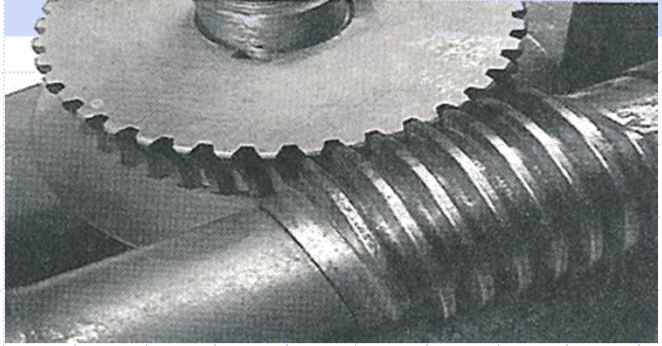
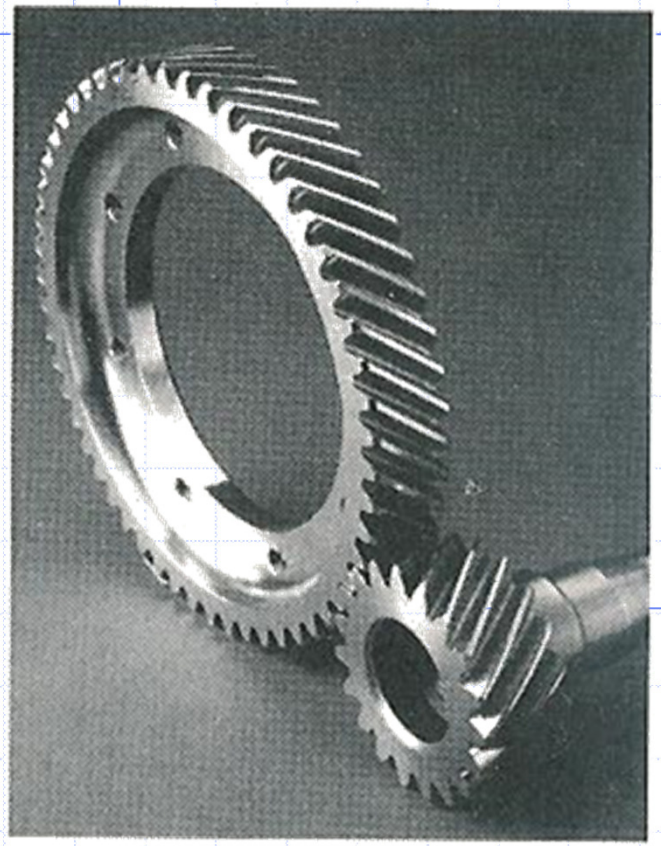
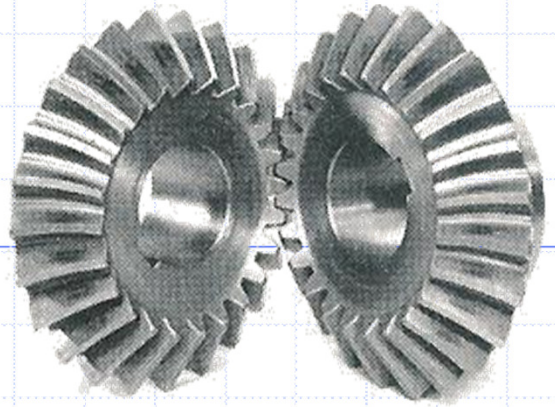
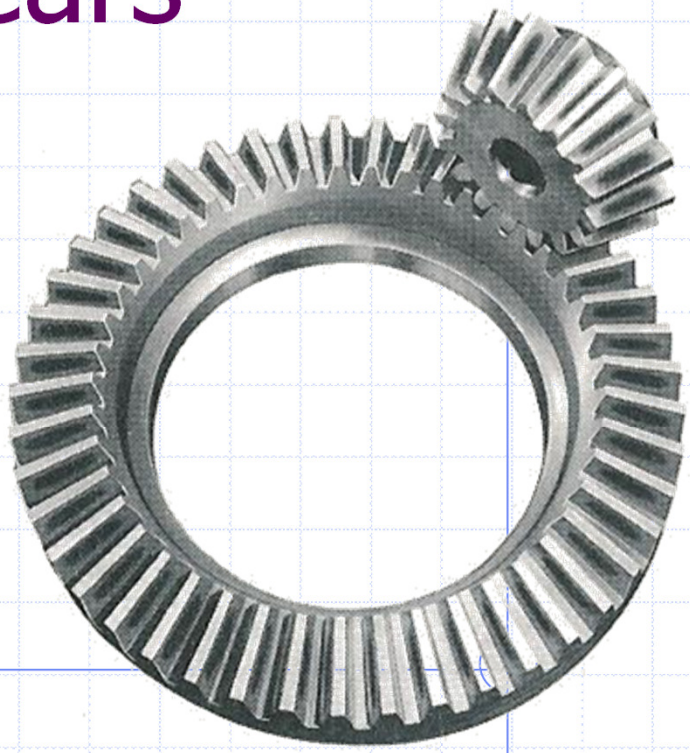


Helical Gears, Bevel Gears and Worm Gears







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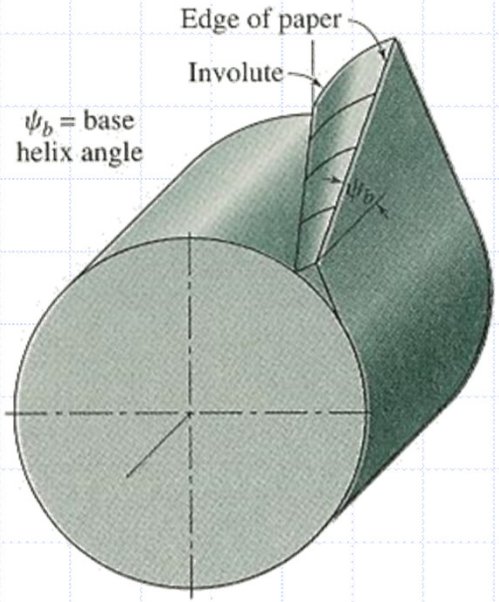
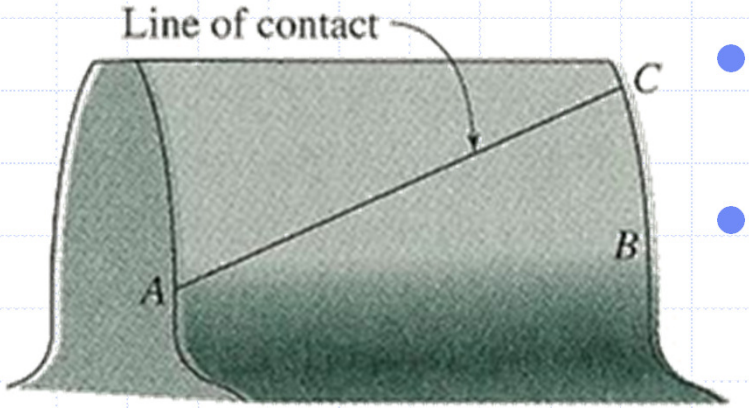
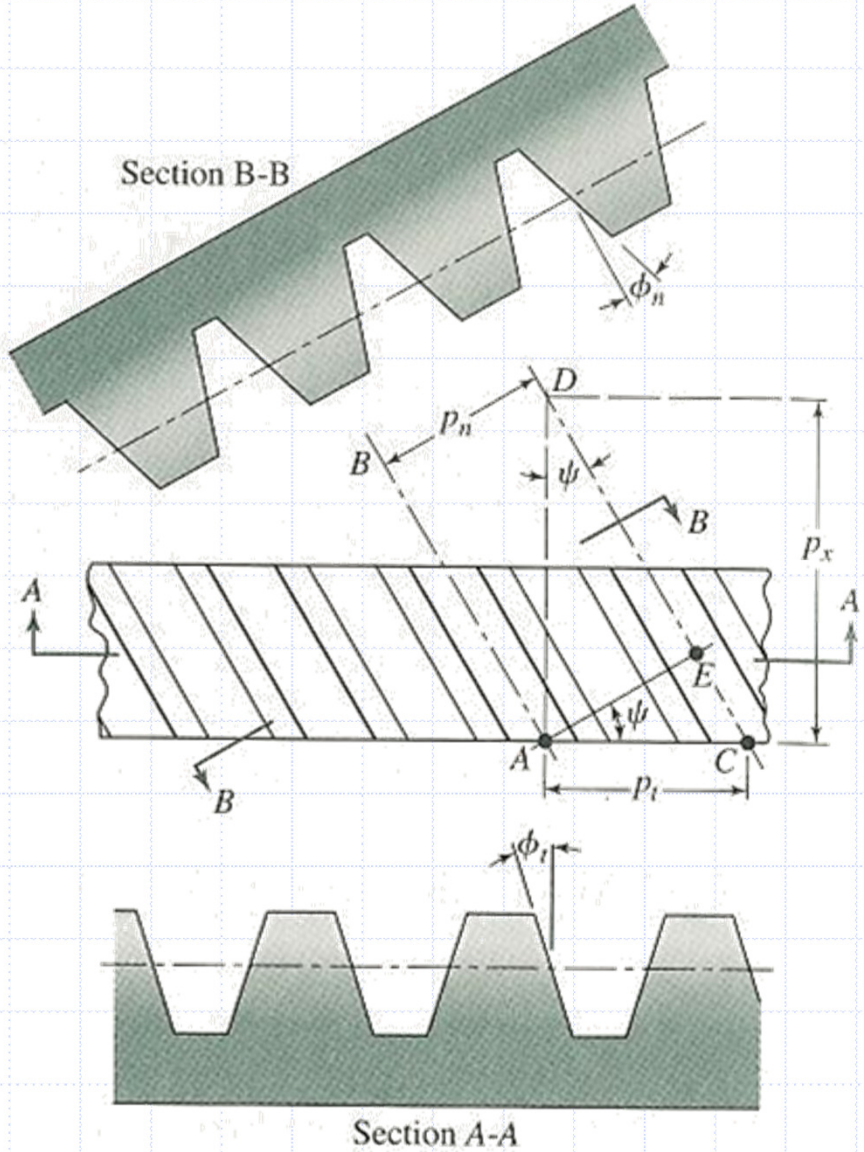
Helical Gear Differences from Spur Gears





- Tooth profile is still involute when looking from side of gear, but profile twists around according to helix angle.
- Line of contact is at angle.
- Initial contact is at point instead of line (gears are quieter).
- Contact ratio is higher (quieter).
- Causes sideways (axial) thrust loads.
- Note that meshing gear must have opposite helix direction.

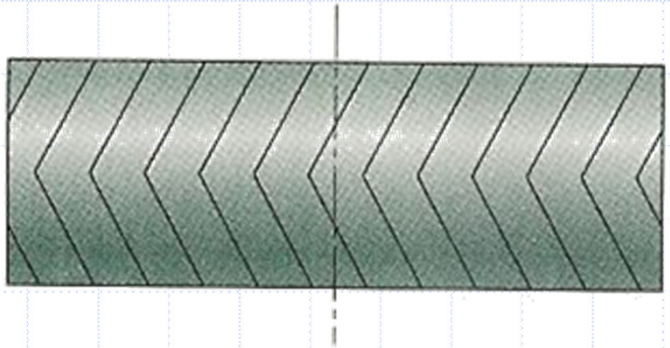
Helix Angle and Pitch



Contact Ratio of Helical Gears

- Contact ratio now also depends on:
  - helix angle
  - gear width

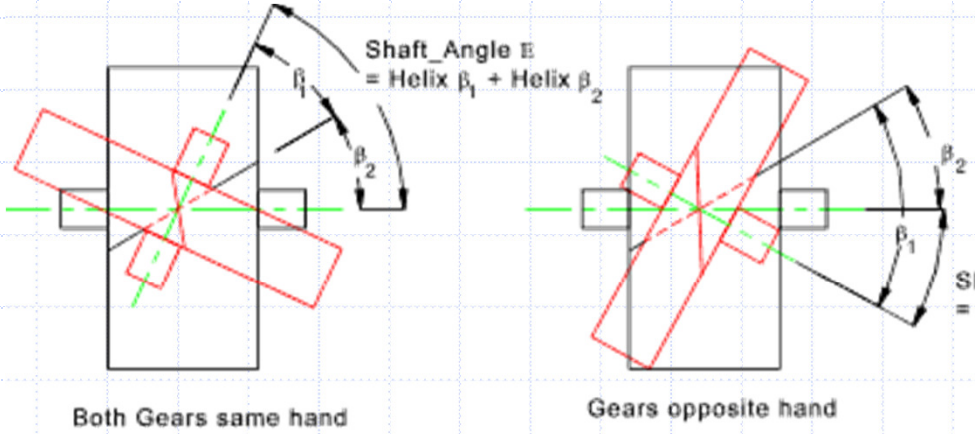
Herringbone Gears



- Avoids axial thrust loads
- More expensive to manufacture.
- Need to allow movement of one of the gears to allow alignment.
- Helix angles can be large, since you don't need to account for large thrust forces.

Crossed-Axis Helical Gears

- Normal helical gears can actually be used with non-parallel axes!



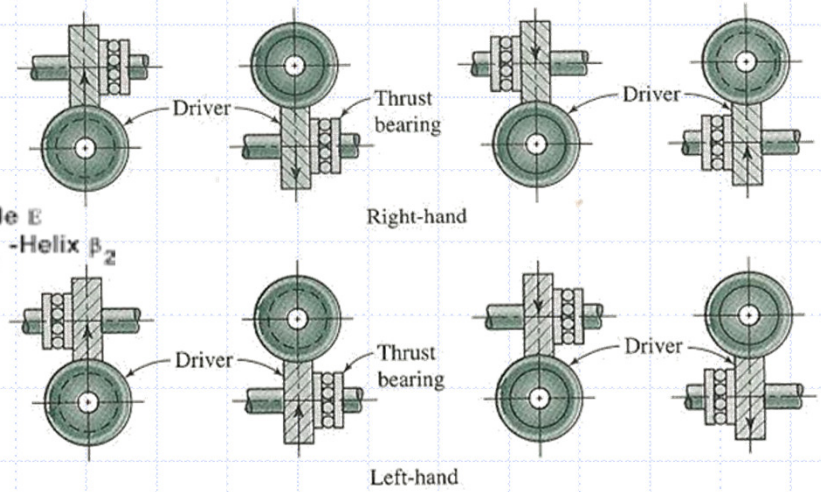
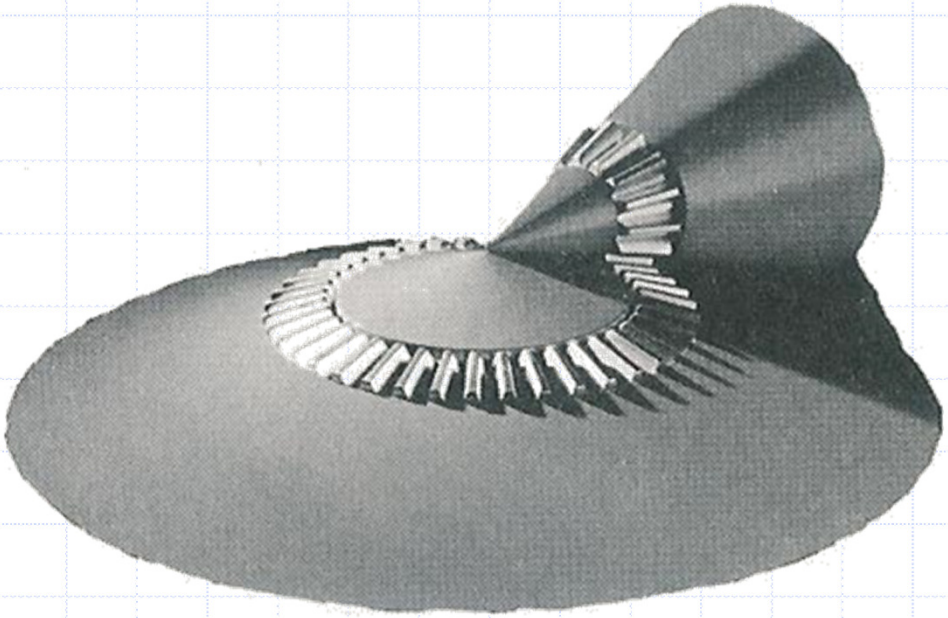


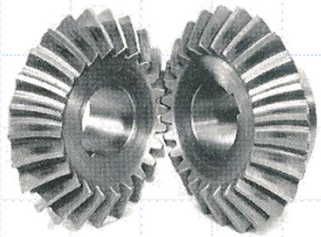
Image from RoyMech.co.uk

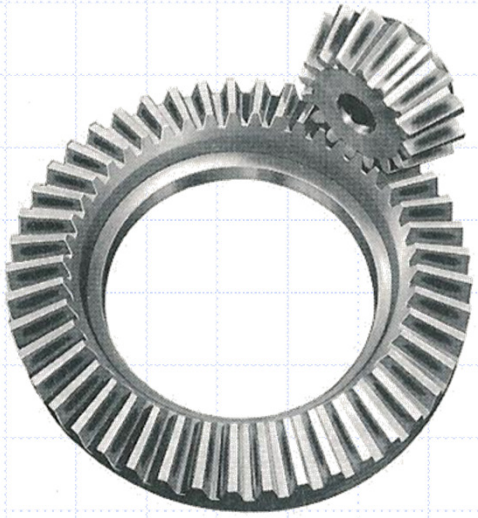
- But has point contact (not line contact).
- Must have same pressure angle & normal pitch.
- Helix angles can be different.
- Can be same or opposite hand.

Bevel Gears
Differences from Spur Gears

- Non-parallel axes
- Pitch **cone** instead of pitch **cylinder** (and **Spherical** tooth ends instead of **planar**)

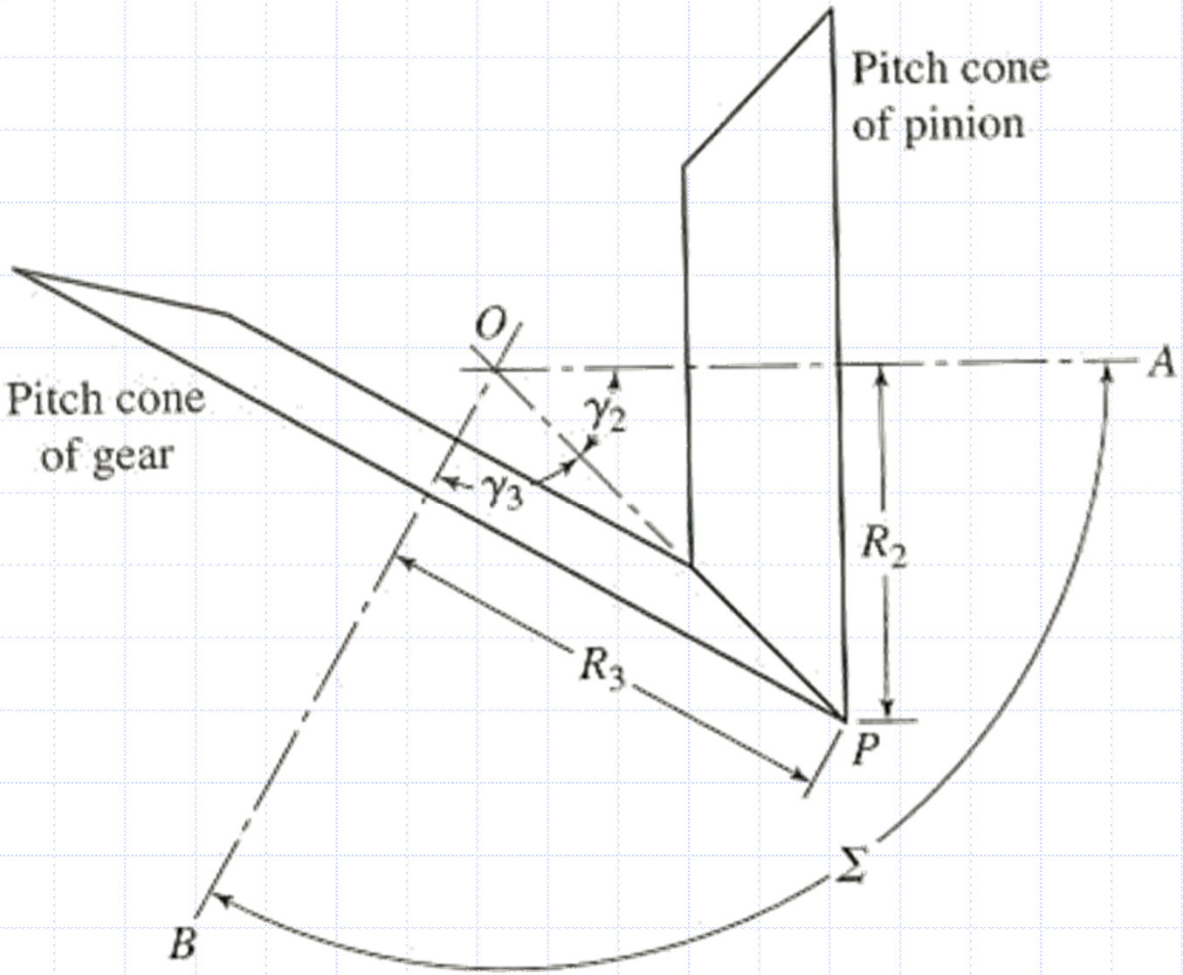






- Narrowing teeth

Bevel Gear Relationships



$$\frac{\omega_3}{\omega_2} = \frac{R_2}{R_3} = \frac{N_2}{N_3}$$

Σ is shaft angle

γ_2, γ_3 are pitch angles

$$\gamma_2 + \gamma_3 = \Sigma$$

$$\tan\gamma_2 = \frac{\sin\Sigma}{\left(N_3/N_2\right) + \cos\Sigma}$$

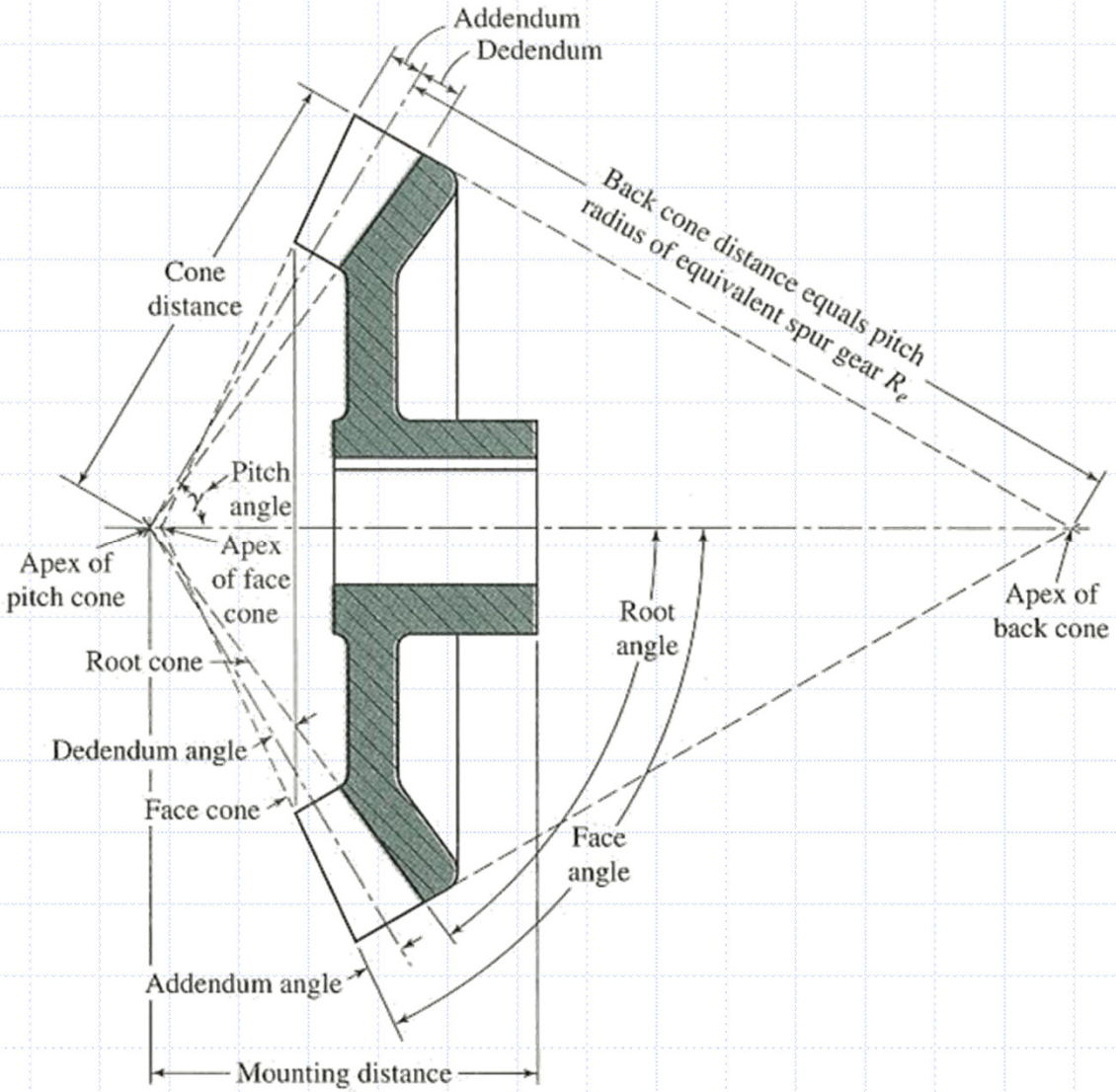
$$\tan\gamma_3 = \frac{\sin\Sigma}{\left(N_2/N_3\right) + \cos\Sigma}$$

Some Standards for Bevel Gears

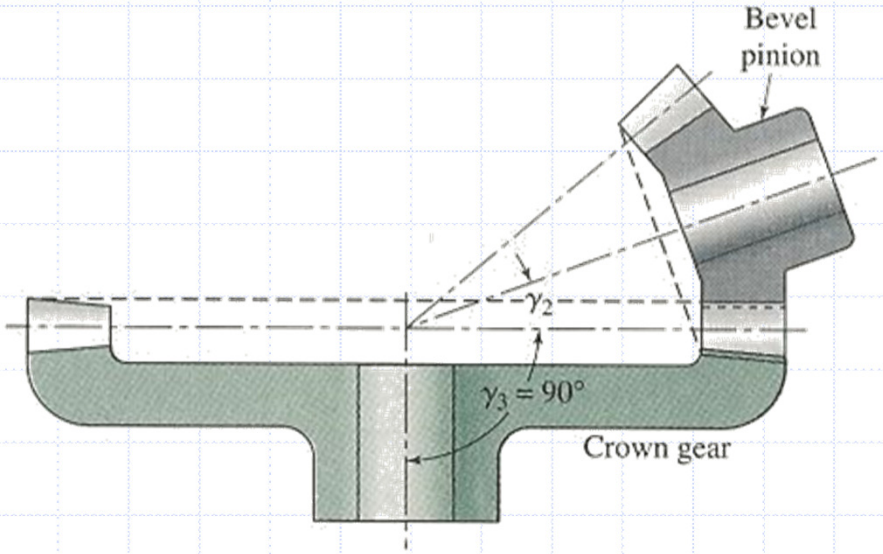
TABLE 8. 2 Tooth Proportions for 20° Straight-Tooth Bevel Gears

Item	Formula
Working depth	$h_k = 2.0/P$
Clearance	$c = 0.188/P + 0.002$ in
Addendum of gear	$a_G = \dfrac{0.540}{P} + \dfrac{0.460}{P(m_{90})^2}$
Gear ratio	$m_G = N_G/N_P$
Equivalent 90° ratio	$m_{90} = \begin{cases} m_G & \text{when } \Sigma = 90° \\ \sqrt{m_G \dfrac{\cos\gamma_P}{\cos\gamma_G}} & \text{when } \Sigma \neq 90° \end{cases}$
Face width	$F = \dfrac{1}{3}$ or $F = \dfrac{10}{P}$, whichever is smaller
Minimum number of teeth	Pinion: 16 15 14 13
	Gear: 16 17 20 30

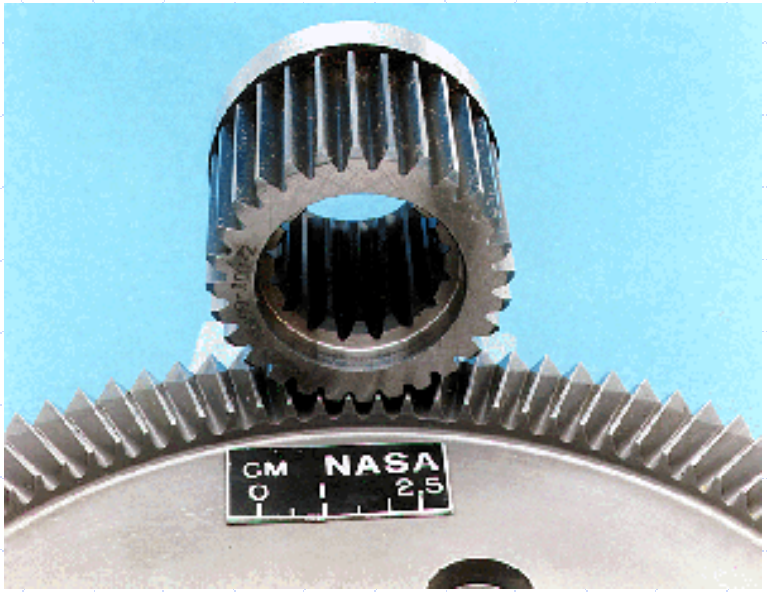
Some Standards for Bevel Gears



Crown and Face Gears



"Crown Gear"

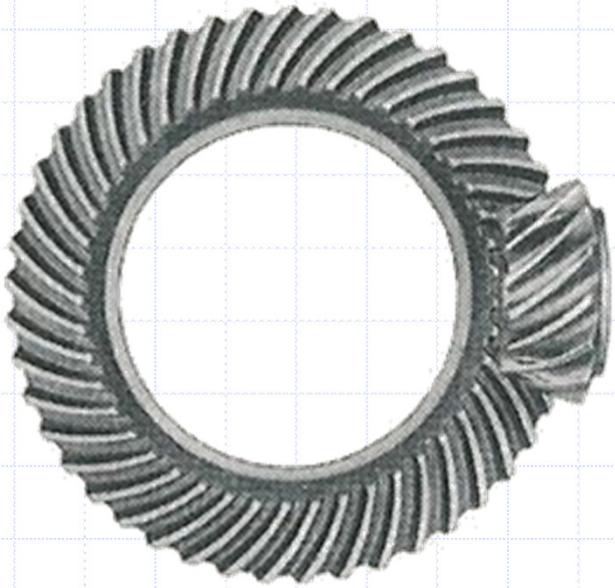


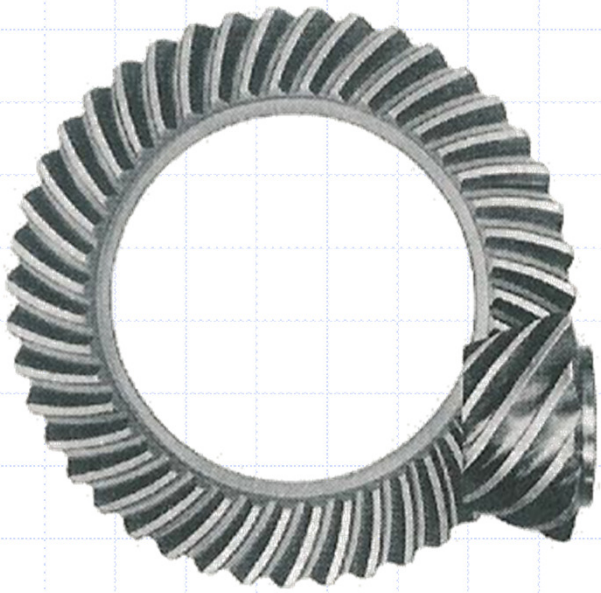
(Image from NASA)

"Face Gear"

Spiral Bevel Gears

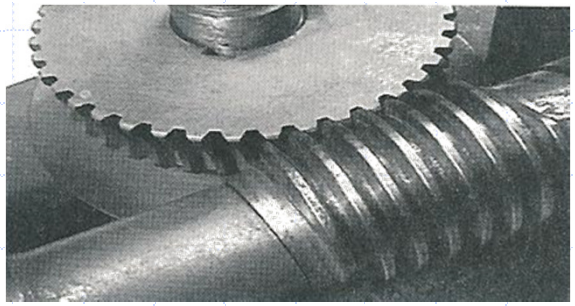
Spiral bevel gears are to bevel gears as helical gears are to spur gears.

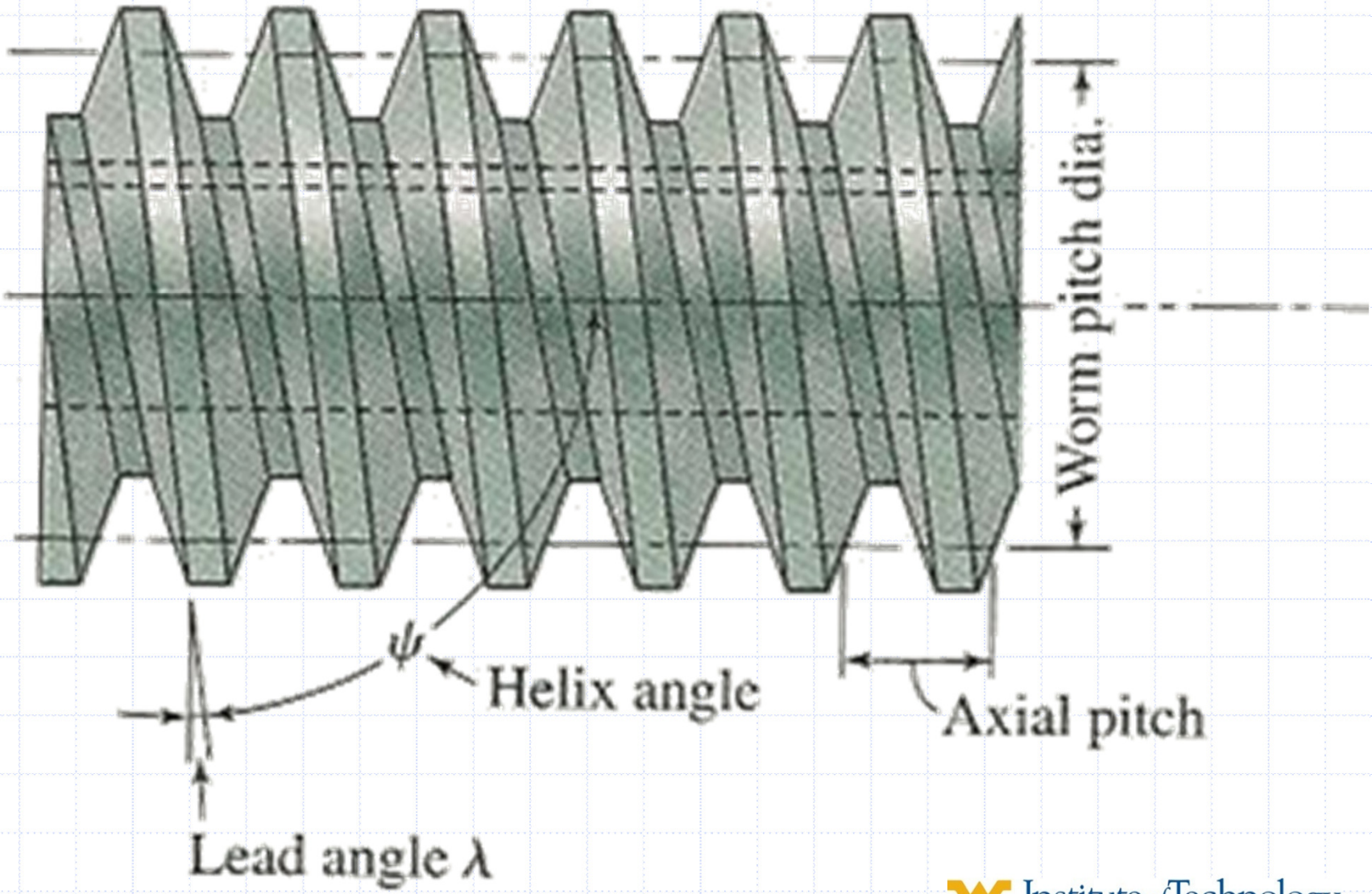




In "hypoid gears," the axes do not intersect!

Worms & Worm Gears
Nomenclature





Nomenclature