MIET2510

Mechanical Design

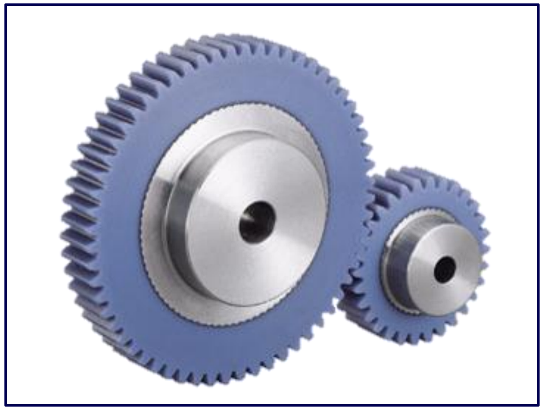
Week 6 – Gear Design – Part 1

School of Science and Technology, RMIT Vietnam

RMIT UNIVERSITY

Gear Introduction

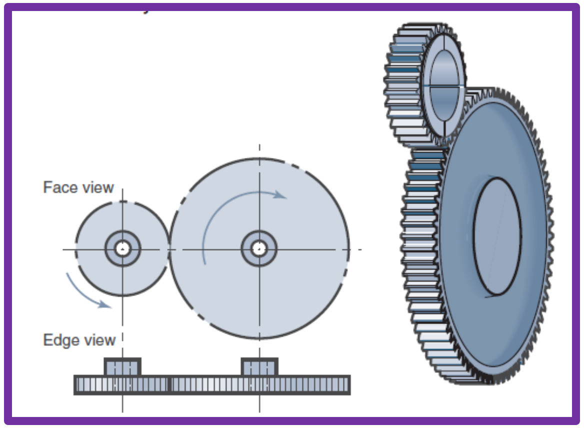
- **A gear** may be thought of as a toothed wheel that, when meshed with another smaller-in-diameter toothed wheel (the pinion), will **transmit rotational motion from one shaft to another**.
- The primary function of a gear is to **transfer power** from one shaft to another while maintaining a fixed ratio between the shaft angular velocities.

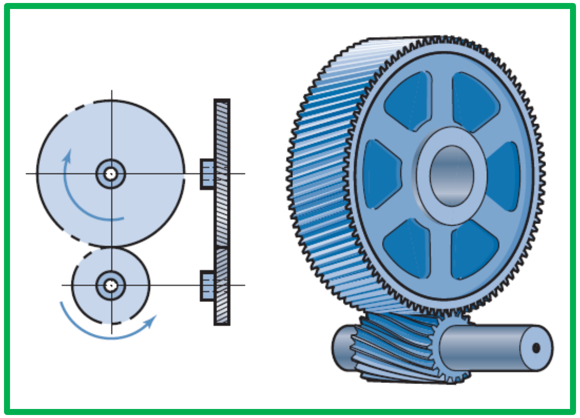


Classification of Gears

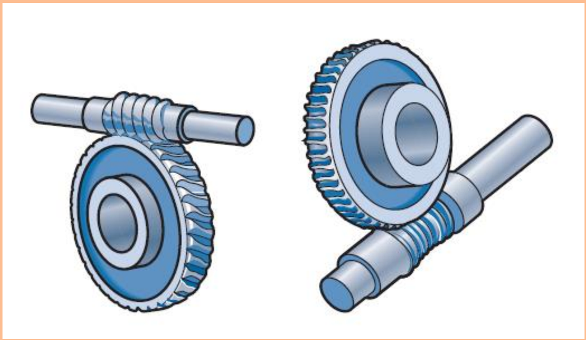
Gears can be divided into **three major classes**:

Parallel-axis gears





Nonparallel but coplanar gears



Nonparallel and noncoplanar gears

Gear Materials

Gear materials should have good strength, high stiffness, good wear resistance, good machinability, reasonable cost.

- Hardened steel
- Case hardened steel
- Bronze
- Iron – cast irons
- Non - metallic materials

Gear Materials Selection

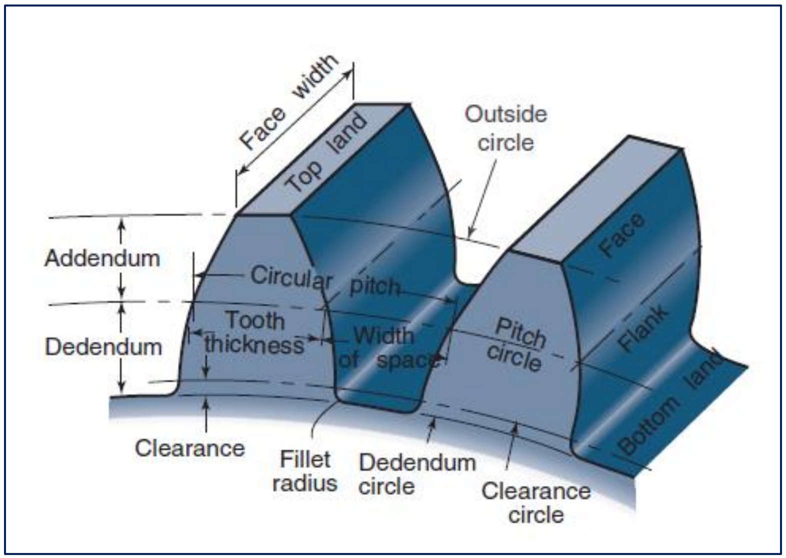
The selection of the gear material depends on:

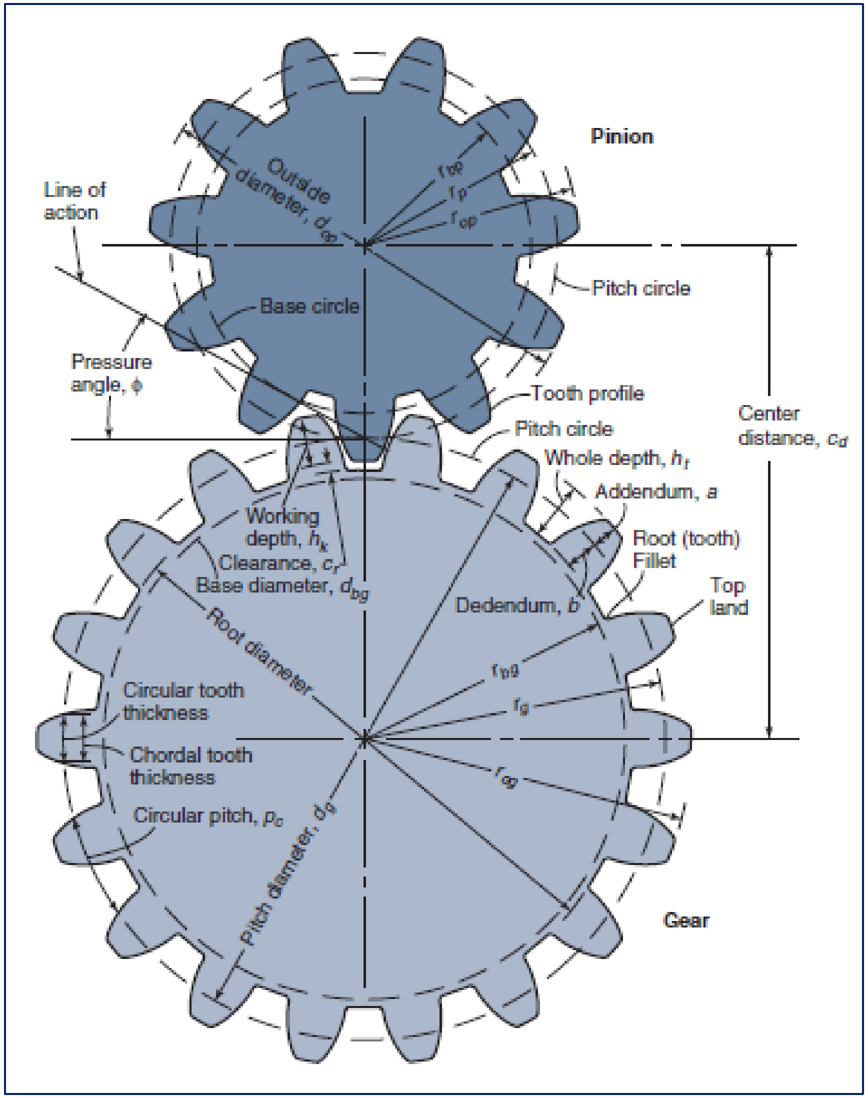
- Peripheral speed
- Degree of accuracy required
- Method of manufacturing
- Required dimensions and weight of the drive
- Allowable stress
- Wear resistance

Spur Gear

A spur gear is a cylindrical shaped gear, in which the teeth are parallel to the axis. It is the **most commonly used gear** with a wide range of applications and is the easiest to manufacture.

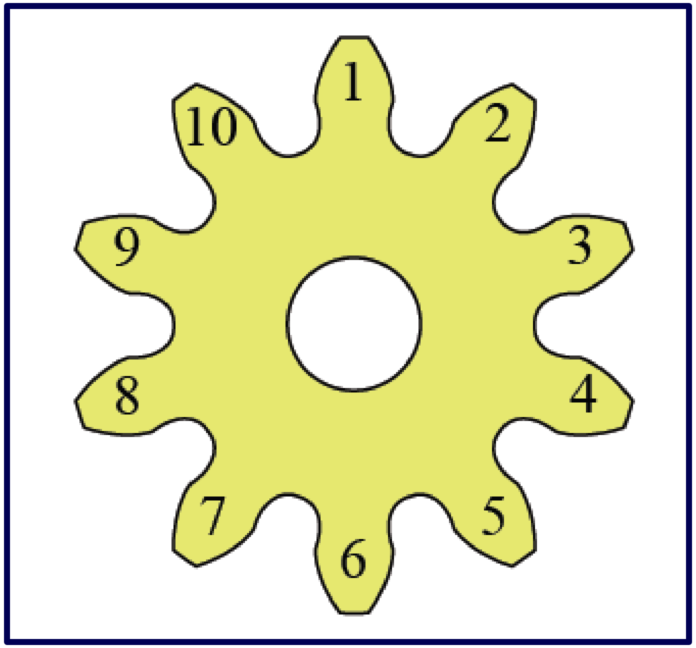
Gear Geometry





Gear Parameter – Fundamental Parameters

- **Number of teeth**: denotes the number of gear teeth.



Gear Parameter – Fundamental Parameters (cont.)

- **Module m**: Module is the ratio of the reference diameter of the gear divided by the number of teeth.

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

where D is the pitch circle diameter, mm

N is the number of the teeth

- **Circular pitch**: the distance from any selected reference point on a tooth to a corresponding point on the next tooth measured along the pitch circle

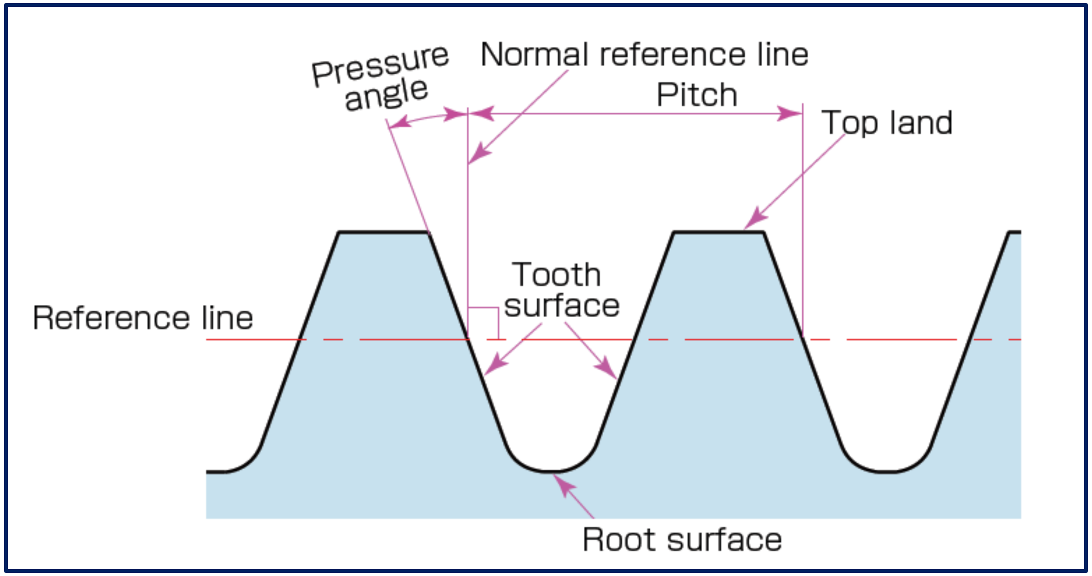
$$p = \frac{\pi D}{N}$$

where D is the pitch circle diameter, mm

N is the number of the teeth

Gear Parameter – Fundamental Parameters (cont.)

- **Pressure Angle**: is the leaning angle of a gear tooth, an element determining the tooth profile.



Gear Parameter – Related Parameters

- **Tooth Depth and Thickness**

- Tooth depth is determined from the size of module m.

$$h = 2.25\, m$$
$$(= \text{Addendum} + \text{Dedendum})$$

- Addendum is the distance between reference line and tooth tip

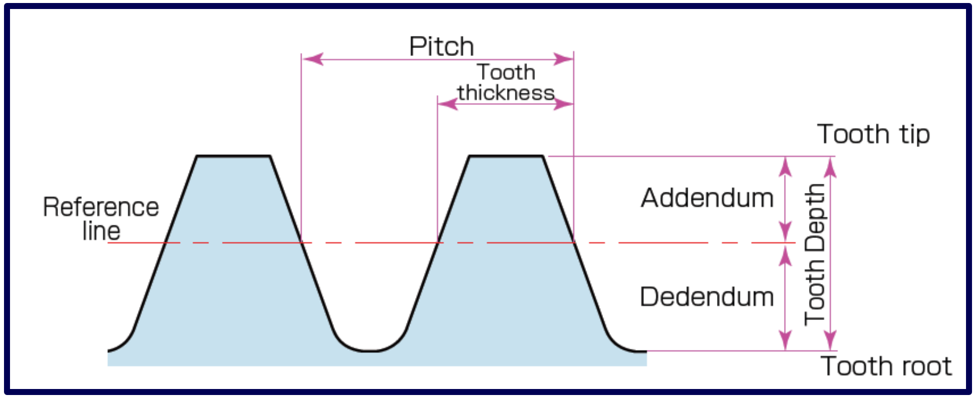
$$h_a = 1.00\, m$$

- Dedendum is the distance between reference line and tooth root

$$h_f = 1.25\, m$$

- Tooth thickness is half of the pitch

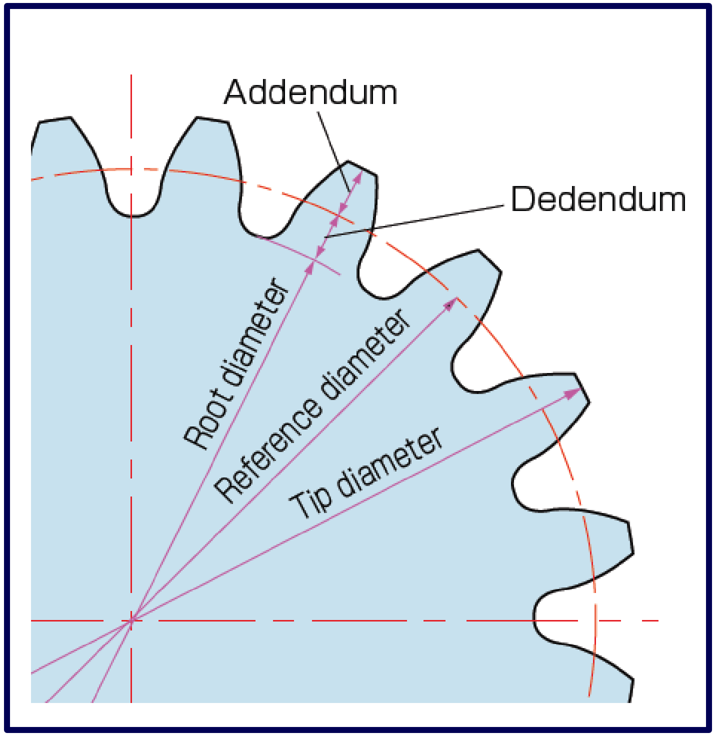
$$s = \frac{\pi m}{2}$$



Gear Parameter – Related Parameters (cont.)

- **Diameter of Gears (Size)**

- Reference Diameter $d = z\,m$
- Tip Diameter $d_a = d + 2\,m$
- Root Diameter $d_f = d - 2.5\,m$

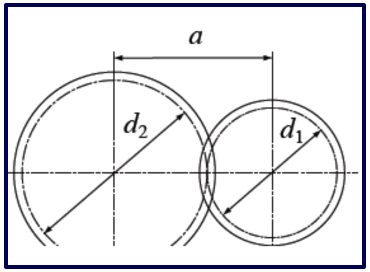


Gear Parameter – Related Parameters (cont.)

- **Centre distance and Backlash**

- When a pair of gears are meshed so that their reference circles are in contact, the centre distance (a) is half the sum total of their reference diameters.

$$a = \frac{(d_1 + d_2)}{2}$$



- It is important to consider a proper backlash (play) between tooth surfaces of paired gears, called Tip and Root clearance (c).

$$c = 1.25\,m - 1.00\,m$$
$$= 0.25\,m$$

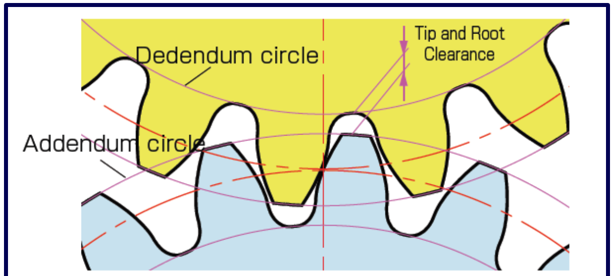


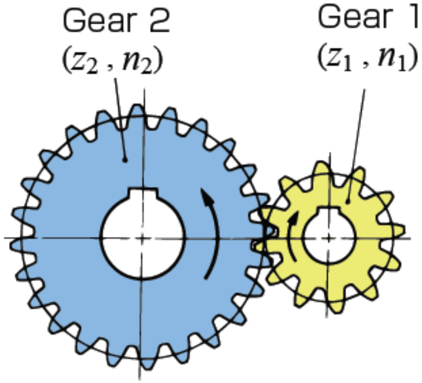
Fig. 2.8 Tip and Root Clearance

Gear Analysis

- **Speed Ratio for one – stage gear train:**

$$\text{Speed Ratio} = \frac{\text{No. of teeth of driven gear } (z_2)}{\text{No. of teeth of drive gear } (z_1)} = \frac{\text{Rotation of drive gear } (n_1)}{\text{Rotation of driven gear } (n_2)}$$

- **Rotational Direction:** The rotational direction of the paired gears is opposite to each other.

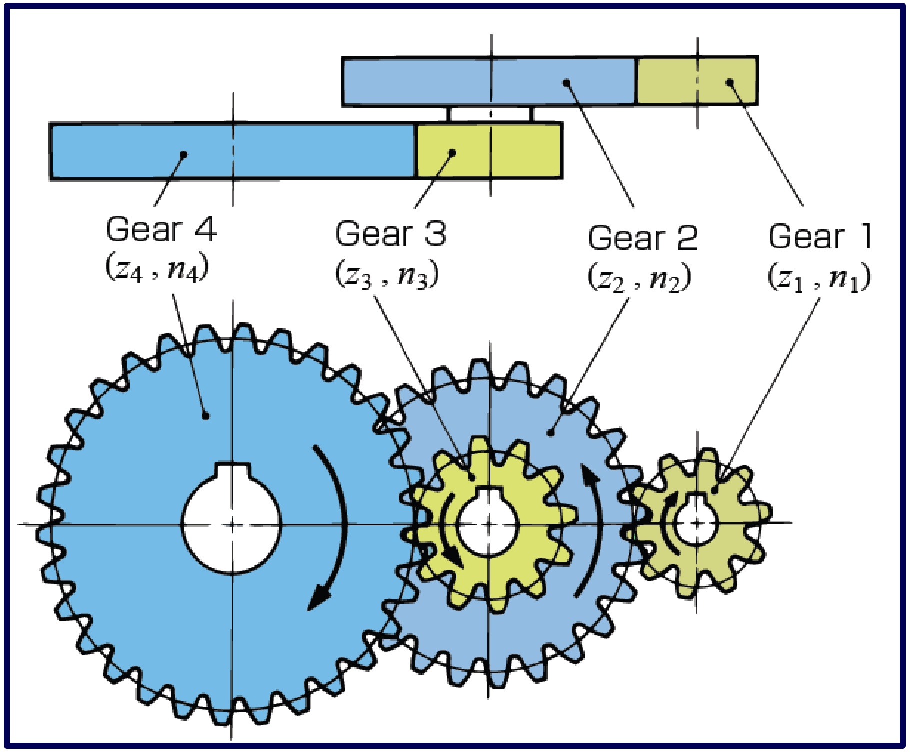


RMIT UNIVERSITY

Gear Analysis (cont.)

- **For two-stage gear train, speed ratio is presented as:**

$$i = \frac{z_2}{z_1} \times \frac{z_4}{z_3} = \frac{n_1}{n_2} \times \frac{n_3}{n_4}$$

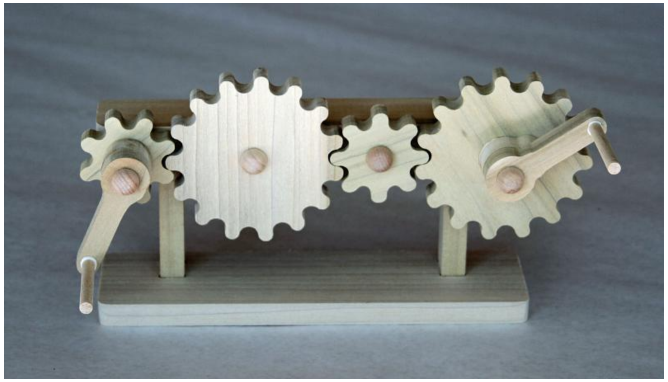


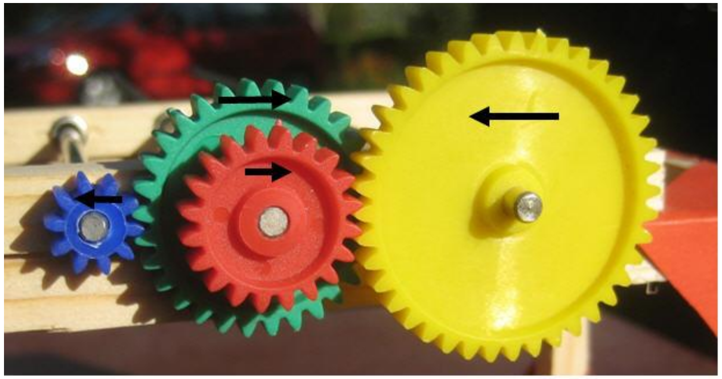
Gear Selection from Catalogue

- Material
- Module
- Number of Teeth
- Pitch Diameter
- Bore Diameter
- Tooth Finish (Standard or High Precision)
- Keyway (No or Yes)
- Allowable Torque

Gear Trains

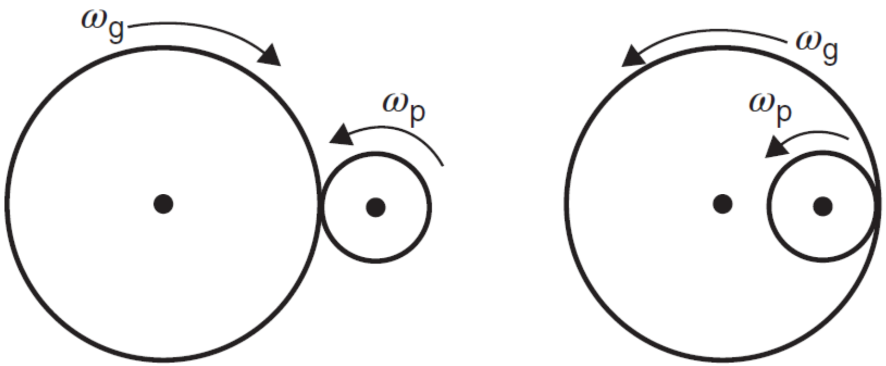
- **A simple gear train** is one with only one gear per shaft and each shaft rotating about a fixed axis.
- **A compound gear train** is one where two or more gears are fastened together and rotate about a common shaft.





Gear Ratio for meshing gear

- **The gear ratio for externally meshing gear** is considered to be negative since the two gears will rotate in opposite directions.
- **The gear ratio for internally meshing gears** is considered to be positive since both gears will rotate in the same direction

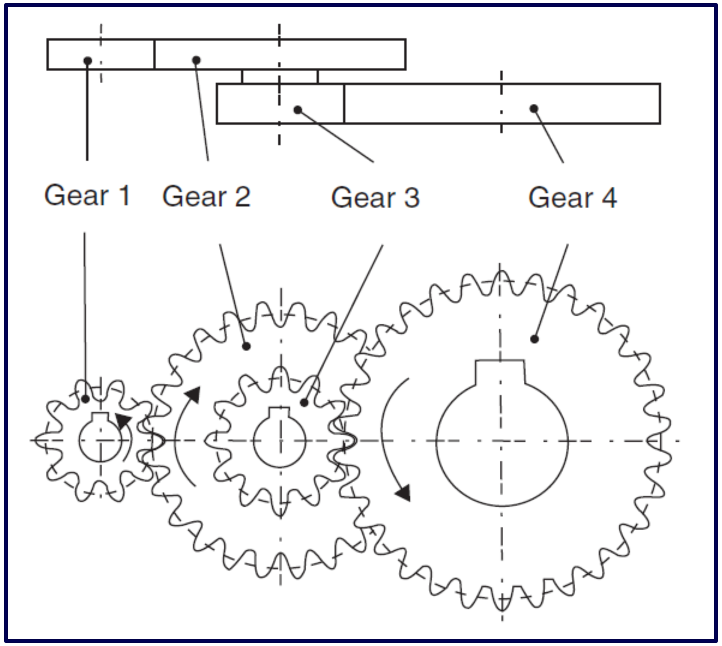


Externally meshing gears

Internally meshing gears

Compound Gear Train

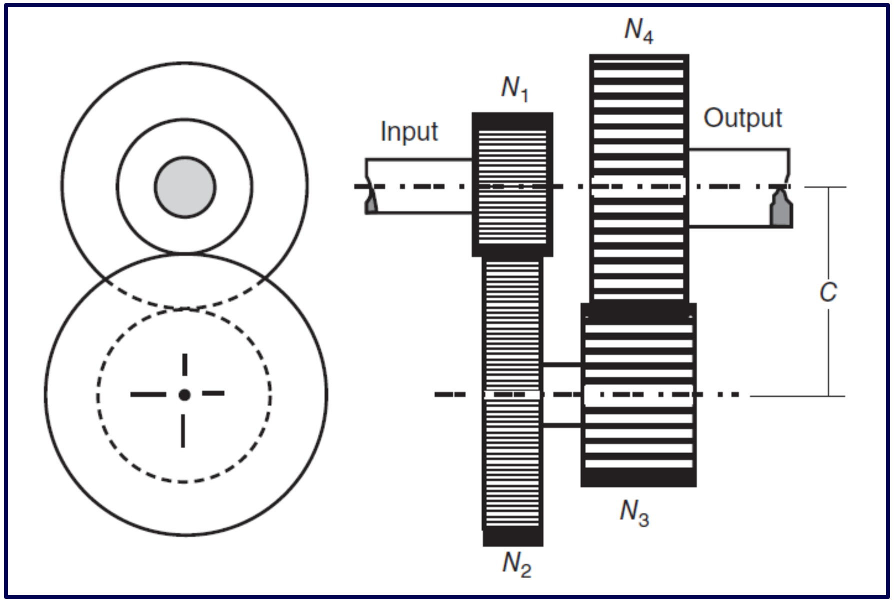
- **A compound gear train** consists of two or more sets of mating gears as shown.



$$\frac{\omega_{\text{out}}}{\omega_{\text{in}}} = \left(-\frac{N_1}{N_2}\right)\left(-\frac{N_3}{N_4}\right) = +\frac{N_1 N_3}{N_2 N_4}$$

Inverted Compound Gear Train

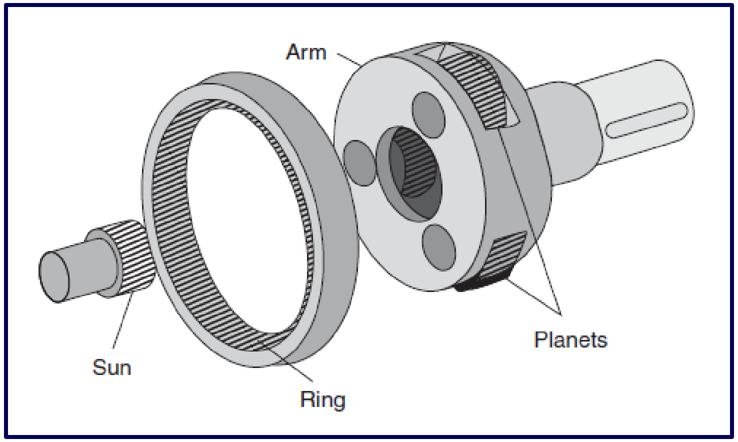
- **The inverted compound gear train** is such that the input shaft and the output shafts are along the same centreline as shown.

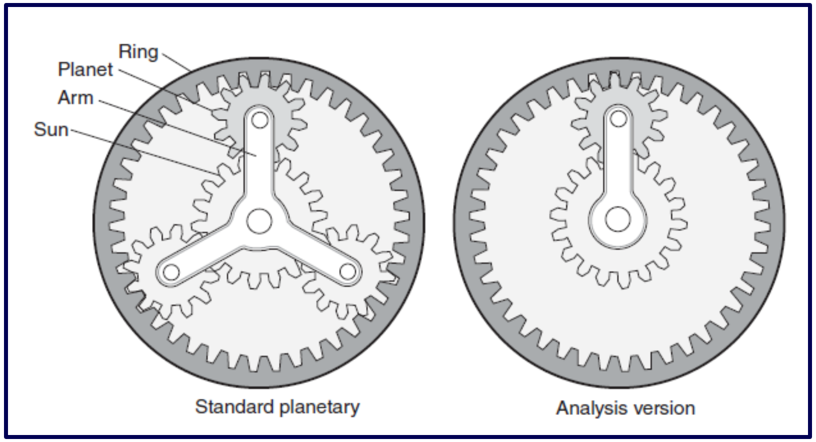


$$\frac{\omega_{out}}{\omega_{in}} = \left(-\frac{N_1}{N_2}\right)\left(-\frac{N_3}{N_4}\right) = +\frac{N_1 N_3}{N_2 N_4}$$

Planetary Gear Systems

A gear train in which the axis of one or more gears moves relative to the frame is referred to as a planetary or elliptical gear train. The gear at the center is called the **sun** since gears revolve around it. The outer gear is referred to as the **ring** gear. The gears between the ring gear and the sun gear are referred to as **planet gears** since they revolve around the sun gear.





Thank you for your attendance :D

Copyright Claim

RMIT UNIVERSITY

Reference

- *Mechanical Design of Machine Components (2nd) by Ansel C.Ugural.*
- *Mechanical Engineering Design (10th) by Richard G.Budynas and J. Keith Nisbett.*
- *Theory of Machines and Mechanisms (5th) by John J.Uicker, Gordon R.Pennock, Joseph E. Singley.*