Objectives

- Understand why teeth profiles are needed.
- Understand the involute curve, its properties and how it is created.
- Learn the basic terminology of gears.
- Understand the equivalent kinematic diagram of gears.
- Identify different types of gears.
Why do we need gears?

Rolling circles, what if friction is not enough?
But, what’s wrong with these designs?

They cannot transmit constant speed
When two profiles are designed to produce a constant relation of angular velocity.
How to find the profile?

- Unfortunately it is not a trivial task.
- But, fortunately only two profiles are widely used:
  - The involute
  - And the cycloid
The cycloid

Check the second video of the references.
The involute
Kinematic equivalence

Pitch circle

Base circle

$O_1$  

$O_2$
What is the pressure angle?

It is an standard value: $20^\circ$, $25^\circ$ and in the past $14.5^\circ$
The pressure angle
• Pitch circles
• Circular pitch
• Addendum
• Clearance
• Working depth
• Whole depth
• Tooth
• Thickness
• Backlash!!
Backlash

Spur gear terms.
Basic relationships

Diametral Pitch

\[ P = \frac{N}{D} \]

N= Number of teeth  
D= Pitch circle diameter

Circula Pitch

\[ CP = \frac{\pi D}{N} \]
Basic relationships

Base pitch:

\[ BP = CP \frac{D_b}{D} \]

\( D \) = Pitch circle diameter

\( D_b \) = Base circle diameter

Line of action:

\[ l = |AC - AP| + |DB - DP| \]

\[ l = \sqrt{(r_2 + a_2)^2 - (r_2 \cos \delta)^2} - r_2 \sin \delta + \sqrt{(r_3 + a_3)^2 - (r_3 \cos \delta)^2} \]

Contact ratio: \[ CR = \frac{l}{BP} \]
Interference

- Adendum circles
- Base circle
- Pitch circles

Interference
The smallest gear is usually called pinion.
What if the diameter of the base circle approaches to infinite?

We get a rack and pinion pair. It does convert rotational motion into linear motion.
They provide a smoother movement than spur gears.

\[ x = r \cos(t), \quad y = r \sin(t), \quad z = pt \]

- \( r \) is the diameter of the helix and \( p \) is the pitch.
Their disadvantage (besides that they are more complex and therefore more expensive) is that they produce forces along the axis. Although there is a solution: Herringbone gears.
They can also transmit movement between axes that do not intersect. And there also is the rack and pinion version.
They are a special case of helical gears, with the pinion helix close to 90°, and the gear close to 0°
Spiral gears

- An improvement of the bevel gears, they use the spiral curve to generate the tooth.

\[ r = a + b\theta \]
An special case are the hypoid gears, they allow higher degrees relations of transmission and smoother motion.
Force analysis of spur gears
Assumption: All the forces are concentrated on the middle of the teeth

\[ W_t = \frac{T}{r_{med}} \]
\[ W_r = W_t \tan \phi \cos \gamma \]
\[ W_a = W_t \tan \phi \sin \gamma \]
Forces of helical gears

\[ W_t = W \sin \phi_n \]
\[ W_r = W \cos \phi_n \cos \psi \]
\[ W_a = W \cos \phi_n \sin \psi \]

Usually \( W_t \) is given, therefore:

\[ W = \frac{W_t}{\cos \phi_n \cos \psi} \]
\[ W_r = W_t \tan \phi_t \]
\[ W_a = W_t \tan \psi \]
Universal milling
Gear shaping
Gear manufacturing

- Hobbing, it cannot produce internal gears
Some videos

- http://www.youtube.com/watch?v=L1x1TRO36gU&feature=related
- http://www.youtube.com/watch?v=xF9CjluRFJ4ç
- http://www.youtube.com/watch?v=o6bPTTyHSBU&feature=related
References

- http://www.youtube.com/watch?v=Dh83mGUCiws
- http://www.youtube.com/watch?v=APeJrQpm5B8
- http://www.youtube.com/watch?v=Z1f29M4o3jl&feature=related