Actuation and transmission design

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Overview

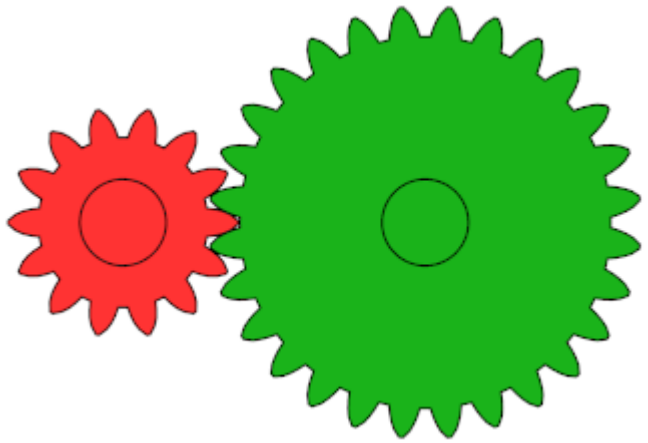
- Purpose:
  - Transmission: Energy from available from to useful or desired form

Gear

From Brick Experiment Channel
https://www.youtube.com/watch?v=MwHHErfX9hI

Gear

- What is gear



Rotation to rotation

Rotation to linear

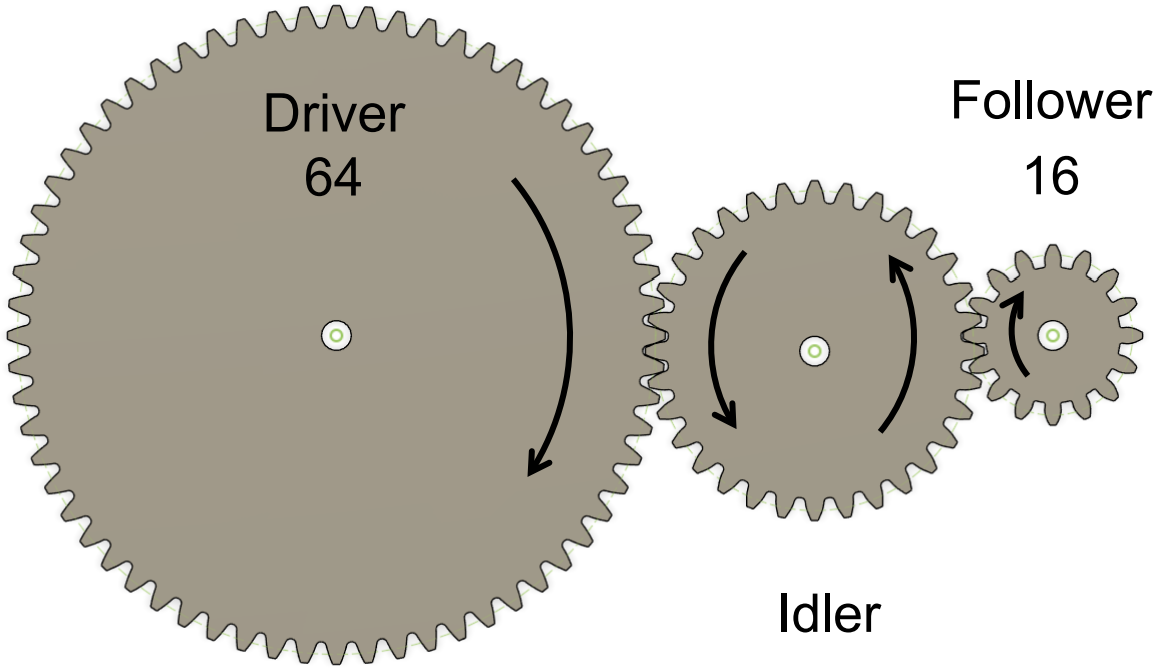
- Why we use it

1) Speed ↑ or↓
2) Change force or torque
3) Change axis of rotation
4) Reverse direction of rotation

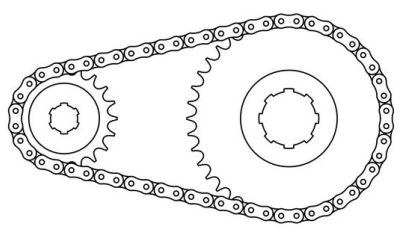
Spur gear - speed

1) Speed ↑ or↓

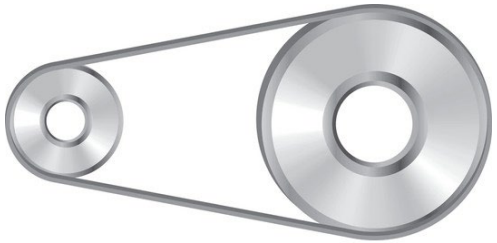
$$Velocity\ ratio = \frac{Velocity\ of\ driver}{Velocity\ of\ follower}$$



4) Reverse direction of rotation



Chain and sprocket



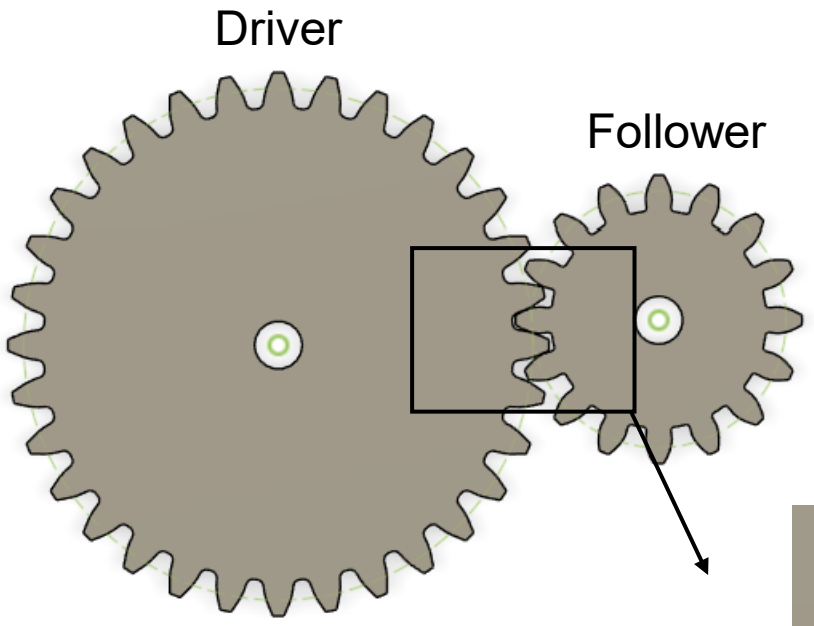
Belt and pulley

→ radius

Same direction

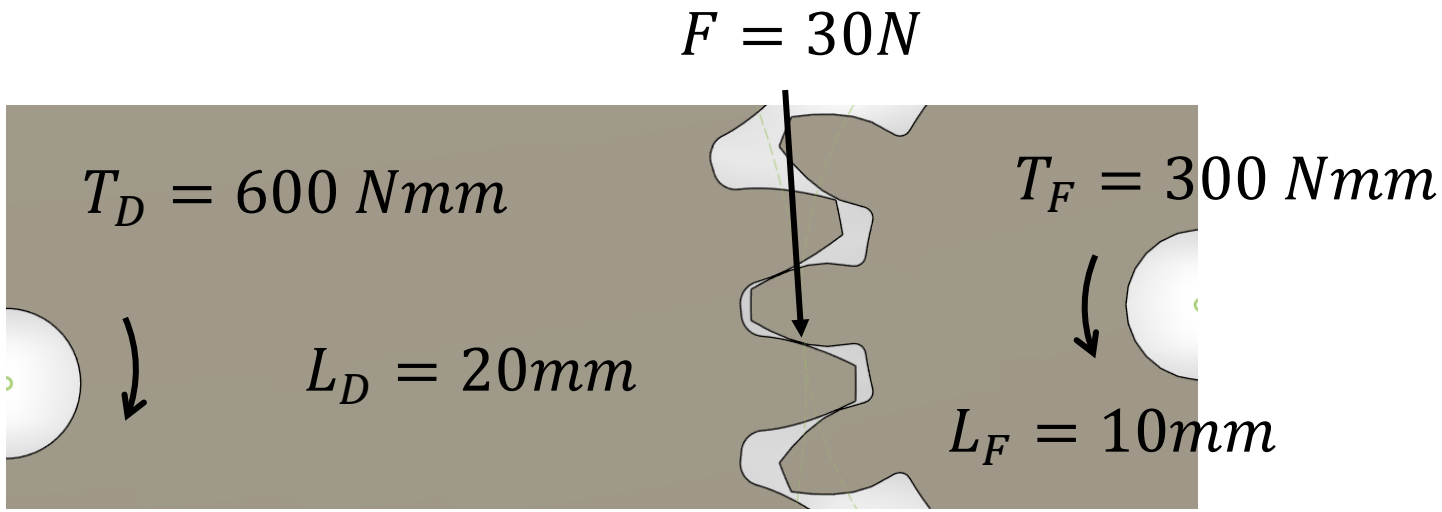
Spur gear -torque

2) Change force or torque



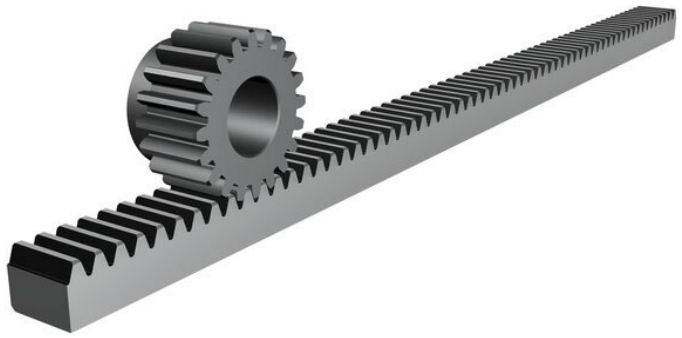
$$\frac{Velocity\ of\ driver}{Velocity\ of\ follower} = \frac{Teeth\ on\ follower}{Teeth\ on\ driver}$$

$$= \frac{Torque\ on\ follower}{Torque\ on\ driver}$$



Spur gear + ?

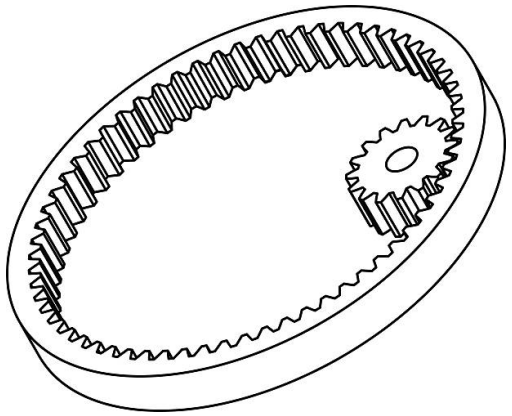
- Rack



- Rack and pinion
- Rotation to linear
- Fine-tune machinery parameters

  Control the amount of fuel

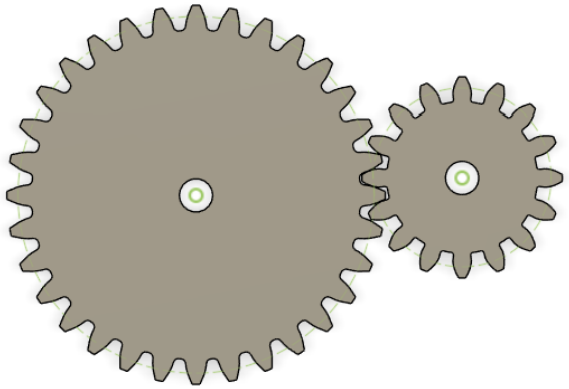
- Internal gear



- Planetary gear system
- Sun, planet and ring gears
- Reduction gears, high torque, high efficiency and compact

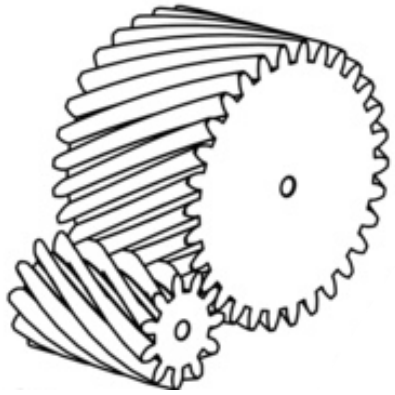
Type of gear (1)

- Teeth structure



Spur gear

1) Linear



Helical gear

2) Helix

Contact gradually

Sustain higher load

Reduce noise and vibration

Double helical gear

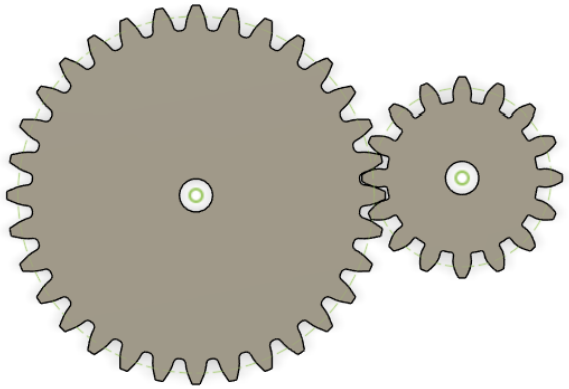
3) Double helical or non linear

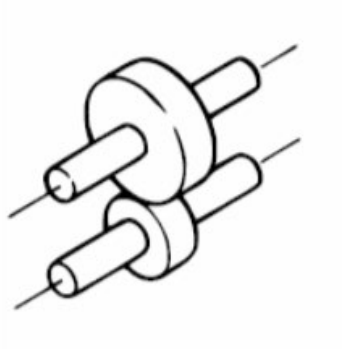
Prevent out axial force

→ High load & High speed application

Type of gear (2)

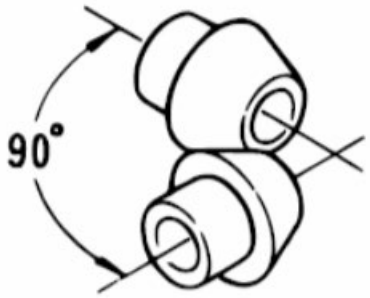
- Gear axis



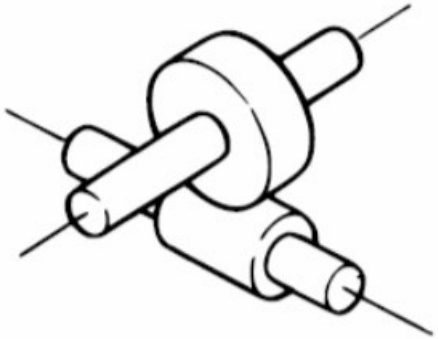


Parallel

3) Change axis of rotation



Intersecting

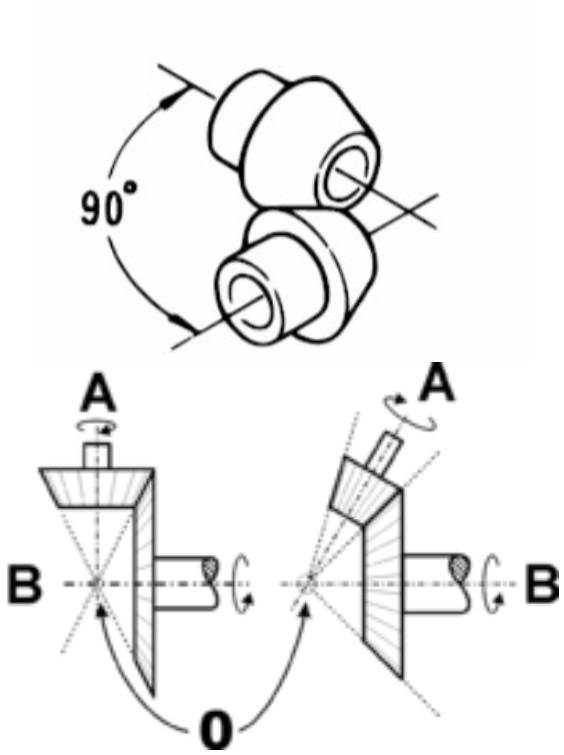


Non-intersecting and non-parallel

Intersecting

Bevel gear

3) Change axis of rotation



- Teeth on conical surface
- Speed and torque equation applied same
- High stress and high noise

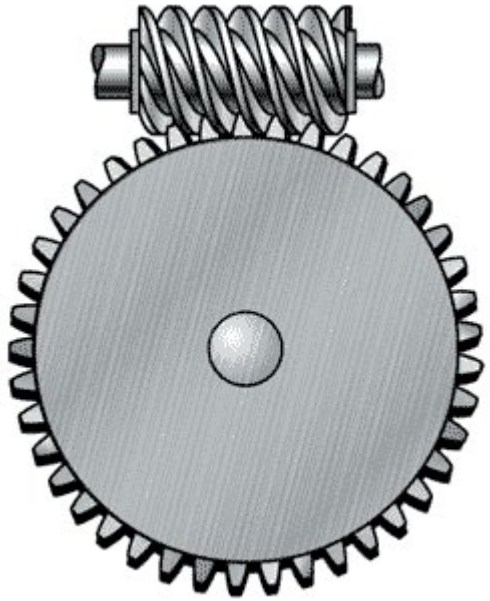
Spiral bevel gear

Non-intersecting and non-parallel

Worm gear

3) Change axis of rotation

Worm gear



Worm wheel

- Resembles a screw
- High gear reduction ratios
  - “Number of teeth on wheel” rotations of worm = 1 rotation of wheel
- Self-locking

  Worm wheel cannot turn worm gear

Backdrivability

The degree of ease of which a motor or geared motor can be **driven by its attached load** when **power is removed** from the motor

Design type

Reduction ratio

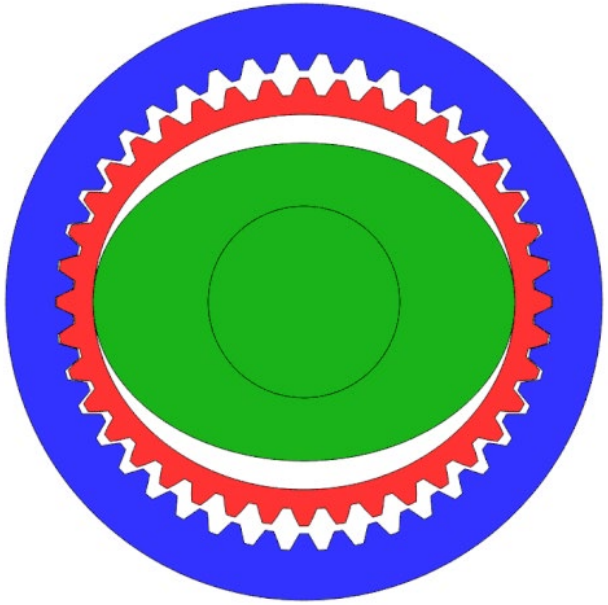
Teeth geometry

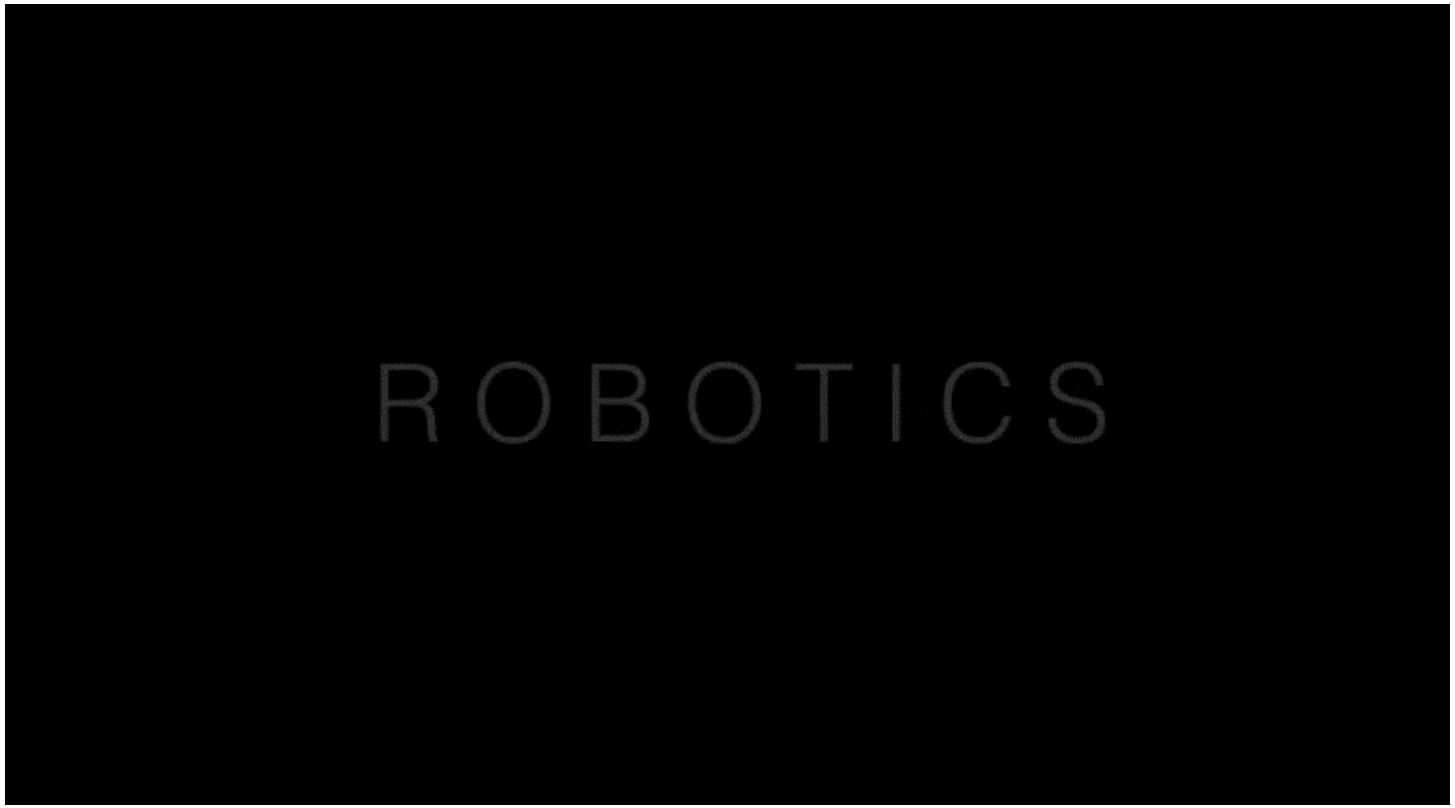
Friction

Etc.

- Mechanism should be moved by hand in case of power loss or maintenance reason
- Robot works with human
  - Safety
  - Bidirectional operation (interaction with dynamic forces)

Harmonic drive



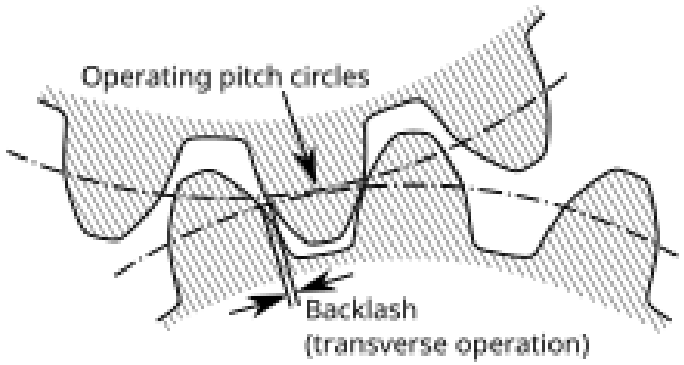


- High precision
- Compact
- Large gear reduction ratio
- Typically backdrivable

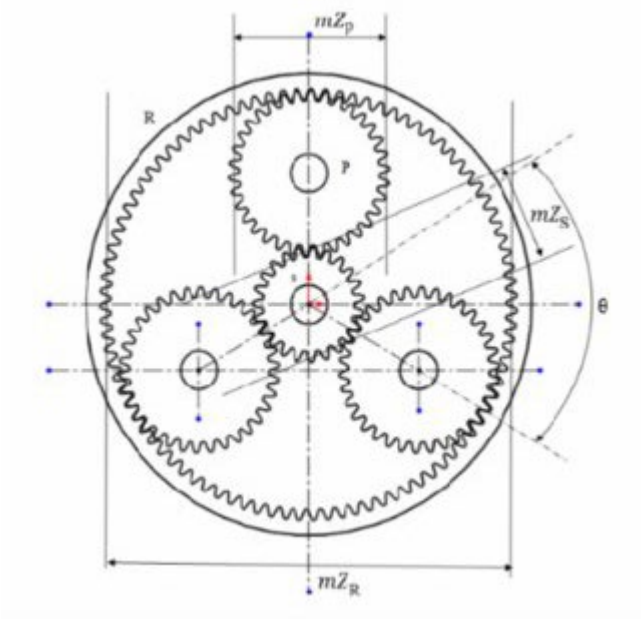
From Oleksandr Stepanenko
https://www.youtube.com/watch?v=So9PoP3rqKo&t=34s

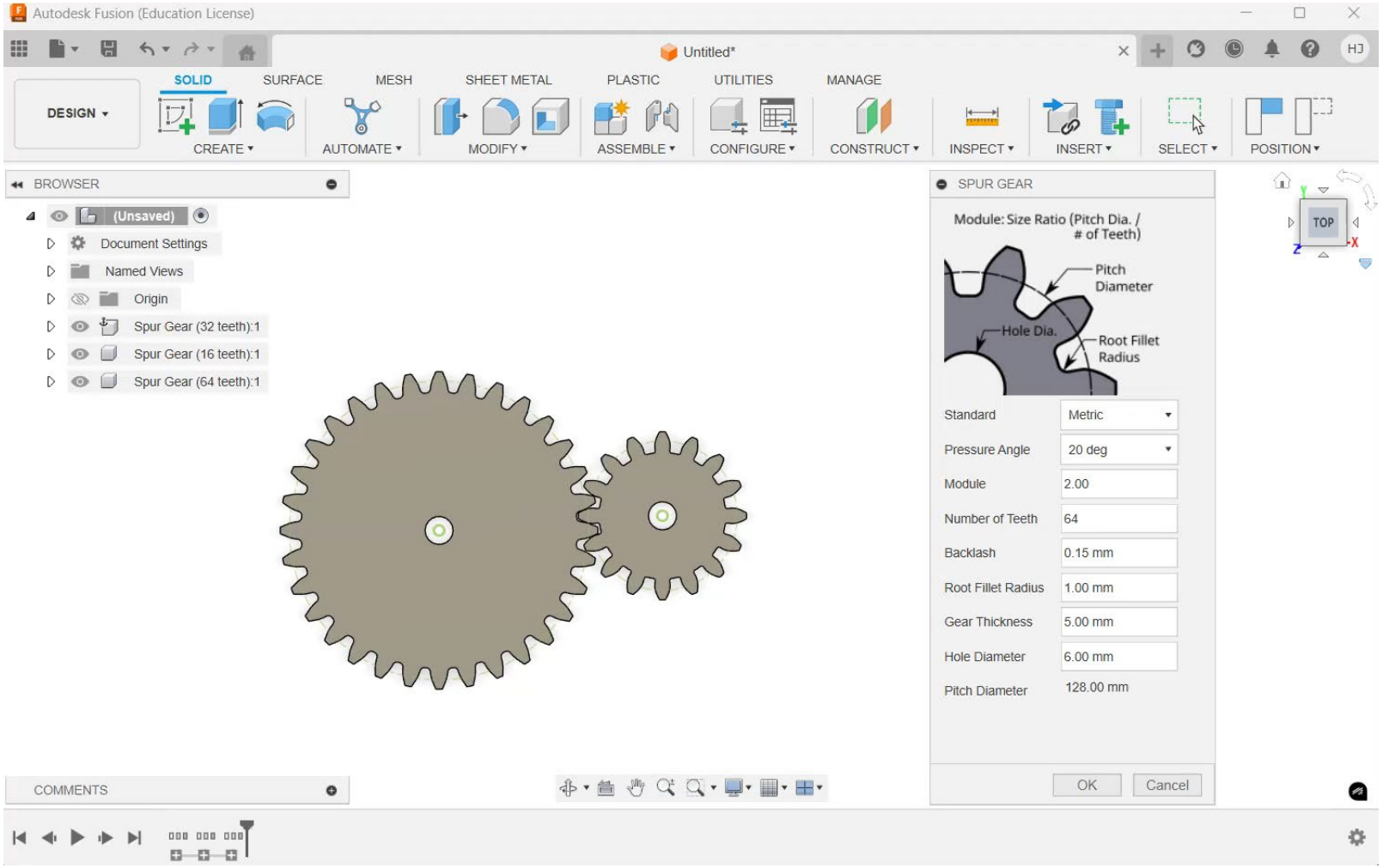
How to choose gear

- Calculate required gear ratio
- Axis relationship
- Specific feature
  - Self locking vs. Backdrivable
  - Compact size with high gear ratio
- Define system acceptable backlash



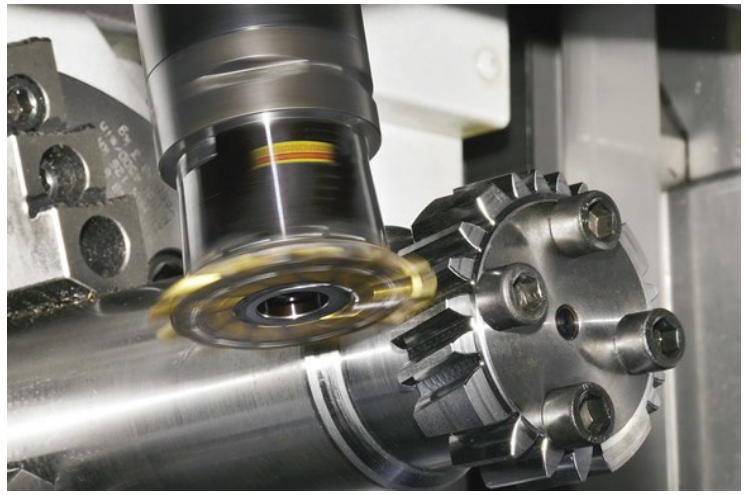
Customize Gear





Customize Gear

- CNC machining



- Laser cutting or 3D printing

For conventional manufacturing method linear teeth gear is easy to fabricate and cheap

However in 3D printing teeth structure does not make difference in fabrication process