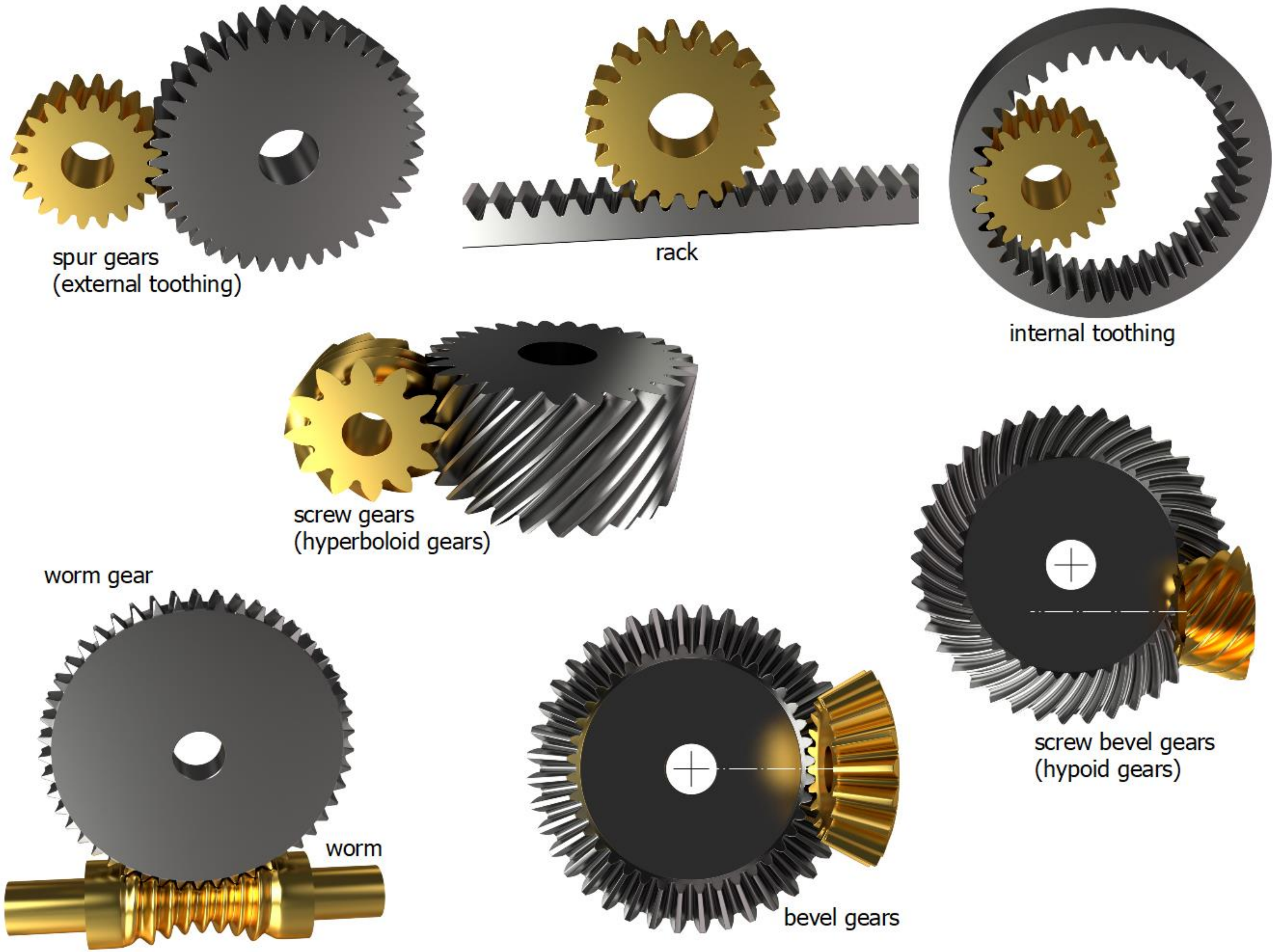
Gears

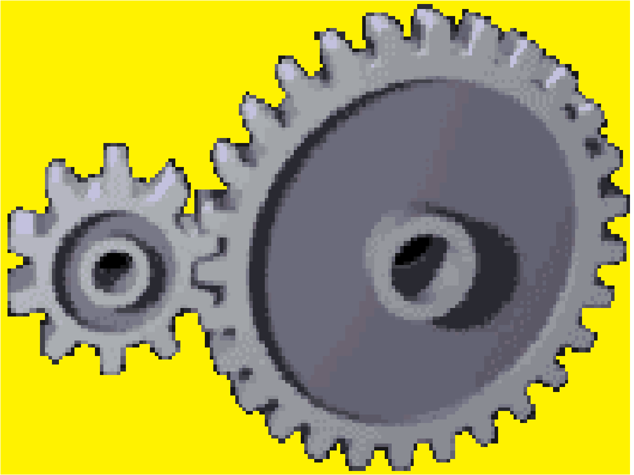


spur gears
(external toothing)
rack
internal toothing
screw gears
(hyperboloid gears)
worm gear
worm
bevel gears
screw bevel gears
(hypoid gears)

Gears

A gear is a wheel with teeth on its outer edge.

The teeth of one gear mesh (or engage) with the teeth of another.



Above

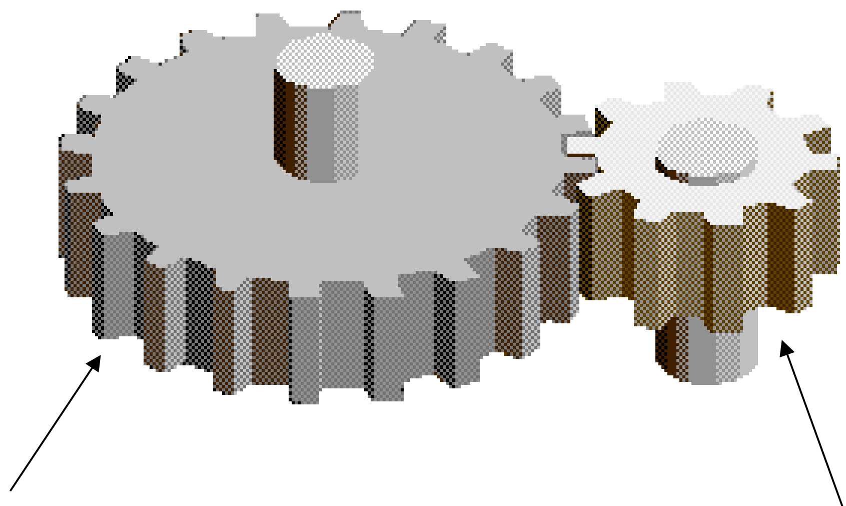
Gears meshing or engaged

Gears

Driver and Driven

- ***Two meshed gears always rotate in opposite directions.***

Spur Gears

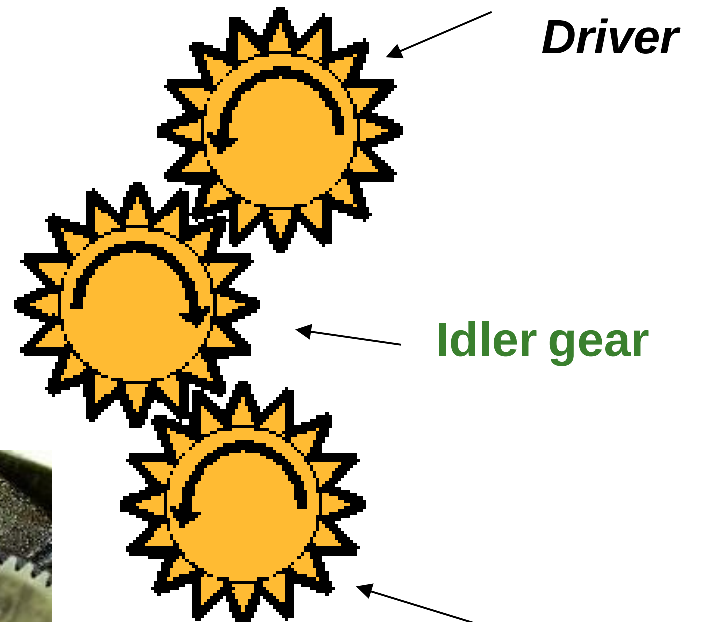


Driven gear

Driver gear

Gears

Idler gear



Classification of Gears:

1. According to the position of axes of the shafts:
    1. Parallel
    2. Intersecting, and
    3. Non intersecting and non parallel
2. According to the peripheral velocity of the gears:
    1. Low Velocity (<3m/s)
    2. Medium Velocity (3 to 15 m/s)
    3. High Velocity(>15m/s)
3. According to the type of gearing
    1. External
    2. Internal, and
    3. Rack and pinion
4. According to the position of teeth on the gear surface
    1. Straight
    2. Inclined, and
    3. Curved

Gears are toothed cylindrical wheels used for transmitting mechanical power from one rotating shaft to another.

Several types of gears are in common use. Four principal types of gears are:

- Spur gears
- Helical gears
- Bevel gears
- Worm gears.

Spur Gears

- Teeth are parallel to the axis of the gear
- Advantages
  - Cost
  - Ease of manufacture
  - Availability
- Disadvantages
  - Only works with mating gear
  - Axis of each gear must be parallel

FIGURE 9-14

A spur gear
Courtesy of Martin Sprocket and Gear Co., Arlington, TX

Gears are toothed cylindrical wheels used for transmitting mechanical power from one rotating shaft to another.

Several types of gears are in common use. Four principal types of gears are:

- Spur gears
- Helical gears
- Bevel gears
- Worm gears.

Helical Gears

- Teeth are at an angle to the gear axis (usually 10° to 45°) – called helix angle
- Advantages
  - Smooth and quiet due to gradual tooth engagements (spur gears whine at high speed due to impact). Helical gears good up to speeds in excess of 5,000 ft/min
  - More tooth engagement allows for greater power transmission for given gear size.
- Disadvantage
  - More expensive
  - Resulting axial thrust component

FIGURE 9-16

Parallel axis helical gears

Courtesy of Martin Sprocket and Gear Co., Arlington, TX

(*a*) Helical gear

Helical Gears

- Mating gear axis can be parallel or crossed
- Can withstand the largest capacity at 30,000 hp

FIGURE 9-17

Crossed axis helical gears

Courtesy of the Boston Gear Division of IMO Industries, Quincy, MA

Double Helical gears are known as herringbone gears

Double Helical Gears

Gears are toothed cylindrical wheels used for transmitting mechanical power from one rotating shaft to another.

Several types of gears are in common use. Four principal types of gears are:

- Spur gears
- Helical gears
- Bevel gears
- Worm gears.

Bevel Gears

- Gear axis at 90°, based on rolling cones
- Advantages
  - Right angle drives
- Disadvantages
  - Get axial loading which complicates bearings and housings

FIGURE 9-21
Straight bevel gears
Courtesy of Martin Sprocket and Gear, Arlington, TX

Intersecting but coplanar shafts

Helical bevel gears

Mitres: Equal teeth and mutually perpendicular

Spiral Bevel Gears

Not intersecting and non parallel-
Skew bevel or spiral

- Same advantage over bevel gears as helical gears have over spur gears!!
- Teeth at helix angle
- Very Strong
- Used in rear end applications (see differentials)

FIGURE 9-22
Spiral bevel gears
Courtesy of the Boston Gear Division of IMO Industries, Quincy, MA

Gears are toothed cylindrical wheels used for transmitting mechanical power from one rotating shaft to another.

Several types of gears are in common use. Four principal types of gears are:

- Spur gears
- Helical gears
- Bevel gears
- Worm gears.

Worm Gears

- **Gears that are 90° to each other**
- **Advantages**
  - Quiet / smooth drive
  - Can transmit torque at right angles
  - No back driving
  - Good for positioning systems
- **Disadvantage**
  - Most inefficient due to excessive friction (sliding)
  - Needs maintenance
  - Slower speed applications

FIGURE 9-18

A worm and worm gear (or worm wheel)
Courtesy of Martin Sprocket and Gear Co., Arlington, TX

According to the type of gearing

1. External Gearing
   - Larger is Spur Wheel
   - Smaller is Pinion
   - Motion of the two wheels is unlike
2. Internal Gearing
   - Larger is Annular Wheel
   - Smaller is Pinion
   - Motion of the two wheels is like
3. Rack and Pinion
   - Gears in a straight line

Rock and Pinion

Internal Gearing

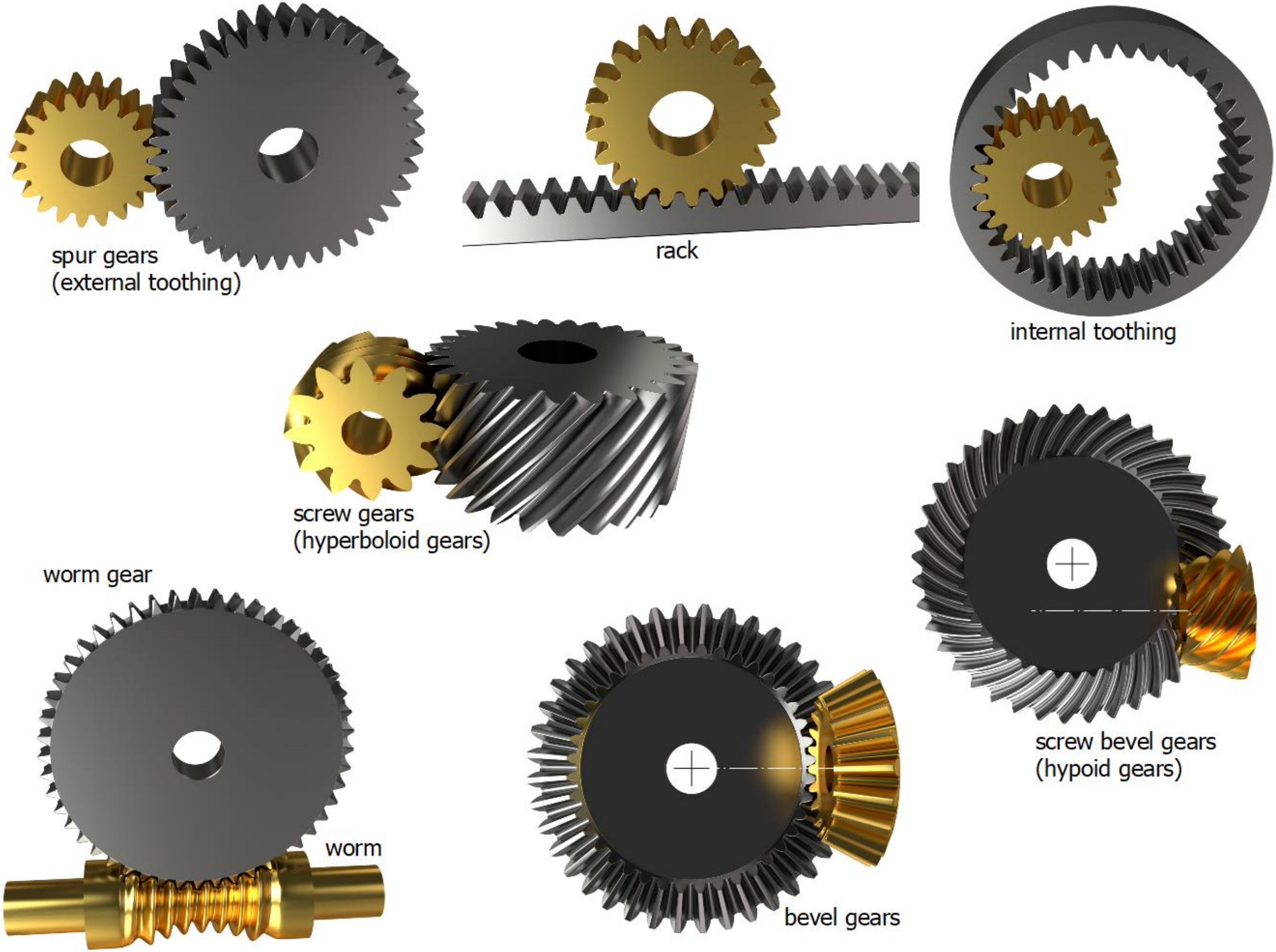
According to the position of teeth on gear surface

1. Straight
   - Spur
2. Inclined
   - Helical
3. Curved
   - Spiral

Helical

Spiral

Worm


spur gears
(external toothing)
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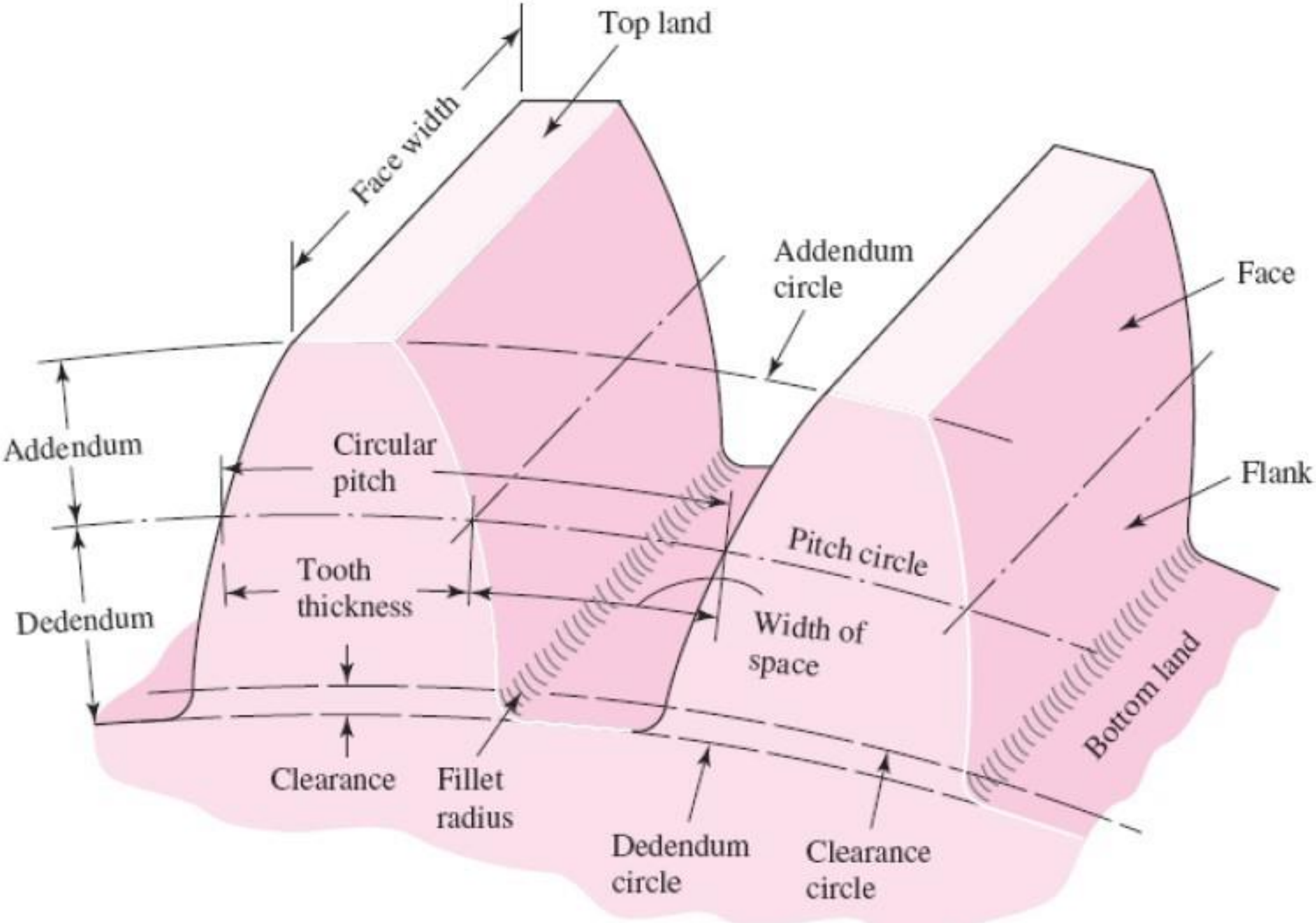
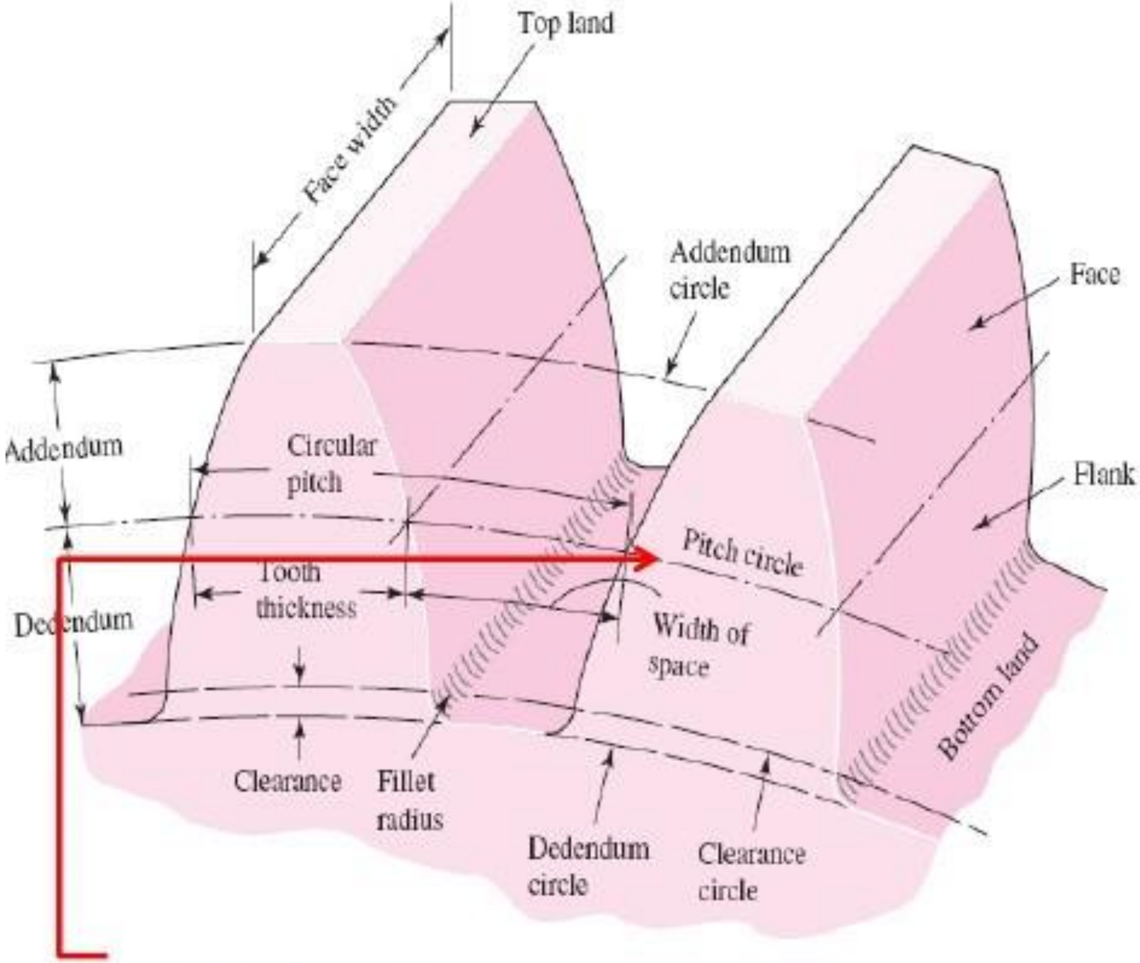
(hyperboloid gears)
worm gear
worm
bevel gears
screw bevel gears
(hypoid gears)


Top land
Face width
Addendum circle
Face
Addendum
Circular pitch
Flank
Pitch circle
Tooth thickness
Dedendum
Width of space
Bottom land
Clearance
Fillet radius
Dedendum circle
Clearance circle



$P =$ diametral pitch, teeth per inch

$N =$ number of teeth

$d =$ pitch diameter, in

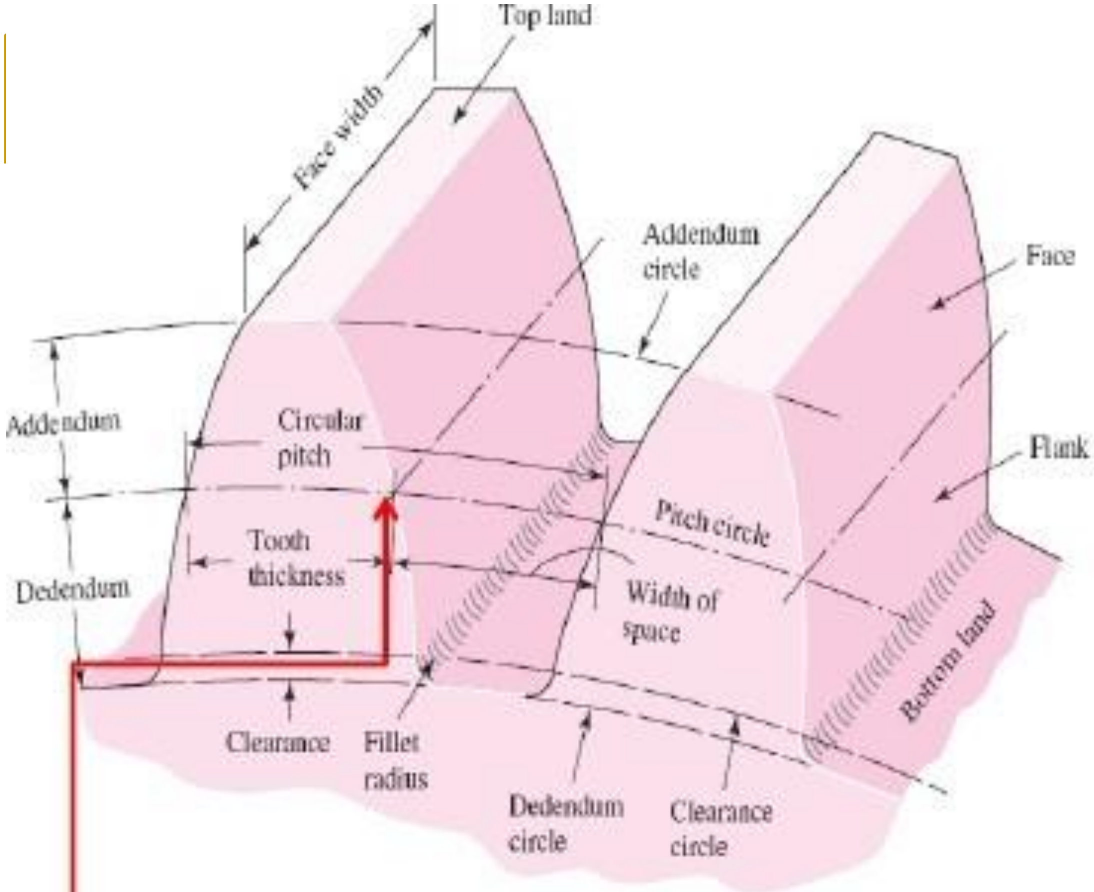
$m =$ module, mm

$d =$ pitch diameter, mm

$p =$ circular pitch

Pitch circle. This is a theoretical circle on which calculations are based. Its diameter is called the pitch diameter.

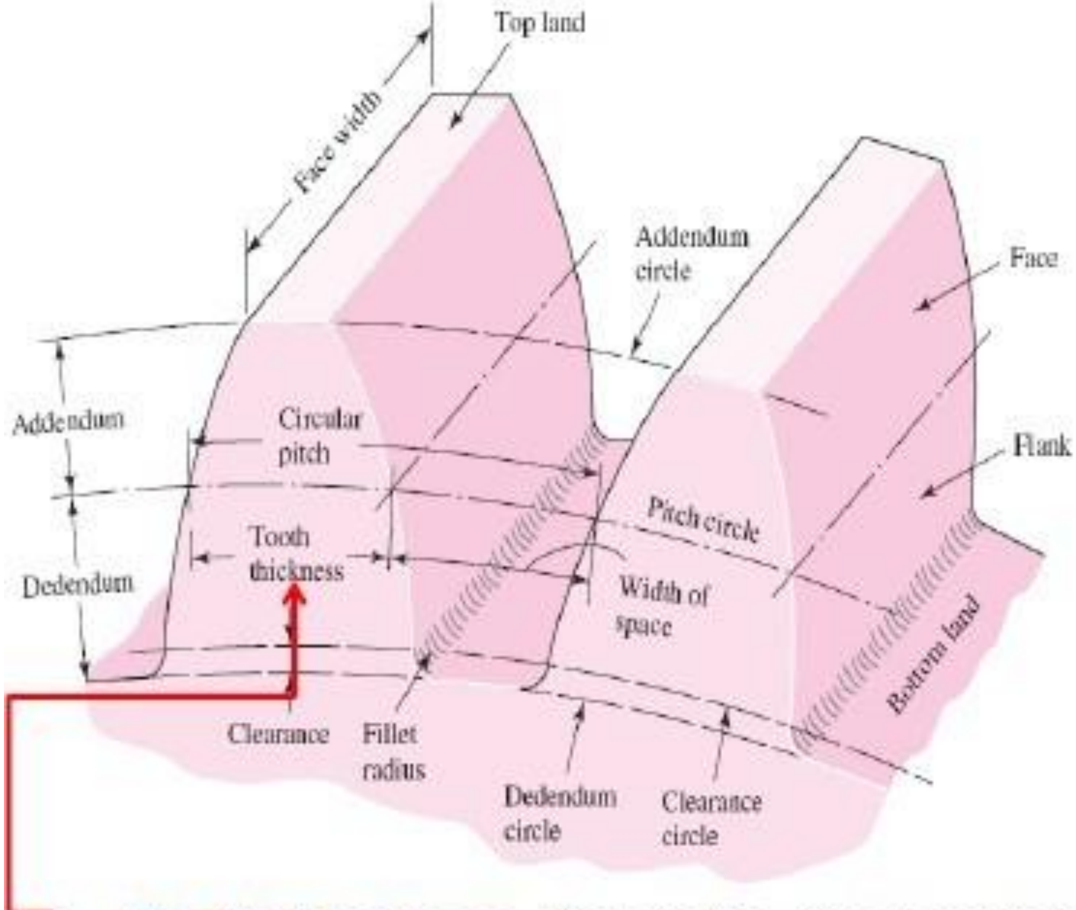
$$d = mN$$



P = diametral pitch, teeth per inch
N = number of teeth
d = pitch diameter, in
m = module, mm
d = pitch diameter, mm
p = circular pitch

Circular pitch. This is the distance from a point on one tooth to the corresponding point on the adjacent tooth measured along the pitch circle.

$$p = \frac{\pi d}{N} = \frac{\pi}{P} = \pi m$$



P = diametral pitch, teeth per inch

N = number of teeth

d = pitch diameter, in

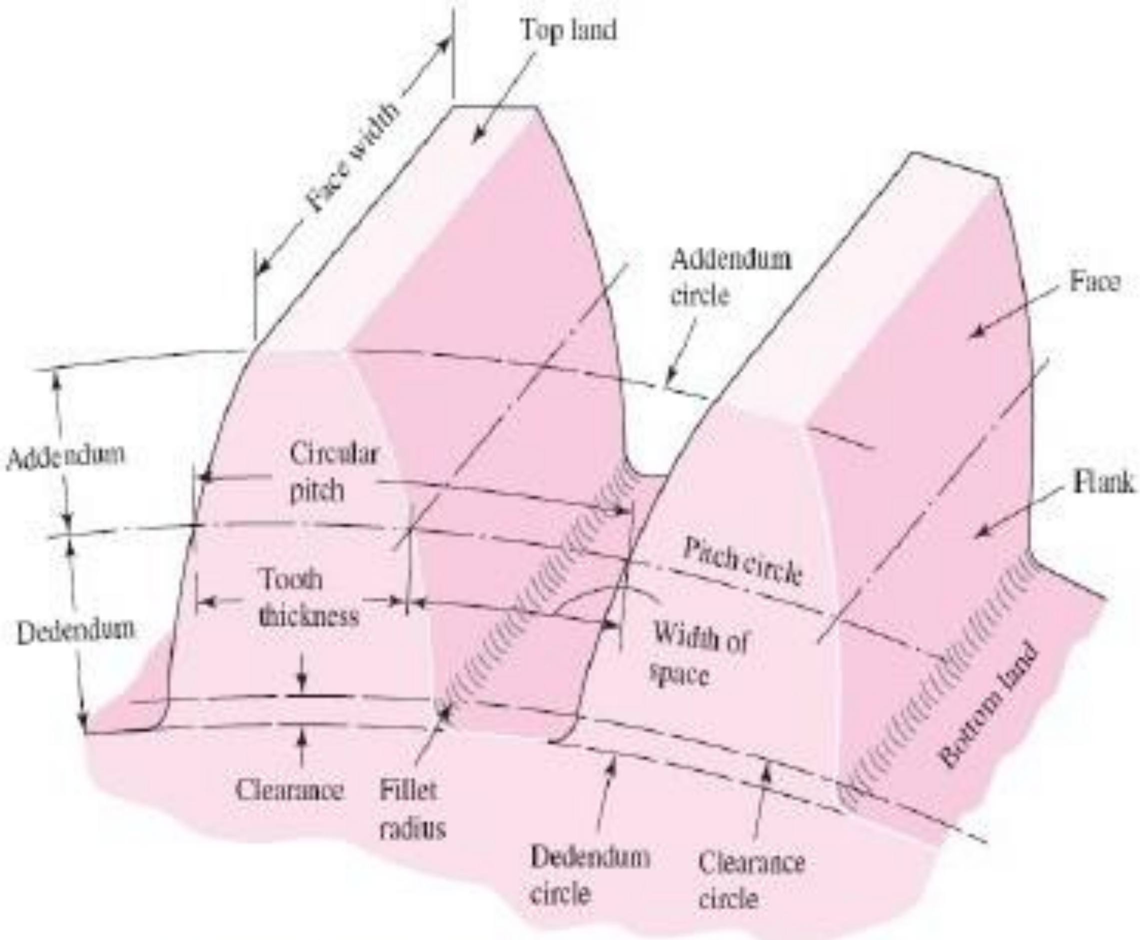
m = module, mm

d = pitch diameter, mm

p = circular pitch

Tooth thickness. This is the distance from a point on one face of tooth to the corresponding point on the adjacent face of the same tooth measured along the pitch circle.

$$t = \frac{p}{2}$$



P = diametral pitch, teeth per inch

N = number of teeth

d = pitch diameter, in

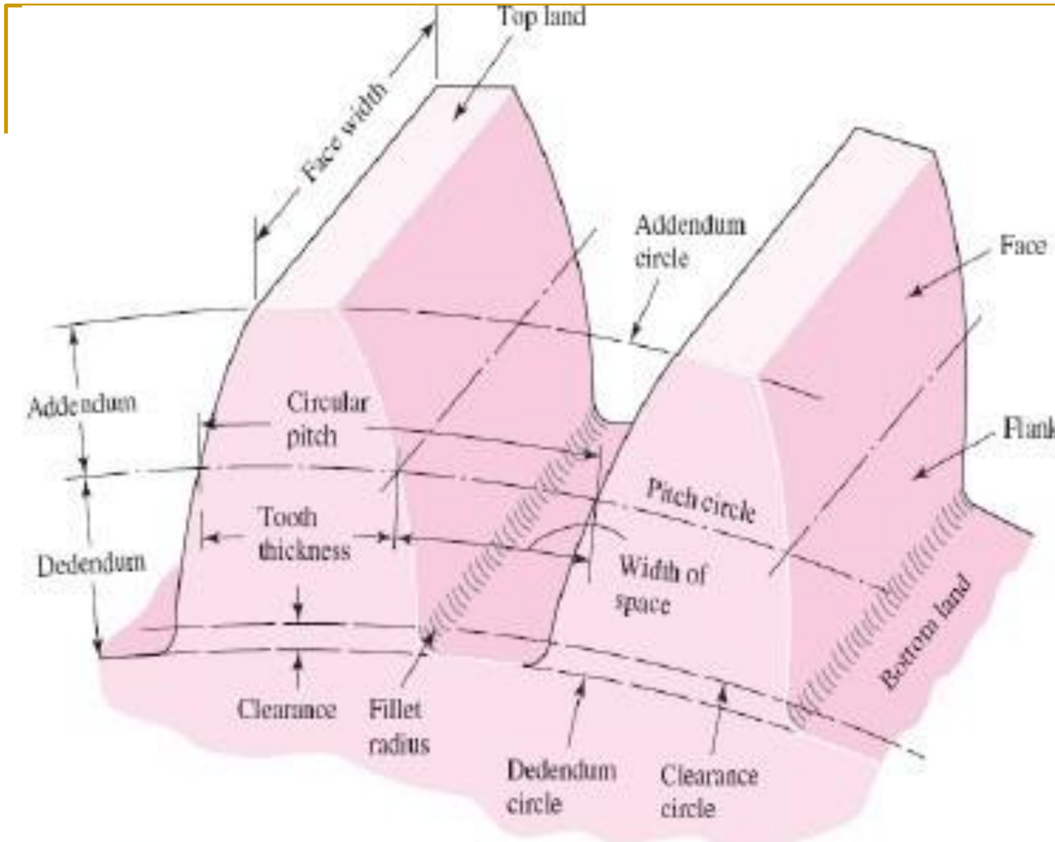
m = module, mm

d = pitch diameter, mm

p = circular pitch

Module. This is the ratio of the pitch diameter to the number of teeth. The unit of the module should be millimeters (mm). The module is defined by the ratio of pitch diameter and number of teeth.

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



P = diametral pitch, teeth per inch

N = number of teeth

d = pitch diameter, in

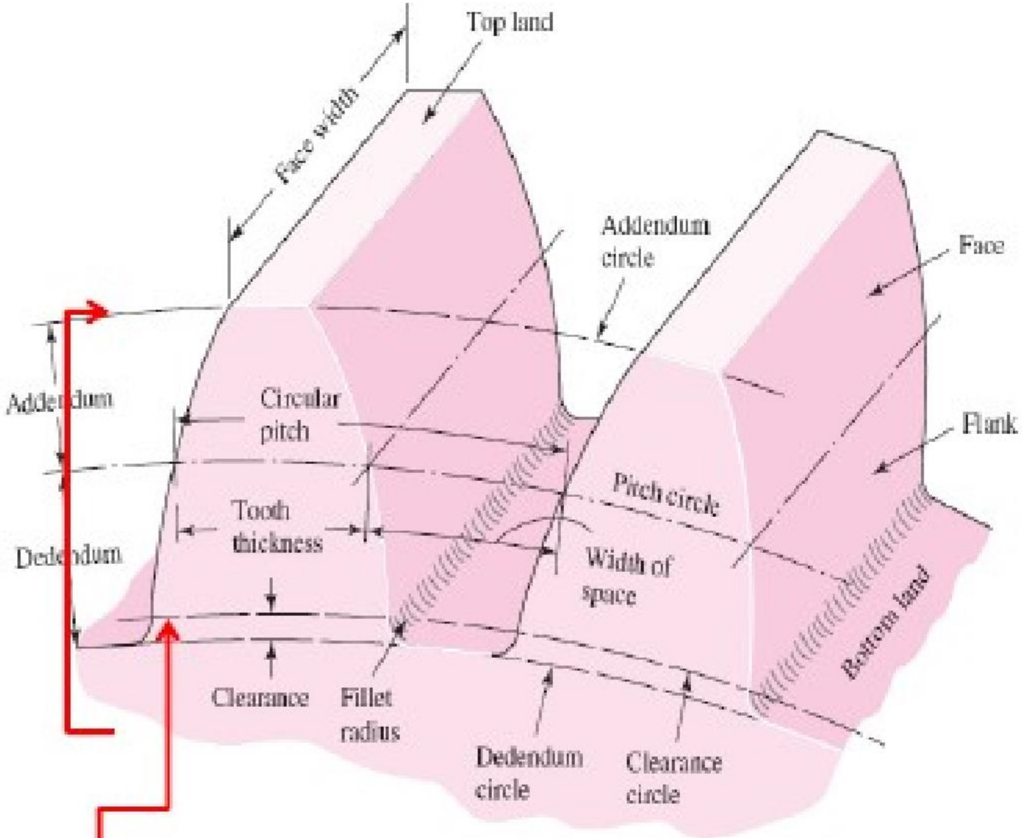
m = module, mm

d = pitch diameter, mm

p = circular pitch

Diametral pitch. This is the ratio of the number of teeth to the pitch diameter. Thus, it is the reciprocal of the module. Since diametral pitch is used only with U.S. units, it is expressed as teeth per inch.

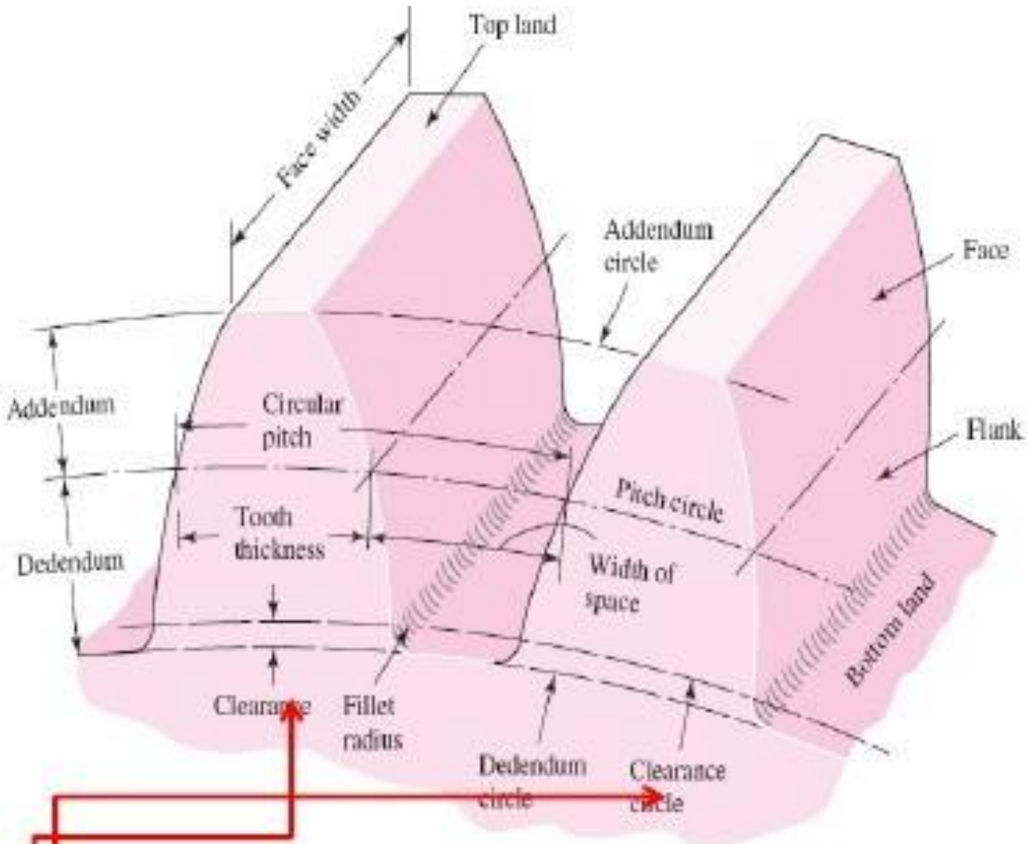
$$P = \frac{N}{d}$$



P = diametral pitch, teeth per inch
N = number of teeth
d = pitch diameter, in
m = module, mm
d = pitch diameter, mm
p = circular pitch

Addendum, a. This is the radial distance from the pitch circle to the outside of the tooth.

Dedendum, b. This is the radial distance from the pitch circle to the bottom land.



P = diametral pitch, teeth per inch

N = number of teeth

d = pitch diameter, in

m = module, mm

d = pitch diameter, mm

p = circular pitch

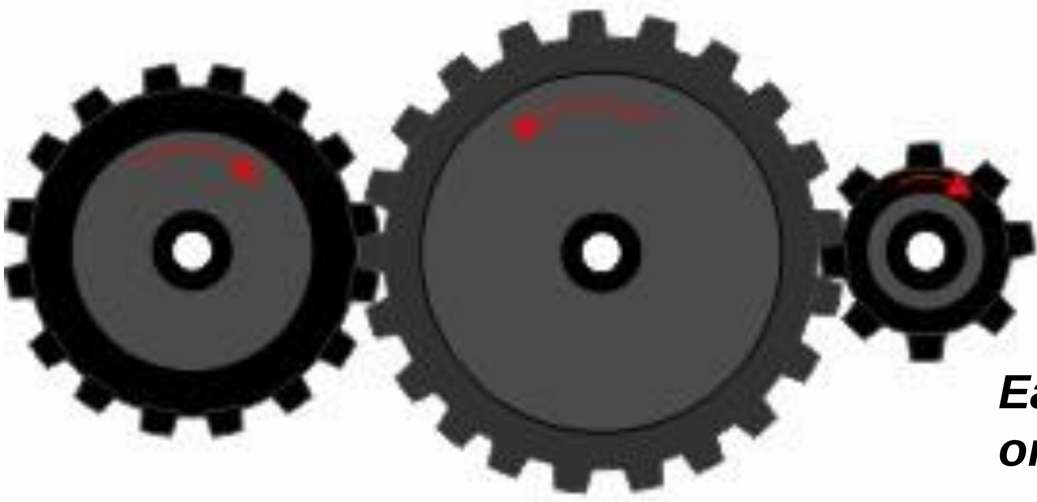
Clearance circle. This is a circle that is tangent to the addendum circle of the mating gear.

Clearance, c. This is the is the amount by which the dedendum in a given gear exceeds the addendum of its mating gear.

Gears

Simple Gear Train

- ***Multiple gears can be connected together to form a gear train.***



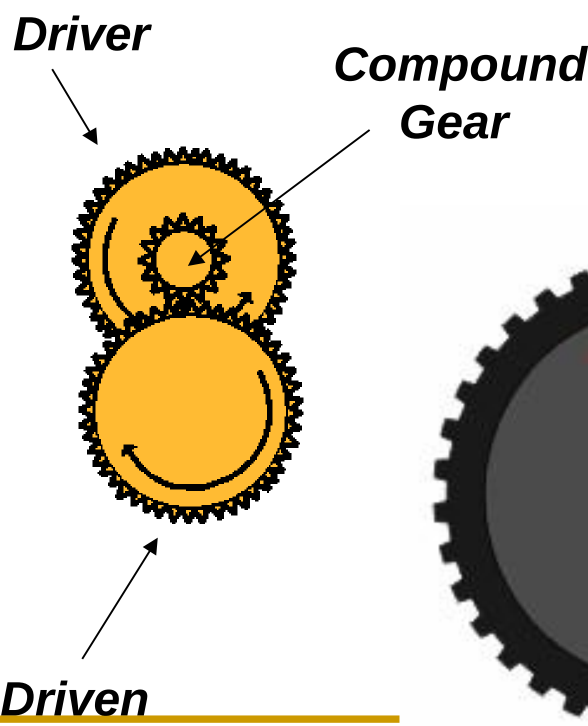
Each shaft carries only one gear wheel.

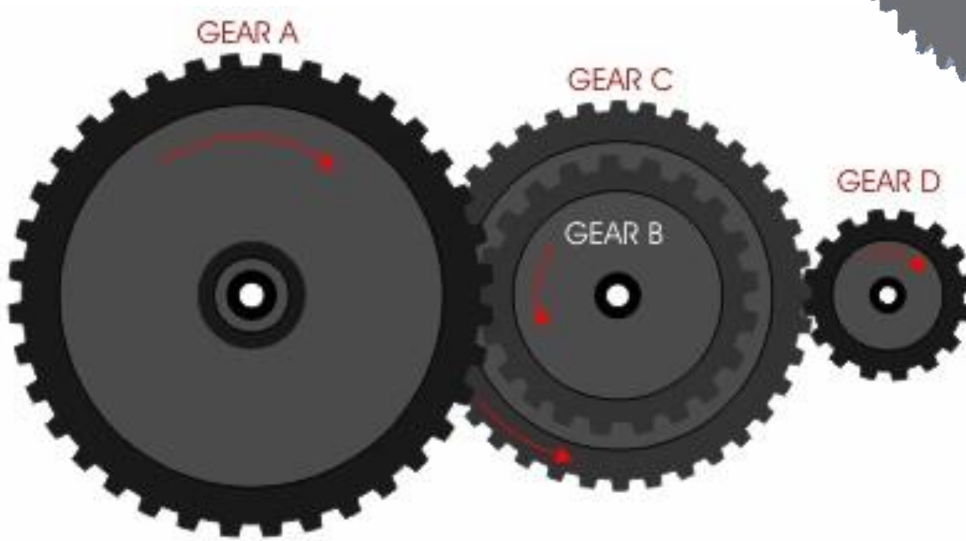
Intermediate gears are known as Idler Gears.

Gears

Compound Gear Train

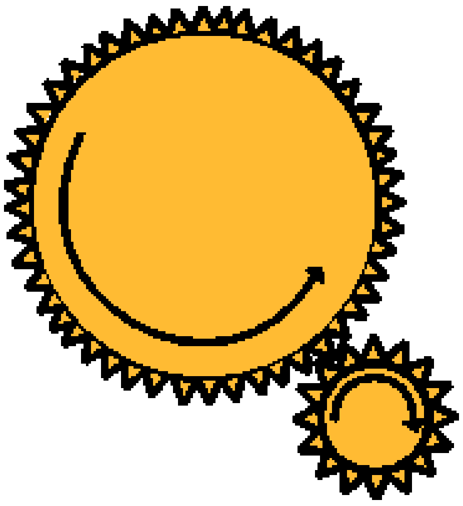
If two gear wheels are mounted on a common shaft then it's a Compound Gear train.





Gears

Gear Ratio

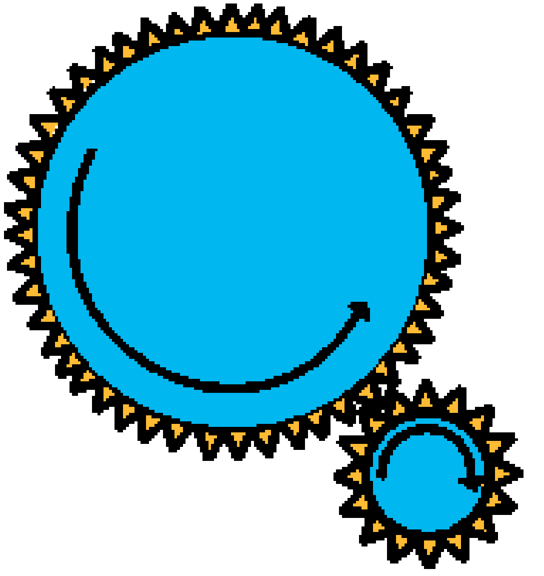


- ***Generally, the Gear Ratio is calculated by counting the teeth of the two gears, and applying the following formula:***

$$\text{Gear ratio} = \frac{\text{Number of teeth on driven gear}}{\text{Number of teeth on driver gear}}$$

Gears

Gear Ratio - Calculation



A 100 tooth gear drives a 25 tooth gear. Calculate the gear ratio for the meshing teeth.

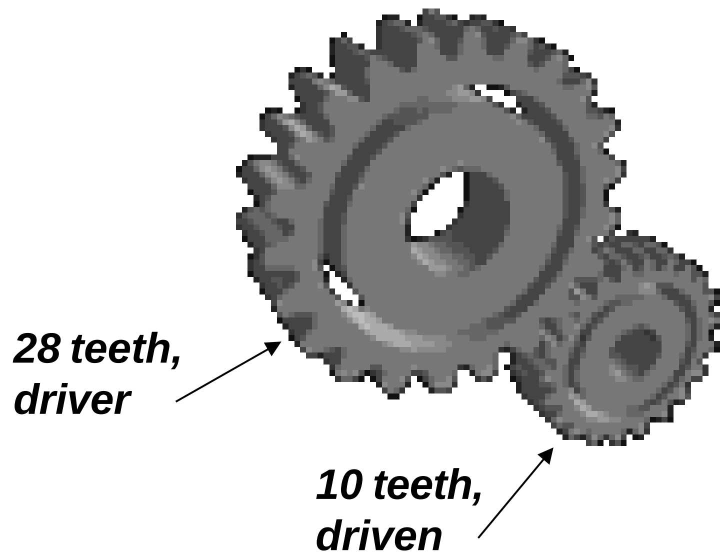
Gear ratio =	$\dfrac{\textbf{Number of teeth on driven gear}}{\textbf{Number of teeth on driver gear}}$

Gear ratio =	driven / driver	25 / 100	=	1 / 4
	This is written as			1:4

Gears

Gear Speed :- Calculation

A motor gear has 28 teeth and revolves at 100 rev/min. The driven gear has 10 teeth. What is its rotational speed?



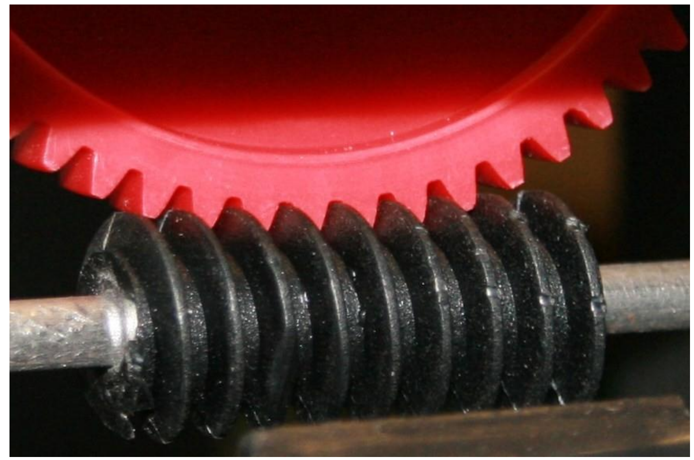
Speed of driven gear = $\dfrac{\textbf{Number of teeth on driver gear}}{\textbf{Number of teeth on driven gear}} \times 100$

Speed of driven gear = $\dfrac{\textbf{driver}}{\textbf{driven}} = \dfrac{28}{10} \times 100 = 280$ **rev/min**

Gears

Worm gear and wheel

- ***The worm gear is always the drive gear***

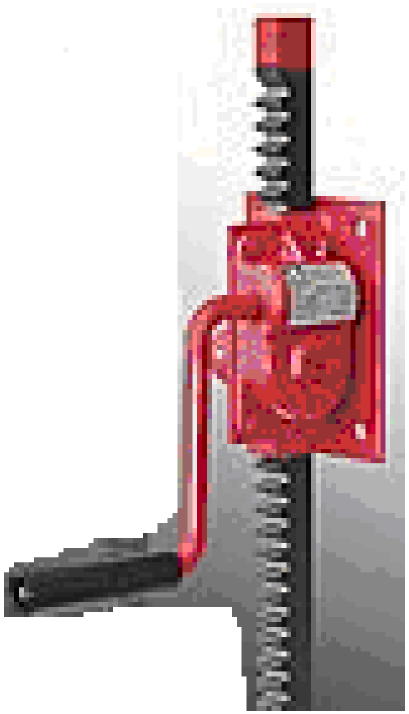


Worm and wheel

Gears

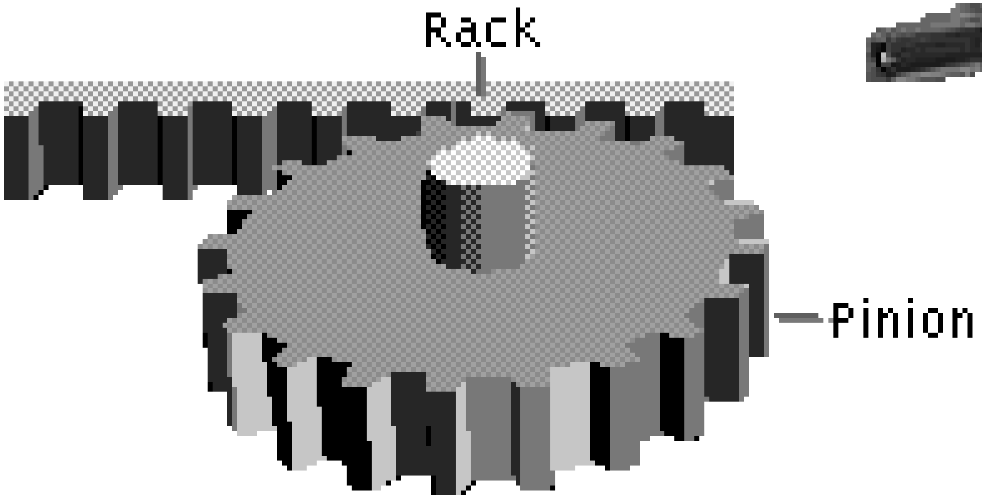
Rack and Pinion

- ***The rack and pinion gear is used to convert between rotary and linear motion.***



Heavy Duty

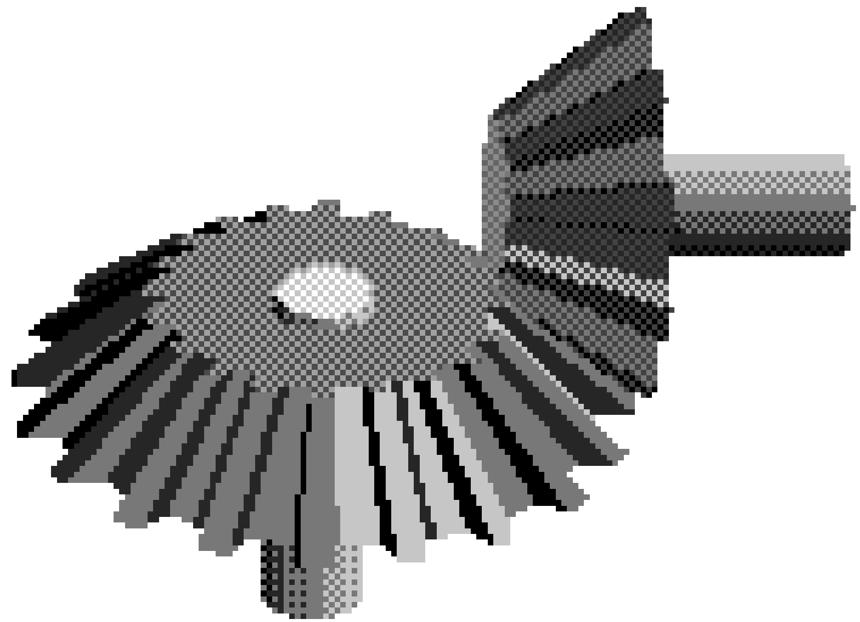
Car Jack



Gears

Bevel gears

- ***Bevel gears are used to transfer drive through an angle of 90^o.***



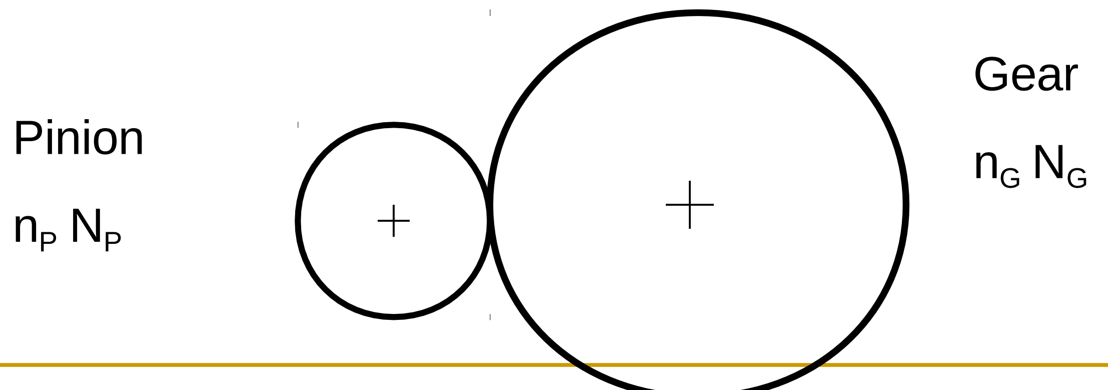
Bevel Gears

Gears used for Speed Reducer

- Recall the main purpose of mating/meshing gears is to provide speed reduction or torque increase.

$$Pitch\ line\ speed = v_t = R\omega = (D/2)\omega$$

$$Velocity\ Ratio = VR = \frac{n_P}{n_G} = \frac{N_G}{N_P} = \frac{N_{driven}}{N_{driver}}$$



$$v_t(ft/\min) = (\pi D n/12)$$

Example:

Want a 3:1 reduction

- N_P=22 teeth
- What is N_G?
- Solution:
  - VR = 3 = N_G/N_P
  - N_G= 3*22 = 66 teeth

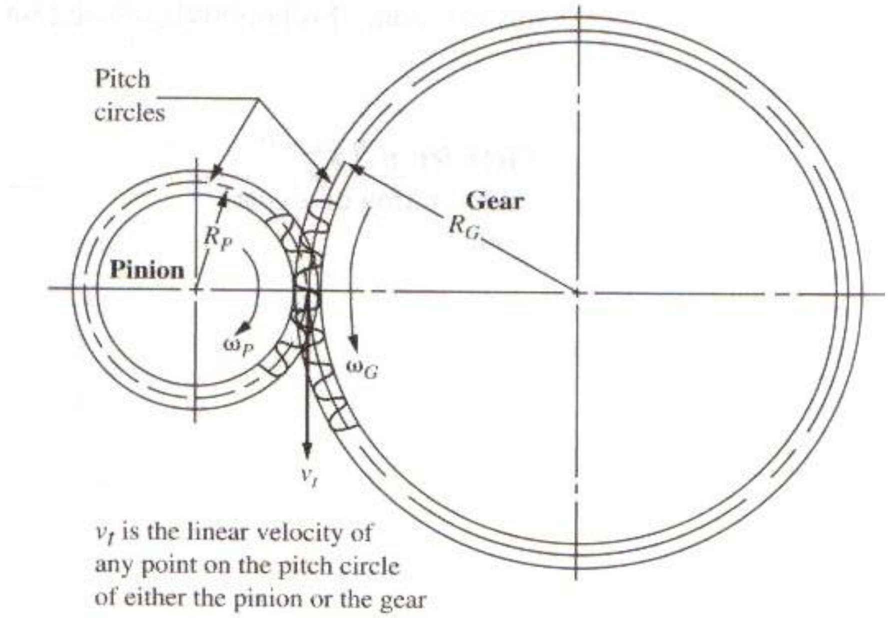
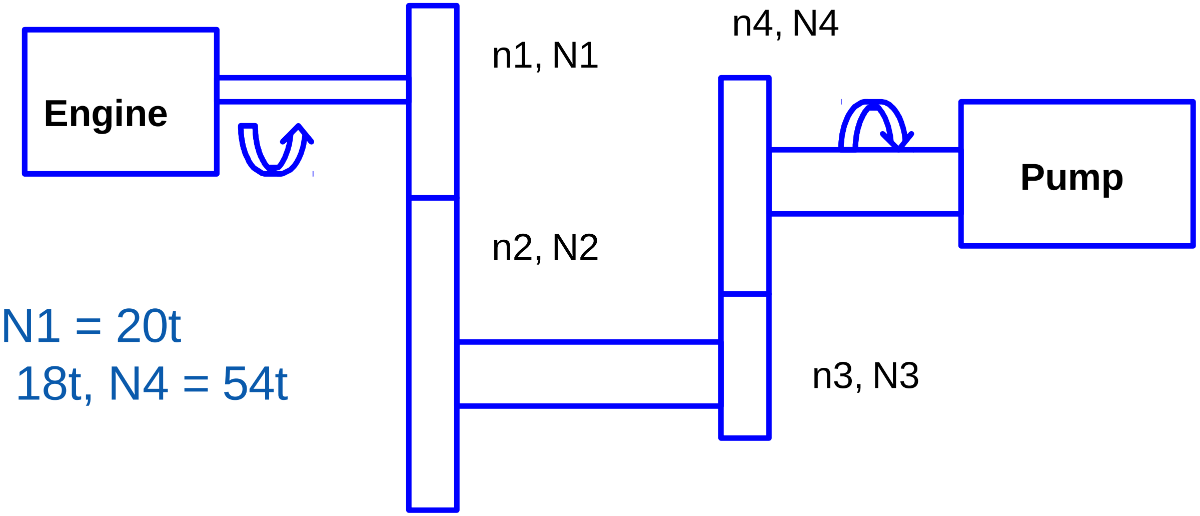


Figure 8-15, pg. 322



Given:

n1 = 500 rpm, N1 = 20t
N2 = 70t, N3 = 18t, N4 = 54t

Find: n4

Example: Double Speed Reducer

Solution:

1. n2 = 500 rpm*(20/70) = 142.8 rpm
2. n3 = n2
3. n4 = 142.8 rpm*(18/54) = 47.6 rpm
4. Total reduction = 500/47.6 = 10.5 (0r 10.5:1)

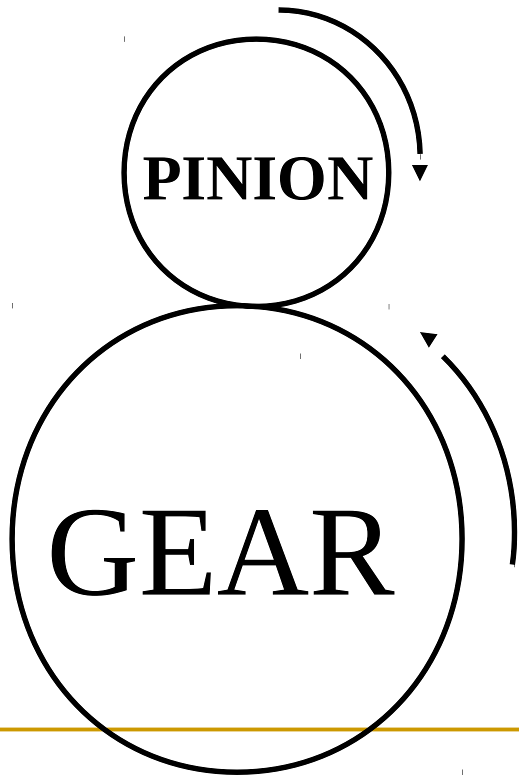
Torque?? Increases by 10.5!!
Power?? Stays the same throughout!

Gear Nomenclature

- N = Number of teeth
  - Use subscript for specific gear
    - N_P=Number of teeth on pinion (driver)
    - N_G=Number of teeth on gear (driven)
    - $N_P < N_G$ (for speed reducer)
    - N_A=Number of teeth on gear A
- Circular Pitch, P is the radial distance from a point on a tooth at the pitch circle to corresponding point on the next adjacent tooth $P=(\pi * D)/N$

Gear Nomenclature

- Gear Train Rule – Pitch of two gears in mesh must be identical



$$P = \frac{\pi D_G}{N_G} \quad \frac{\pi D_P}{N_P}$$

Gear Nomenclature

- Diametral Pitch, (P_d) – Number of teeth per inch of pitch diameter

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

*Two gears in mesh must have equal P_d:

$$P_d = \frac{N_G}{D_G} = \frac{N_P}{D_P}$$

*Standard diametral pitches can be found in Table 8-1 and 8-2