Spur Gears

General: Spur gears are the most commonly used gear type. They are characterized by teeth which are perpendicular to the face of the gear. Spur gears are by far the most commonly available, and are generally the least expensive. The basic descriptive geometry for a spur gear is shown in the figure below.

Limitations: Spur gears generally cannot be used when a direction change between the two shafts is required.

Advantages: Spur gears are easy to find, inexpensive, and efficient.

Helical Gears

General: Helical gears are similar to the spur gear except that the teeth are at an angle to the shaft, rather than parallel to it as in a spur gear. (See the references for more specific information). The resulting teeth are longer than the teeth on a spur gear of equivalent pitch diameter. The longer teeth cause helical gears to have the following differences from spur gears of the same size:

- Tooth strength is greater because the teeth are longer,
- Greater surface contact on the teeth allows a helical gear to carry more load than a spur gear
- The longer surface of contact reduces the efficiency of a helical gear relative to a spur gear

Helical gears may be used to mesh two shafts that are not parallel, although they are still primarily use in parallel shaft applications. A special application in which helical gears are used is a crossed gear mesh, in which the two shafts are perpendicular to each other:

The basic descriptive geometry for a helical gear is essentially the same as that of the spur gear, except that the helix angle must be added as a parameter.

Limitations: Helical gears have the major disadvantage that they are expensive and much more difficult to find (at least insofaras an ME3110 student is concerned). Helical gears are also slightly less efficient than a spur gear of the same size (see above).

Advantages: Helical gears can be used on non parallel and even perpindicular shafts, and can carry higher loads than can spur gears.

Bevel Gears

General: Bevel gears are primarily used to transfer power between intersecting shafts. The teeth of these gears are formed on a conical surface. Standard bevel gears have teeth which are cut straight and are all parallel to the line pointing the the apex of the cone on which the teeth are based. Spiral bevel gears are also available which have teeth that form arcs. Hypocycloid bevel gears are a special type of spiral gear that will allow non-intersecting, non-parallel shafts to mesh. Straight tool bevel gears are generally considered the best choice for systems with speeds lower than 1000 feet per minute: they commonly become noisy above this point.

One of the most common applications of bevel gears is the bevel gear differential,

Limitations: Limited availability. Cannot be used for parallel shafts. Can become noisy at high speeds.

Advantages: Excellent choice for intersecting shaft systems.

Worm Gears

General: Worm gears are special gears that resemble screws, and can be used to drive spur gears or helical gears. Worm gears, like helical gears, allow two non-intersecting 'skew' shafts to mesh. Normally, the two shafts are at

right angles to each other. A worm gear is equivalent to a V-type screw thread. Another way of looking at a worm gear is that it is a helical gear with a very high helix angle.

Worm gears are normally used when a high gear ratio is desired, or again when the shafts are perpendicular to each other. One very important feature of worm gear meshes that is often of use is their *irreversibility*: when a worm gear is turned, the meshing spur gear will turn, but turning the spur gear will not turn the worm gear. The resulting mesh is 'self locking', and is useful in racheting mechanisms.

Limitations: Low efficiency. The worm drives the drive gear primarily with slipping motion, thus there are high friction losses.

Advantages: Will tolerate large loads and high speed ratios. Meshes are self locking (which can be either an advantage or a disadvantage).

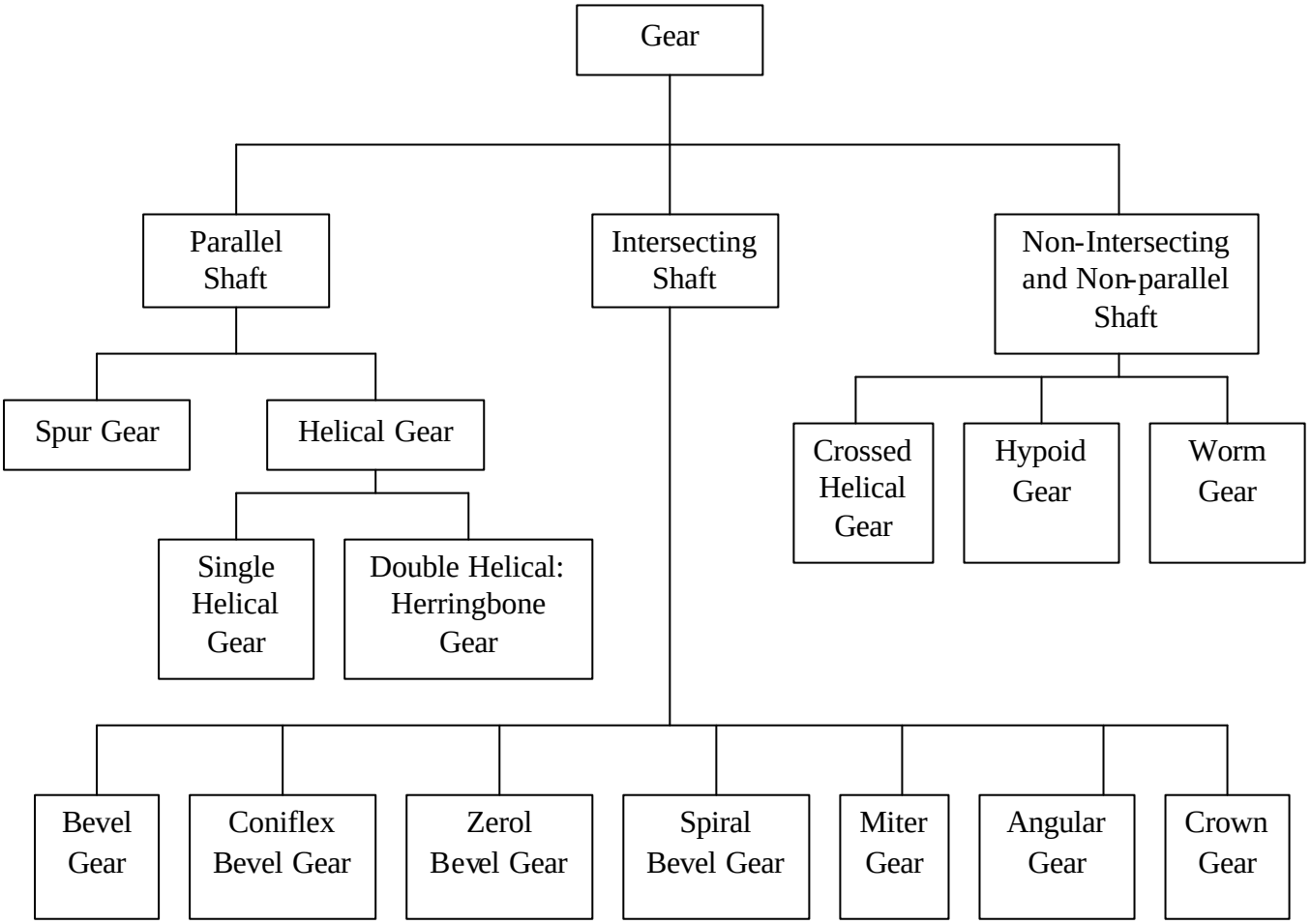
Racks (straight gears)

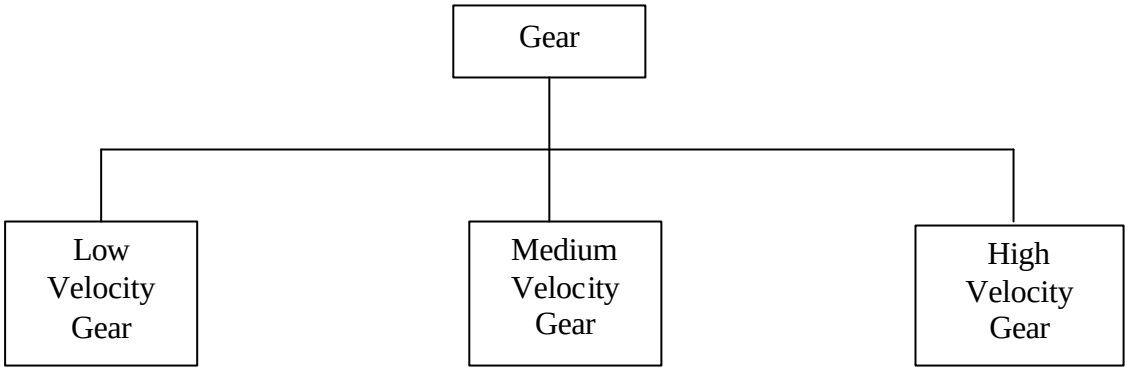
General: Racks are straight gears that are used to convert rotational motion to translational motion by means of a gear mesh. (They are in theory a gear with an infinite pitch diameter). In theory, the torque and angular velocity of the pinion gear are related to the Force and the velocity of the rack by the radius of the pinion gear, as is shown below:

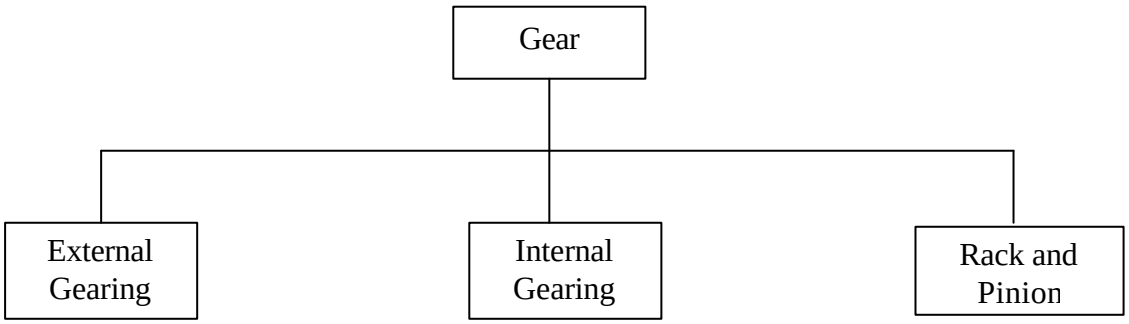
Perhaps the most well-known application of a rack is the rack and pinion steering system used on many cars in the past.

Limitations: Limited usefulness. Difficult to find.

Advantages: The only gearing component that converts rotational motion to translational motion. Efficiently transmits power. Generally offers better precision than other conversion methods.


Gear
Parallel Shaft
Intersecting Shaft
Non-Intersecting and Non-parallel Shaft
Spur Gear
Helical Gear
Crossed Helical Gear
Hypoid Gear
Worm Gear
Single Helical Gear
Double Helical: Herringbone Gear
Bevel Gear
Coniflex Bevel Gear
Zerol Bevel Gear
Spiral Bevel Gear
Miter Gear
Angular Gear
Crown Gear


Gear
Low Velocity Gear
Medium Velocity Gear
High Velocity Gear


Gear
External Gearing
Internal Gearing
Rack and Pinion

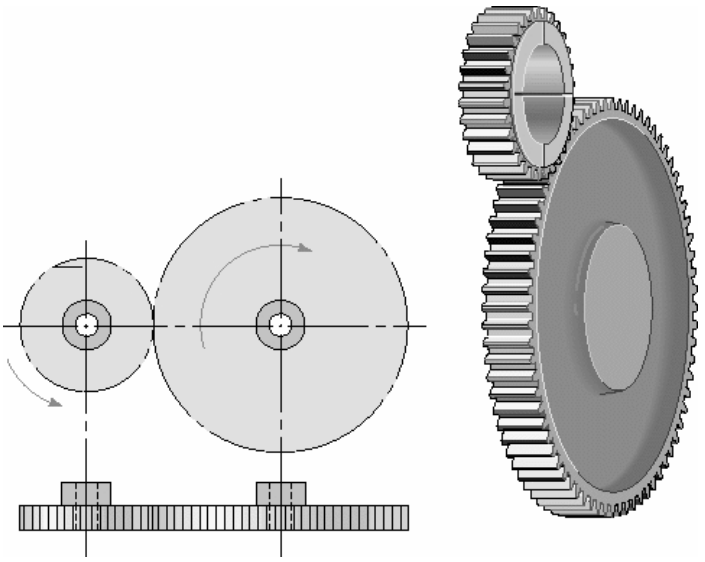


Figure 1: Spur Gear

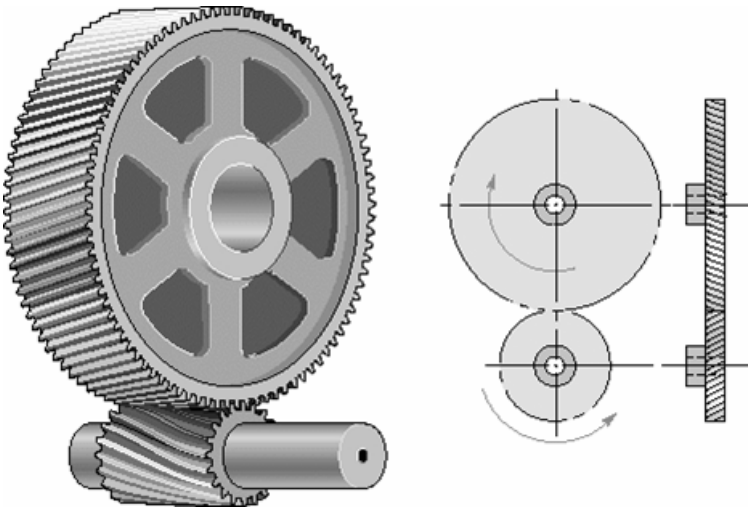


Figure 2: Helical Gear

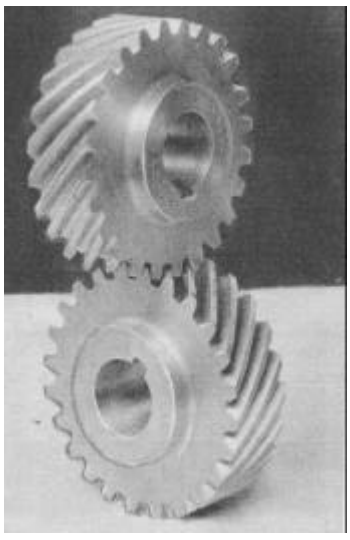


Figure 3: Crossed Helical Gear

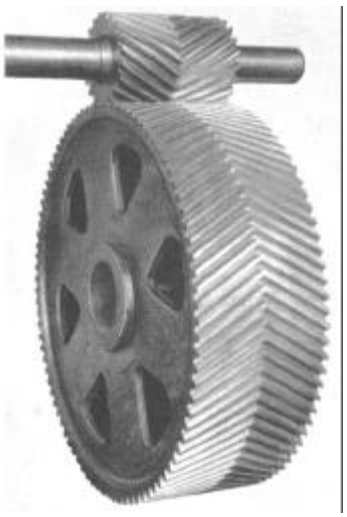


Figure 4: Herring Bone Gear

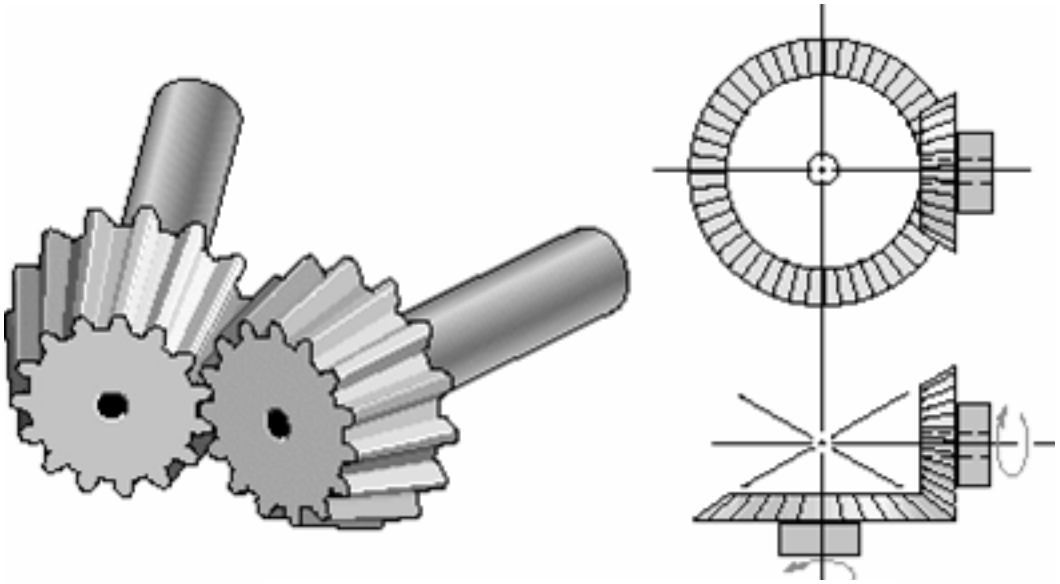


Figure 5: Bevel Gear

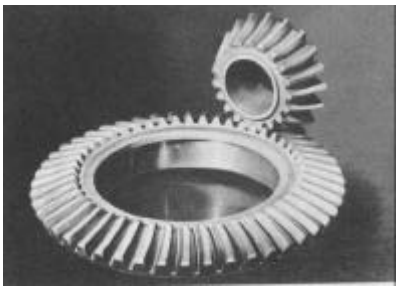


Figure 6: Zerol Bevel Gear

Figure 7: Hypoid Gear

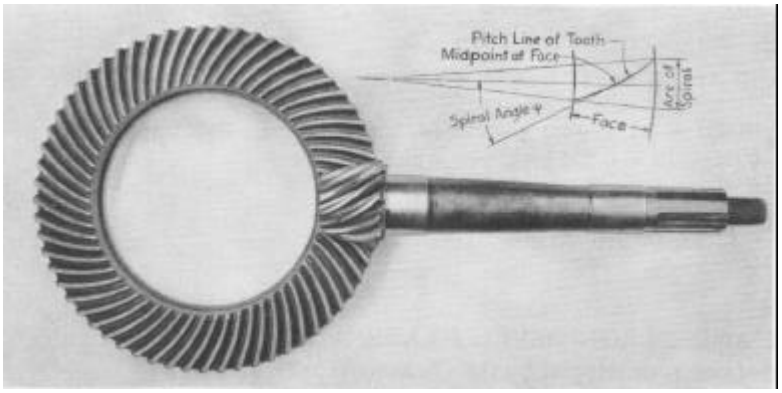


Figure 8: Spiral Bevel Gear

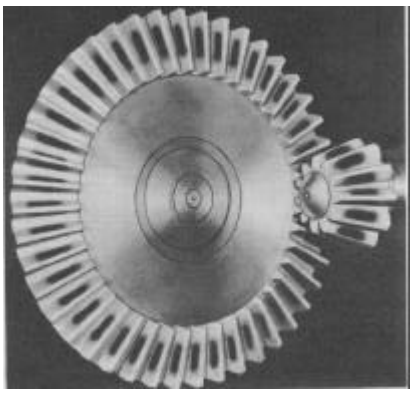


Figure 9: Coniflex Gear

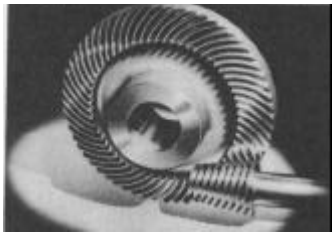
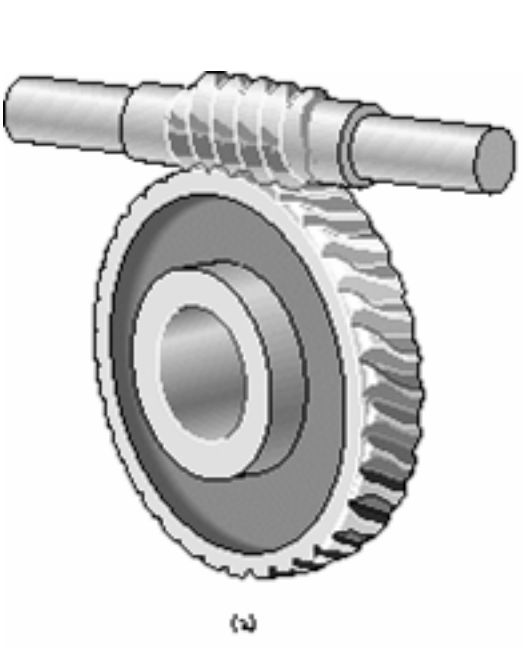


Figure 10: Spiroid Gear

Figure 11: Angular Gear

Figure 12: Miter Gear

Figure 13: Internal Gear



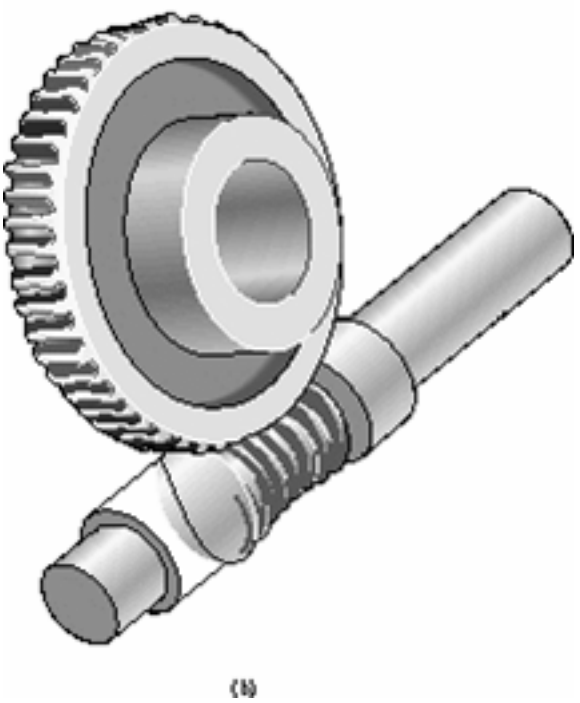


Figure 14: Worm Gear

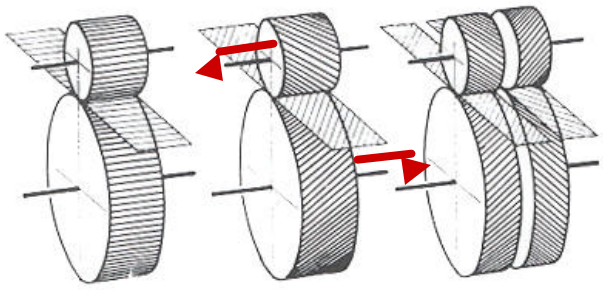
Other Gears

Helical Gears

Bevel Gears

Worm Gears

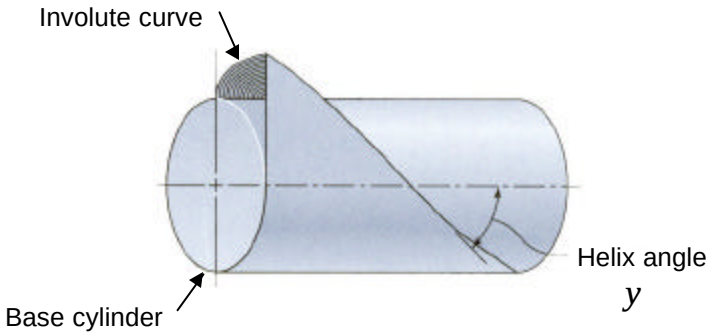
Helical Gears
(Parallel Shafts)



Spur Helical Double Helical

Cancel out
axial force

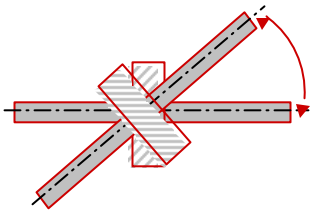
Helical Involute Profile

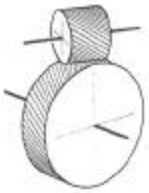


Helical Gears
(Parallel Shafts)

- Advantages
  - Smooth action
  - Stronger than spur gears
  - Used in automobile transmissions
- Disadvantage
  - Axial force
    - Can cancel with double helical or herringbone gears

Helical Gears
(Crossed Shafts)





$$\Sigma = \gamma_2 \pm \gamma_3$$

γ = helix angle

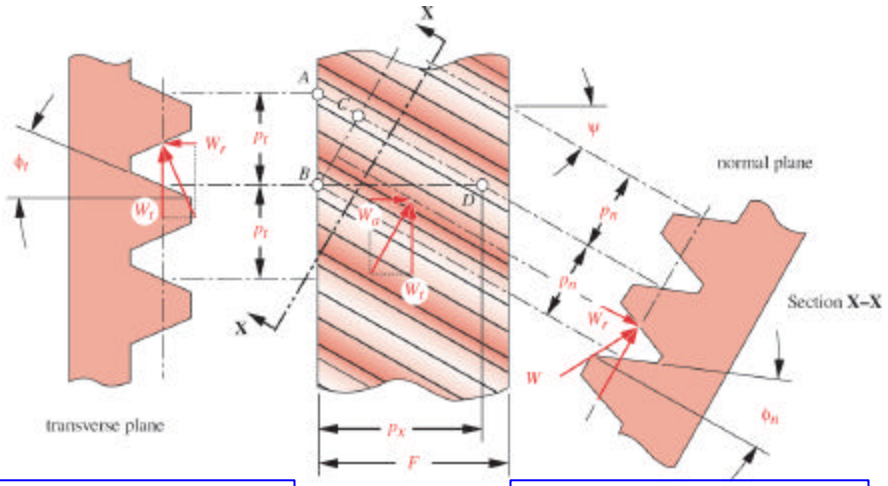
\+ → same hand
\- → opposite hand

Helical Gears
(Crossed Shafts)

- Advantages
  - Non-intersecting shafts
  - Arbitrary shaft angle
- Disadvantages
  - Pure sliding motion
    - Limited power
    - High friction

Example use: Distributor drive in automobile engines

Helical Rack Geometry



Plane on which teeth run

Plane on which teeth are cut

Helical Gear Forces

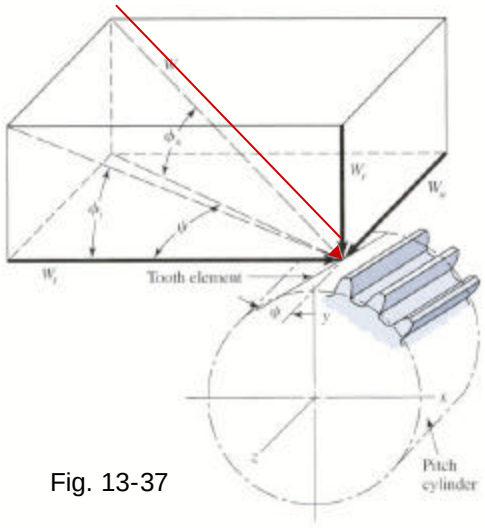


Fig. 13-37

$$W_r = W_t \tan f_t$$

$$W_a = W_t \tan y$$

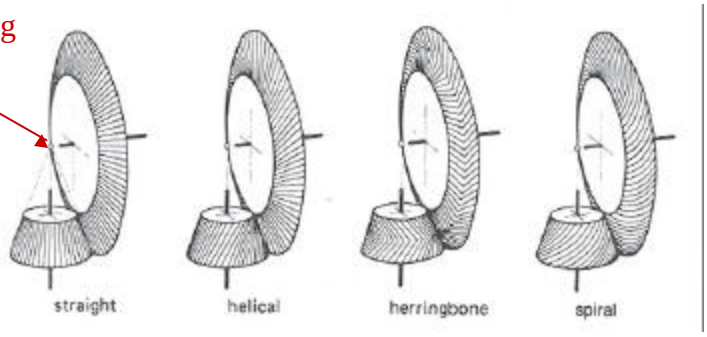
$$W = \frac{W_t}{\cos f_n \cos y}$$

W is always normal to tooth

Bevel Gears

High efficiency drive across non-parallel shafts

Intersecting shafts



Pitch surfaces are cones

Range of Bevel Gearing

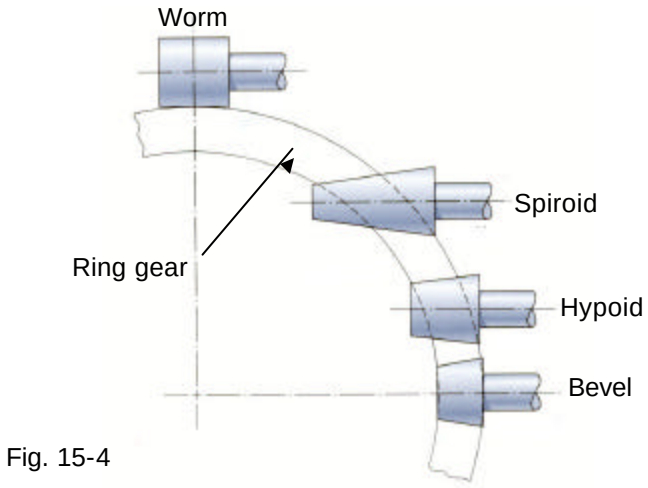
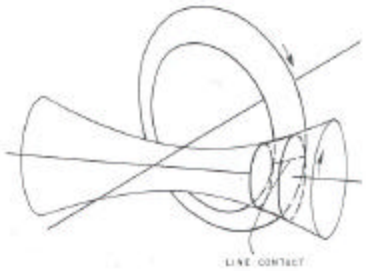
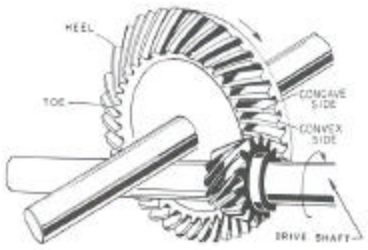


Fig. 15-4

Non-Intersecting Shafts



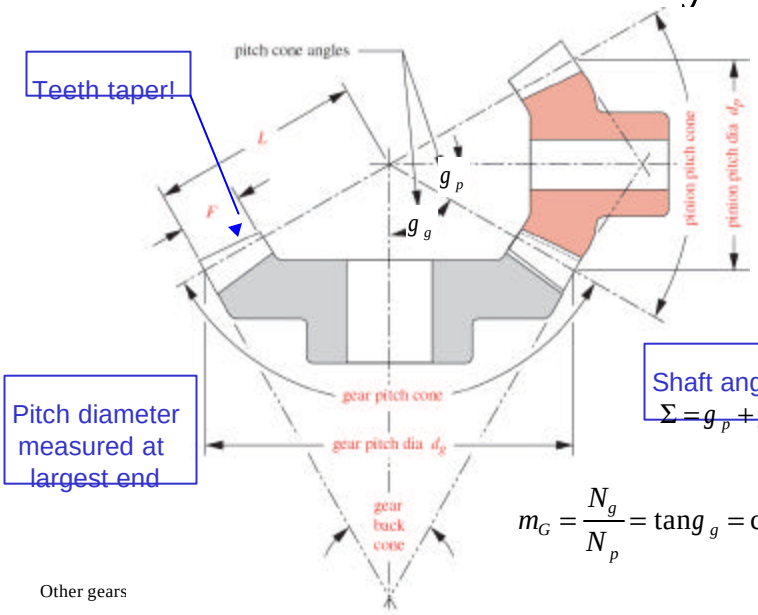


Hypoid Gear & Pinion

Pitch surfaces are hyperboloids

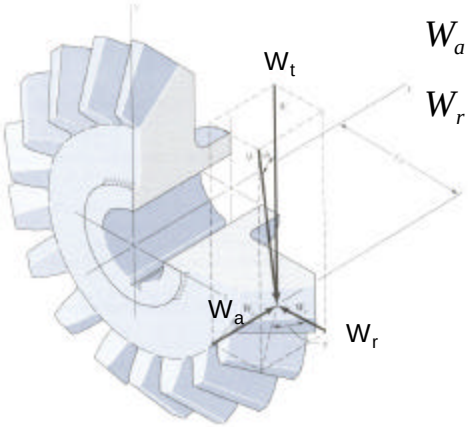
The Hypoid gear is used in automobile differentials. Its invention allowed for the drive shaft to be located lower than the center of the rear axle, thus facilitating lower body designs.

Bevel Gear Geometry



$$m_G = \frac{N_g}{N_p} = \tan\gamma_g = \cot\gamma_p$$

Bevel Gear Forces



$$W_a = W_t \tan f \sin g \quad (13\text{-}29)$$

$$W_r = W_t \tan f \cos g \quad (13\text{-}30)$$

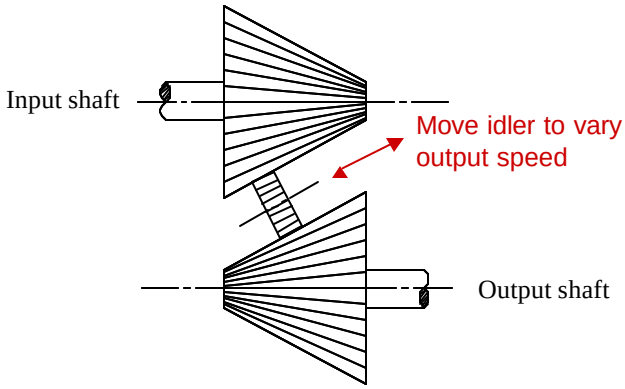
Fig. 13-34

Workshop 21

A 20° 10 diametral pitch straight bevel pinion has 20 teeth and drives a bevel gear with a 4:1 gear ratio. The pinion is turning at 500 rpm and is transmitting 2 HP. The bevel gears have a shaft angle = 90°.

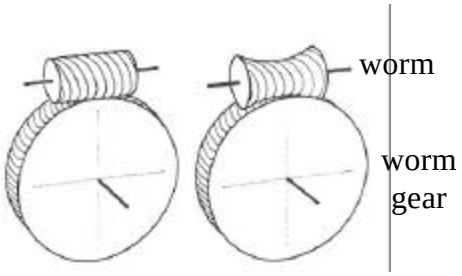
a) Calculate the pitch cone angles of both gears
b) Sketch the two gears
c) Calculate and show the forces acting on each gear

The Patented Variable Transmission That Won't Work!



Worm Gears

Essentially crossed helical gears with a very large helix angle



Q: How many teeth does a worm have?

A: One!

Worm Gears

- Advantages
  - Large speed reduction
  - Compact
  - Self locking
- Disadvantages
  - Pure sliding motion
  - Inefficient
  - Low power applications