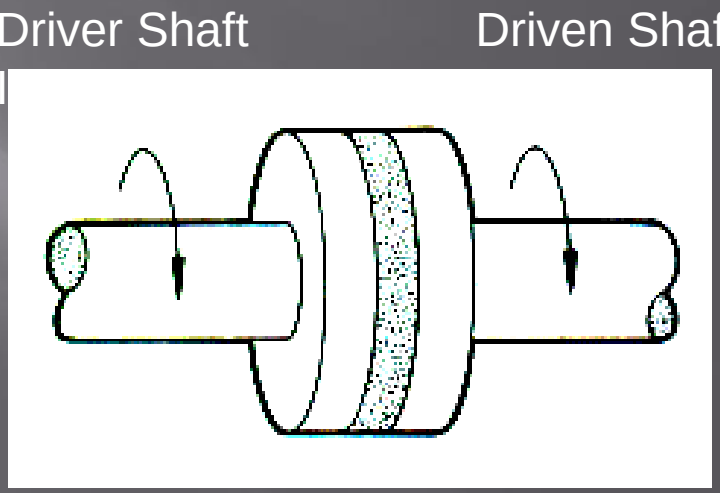


- Grooves are cut into the shaft and the fixed part.
- A key is put in the grooves to lock the two parts together.

Friction Coupling



Clutch Disengaged

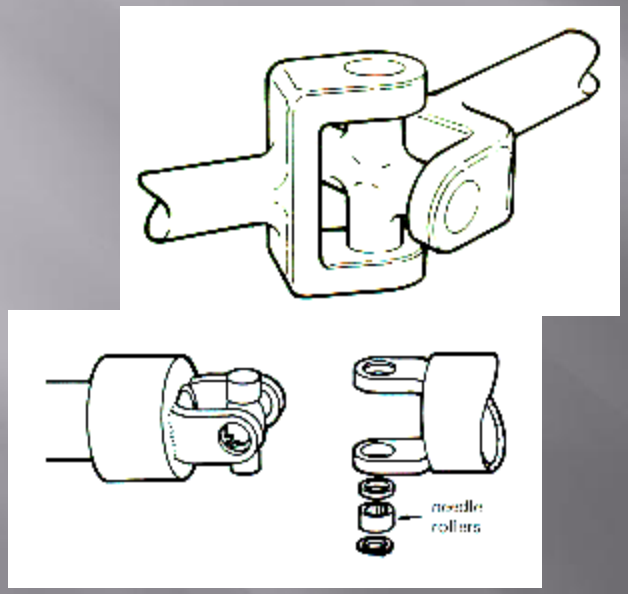


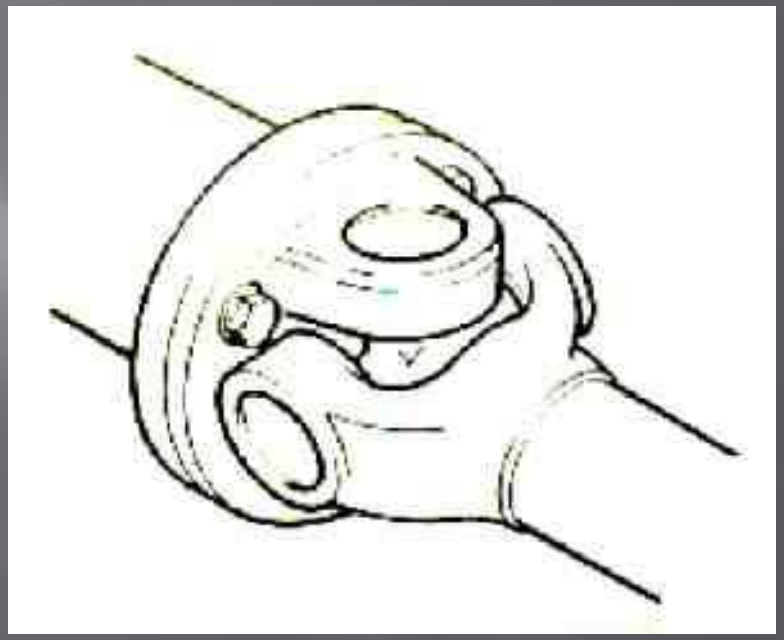
Clutch Engaged

Non-Aligned Shaft Couplings

- Used to join shafts that meet at a slight angle.
- Angle may still change while running due to vibration or load.
- Types:
  - Universal
  - Constant Velocity
  - Flexible

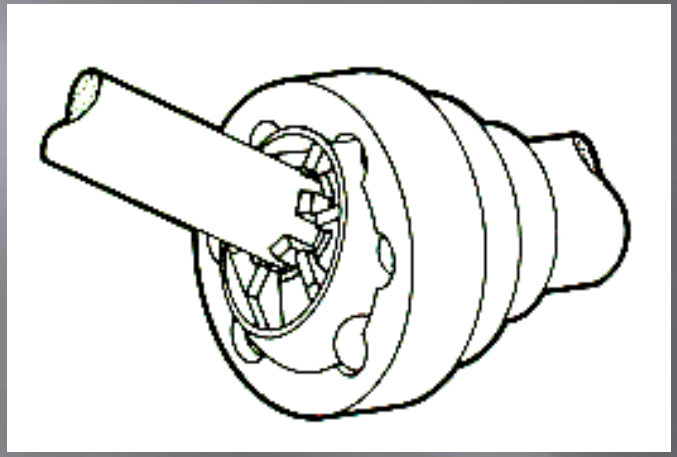
Universal Joint





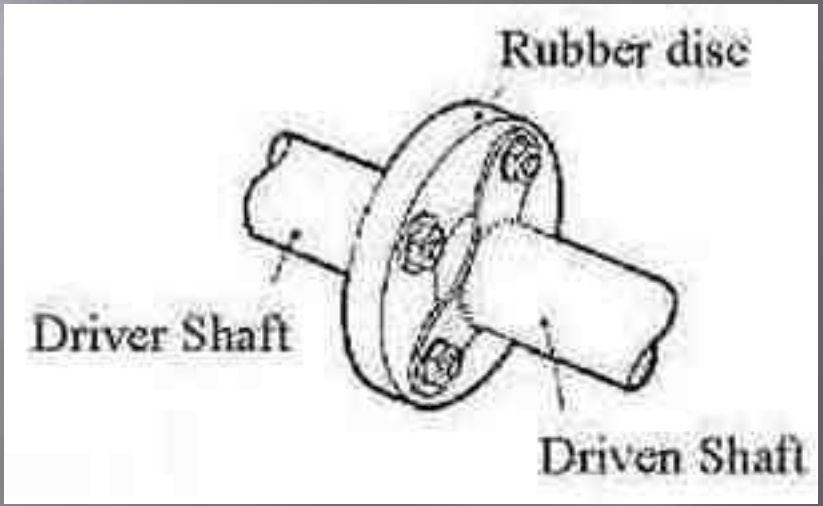
- Consist of two end yokes and a center bearing block.
- Provides for angular misalignment of up to 45 degrees.

Constant Velocity Joint



- Used where angles are greater than 20° and there is no room to use two universal joints.
- Driven shaft maintains a constant speed regardless of driver shaft angle.
- Used on driveshafts on front wheel drive cars.

Flexible Coupling



- Both shafts are bolted to a rubber disc. The flexibility of the disc compensates for the change in angle.
- Can handle approximately 3⌖ of angular misalignment.