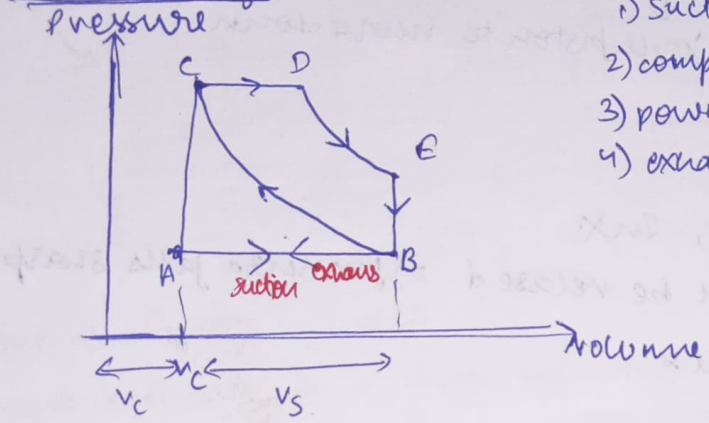
Mech

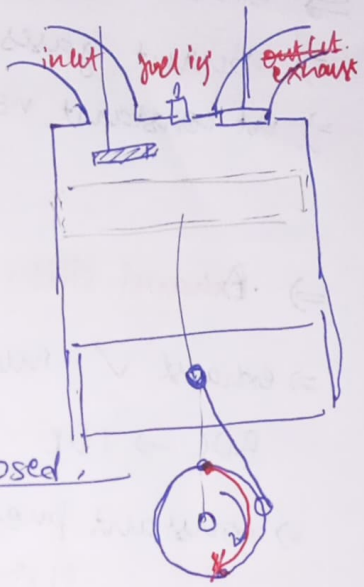
• classification of IC engine

four stroke engine (disel).



1) suction stroke ⇒ AB
2) compression stroke ⇒ ~~B~~ BC , CD
3) power stroke ⇒ D-E , ~~E~~
4) exhaust stroke ⇒ ~~B~~ E-B, BA.

V_c =



A→B ⇒ constant pressure

⇒ suction stroke

⇒ ~~cover end~~ → ~~crank end~~ } piston

(TDC) → (BDC)

⇒ ~~inlet valve is open, exhaust is closed~~,

inlet ✓ open

exhaust × closed

fuel injetor ×

⇒ only air enters the cylinder.

Energy comes from "cranking" → when you start.

⇒ flywheel is running

B-C ⇒ Reversible adiabatic compression.

⇒ compression stroke

⇒ inlet ×, exhaust ×, fuel Inj ×

BDC → TDC

⇒ air hot → coz of compression

⇒ at the end ⇒ fuel Inj ✓ ⇒ diesel comes in hot air.

⇓

as fine spray

C→D ⇒ constant pressure

⇒ diesel comes in as fine spray

⇒ burnt In ×, out × Inj ✓

D-E ⇒ reversible adiabatic expansion
Power Stroke.
⇒ burnt up fuel ⇒ releases gases
↓
force piston to move down
TDC → BDC.

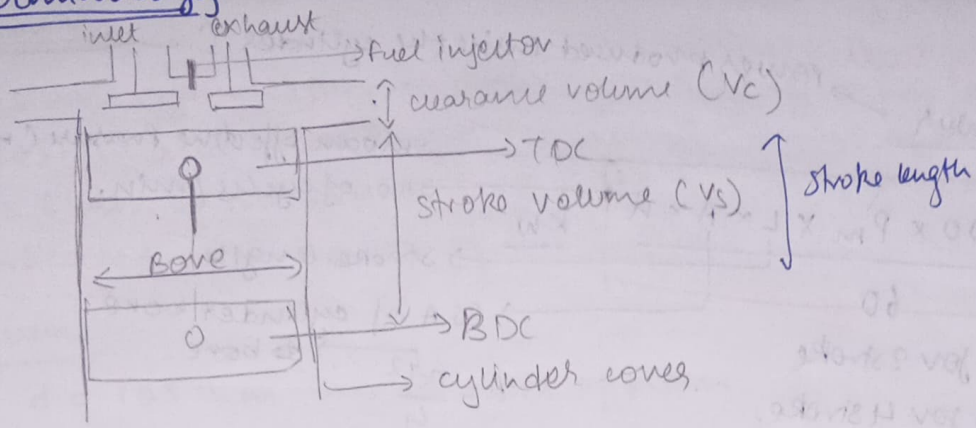
EB ⇒ exhaust ✓, fI X, In X
⇒ burnt gases will be released ⇒ pressure falls sharply
⇒ at constant volume.

B-A ⇒ Exhaust stroke
⇒ exhaust ✓ inlet X
BDC → TDC ⇒ push gases out.
⇒ constant pressure

4 stroke cycle or "~~constant volume cycle~~ Constant pressure cycle" maybe.

Suction	Compression	working or Power	Exhaust
• A → B	B → C, C → D	D → E	E → B, B → A.
• const pressure. vol ↑↑ ⇒ Temp↑	• Rev. Adia. Comp.	• Rev. Adia. Expan	• const pressure, vol ↓↓
• TDC → BDC (0° → 180°)	BDC → TDC (180° − 0°)	TDC → BDC	BDC → TDC.
• inlet ✓	X X	X	X X
exhaust X	X X	X	✓ ✓
fuel inject X	X ✓	X	X X
• only air is sucked in.	• ~~fuel is~~ air is compressed and made hot. • fuel is injected	• fuel is burnt coz its hot.	• exhaust gases are released.

Terminology



- Bore ⇒ dia. of cylinder.
- crank radius ⇒ R_c = linear dist. shaft centre ← R_c → crank pin centre

$$R_c = \frac{\text{stroke length}}{2}$$

- TDC / IDC (Inner DC)
  - ↳ extreme position towards the cover end side.
  - " crank pin comes between piston and crankshaft
- BDC / → " " " " crank end side.
  - Outer DC
- Swept volume ⇒ volume piston moves in one stroke.
  - = $\pi R^2 \times$ stroke length.
  - ↳ piston surface area
- Stroke (L) ⇒ ~~$L = 2\pi R_c$~~ $L = 2R_c$ TDC ⟷ BDC
- V_c = Vol in between top of the cylinder head and TDC.
  - Piston never touches cylinder head.
- Compression Ratio ⇒ $CR = \left(\frac{V_s + V_c}{V_c}\right)$ Petrol 4:1 ⟷ 10:1, Diesel → 12:1 ⟷ 22:1
- Piston speed ⇒ $\frac{\text{dist by piston}}{\text{time}}$
- cycle of operation.

classification of IC engine

1) Nature of thermodynamic cycle → Diesel engine, otto engine, Dual combustion
2) Fuel used → Petrol, Diesel, Bio gas
3) No. of strokes → 2 stroke, 4 stroke
4) Method of cooling → Air cooled, water cooled
5) Type of ignition → Spark ignition / compression ignition.
6) Number of cylinders → single / Multi
7) Pos. of cylinder → Horizontal, Vertical, Inline, Radial

• piston speed = 8 m/sec.

IP = 50 kW.

Cylinder
→ grey cast iron

Cylinder head (valves)
→ cast iron + Ni + Cr + Mo

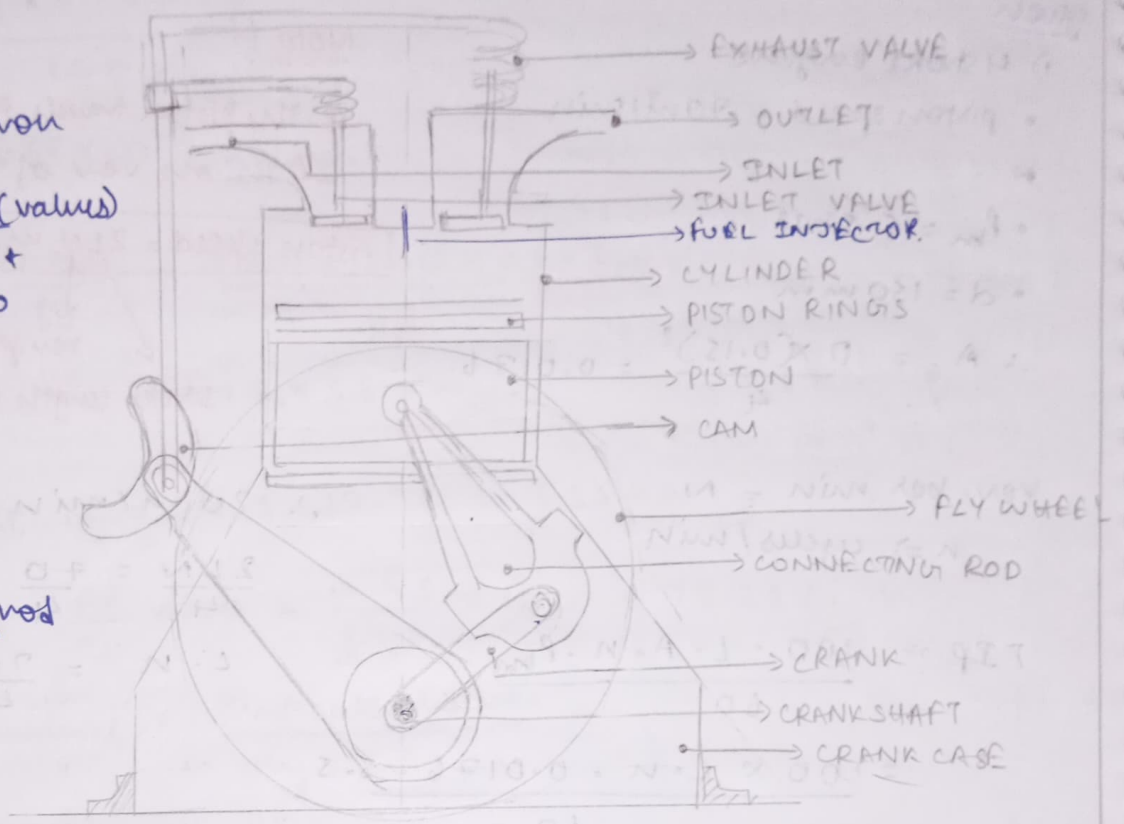
Piston
Al alloys

Piston rings
cast iron

connecting rod
steel alloy

crank
C + steel

fly wheel
cast iron



PARTS OF A FOUR STROKE IC ENGINE

Gears

Spur Gears, Helical Gears

Gears ⇒ are toothed wheels used to transmit power from one shaft to another shaft.

⇒ when a constant velocity ratio is desired and the distance between shafts is relatively small.

i) According to relative position of shaft axes:

i) Parallel axes → spur gear, helical gear

ii) Intersecting ~~gears~~ axes → Bevel gears

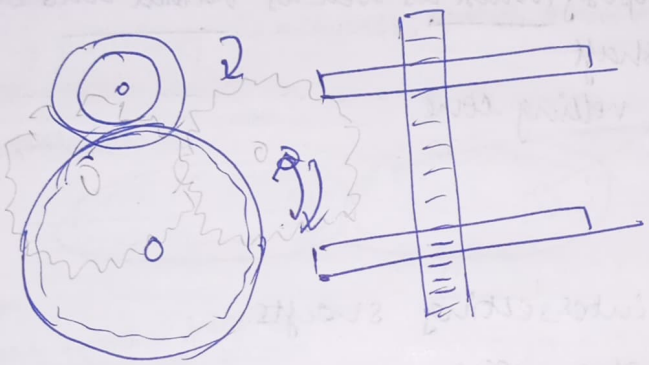
iii) Non Parallel, non-intersecting : worm gears

Spur gears

- simplest form of gear.
- power transmission is in between 2 ∥ shafts
- teeth are straight and ⊥ to the axis
- ⇒ only impose radial load on bearings.
- ⇒ coz of instantaneous line of contact during meshing ⇒ noisy.
- ⇒ used in machine tools, automobile gear boxes etc.

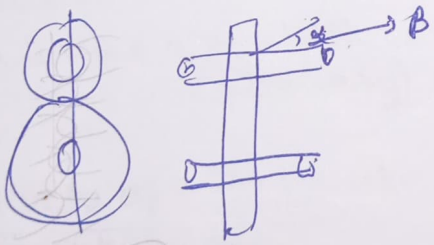
Note

Gear → Driving gear (part) ⇒ Pinion
→ Driven part ⇒ Gear.



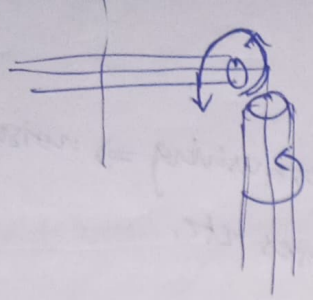
Helical Gears

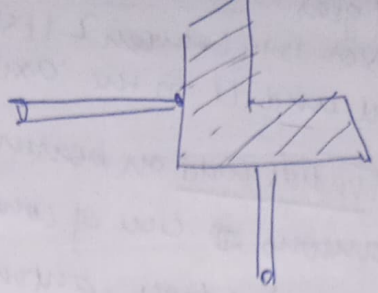
- same as spur gears ⇒ used to transmit power between
- Teeth are inclined to the axis of the shaft at an angle.
  (Helix angle) ⇒ (15° - 45°)
- quieter gears → coz of progressive engagement of teeth. } adv.
- produce axial thrust. ⟶ dis adv
  (↳ to ~~prv~~ ∴ double helical gears (herringbone gears are used)



Bevel Gears

- most commonly used for transmitting power between intersecting shafts

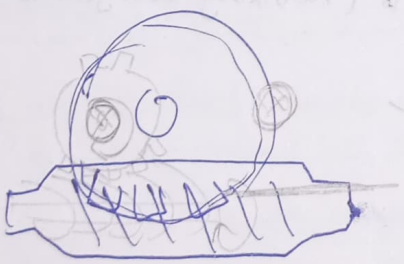




- When two equal bevel gears have the axes at right angles, they are called ~~Miter~~ bevel gears.
- They (all bevel gears) impose thrust (axial) as well as radial load on the bearing supporting the shaft.
- Pitch surface is usually rolling cone

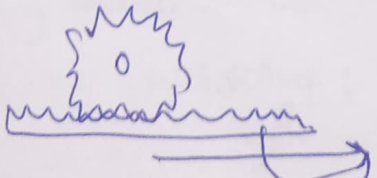
Worm gears

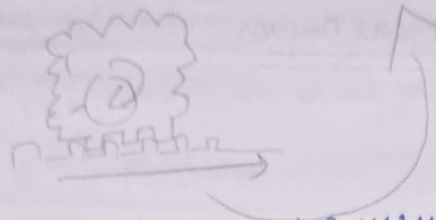
- 2 worm parallel, non intersecting shafts.
- ~~A worm drive consists of a worm~~
  Worm drive → worm shaft
  → worm wheel.
  - used for high speed reduction → 60:1
  - "self locking" ⇒ does not allow reversal of direction



Rack and Pinion

- when rotary motion is to be converted ~~to~~ into a linear motion (rack pinion)



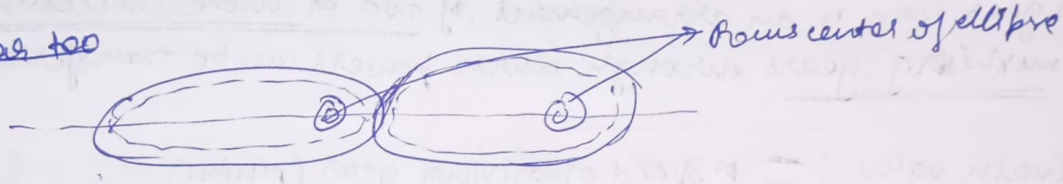


↳ has ∞ radius, and 0 curvature.
∴ shaft is at ∞ distance from the pinion ka shaft.

Eliptical Gears

- Are used when there is a requirement for varying speed of the driven gear in each revolution
- Four ~~types of~~ times the speed will change. → 2 maximum
  2 minimum.
- used → printing machines, quick return motion etc.

Gear too



Gear tooth profiles

- Gears are mainly used for transmission of power, thus must be of accurate profile to obtain exact velocity ration
- 2 teeth profiles

Involute profile

- The path described by a point on an ~~external~~ inextensible cord unwound from around a cylinder (stationary)

Cycloidal profile

- The path traced by the point on the rim of a circle which rolls without slipping on a fixed straight line

Adv & disadv of Gear trains

- can ~~transmit~~ heavy loads

Adv

- They are positive drives for high power transmission between closely spaced shafts
- less maintained, reliability, long life
  high efficiency.

dis adv

- Not good for large separation between shafts.
- high cost of production
- Errors in the production can coz gears to start making ~~too~~ noise and produce vibration at high speed

Velocity ratio in Gear Drives

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} = \frac{z_1}{z_2}$$

Speed of the driving pulley (pinion) / Speed of the driven pulley (gear) = Pitch circle dia of pinion / Pitch circle dia. of gear

= no. of teeth on driver gear (pinion) / no. of teeth on gear

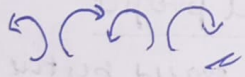
Gear trains

- A gear train is an arrangement of two or more successively meshing gears through which powers can be transferred.

Train value = Speed of driving gear (pinion) / Speed of driven gear (gear)

= 1 / velocity ratio

Direction of rotation



mesh externally => direction is opposite. (adj. ones. pinion & gear)

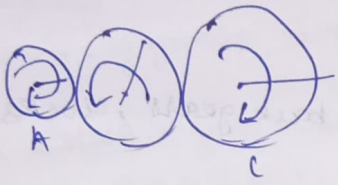
mesh internally => direction is same (adjacent ones)

- Simple Gear Train
- Compound Gear Train
- Reversed Gear Train
- Epicyclic Gear Train

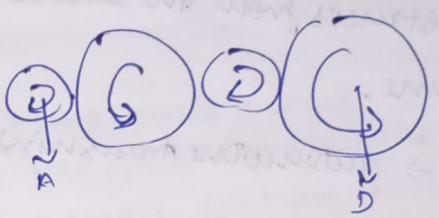
Simple gear train

- Each shaft carries only on gear.
- eg: A → pinion
  D → gear (driven)
  B & C → "idler gears" or intermediate gears
  ⇓
  do not affect the velocity ratio ⇒ just bridge gap.

trick → odd no. of idler gears → pinion & gear same direct
even no. of idler gears → pinion & gear & diff direction.



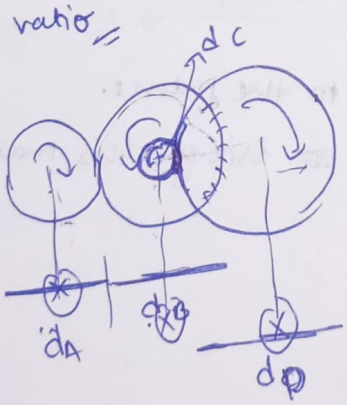
$$\frac{n_C}{n_A} = \frac{Z_A}{Z_C}$$



$$\frac{n_D}{n_A} = \frac{v_A}{v_D} = \frac{Z_A}{Z_D}$$

Compound gear train

- Intermidiate shaft carries two or more gears which are keyed to it.
- Aveused when → high velocity ratio is req. in a limited space
  ⇓
  ## Intermediate gear will effect the overall velocity ratio =



$\frac{n_B}{n_A} = \frac{Z_A}{Z_B}$ $\frac{n_d}{n_C} = \frac{Z_C}{Z_D}$ } ⇒ two simple trains

$$\frac{n_B}{n_A} \times \frac{n_D}{n_C} = \frac{Z_A}{Z_B} \times \frac{Z_C}{d_D} \Rightarrow \frac{n_D}{n_A} = \frac{Z_A \times Z_C}{Z_B \times Z_D}$$

Speed of pinion / speed of gear = product of teeth on (simple) pinions / product of teeth on (simple) gears

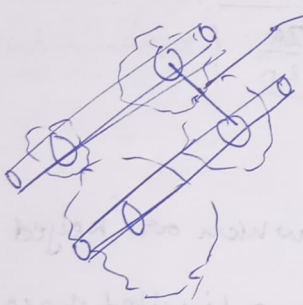
= product of pitch circle dia. of pinions / product of pitch circle dia of gears

Reverted gear train

- A type of compound gear train
- The first and the last gears are on the same axis

⇒ The distances from the centres of the two gears pairs must be same.

Used in → automotive transmissions, lathe back gears, clocks



$$A_S \left(\frac{d_A + d_B}{2}\right) = \left(\frac{d_C + d_D}{2}\right)$$

Epicyclic gear trains

- When the axis of one or more shafts relative to the frame.
- Large speed reductions are obtained using this train
- compact size and automobile differential.

Classification of gears

on the basis of

- pos of shafts
  - ∥ axes
    - → spur
    - → helical
  - X axes
    - ↪ Bevel
  - non ∥ non intersec
    - → worm
- peripheral velocity
  - v < 3 m/s
    - low velocity
  - 3 < v < 15
    - → medium velo
  - v > 15
    - → high velocity
- ~~External gearing~~ acc to type of gearing
  - External
    - → rotate in opp. direction
  - internal
    - → rotate in same dirn
- pos of teeth on gear surface
  - straight teeth
    - spur gear
  - inclined teeth
    - helical gear
  - skewed (curved) teeth
    - spiral gears

some random notes

Petrol engine vs Diesel engine

- works on otto cycle
- Air and petrol are mixed in carburetor before hand
- cylinder is fitted with spark plug
- high engine speeds about 3000rpm
- less thermal efficiency

- works on diesel cycle
- only air enters, diesel is sprayed onto hot air (fine spray)
- No spark plug only fuel injector.
- Low engine speed 1500 rpm.
- more thermal efficiency

four stroke engine vs two stroke engine

- one working cycle for every 2 revolution of crank shaft
- less fuel consumption high thermal efficiency
- Engine crankshaft can rotate in one direction
- req. heavy flywheel coz high torque fluctuations
- less noise

- one working cycle for each rev. of the crank shaft
- more fuel less thermal effi
- Engine crankshaft can rotate in both directions.
- requires right flywheel coz low torque fluctuations
- more noise.

Thermocouple