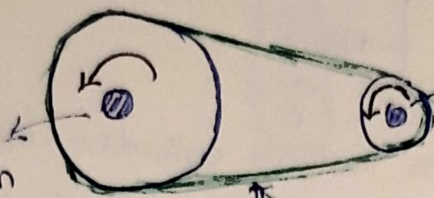
BME - Unit - 4

Power transmission system



Driver shaft → which is connected to motor.

driven shaft ↓ which is stationary & is to be rotated by driver.

Power transmission element. → used to transmit power from on shaft to another shaft.

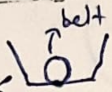
Ex. Belt, chain, Gear.

System in which power is transmitted from one driver shaft to driven shaft.

Different type of belt

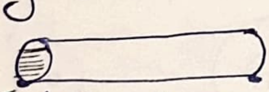
(i) • **Circular belt** (rope belt)

belt



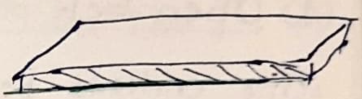
(pully)

→ It has point contact
→ So friction is less.
Slip is more.
→ less power transmitted.
efficiency less.



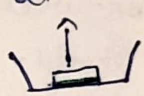
Point contact ← (Circular)

(ii) • **Flat belt**



→ a line contact
→ friction is more
→ slip is less.
→ more power transmitted.
efficiency is more then Circular.

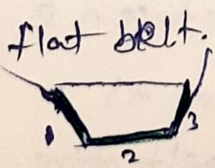
belt



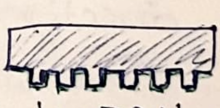
(iii) • **V-belt**

(V belt)

3 line contact
friction is more.
slip ↓
Power transmission is more,
efficency ↑ > flat belt.

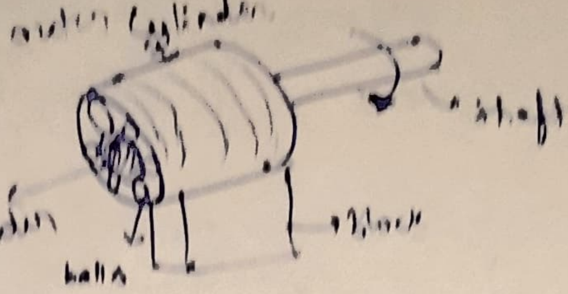


(iv) (Ribbed belt)
• **Timing belt**



→ Internal surface is constructed by slots
→ Surface area contact is max.
→ friction max, Slip min.
→ Power transmission max.
efficiency max.

* Ball Bearing

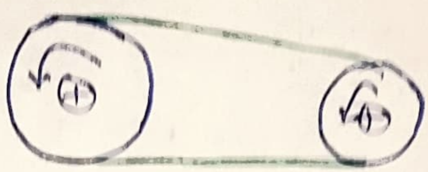


Application
- Fan
- Mixture
- Cycle
- automobile vehicles
- Cars etc

- One inner hollow cylinder which is inserted inside outer hollow cylinder
- gap between both cylinder filled with balls → ball bearings.
- Shaft inside the inner cylinder.

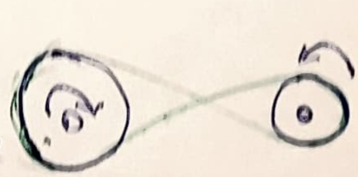
* Different type of belt Drive

(1) Open belt drive -



- One endless belt is mounted between driver to driven shaft.
- Power transmission in same direction in which driver shaft is rotating.
- Used when axis of both shafts are parallel.

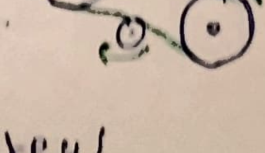
(2) Crossed belt drive -



- Similar to open belt drive.
- power transmission in opposite direction in which driver shaft is rotating.
- Used when axis are parallel.

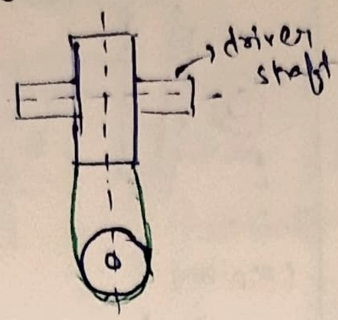
(3) Intermediate belt drive

- Used when 2 shafts are placed at large distance.
- One more pulley is placed between 2 shaft.



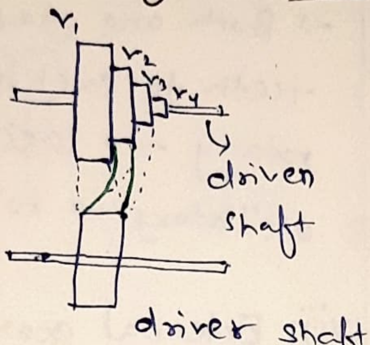
- Used for It is also known as Idler Pulley belt drive. (Jockey)

(4) Quartery (Right angled) belt drive -



two shafts are arranged at right angle.

(5) Cone Pulley / Step Pulley belt drive -



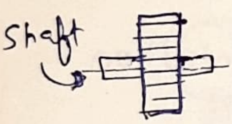
→ when varities of speed is required on driven shaft. with constant speed. motor (driver)

→ It has more then one pulley (Step)

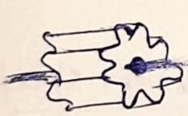
→ Shape ⇒ cone like

- **Gears** :- Power transmission element.

Types (i) Spur Gear



→ teeth are parallel to axis on outer surface. (Shaft)

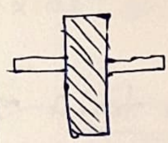


→ Used in wrist watch.

→ vernier caliper (Precision measuring instru.)

→ for low power transmission.

(ii) Helical Gear

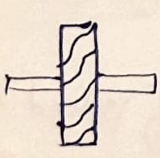


teeth are cut in helical form

→ Used for high speed.

→ Smooth operation.

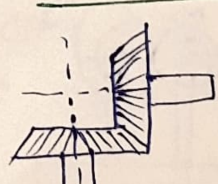
(iii) Spiral Gear



→ teeth are cut in spiral form on outer surface.

→ when axis are not parallel but intersecting each other.

(iv) Beval gear

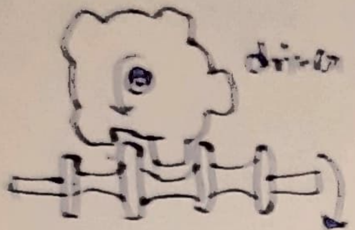


It has two cone gear.

It is used to transmit power at an angle 90°.

It is used in auto mobile.

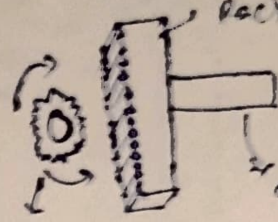
(v) Worm Gear



- It has a large wheel on which teeth are constructed.
- below that wheel, screw is placed.
- when wheel will rotate, screw will also rotate.

at 90° or 180°

(vi) Rack Gear



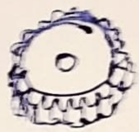
→ It has one small gear and one slab with teeth.
→ Both are mashed with teeth to each other and

rotary ⟶ oscillatory
oscillatory → rotary motion

(vii) Internal gear

Teeth are inside of gear ring.

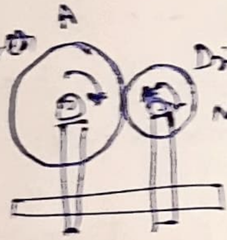
(viii) External gear



teeth are outside of gear ring.

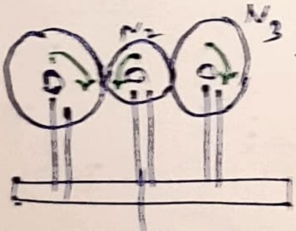
* Gear train

(i) Simple gear train → Only one gear is mounted on each shaft.



$$\text{Train value} = \frac{N_2}{N_1} = \frac{\text{Driven speed}}{\text{Driver speed}}$$

$$\frac{D_A}{D_B} = \frac{N_2}{N_1}$$



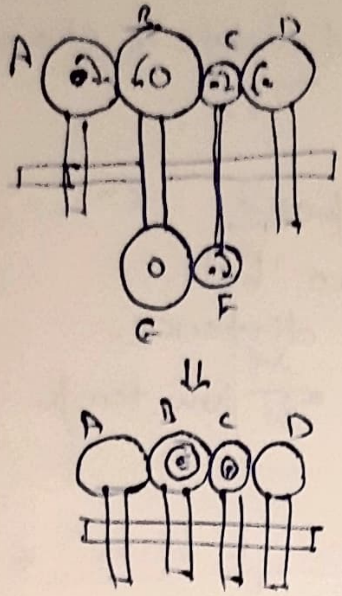
Note

(i) No of (Intermediate gear) is ~~enn~~ even then direction of speed of driver & driven are opposite.

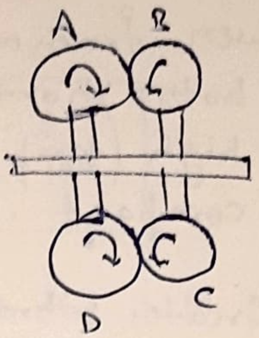
(ii) No of (Intermediate gear) is odd. then direction of speed is same

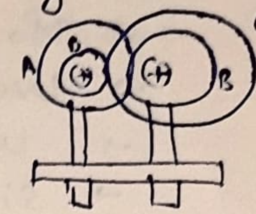
Used ~~when~~ to cover the gap between driver & driven. as desired direction of velocity.

(ii) Compound gear train :-



When two or more gear are on one shaft & rpm of both shaft is same, then this type of arrangement is known as compound gear train.



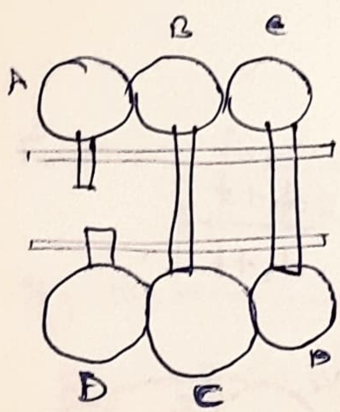


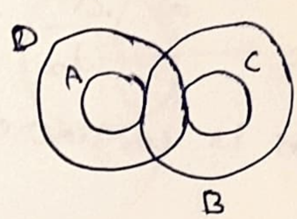
$$\boxed{R_A + R_B = R_D + R_C}$$

Speed ratio

$$\frac{N_A}{N_B} = \frac{D_B}{D_A} \quad \& \quad \frac{N_C}{N_D} = \frac{D_D}{D_C}$$

(iii) Reverted gear train :- When driver & driven are mounted on ~~same~~ shaft, co-axial shaft.

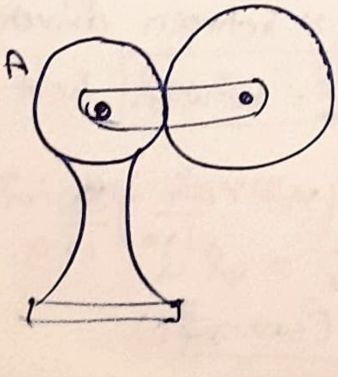




$$\boxed{r_A + r_B = r_C + r_D}$$

(iv) Epicyclic gear train :- When one gear rotates in cyclic motion about another gear.

→ The axes of shaft, over which the gear ~~are~~ mounted, may move relative to a fixed axis.



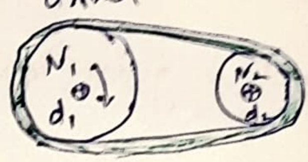
* Chain Drive

→ In belt drive some slip is present, but in chain drive, it is eliminated.

Advantage ⇒ No Slip, Accurate speed.
→ More power transmission then belt.
→ Used in both short & long distance.
→ Used at high temp as well as low temp.
→ Size is compact.

Disadvantage ⇒ → Creates vibration
→ Production cost is high.
→ Proper alignment is required.
→ Required maintainance & lubrication.

driver



* **Velocity ratio** $= \dfrac{N_{driver}}{N_{follower}}$

$V_{driver} = \pi d_1 N_1$

$V_{follower} = \pi d_2 N_2$

$$\Rightarrow \frac{d_1}{d_2} = \frac{N_2}{N_1}$$

if thickness is considered (t) ⇒ $\boxed{\dfrac{N_2}{N_1} = \dfrac{d_1+t}{d_2+t}}$

* **Slip** :- Some forward motion of the driver without carrying the belt with it (relative motion)

S_1 ⇒ between driver & belt
S_2 = between belt & driven

$$(\text{speed})_{belt} = V_1 - V_1 \times \frac{S_1}{100}$$

driven speed

$$V_2 = \left(V_1 - V_1\frac{S_1}{100}\right) - \left(V_1 - V_1\frac{S_1}{100}\right)\frac{S_2}{100}$$

$$V_2 = \frac{V_1(100-S_1)(100-S_2)}{10000}$$

$\because V = \frac{\pi d N}{60}$

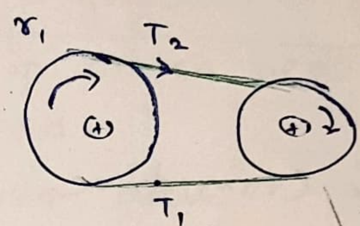
$\Rightarrow \frac{\pi d_2 N_2}{60} = \frac{\pi d_1 N_1}{60} \times \frac{(100 - s_1)(100 - s_2)}{10000}$

$\Rightarrow \frac{N_2}{N_1} = \frac{d_1}{d_2}\left[1 - \left(\frac{s_1 + s_2}{100}\right)\right]$ $\left(\because s_1 + s_2 = s \text{ total slip}, \; s_1 s_2 \approx 0\right)$

$$\boxed{\frac{N_2}{N_1} = \frac{d_1}{d_2}\left(1 - \frac{s}{100}\right)}$$

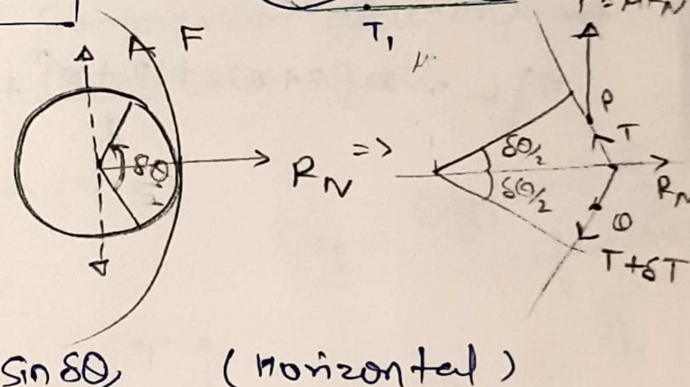
* Creep of Belt :- when the belt passes from slack side to tight side, a certain portion of belt extends. (also when ~~sta~~ tight to slack side)

Due to length change, relative motion accurs known as creep.



effective turning force $= T_1 - T_2$

word done/sec $= \boxed{P = (T_1 - T_2)v}$



Friction force

$F = \mu R_n$

By NLM,

$R_N = T \sin\frac{\delta\theta}{2} + (T + \delta T)\sin\frac{\delta\theta}{2}$ (horizontal)

($\delta\theta \approx$ small)

$R_N = T\frac{\delta\theta}{2} + \cancel{\frac{\delta T\,\delta\theta}{2}}^{\to 0} + \frac{T\delta\theta}{2}$

$$\boxed{R_N = T\delta\theta}$$

Friction force in vertical direction.

$\mu R_N = (T + \delta T)\cos\frac{\delta\theta}{2} - T\cos\frac{\delta\theta}{2}$

$\mu R_N = \delta T$

$$\boxed{R_N = \delta T/\mu}$$

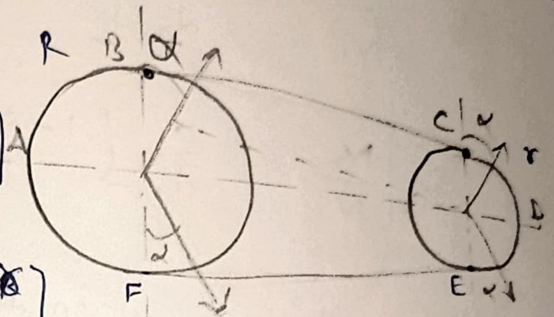
$$\frac{\delta T}{T} = \mu \delta\theta \quad (T_1 \text{ to } T_2)$$

$$\Rightarrow \boxed{\frac{T_1}{T_2} = e^{\mu\theta}} \quad \text{(Tension Ratio)}$$

x — x — x — x

* Length of Belt

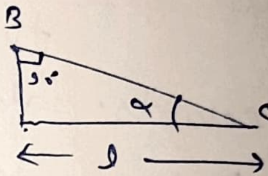
(open drive)



$$\text{Length} = 2\left[\text{Arc}(AB) + BC + \text{Arc}(CD)\right]$$

$$= 2\left[\left(\frac{\pi}{2}+\alpha\right)R + BC + \left(\frac{\pi}{2}-\alpha\right)r\right]$$

$$= \cancel{2}\left[\pi(R+r) + 2\alpha(R-r) - \left(\frac{R-r}{l}\right)^2 + 2l\right)$$



$$\boxed{L = \pi(R+r) + \frac{(R-r)^2}{l} + 2l}$$

$$BC = l\left[1 - \frac{(R-r)^2}{2l^2}\right]$$

$$\sin\alpha = \frac{R-r}{l}$$

$$\left(\alpha = \frac{R-r}{l}\right)$$

for cross drive

$$\Rightarrow L = \pi(R+r) + \frac{(R+r)^2}{l} + 2l$$