Gear Drives

→ Gears are defined as toothed wheels which transmit power & motion from one shaft to another by means of successive engagement of teeth

→ Advantages compared to chain/belt drives :

i) It is positive drive & velocity ratio remains constant

ii) Centre distance b/w shafts is small, leads to compact construction

iii) Transmits very large power beyond range of chain/belt drives

iv) Can transmit even at low velocity, not possible in chain drives

v) Provision can be made in gearbox for gear shifting, changing velocity ratio over wide range.

Gear Drives are 3 types:

1) Parallel Shafts

i) Spur gears

ii) Helical Gears

iii) Double Helical / Herringbone Gears

2) Intersecting Shafts

i) Straight Bevel Gears

ii) Spiral Bevel Gears

3) Skew Shafts

i) Hypoid Gears

ii) Worm Gears

Spur Gears

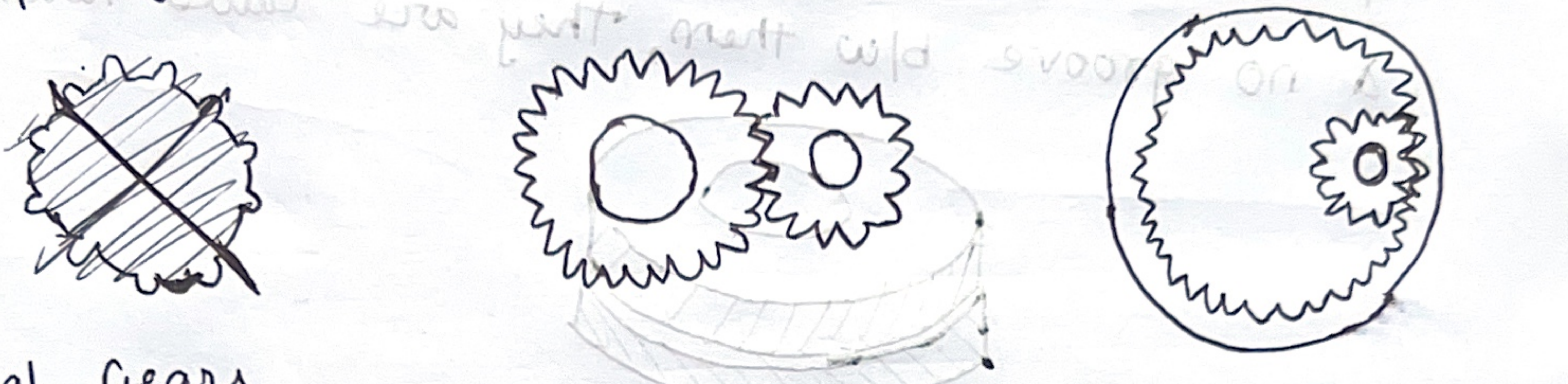
→ They have straight teeth $||^{al}$ to axes

→ At time of engagement of 2 gears, contact extends across entire width on a line $||^{el}$ to axes of rotation.

Results in sudden application of load, high impact stress & excessive noise at high speeds

→ If gear has external teeth ⇒ shaft rotates in opposite direction

If 1 gear is internal (inside bigger) ⇒ shaft rotates in same direction



Helical Gears

→ Teeth are curved, each being in helical shape

→ 2 Mating gears have same helix angle but have teeth of opposite hands.

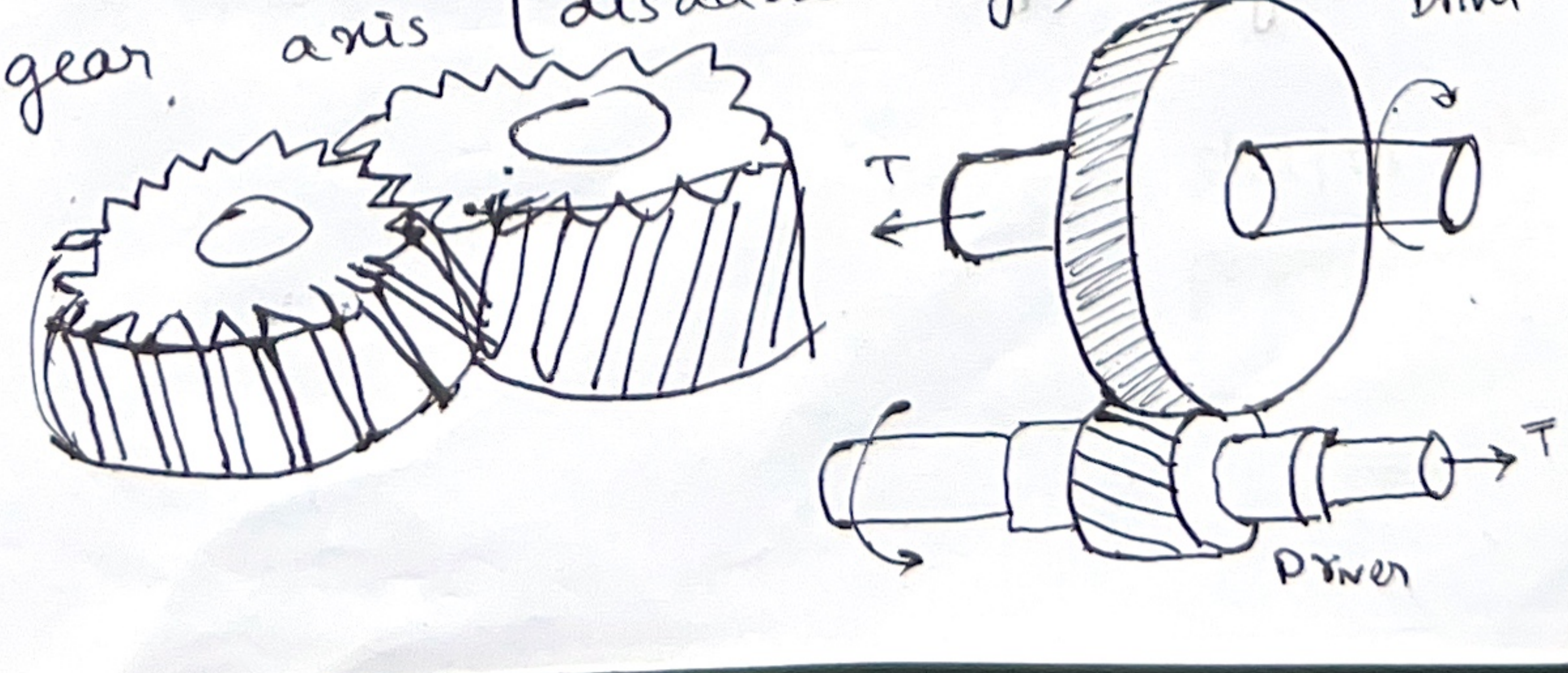
→ At beginning of engagement, contact occurs at point of leading edge of curved path, but extends along diagonal line, as gears rotate.

→ Low impact stress, So, noise reduced.

They can be used at higher velocities

" for greater load carrying cap.

→ They have end thrust cuz of a force component along gear axis (disadvantage)

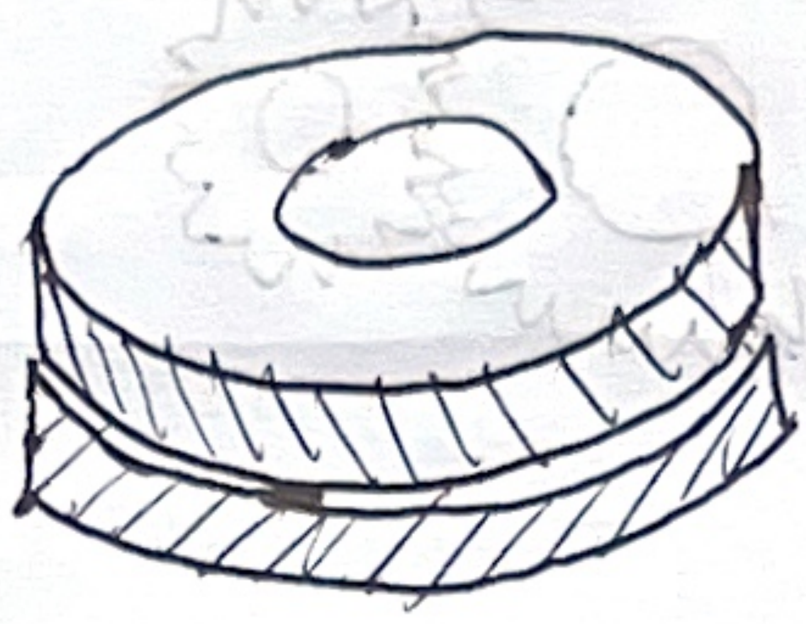


Double-Helical Gears

→ Equivalent to a pair of helical gears secured together one right hand helix, other left hand helix.

→ Both the teeths are seperated by a groove.
No axial thrust as one cancels the other
Can be run at high speeds & less noise & vibration

→ If left & right gears meet at common apex, & no groove b/w them, they are called herringbone gear.



Straight Bevel Gears

→ Teeth are straight, radial to point of intersection of shaft axes & vary in cross-section through out the length.

→ Usually used to connect shafts at right angles which run at lower speeds.
Gears of same size & connecting 2 shafts at right angles to each other are called mitre gears

Spiral Bevel Gears

→ Teeth of bevel gears are inclined at an angle to face of bevel, they are called spiral/helical bevels.

→ Smoother in action & quieter because of gradual load application & low impact stress.

→ But axial thrust exist, calling for stronger Bearing & supporting assembies

→ used to drive the differential of an automobile.

Hypoid Gears

→ They are a type of spiral bevel gears but they have axes that are non-intersecting / parallel

→ They are hyperbolic rather than regular conical geometry

→ Mostly used in automotive industry

Worm Gears

→ Consist of a worm & worm wheel

→ Worm is a form of threaded screw which meshes with matching wheel

→ Worm gear drives are used for shafts which have axes that aren't parallel or perpendicular

→ They are characterized by high speed reduction ratio

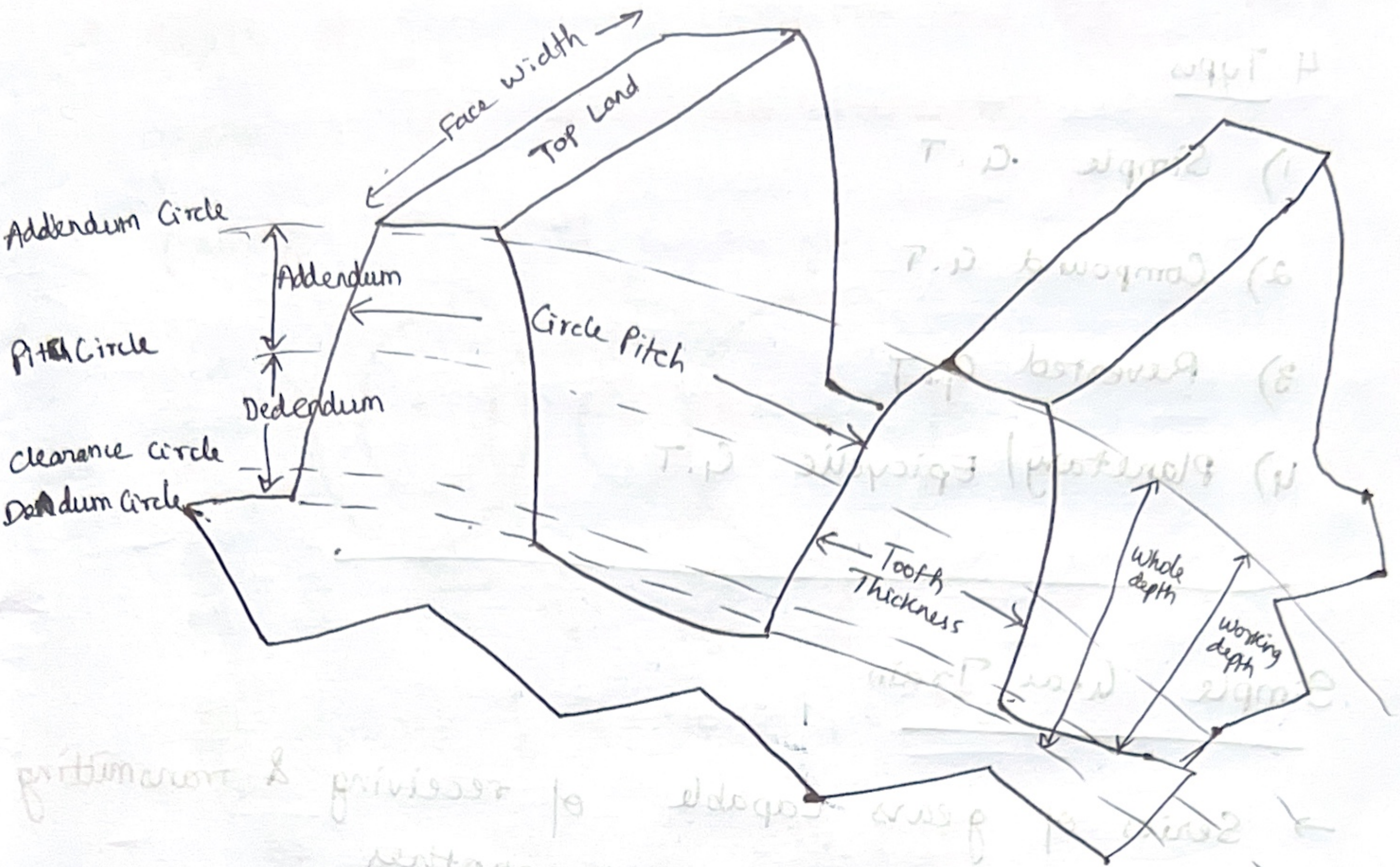
Spur Rack & Pinion

→ It is a special case of spur gears with ∞ diameter

→ It converts rotary motion to translatory motion or vice versa

→ ex: used in lathe which rack transmits motion to saddle

Gear Terminology



Circular pitch $\Rightarrow P = \frac{\pi d}{T}$

d: pitch diameter

T: no. of teeth

Diametral pitch $\Rightarrow P = \frac{T}{d}$

Module $\Rightarrow m = \frac{d}{T}$

Velocity ratio $\Rightarrow VR = \frac{\omega_2}{\omega_1} = \frac{N_2}{N_1} = \frac{d_1}{d_2} = \frac{T_1}{T_2}$

ω: angular velocity (rad/s)

N: ,, (rpm)

T: no. of teeth

d: pitch diameter

Gear Trains

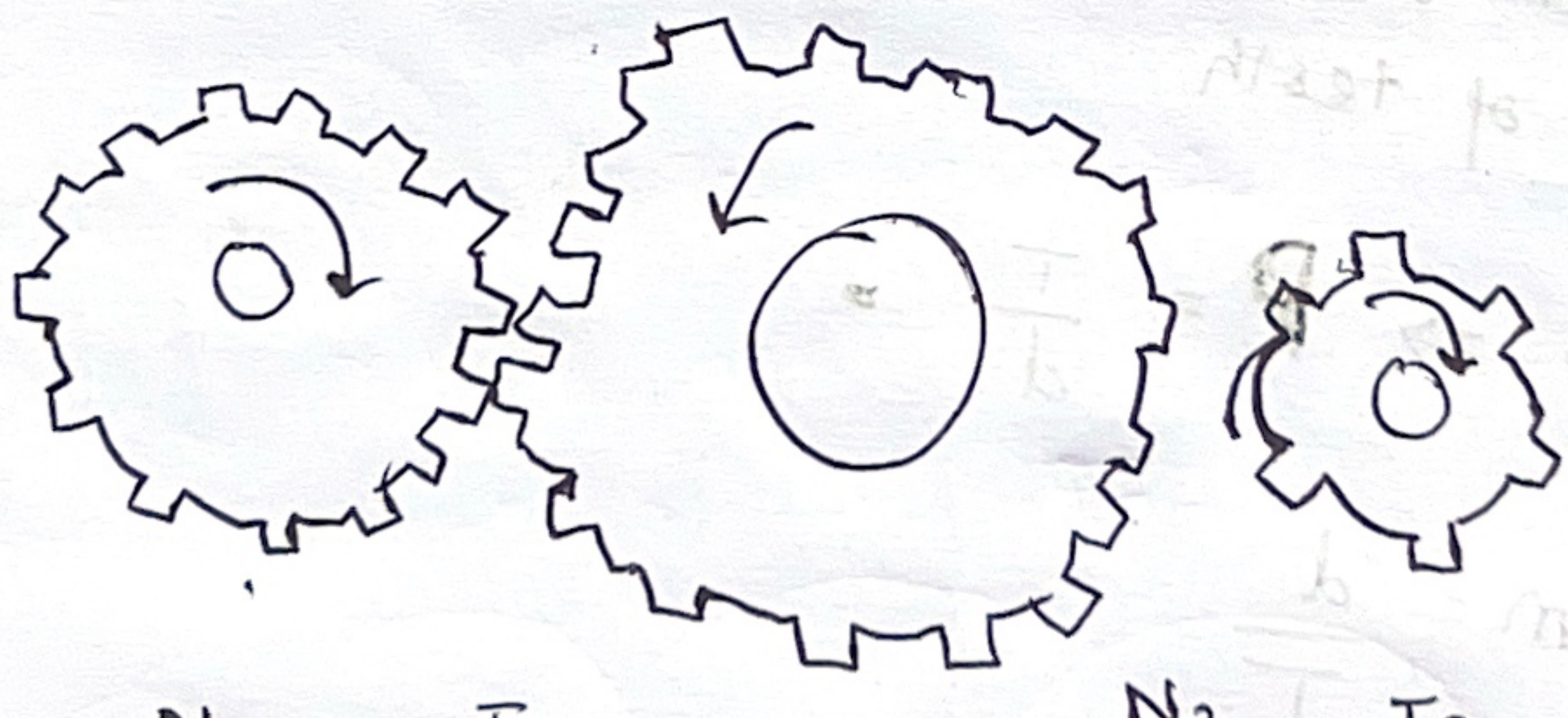
4 Types

1) Simple G.T
2) Compound G.T
3) Reverted G.T
4) Planetary/ Epicyclic G.T

Simple Gear Train

→ Series of gears capable of receiving & transmitting motion from 1 gear to another

→ 1 shaft, 1 Gear



$$\frac{N_2}{N_1} = \frac{T_1}{T_2} \qquad \frac{N_3}{N_2} = \frac{T_2}{T_3}$$

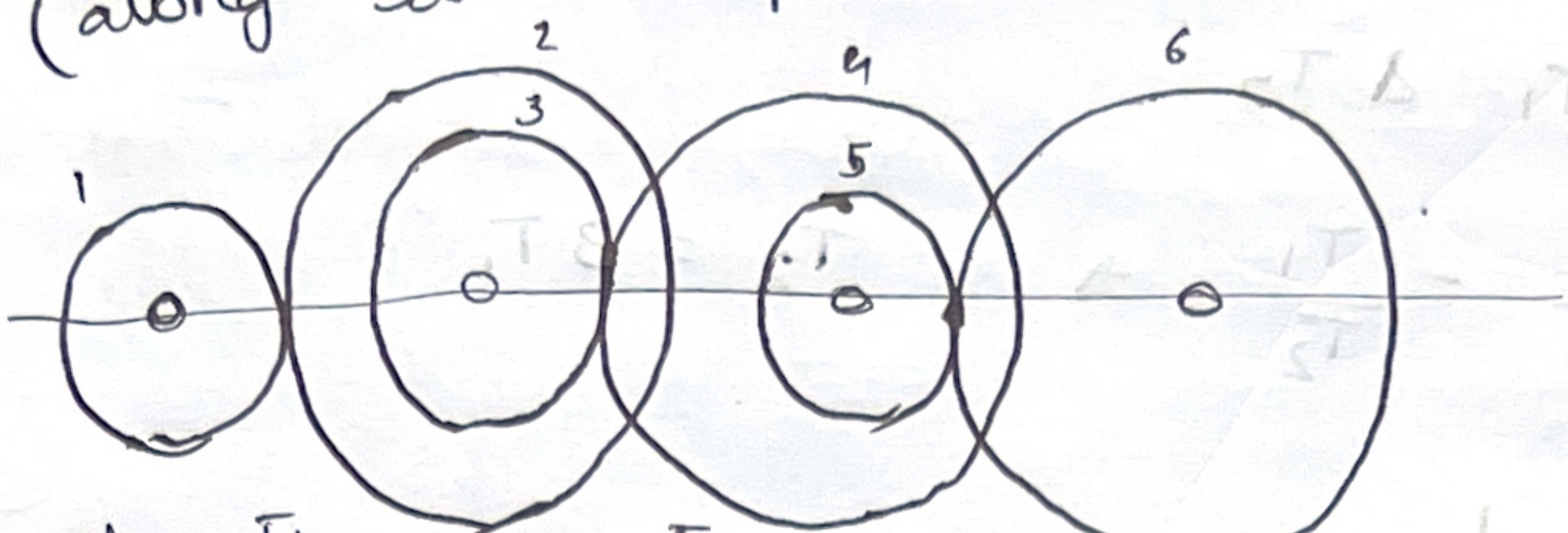
$$\Rightarrow \frac{N_2}{N_1} \times \frac{N_3}{N_2} = \frac{T_1}{T_2} \times \frac{T_2}{T_3}$$

$$\frac{N_3}{N_1} = \frac{T_1}{T_3}$$

Intermediate gears have no effect on speed ratio & called idlers

Compound Gear Train

→ Series of gears are connected such that 2 or more gears rotate with same angular velocity (along same shaft)



$$\frac{N_2}{N_1} = \frac{T_1}{T_2} \qquad \frac{N_4}{N_3} = \frac{T_3}{T_4} \qquad \frac{N_6}{N_5} = \frac{T_5}{T_6}$$

$N_2 = N_3$; $N_4 = N_5$; N ; N_6

$$\frac{N_2}{N_1} \times \frac{N_4}{N_3} \times \frac{N_6}{N_5} = \frac{T_1}{T_2} \times \frac{T_3}{T_4} \times \frac{T_5}{T_6}$$

$$\frac{N_6}{N_5} = \frac{T_1 \times T_3 \times T_5}{T_2 \times T_4 \times T_6}$$

Reverted Gear Train

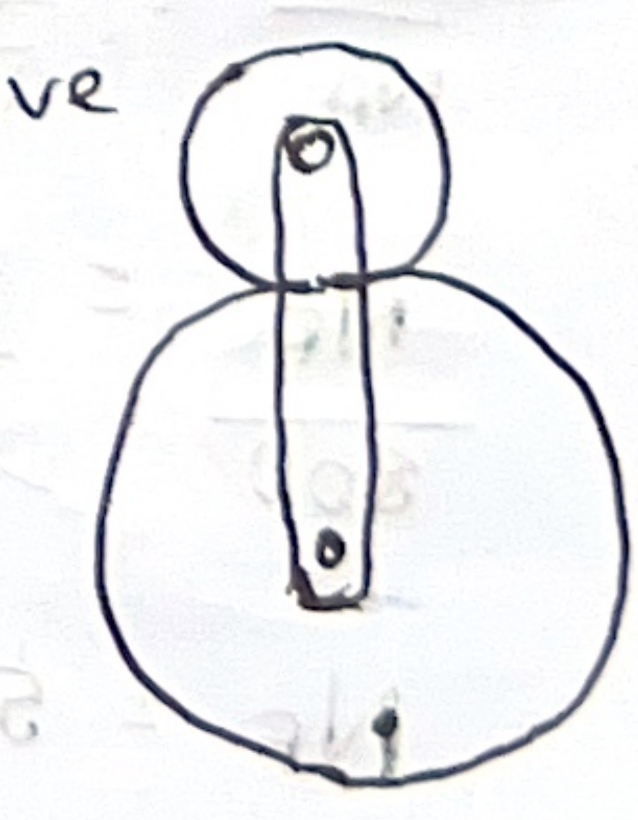
→ Axes of first & last wheels of compound gear coincide

→ used in clocks & simple lathes where back gear is used to give slow speed to chunk

Planetary / Epicyclic Gear Train

→ Gear Train having relative motion of axes

→ Axis of atleast 1 gear moves relative to frame



→ Usually wheel that rolls outside is called epicyclic

→ Large speed reductions are possible

→ Even more compact unit is possible

→ Used in transmission, computing devices etc., Q1. The following data relate to 2 meshing gears -

Velocity ratio - $1/3$

Module - 4mm

Centre distance - 200mm

Find T_1 & T_2

A. $\frac{N_2}{N_1} = \frac{1}{3} = \frac{T_1}{T_2} \Rightarrow T_2 = 3T_1$

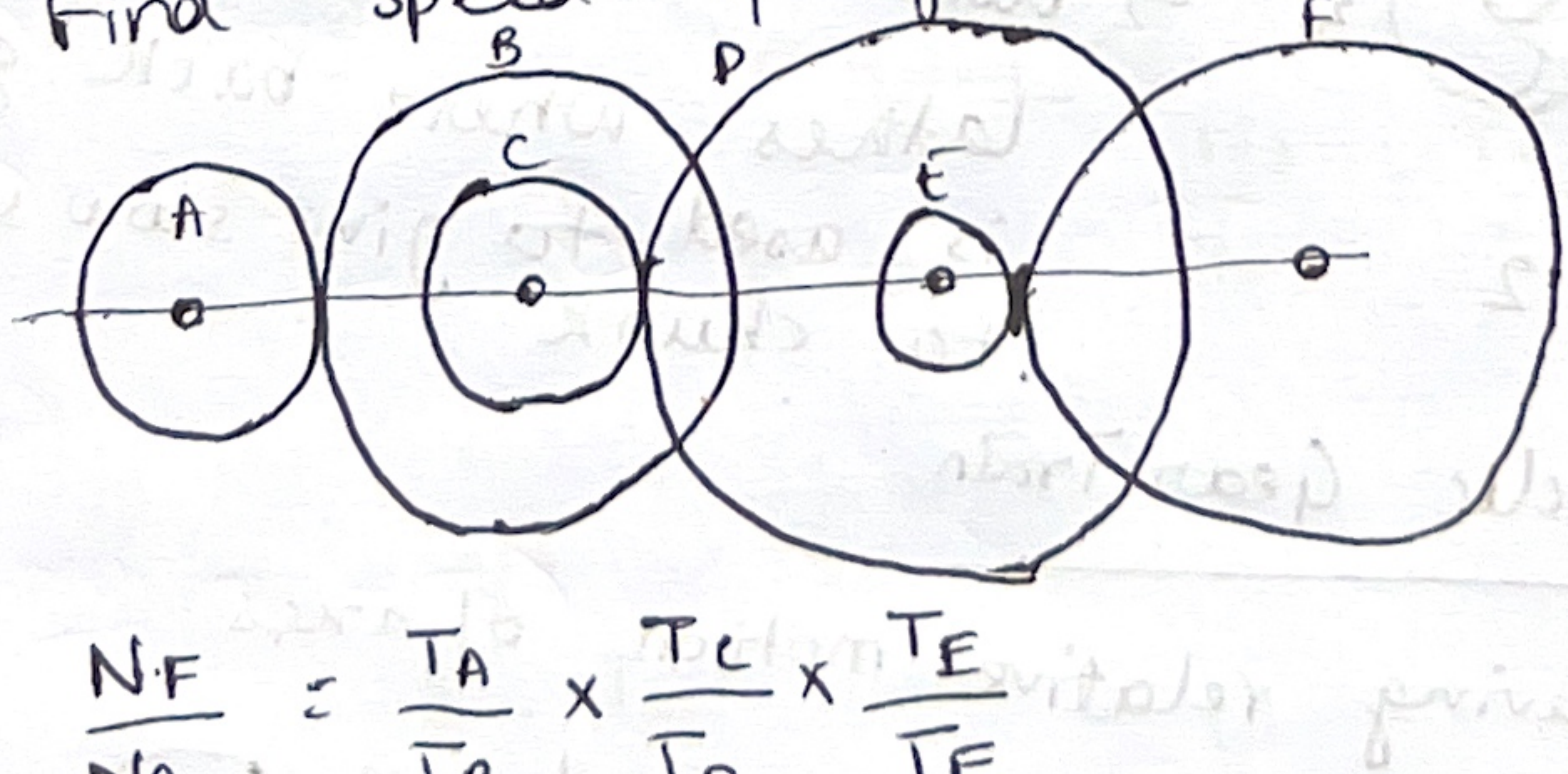
$C = \frac{d_1 + d_2}{2} = 200$

$= \frac{m(T_1 + T_2)}{2} = 200 \Rightarrow m(4T_1) = 400$

$T_1 = \frac{400}{16} = 25$

$T_2 = 75$

Q2. Compound Gear Train. Motor shaft rotating at 800 rpm connected to gear A. No of Teeth on A, B, C, D, E, F are 24, 56, 30, 80, 32, 72. Find speed of gear F

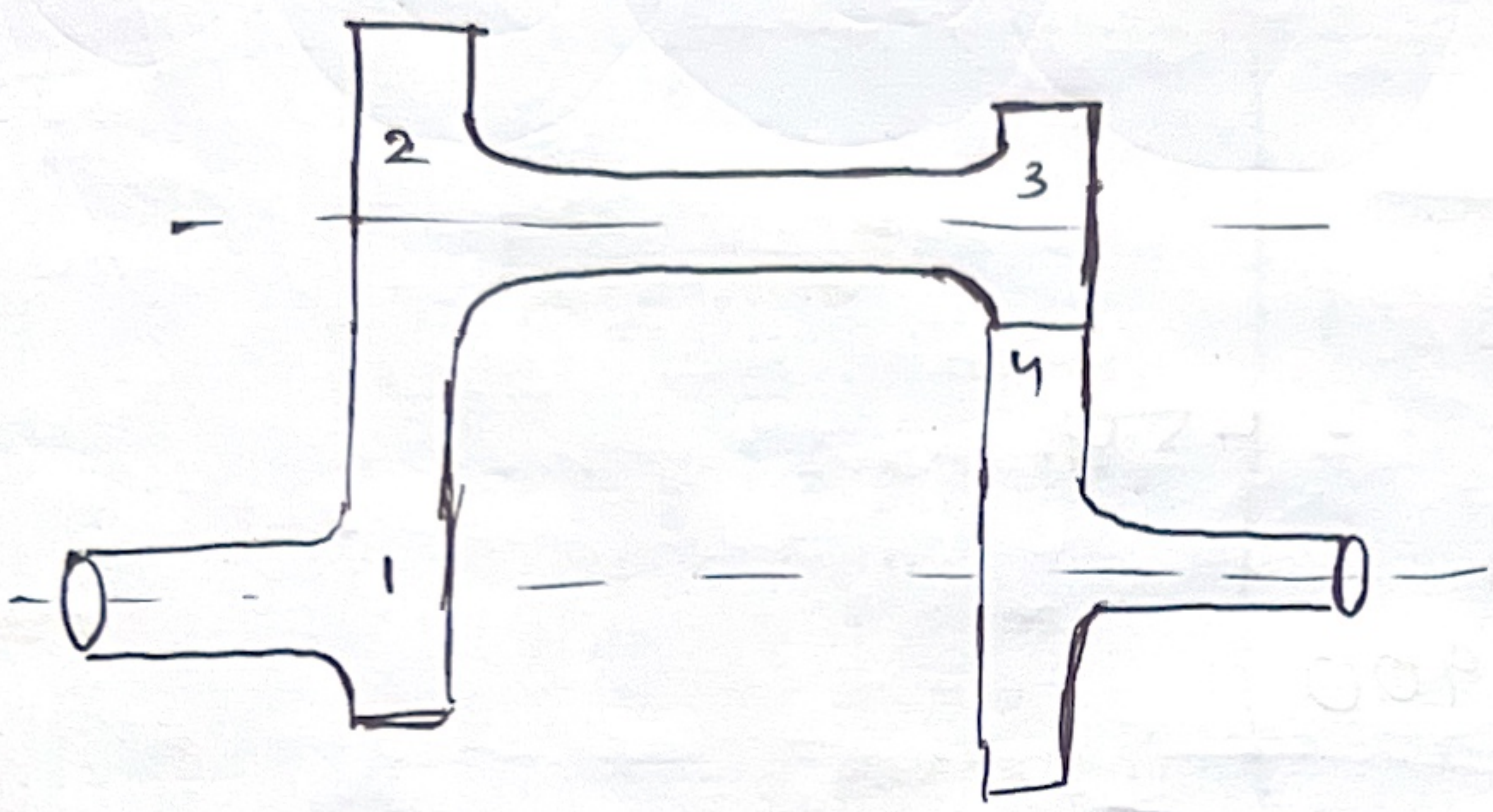


A. $\frac{N_F}{N_A} = \frac{T_A}{T_B} \times \frac{T_C}{T_D} \times \frac{T_E}{T_F}$

$\frac{N_F}{800} = \frac{24}{56} \times \frac{30}{80} \times \frac{32}{72}$

$N_F = 57.143$ rpm

Q3. A reverted G.T. shown is used to provide speed ratio of 10. Module of gear 1 & 2 is 3.2mm & 3 & 4 is 2mm, Determine suitable no. of teeth for each gear. No gear has less than 20 teeth. Centre distance b/w shafts is 160 mm.



A. $\frac{N_1}{N_2} = 2.5 = \frac{T_2}{T_1}$

$\frac{N_3}{N_4} = 4 = \frac{T_4}{T_3}$

$r_1 + r_2 = 160 \Rightarrow \frac{m_1 T_1}{2} + \frac{m_2 T_2}{2} = 160$

$r_3 + r_4 = 160 \Rightarrow \frac{m_3 T_3}{2} + \frac{m_4 T_4}{2} = 160$

$\cancel{3.2}(T_1 + T_2) = \overset{100}{\cancel{320}}$

$T_1 + 2.5T_1 = 100$

$3.5T_1 = 100$

$T_1 = 28$

$T_2 = 72$

$2(T_3 + T_4) = 320$

$2(T_3 + 4T_3) = 320$

$T_3 = \frac{160}{5} = 32$

$T_4 = 128$

$\Rightarrow V.R = \frac{T_2}{T_1} \times \frac{T_4}{T_3} = \frac{72}{28} \times \frac{128}{32} = 10.29$

4. 2 Spur gears A & B connected two $\parallel^{el}$ shafts are 450 mm apart. Gear A runs at double speed of gear B. Gear B runs at 150 rpm A. CW. If circular pitch is given to be 20, Calculate no. of teeth on gears A & B

A. $P = \frac{\pi d}{T}$

$C = \frac{d_1 + d_2}{2} = 450$

$d_1 + d_2 = 900$

$20 = \frac{\pi \times d_1}{T_1} = \frac{\pi d_2}{T_2}$

$\frac{20 T_1}{\pi} = d_1$ $\quad d_2 = \frac{20 T_2}{\pi}$

$\frac{N_1}{N_2} = 2 \Rightarrow N_1 = 300$

$\frac{T_2}{T_1} = 2 \Rightarrow T_2 = 2T_1$

$\frac{20}{\pi}(T_1 + T_2) = 900$

$\frac{20}{\pi}(T_1 + 2T_1) = 900$

$\frac{60}{\pi} T_1 = 900$

$T_1 = 47$

$T_2 = 94$