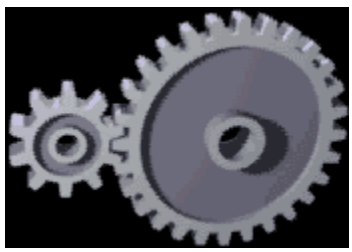
Gear Design

ME 313: Mechanical Design
Week 9

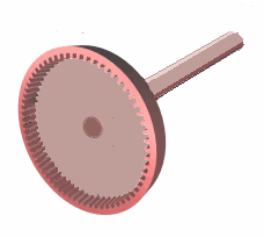
What are Gears?

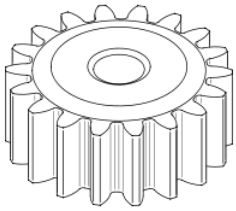
- Rotating machines with cut *teeth* or *cogs* to transmit torque



Type of Gears

- Internal vs External Gears

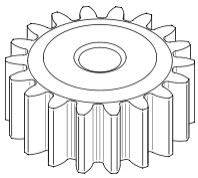




  - While most gears we use are usually external gears, there are still some uses for internal gears

Type of Gears

- Spur gears



- Bevel gears

Type of Gears (cont)

- Helical gears

- Double helical gears

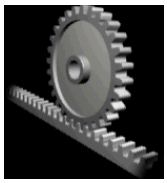
Type of Gears (cont)

- Crown Gears

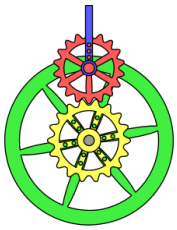
- Worm Gear

Types of Gears

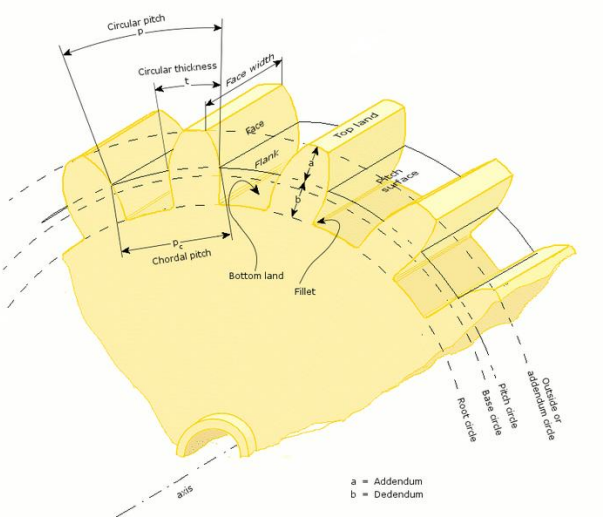
- Rack and Pinion



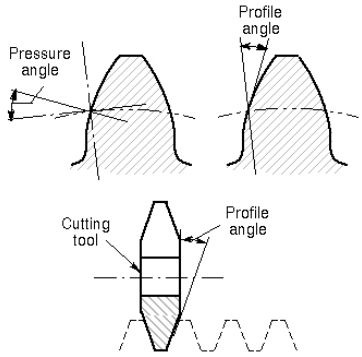
- Planetary Gear



Gear Geometry



Pressure Angle



- Angle of gear surface compared to pitch circle tangent line
- Typical values are 20 and 25 degrees

Mating Two Gears

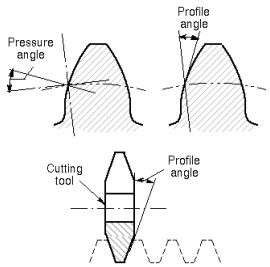
- Two mating gears must have the same circular pitches
- They also must have the same pressure angles

Fundamentals of Gear Motion

$$\frac{\omega_1}{\omega_2} = \frac{r_2}{r_1} = \frac{D_2}{D_1}$$

- Gear angular velocity ratio is dependent on gear pitch radius ratio

Force Transmission



- Force transmitted in gear is dependent on the pressure angle, ϕ
  - where F is the total reaction force

$$W_t = F\cos\phi$$
$$W_a = F\sin\phi$$

Torque Transmission

- Only the tangential force transmit torque and power

$$T = \frac{D}{2} W_t$$

- If pitch line velocity is *v*, then power, *P*, is

$$P = W_t v$$
$$= T\omega$$

Bevel Gear

- Aside from pressure angle ϕ, bevel gear is also defined by angle of pitch surface, γ

Force Analysis—Bevel Gears

- Assume that the forces were concentrated at the midpoint of the tooth

$$W_t = \frac{T}{r_{av}}$$

  - r_{av} is the pitch radius at midpoint

- Force acting on the tooth have three components: axial, radial, and tangential

$$W_r = W_t \tan\phi \cos\gamma$$
$$W_a = W_t \tan\phi \sin\gamma$$

Helical Gears

- Defining angles are pressure angle ϕ and helix angle ψ

Force Analysis—Helical Gear

- Point of force is at the middle of the gear face

$$W_r = W \sin\phi$$
$$W_t = W \cos\phi \cos\psi$$
$$W_a = W \cos\phi \sin\psi$$

Worm Gears

- Defining angles are pressure angle ϕ and helix angle λ
- Additionally, worm and pinion surfaces are always sliding
  - Friction becomes an important factor
- Worm gears are not 100% efficient

Force Analysis—Worm Gears

- Directions are relative to the worm

$$W_x = W(\cos\phi \sin\lambda + \mu \cos\lambda)$$
$$W_y = W \sin\phi$$
$$W_z = W(\cos\phi \cos\lambda - \mu \sin\lambda)$$

- Efficiency

$$\eta = \frac{\cos\phi - \mu \tan\lambda}{\cos\phi + \mu \cot\lambda}$$