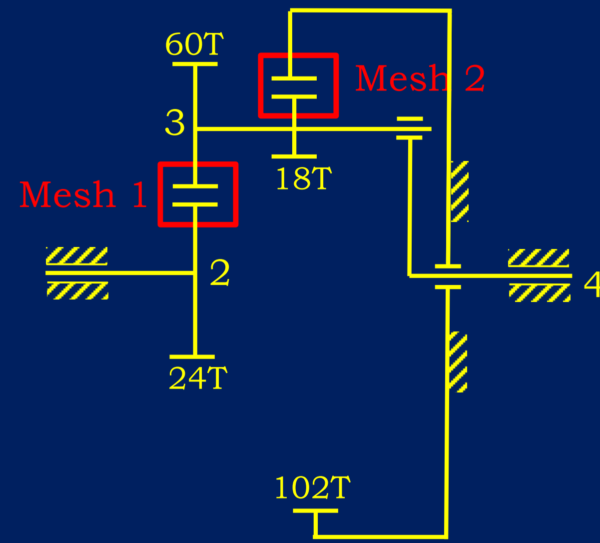
3. Gears

Example:

Determine $\frac{\omega_{14}}{\omega_{12}}$



Mesh 1, planetary, arm 4, external

$$R_{23} = -\frac{T_2}{T_3} = -\frac{24}{60} = \frac{\omega_{13} - \omega_{14}}{\omega_{12} - \omega_{14}}$$

Mesh 2, planetary, arm 4, internal

$$R_{31} = \frac{T_{3'}}{T_1} = \frac{18}{102} = \frac{\omega_{11} - \omega_{14}}{\omega_{13} - \omega_{14}}$$

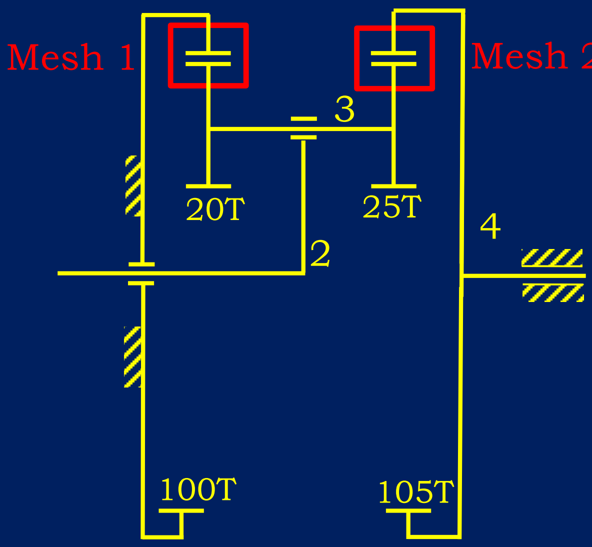
$$R_{23} \times R_{31} = \frac{\omega_{13} - \omega_{14}}{\omega_{12} - \omega_{14}} \times \frac{-\omega_{14}}{\omega_{13} - \omega_{14}} = -\frac{24}{60} \times \frac{18}{102} = -\frac{6}{85}$$

$$\frac{\omega_{14}}{\omega_{12}} = \frac{6}{91}$$

3. Gears

Example:

Determine $\frac{\omega_{14}}{\omega_{12}}$



Mesh 1, planetary, arm 2, internal

$$R_{13} = \frac{T_1}{T_3} = \frac{100}{20} = \frac{\omega_{13} - \omega_{12}}{\omega_{11} - \omega_{12}}$$

Mesh 2, planetary, arm 2, internal

$$R_{34} = \frac{T_{3'}}{T_4} = \frac{25}{105} = \frac{\omega_{14} - \omega_{12}}{\omega_{13} - \omega_{12}}$$

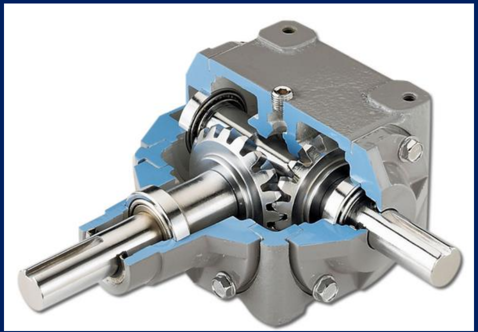
$$R_{13} \times R_{34} = \frac{\omega_{13} - \omega_{12}}{-\omega_{12}} \times \frac{\omega_{14} - \omega_{12}}{\omega_{13} - \omega_{12}} = \frac{100}{20} \times \frac{25}{105} = \frac{25}{21}$$

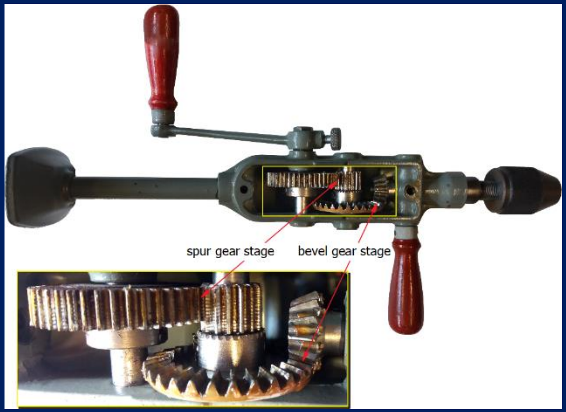
$$\frac{\omega_{14}}{\omega_{12}} = \frac{4}{25}$$

3. Gears

Bevel Gears

Floodgate power screw
operated by bevel gear





Hand powered drill

3. Gears

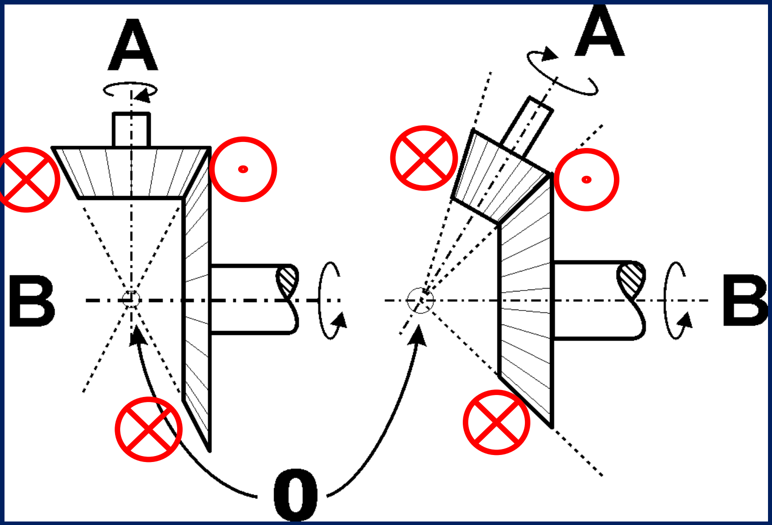
Bevel Gears

In bevel gears since rotation axes of two meshing gears are **not** parallel, the sign convention in simple and planetary gear trains **do not** work.

For simple bevel gears inspection works very well.

⊙ Designates velocity vector tip (out of page)

⊗ Designates velocity vector tail (into page)



3. Gears

Example:

Determine $\frac{\omega_{14}}{\omega_{12}}$

Mesh 1, bevel, simple

$$R_{23} = \frac{T_2}{T_3} = \frac{20}{80} = \frac{\omega_{13}}{\omega_{12}} \text{ (Direction on figure!)}$$

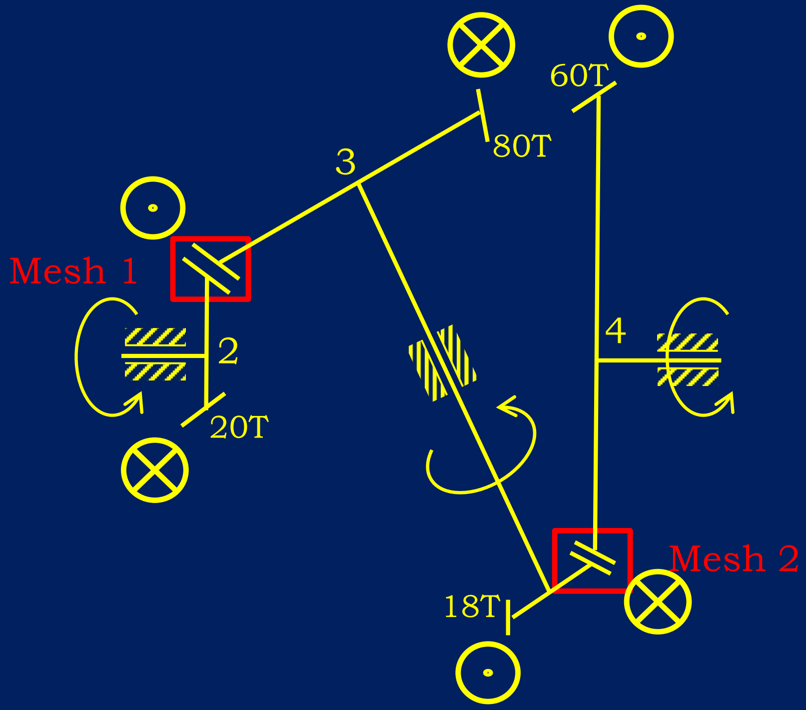
Mesh 2, bevel, simple

$$R_{34} = \frac{T_{3'}}{T_4} = \frac{18}{60} = \frac{\omega_{14}}{\omega_{13}}$$

$$R_{23} \times R_{34} = \frac{\omega_{13}}{\omega_{12}} \times \frac{\omega_{14}}{\omega_{13}} = \frac{\omega_{14}}{\omega_{12}} = \frac{20}{80} \times \frac{18}{60} = \frac{3}{40}$$

Since shafts 2 and 4 are parallel and rotate in the same direction (obtained by **<u>inspection</u>**)

$$\frac{\omega_{14}}{\omega_{12}} = +\frac{3}{40}$$



3. Gears

Bevel Gears

For planetary bevel gears,

1. Fix the arm, let the fixed (if any) gears move.
2. Write the gear ratio of the simple gear train *with proper signs*, equate it to the speed ratio of the planetary gear train.
3. If result is + then output is in the same direction obtained in (2) if – opposite direction to (2).

3. Gears

Example: (3.5 of textbook)

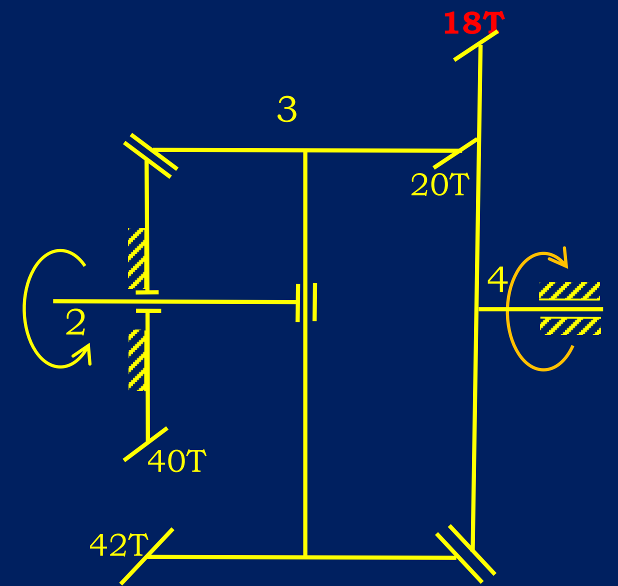
Determine $\frac{\omega_{14}}{\omega_{12}}$

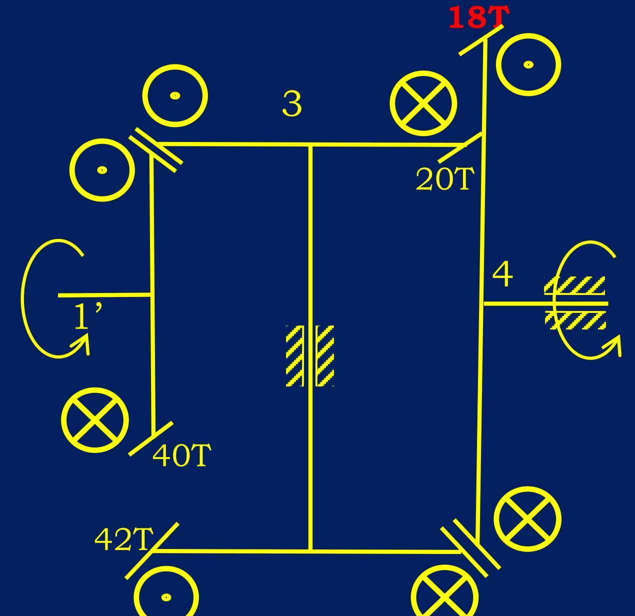
1. Fix the arm (2), let the fixed (if any) gears (1→1') move
2. Write the gear ratio of the simple gear train with proper signs, equate it to the speed ratio of the planetary gear train

$$R_{1'4} = \frac{T_1 \times T_{3'}}{T_3 \times T_4} = \frac{40 \times 42}{20 \times 18} = \frac{14}{3} = \frac{\omega_{14} - \omega_{12}}{\omega_{11} - \omega_{12}}$$

3. If result is + then output is in the same direction obtained in (2) if – opposite direction to (2).

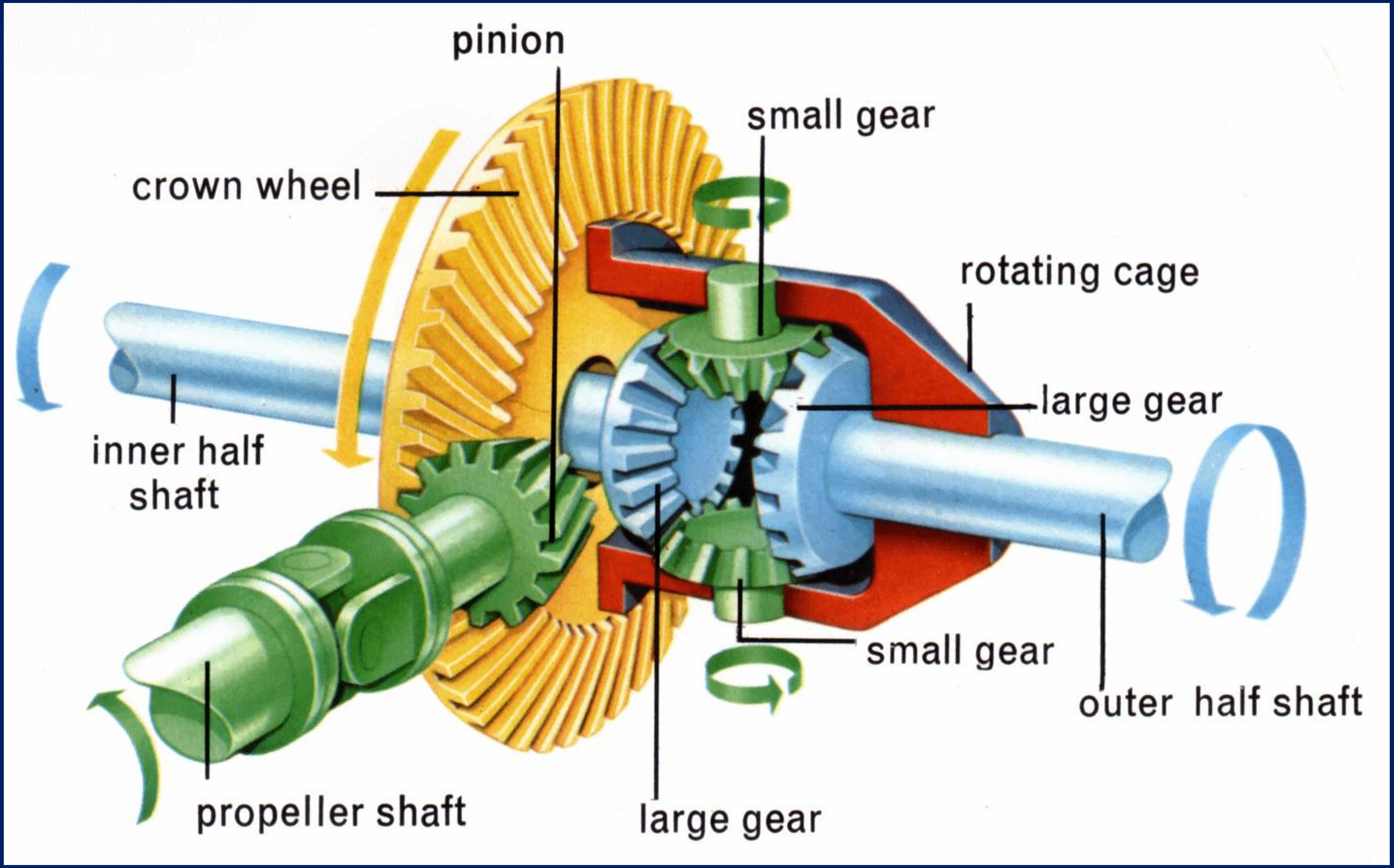
$$\frac{\omega_{14}}{\omega_{12}} = -\frac{11}{3}$$



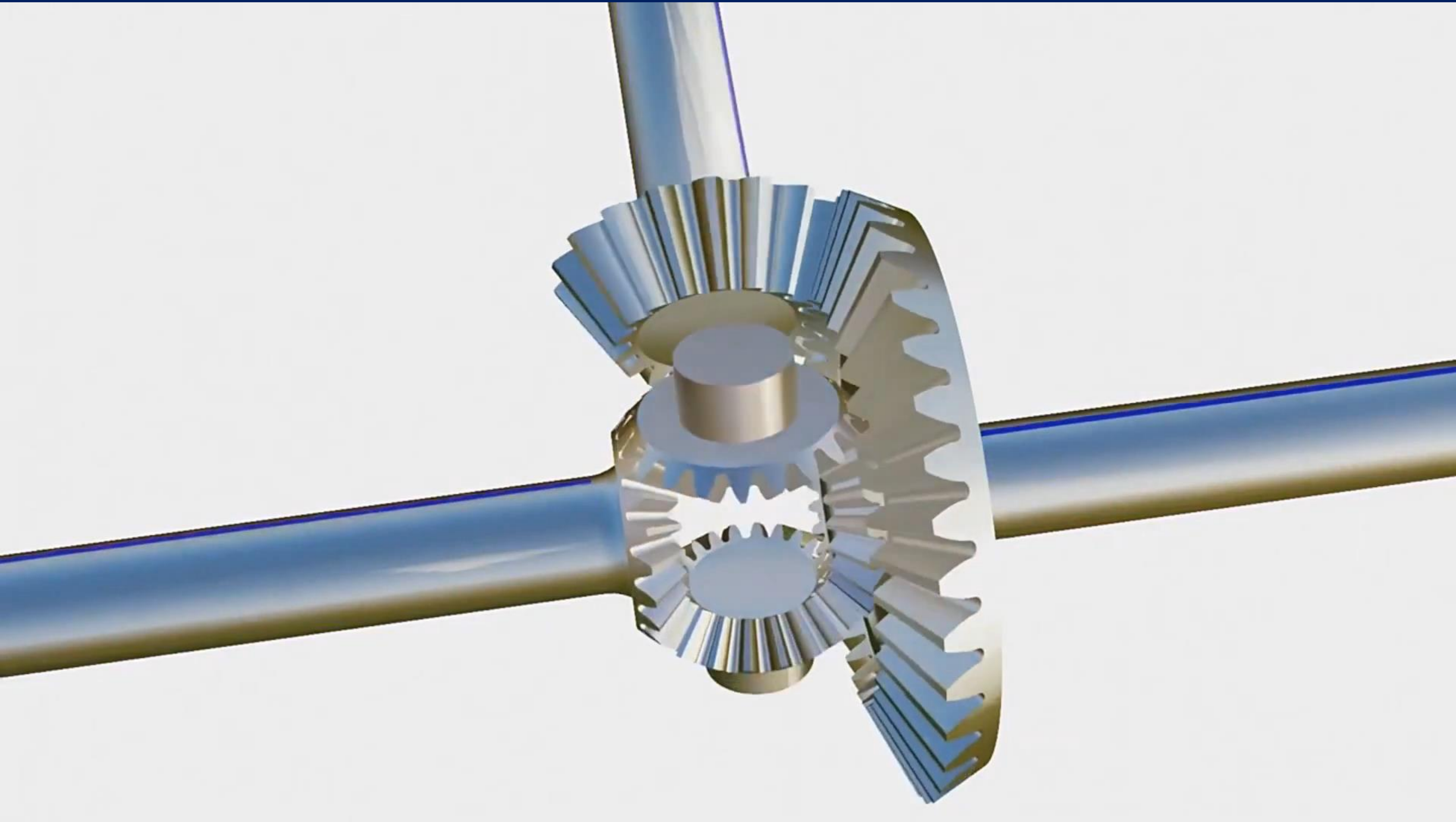


3. Gears

Example: (Car differential)



3. Gears



https://www.youtube.com/watch?v=LrkWjpdk66E

3. Gears

Example: (Car differential)

$$R_{23} = \frac{T_2}{T_3} = \frac{16}{48} = \frac{\omega_{13}}{\omega_{12}}$$ (Direction on figure by inspection!)

1. Fix the arm (3), let the fixed (none) gears move
2. Write the gear ratio of the simple gear train with proper signs, equate it to the speed ratio of the planetary gear train

$$R_{56} = \frac{T_5 \times T_4}{T_4 \times T_6} = \frac{20 \times 14}{14 \times 20} = -1 = \frac{\omega_{16} - \omega_{13}}{\omega_{15} - \omega_{13}}$$

$$\omega_{15} + \omega_{16} = \frac{2}{3}\omega_{12}$$

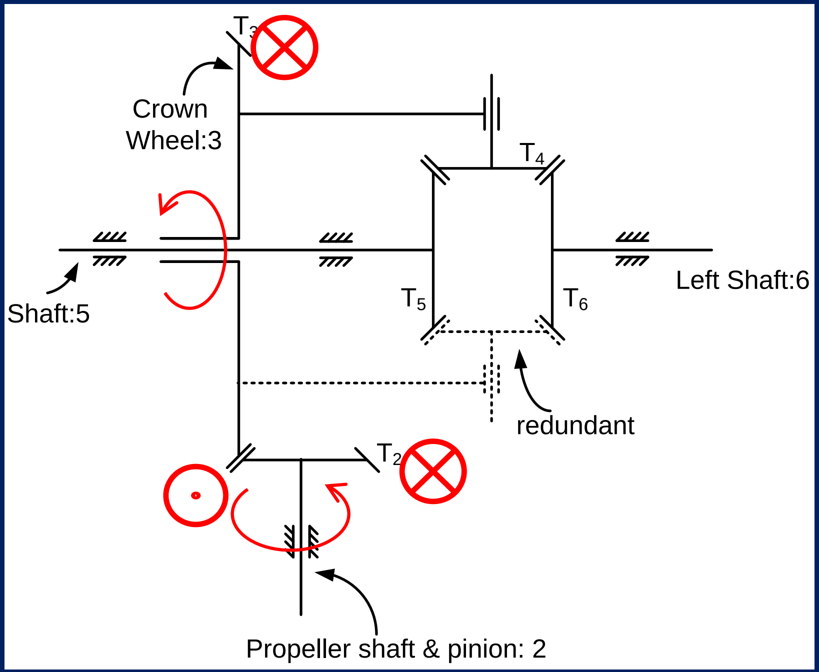
On straight road,

$$\omega_{15} = \omega_{16} = \frac{\omega_{12}}{3}$$

On a curve

$$\omega_{15} \neq \omega_{16}$$

This is a F = 2 mechanism but there is only one input. The road conditions determine the motion, underactuation.



Typical Tooth Number
$T_2 = 16$
$T_3 = 48$
$T_4 = 14$
$T_5 = T_6 = 20$