Machine Design –II

Gears-
Spur Gears & Bevel Gears

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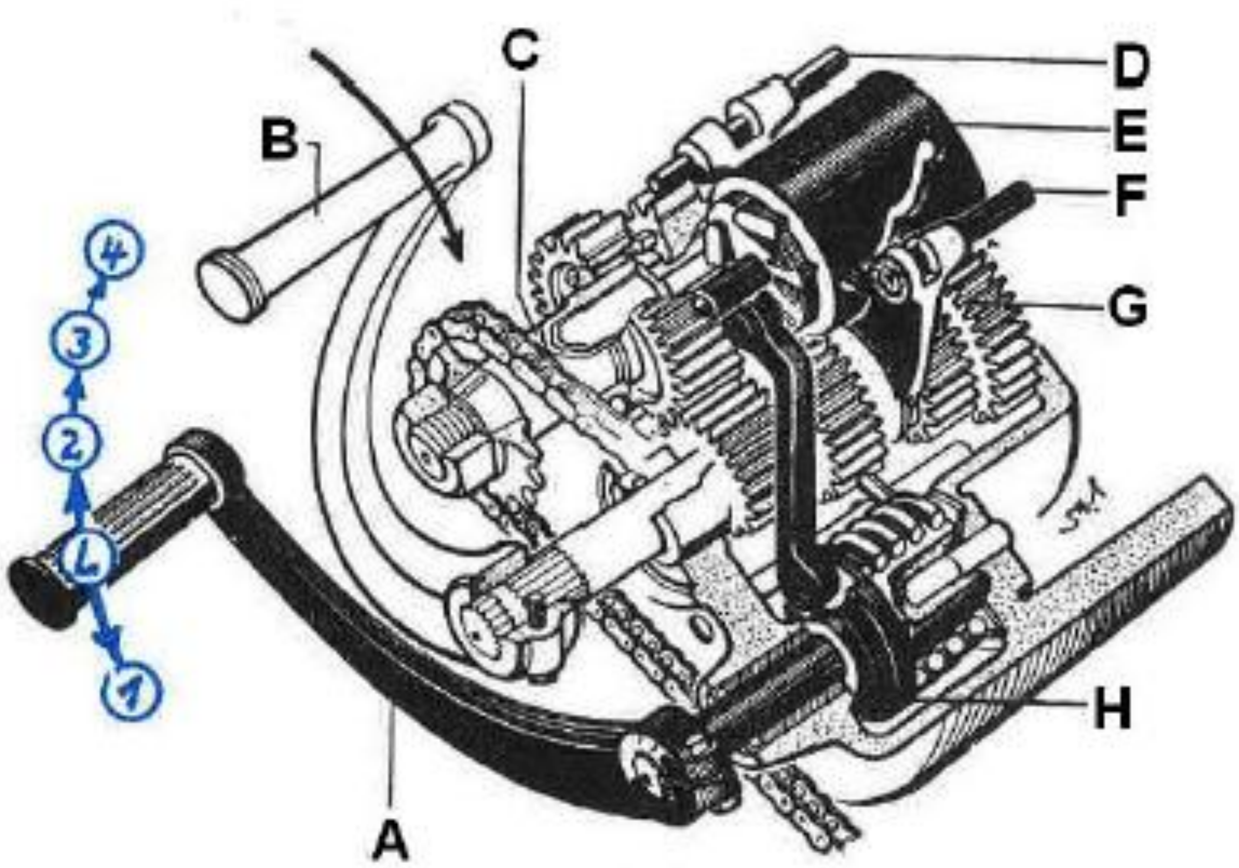
Gears Overview

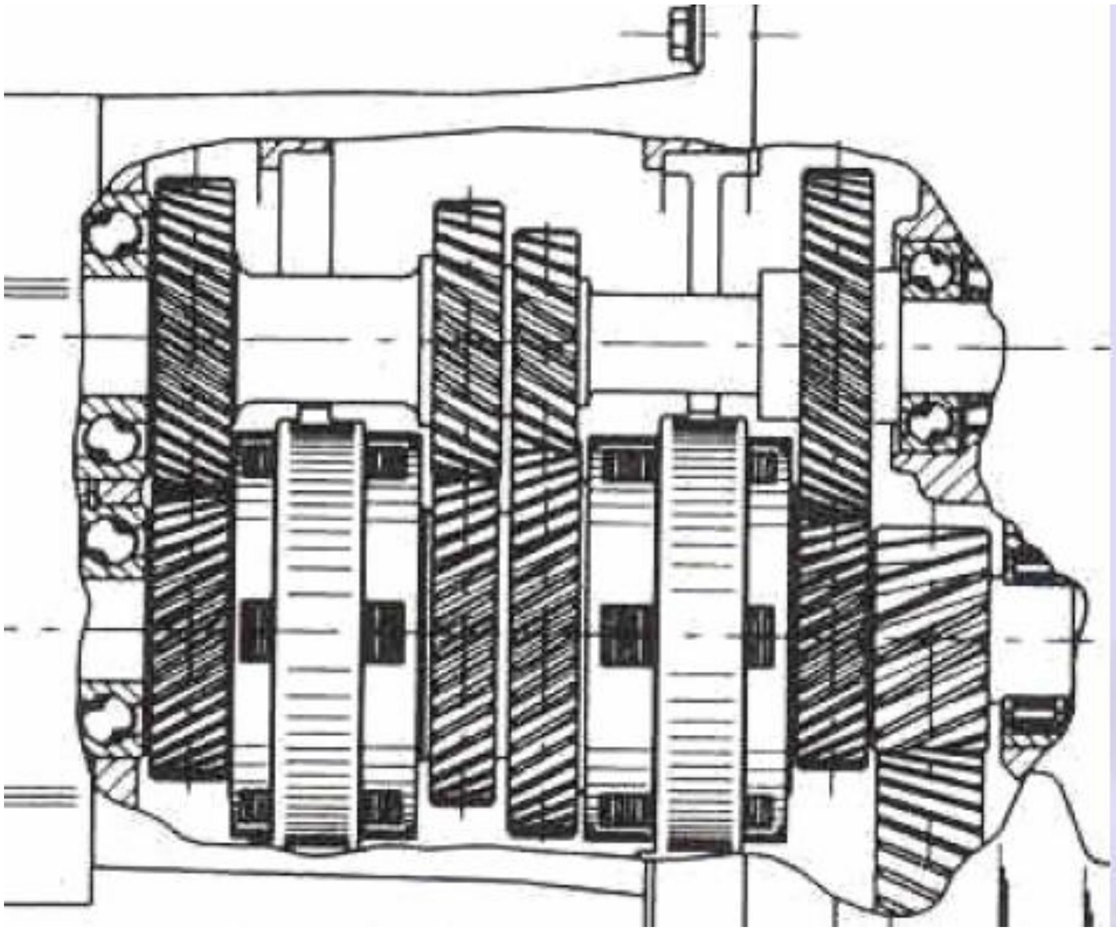
- Classification
- Applications
- Terminologies
- Materials
- Undercut & interference
- Law of gearing
- Tooth failure
- Design of spur gear – dynamic , static , wearing loading condition
- Design of helical gear - dynamic , static , wearing loading condition

Identify the type of gear ???



Foot pedal gear control by shift cam assembly

Identify the type of gear ???



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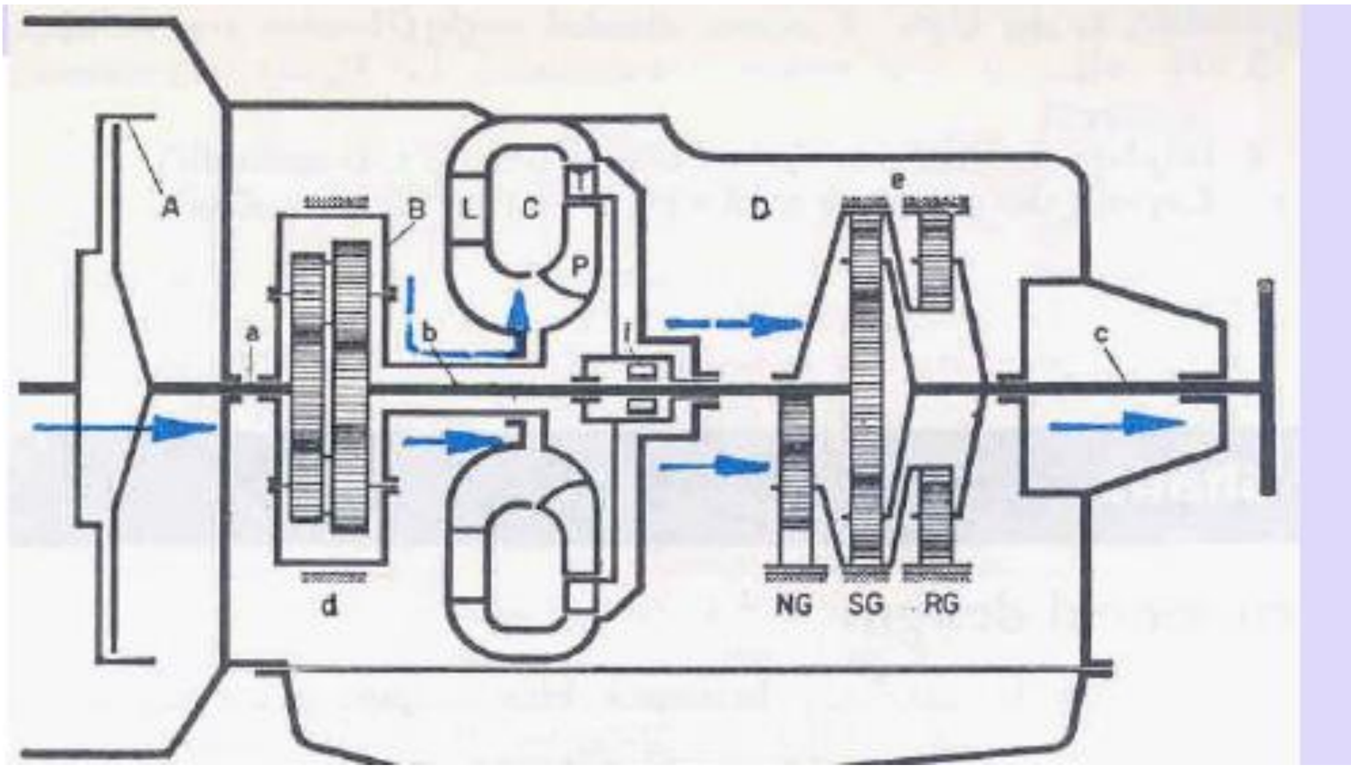

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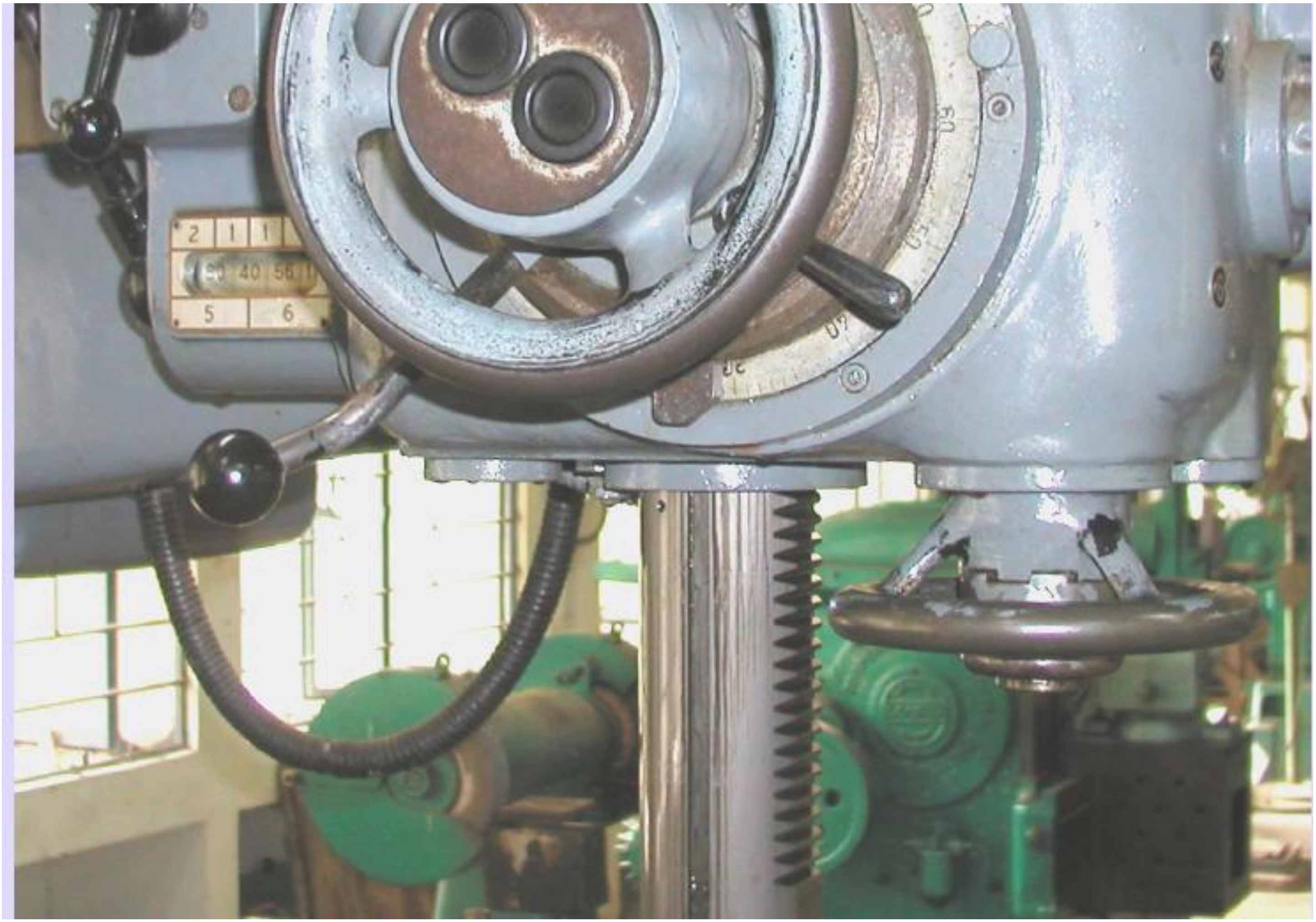

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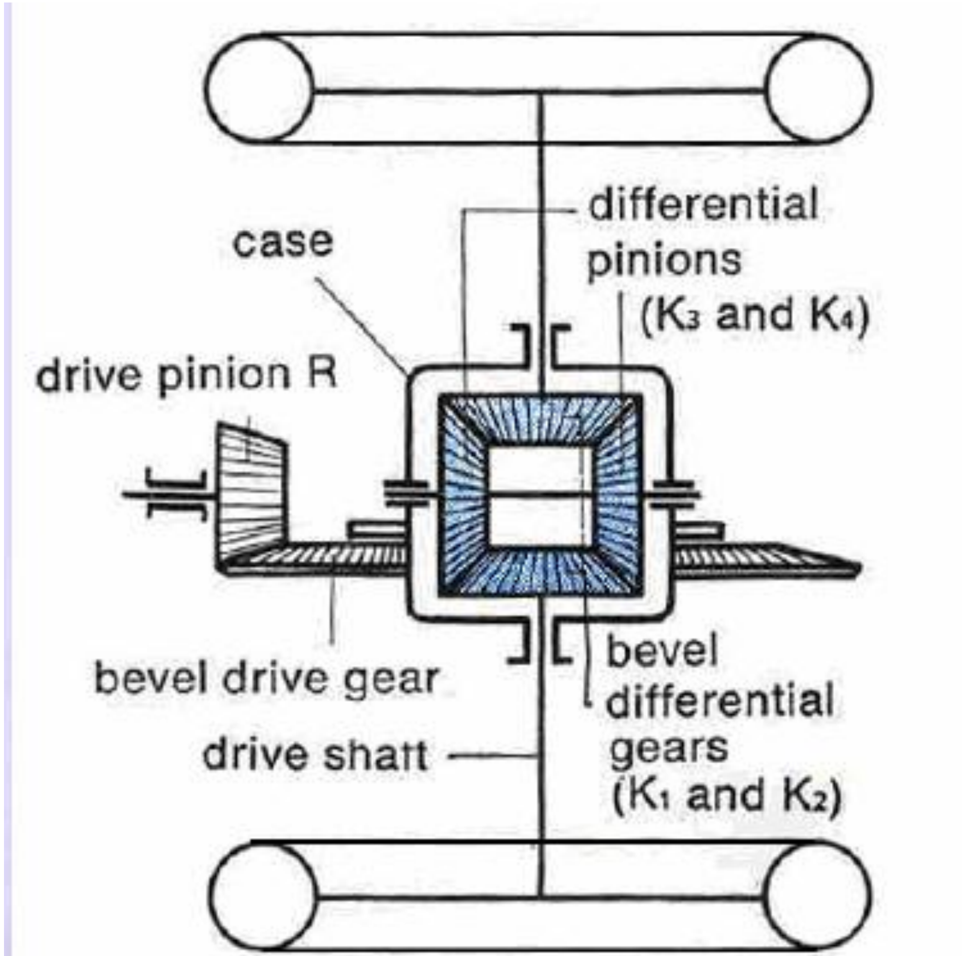
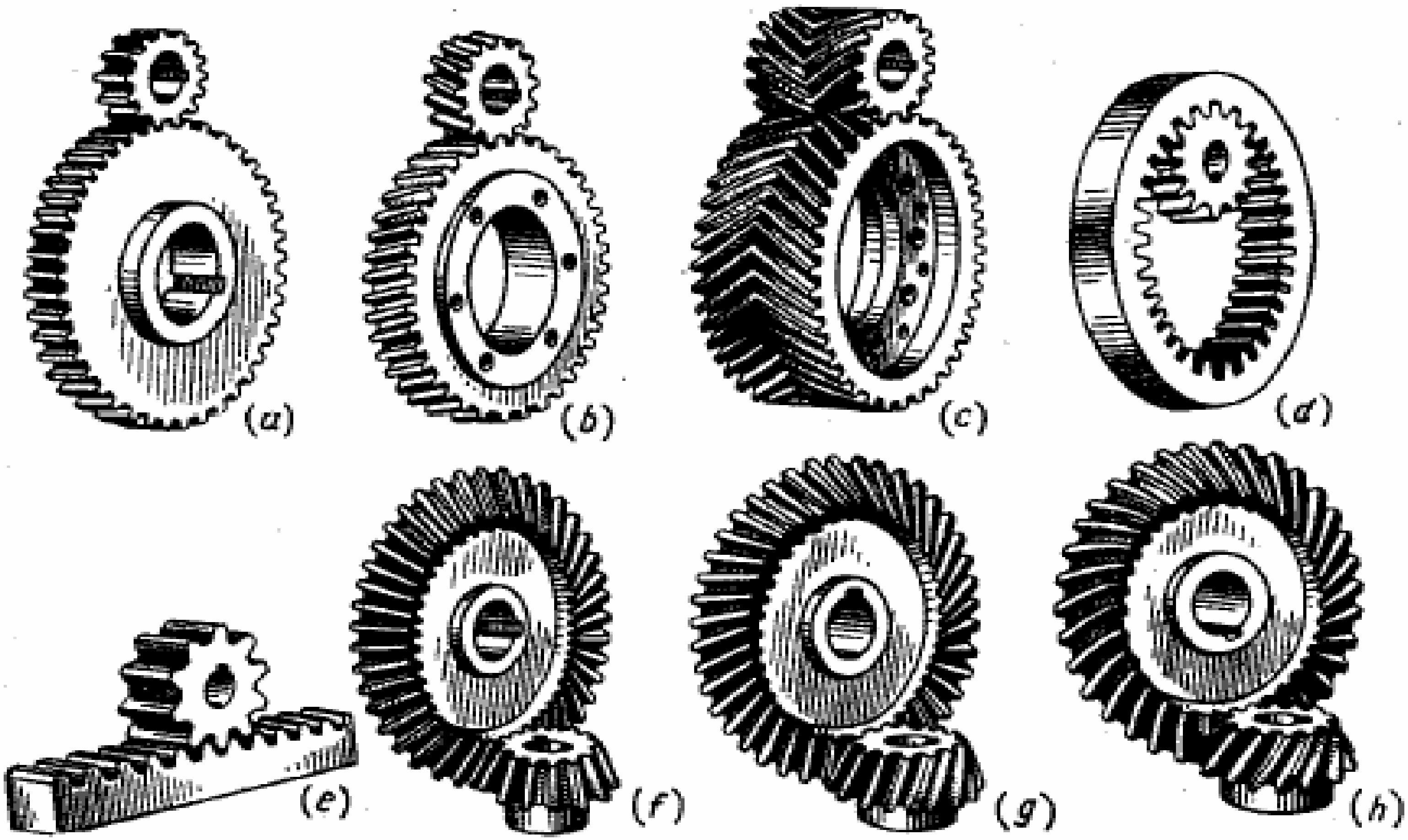


Gear classification



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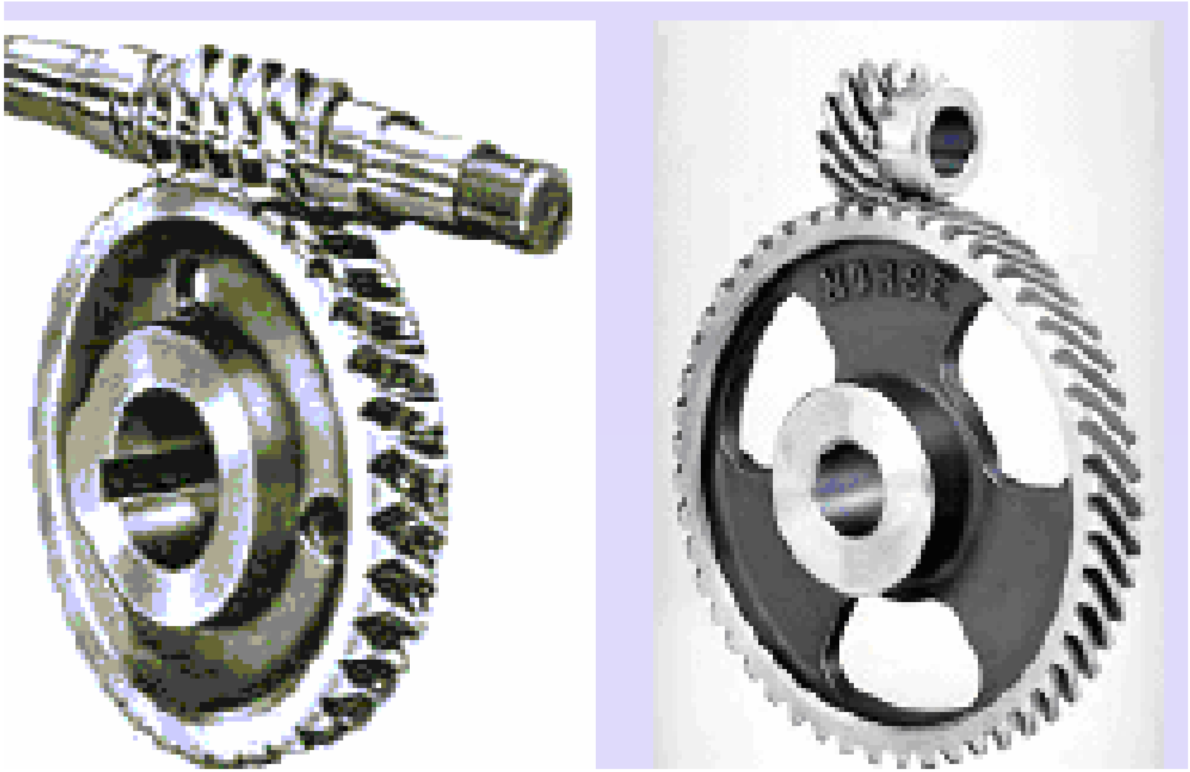

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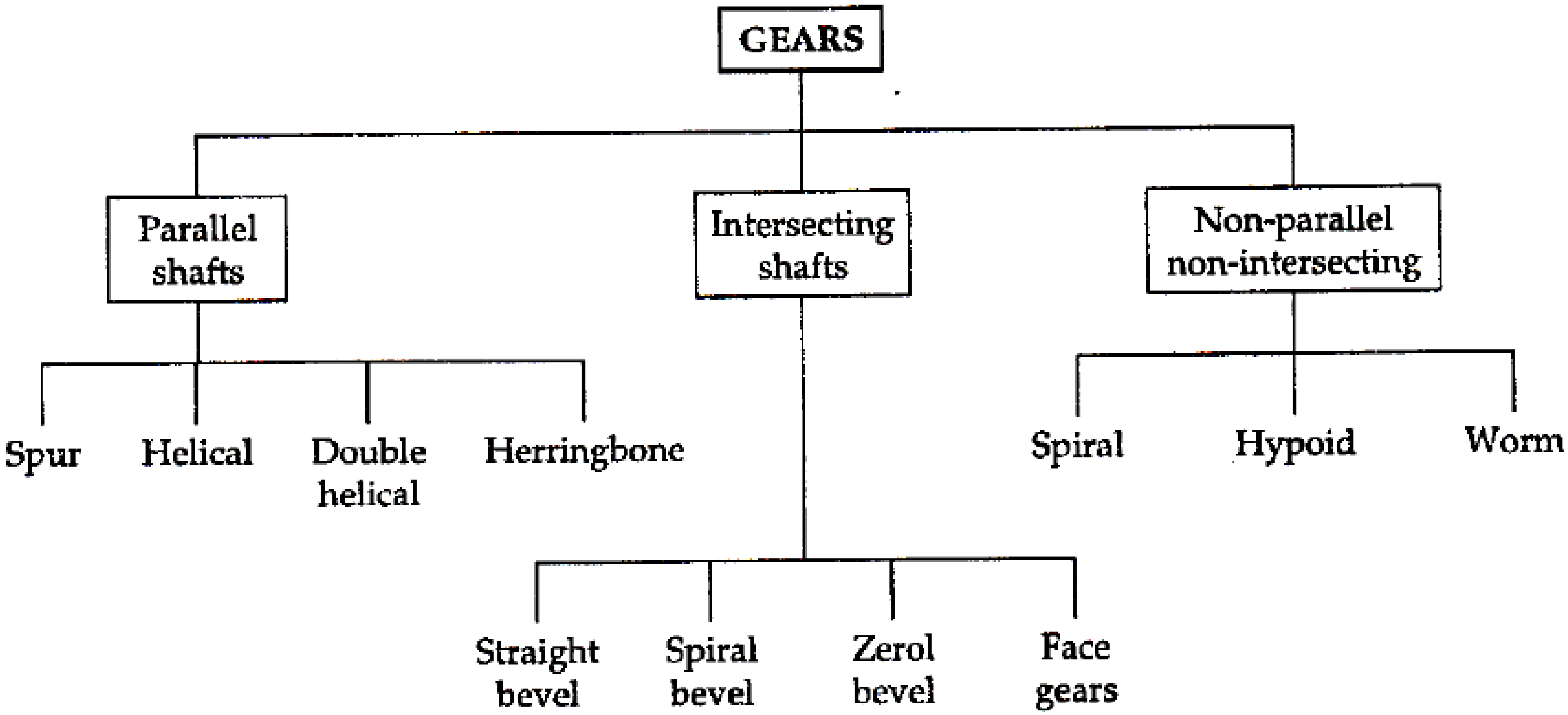
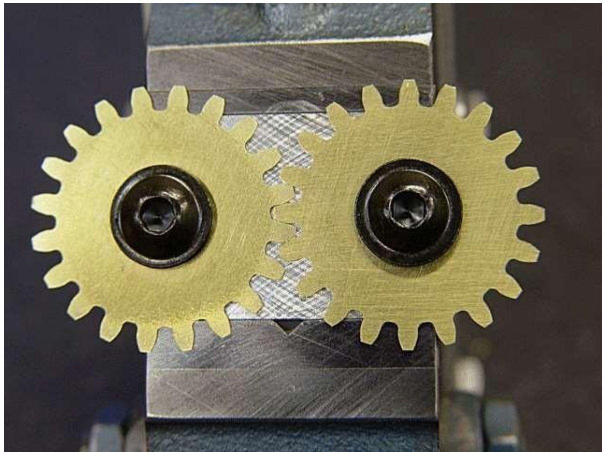


SPUR GEAR

- Teeth is parallel to axis of rotation
- Transmit power from one shaft to another parallel shaft
- Used in Electric screwdriver, oscillating sprinkler, windup alarm clock, washing machine and clothes dryer

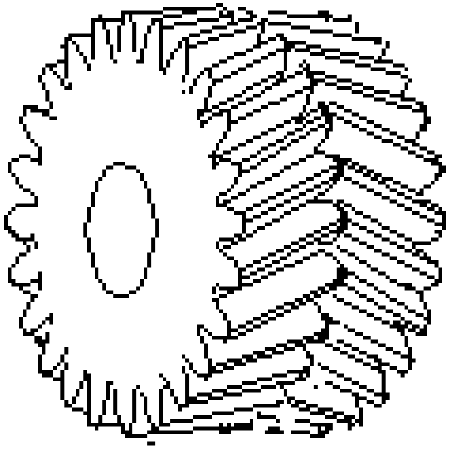


Helical Gear

- The teeth on helical gears are cut at an angle to the face of the gear
- This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears
- One interesting thing about helical gears is that if the angles of the gear teeth are correct, they can be mounted on perpendicular shafts, adjusting the rotation angle by 90 degrees

Herringbone gears

- To avoid axial thrust, two helical gears of opposite hand can be mounted side by side, to cancel resulting thrust forces

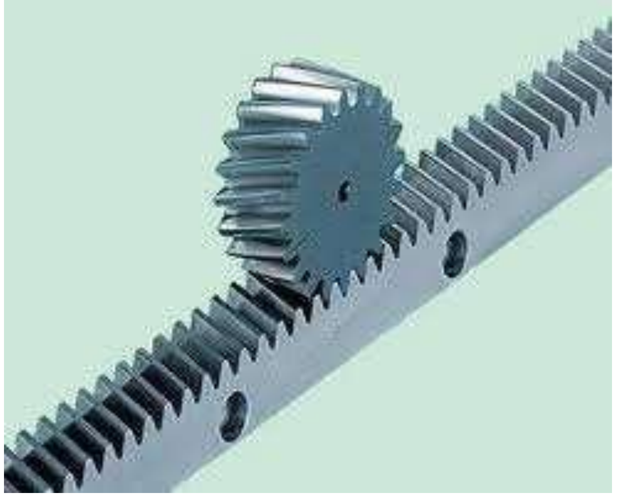


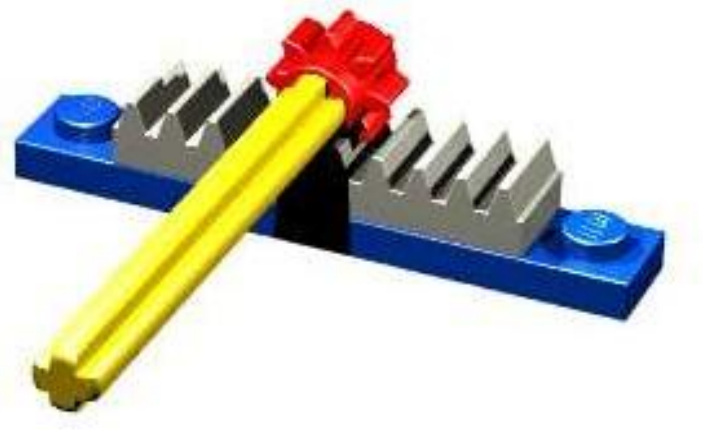
- Herringbone gears are mostly used on heavy machinery.

Rack and pinion

- **Rack and pinion gears** are used to convert rotation (From the pinion) into linear motion (of the rack)

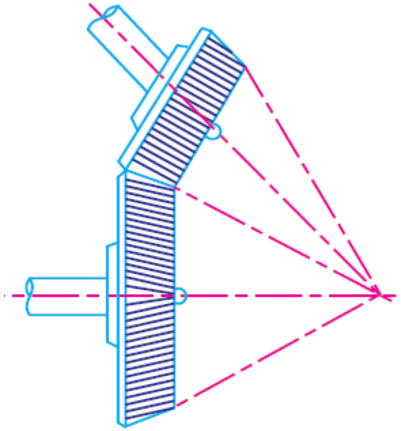
- A perfect example of this is the steering system on many cars





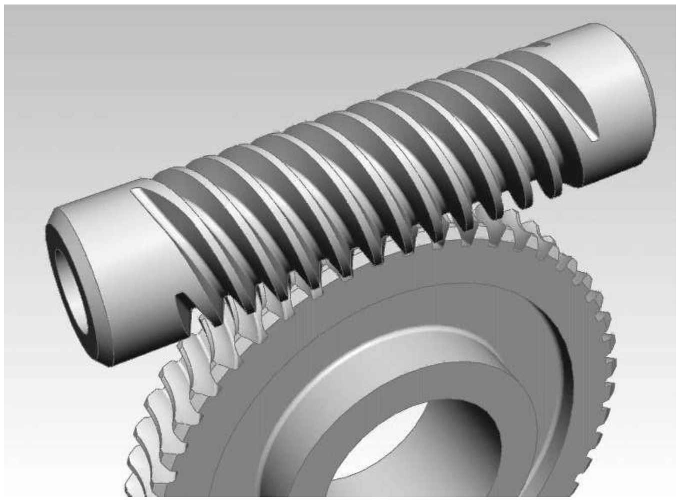
Bevel gears

- **Bevel gears** are useful when the direction of a shaft's rotation needs to be changed
- They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well
- The teeth on bevel gears can be **straight**, **spiral** or **hypoid**
- locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

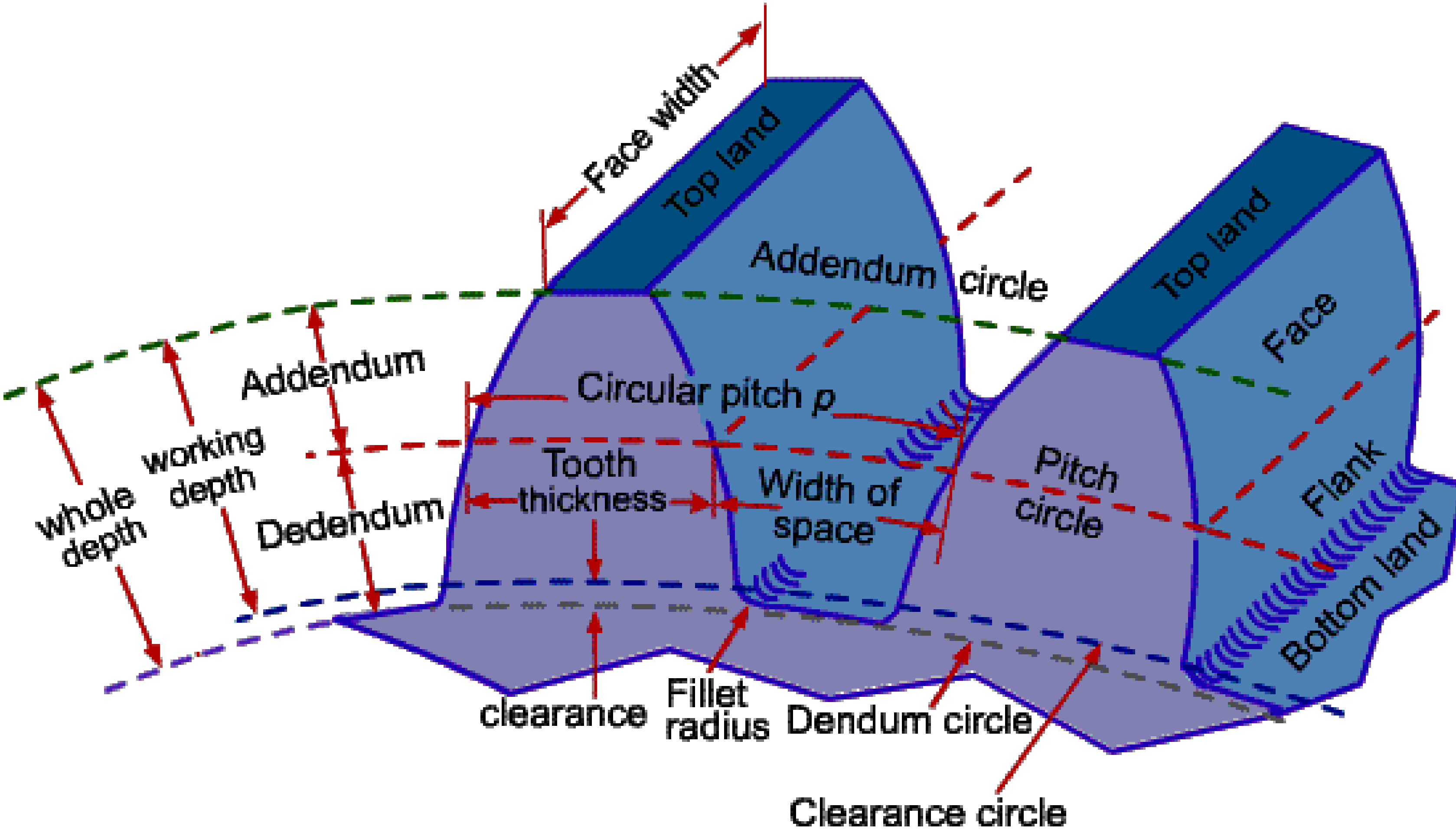


WORM AND WORM GEAR

- **Worm gears** are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater
- Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm
- Worm gears are used widely in material handling and transportation machinery, machine tools, automobiles etc

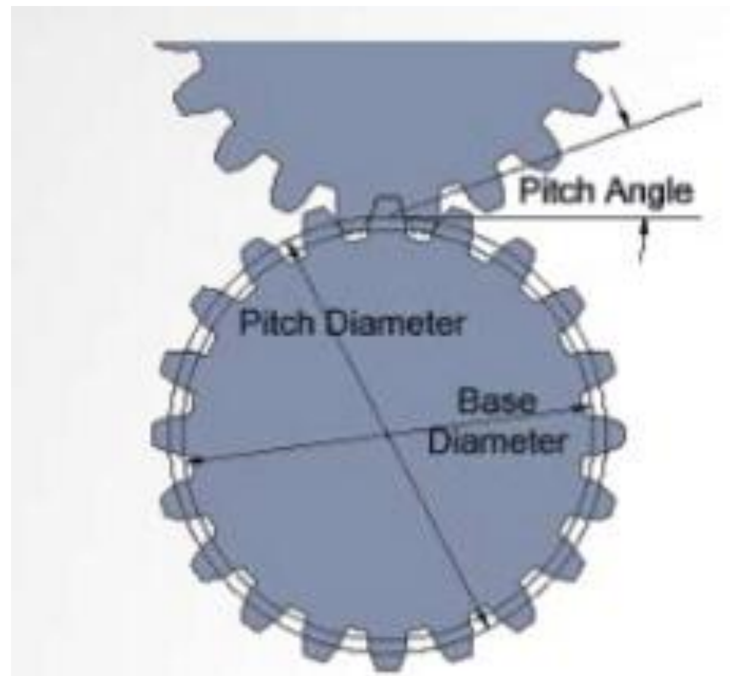


Gear Terminology for Involute

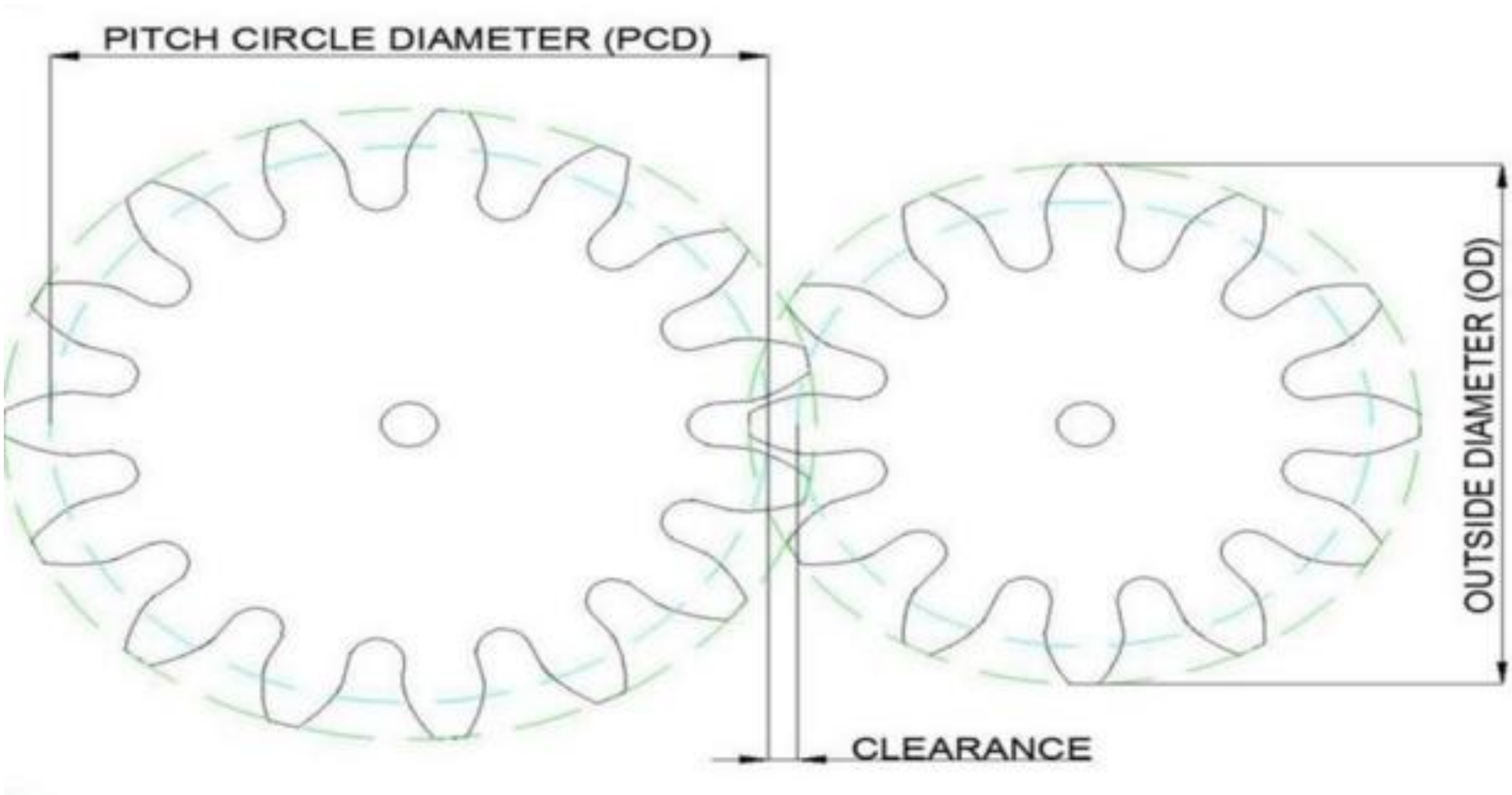


Gear Terminology for Involute

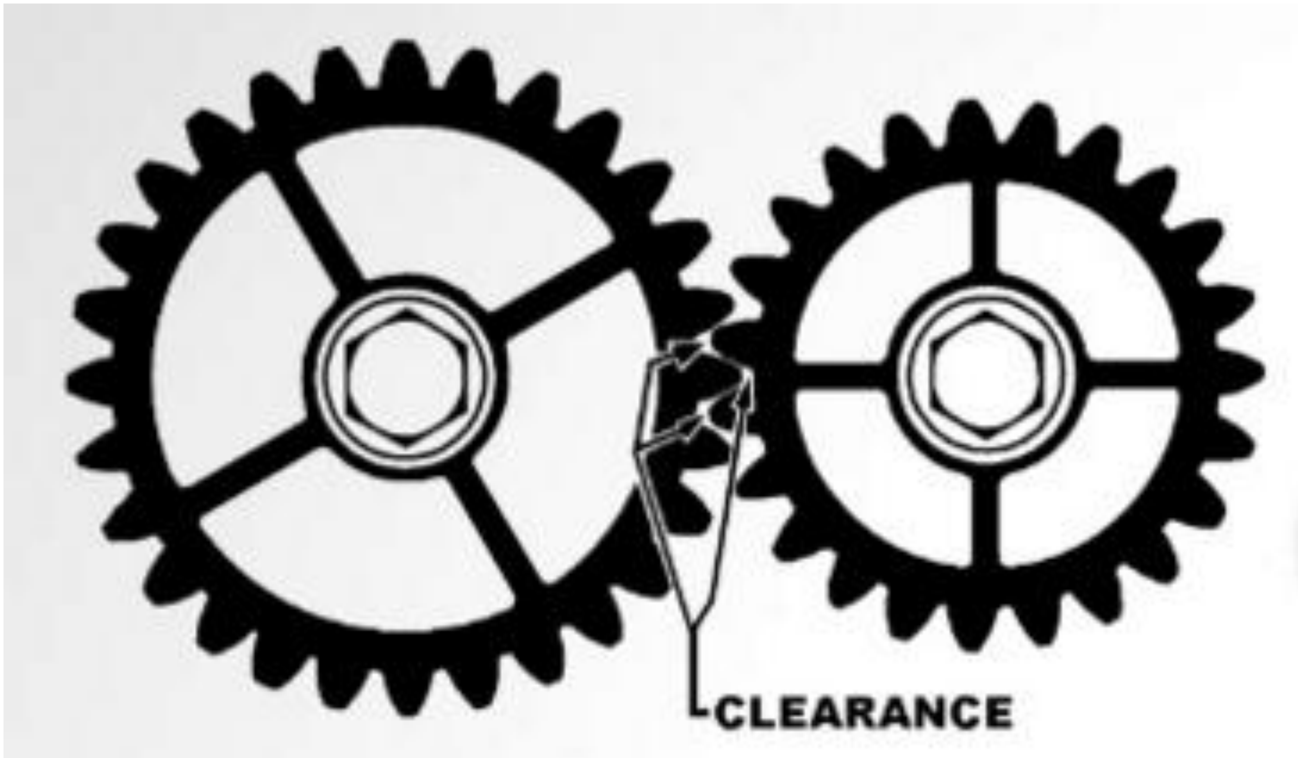
Pitch circle diameter
Circular pitch
Diametral pitch
Module
Clearance
Backlash
Tooth thickness
Tooth space
Pressure angle
Crowning



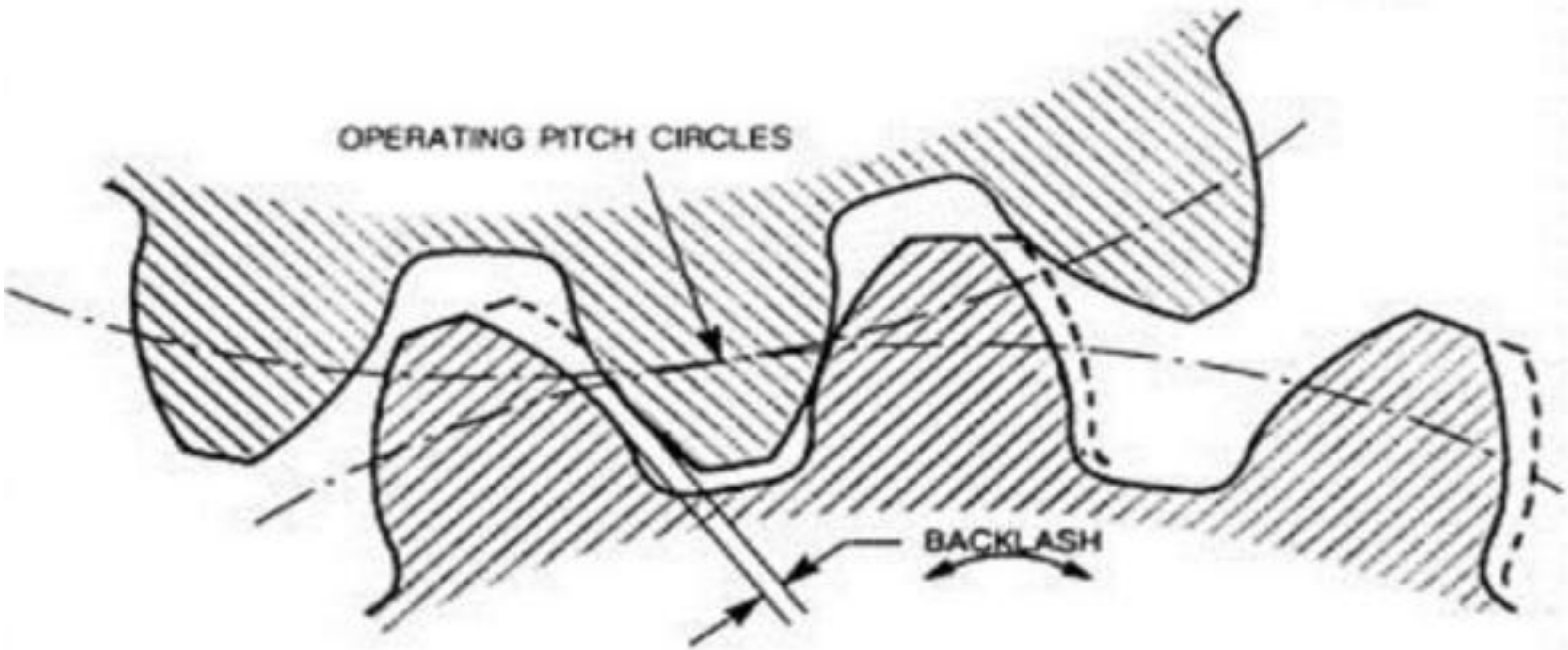
Gear Terminology for Involute



Clearance



Backlash



Gear material & manufacturing Process

Manufacturing Process Involved for gears are ,

Casting
Metal Removal Process
- **Milling**
- **Hobbing**
- **Broaching**

Forming

Followed by Heat Treatment & minor machining

Gear material & manufacturing Process

Taking external/environmental considerations, force/load conditions and noise considerations as well materials like
brass, bronze, phosphor bronze etc for medium to heavy working conditions.

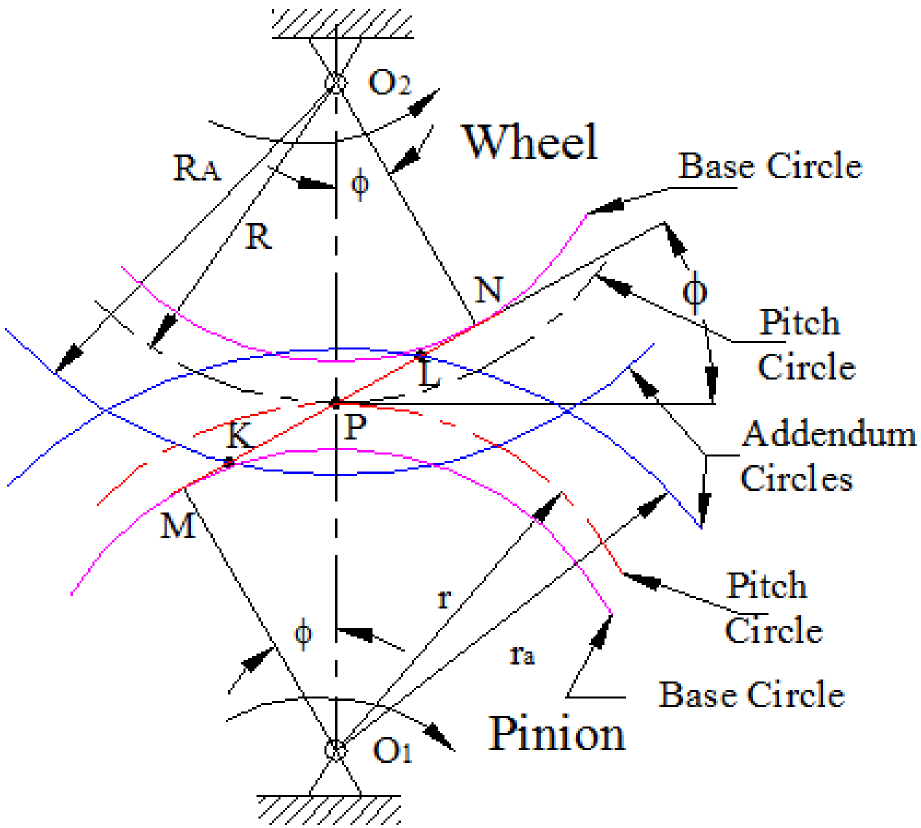
steel & cast iron for heavy duty applications

Materials like plastics are used in toys/light duty applications.

While using gears of steel or cast iron material, appropriate heat treatment such as case hardening is done to give sufficient surface hardness for wear resistance and sufficient toughness at core to withstand loads applied.

Law of gearing

The fundamental **law of gearing** states that the angular velocity ratio between the **gears** of a **gear** set must remain constant throughout the mesh.
The law of gearing states that the common normal at the point of contact between a pair of teeth must always pass through the pitch point.
Pitch point is the common point of contact between two pitch circles of the gears in mesh.



Design of spur gear

Spur gear Strength based on Lewi's Equation

y = Lewi's form factor

$$W_T = \sigma_w . b . p_c . y = \sigma_w . b . \pi m . y$$

$$v = \frac{\pi D.N}{60} = \frac{\pi m.T.N}{60} = \frac{p_c.T.N}{60}$$

m = Module in metres, and

T = Number of teeth.

$\sigma_w = \sigma_o \times C_v$

σ_o = Allowable static stress, and

C_v = Velocity factor.

$$W_T = \frac{P}{v} \times C_S$$

W_T = Permissible tangential tooth load in newtons,

P = Power transmitted in watts,

*v = Pitch line velocity in m / s $= \frac{\pi D N}{60}$,

D = Pitch circle diameter in metres,

Design of spur gear

Standard Values for Modules : 1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 16,20, 25, 32, 40 and 50.

$$y = 0.124 - \frac{0.684}{T}, \text{ for } 14\tfrac{1}{2}^\circ \text{ composite and full depth involute system.}$$

$$= 0.154 - \frac{0.912}{T}, \text{ for } 20^\circ \text{ full depth involute system.}$$

$$= 0.175 - \frac{0.841}{T}, \text{ for } 20^\circ \text{ stub system.}$$

$$C_v = \frac{3}{3 + v}, \text{ for ordinary cut gears operating at velocities upto 12.5 m / s.}$$

$$= \frac{4.5}{4.5 + v}, \text{ for carefully cut gears operating at velocities upto 12.5 m/s.}$$

$$= \frac{6}{6 + v}, \text{ for very accurately cut and ground metallic gears operating at velocities upto 20 m / s.}$$

$$= \frac{0.75}{0.75 + \sqrt{v}}, \text{ for precision gears cut with high accuracy and operating at velocities upto 20 m / s.}$$

$$= \left(\frac{0.75}{1 + v}\right) + 0.25, \text{ for non-metallic gears.}$$

Design of spur gear

Table 28.10. Values of service factor.

Type of load	*Type of service*		
	Intermittent or 3 hours per day	*8-10 hours per day*	*Continuous 24 hours per day*
Steady	0.8	1.00	1.25
Light shock	1.00	1.25	1.54
Medium shock	1.25	1.54	1.80
Heavy shock	1.54	1.80	2.00

Numerical -Design of spur gear

- **A gear drive is required to transmit a maximum power of 22.5 kW. The velocity ratio is 1:2 and r.p.m. of the pinion is 200. The approximate centre distance between the shafts may be taken as 600 mm. The teeth have 20° stub involute profiles. The static stress for the gear material (which is cast iron) may be taken as 60 MPa and face width as 10 times the module. Find the module, face width and number of teeth on each gear.**

Numerical -Design of spur gear

A pair of straight teeth spur gears is to transmit 20 kW when the pinion rotates at 300 r.p.m. The velocity ratio is 1 : 3. The allowable static stresses for the pinion and gear materials are 120 MPa and 100 MPa respectively. The pinion has 15 teeth and its face width is 14 times the module. The teeth have 20° full depth involute profile for velocity less than 12 m/s.Determine: 1. module; 2. face width; and 3. pitch circle diameters of the pinion and the gear from the standpoint of strength only, taking into consideration the effect of the dynamic loading.

Design of Helical gear

Helical gear based on Helix angle

$T_E = T / \cos^3 \alpha$

T = Actual number of teeth on a helical gear, and

α = Helix angle.

$$W_T = \sigma_w \,.\, b \,.\, p_c \,.\, y = \sigma_w \,.\, b \,.\, \pi m \,.\, y$$

$\sigma_w = \sigma_o \times C_v$

σ_o = Allowable static stress, and

C_v = Velocity factor.

$$v = \frac{\pi D.N}{60} = \frac{\pi m.T.N}{60} = \frac{p_c.T.N}{60}$$

m = Module in metres, and

T = Number of teeth.

$$W_T = \frac{P}{v} \times C_S$$

W_T = Permissible tangential tooth load in newtons,

P = Power transmitted in watts,

*v = Pitch line velocity in m / s $= \frac{\pi D N}{60}$,

D = Pitch circle diameter in metres,

Numerical -Design of Helical gear

A pair of helical gears is to transmit 15 kW. The teeth are 20° stub in diametral plane and have a helix angle of 45°. The pinion runs at 10 000 r.p.m. and has 80 mm pitch diameter. The gear has 320 mm pitch diameter. If the gears are made of cast steel having allowable static strength of 100 MPa; determine a suitable module and face width from static strength considerations and check the gears for wear, given σes = 618 MPa.