UNIT-2
Gear Trains

Syllabus

- Types of gear trains
- Velocity ratio of gear train’s

Introduction

- Questions…
  - What is a gear train?
    - Combination of gears arranged in a series manner is called as a gear train
  - Why it is used?
    - To transfer power with large speed reduction in a small space.
  - Where it is used?
    - When power is to be transferred from one plane to another plane
    - When power is to be transferred over a large distances without using heavier gears.
    - When power is to be distributed to various sources

Different types of gears and gear trains

Classification and Aim of gear trains topic

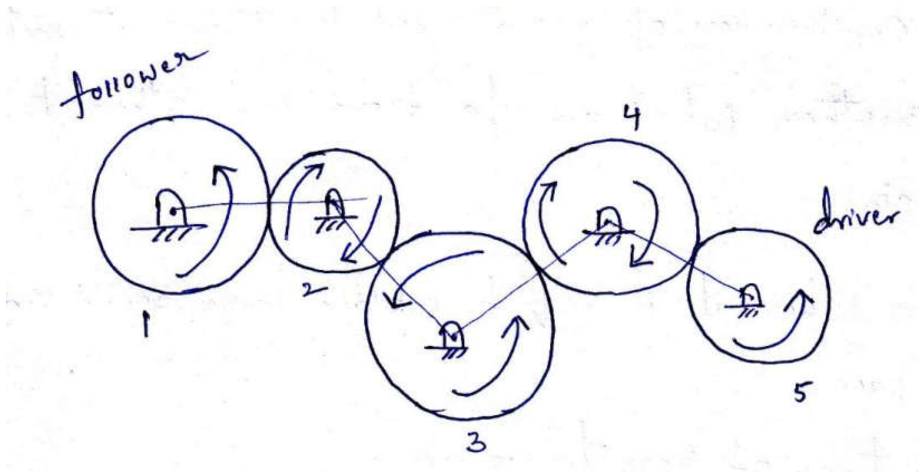
- Gear trains are classified mainly into 4 types
  1. Simple gear train
  2. Compound gear train
  3. Reverted gear train
  4. Epicyclic gear train
- Aim of learning this topic:
  - To analyze how power is transferred from driver to others by using these gear trains.
  - So we know the formula of power..?
    - P = Torque × angular velocity
  - Torque is a rotational force which cannot be measured directly.
  - So the remaining parameter is angular velocity.
- **Hence we need to find ω in our analysis (which is our Aim of our topic)**

Analysis of gear trains

- In any gear train we have some constant things in the system:
  - Driver gear (input)
  - Driven gear (final output)
  - Intermediate gears (intermediate outputs)
- Gear ratio or velocity ratio…?
  - Ratio of speed of driven gear to driver gear
- Train value:
  - Reverse of gear ratio is known as train value.
- So do we have any relation between velocity ratio and number of teeth of gears..?
  - Yes
  - For a pair of gears $\frac{N_2}{N_1} = \frac{T_1}{T_2}$
- So as per our aim we need to find N_1 or N_2.

Simple gear train

- What is the aim of the topic..?
  - To find the gear ratio

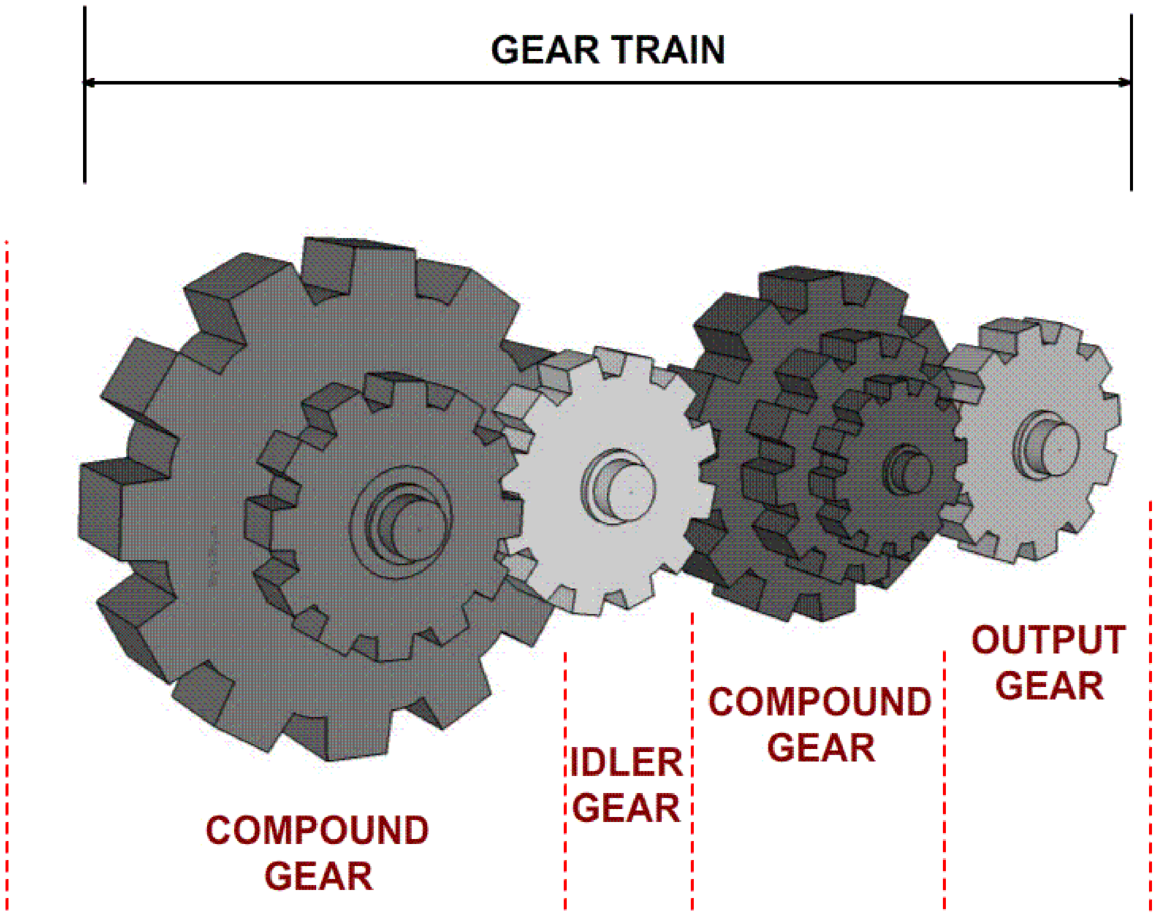


- A simple gear train contains a driver, follower connected by means of individual gears in a series manner.
- So how the power will be transferred from driver to follower..?
- Now we need to find the gear ratio for this gear train.

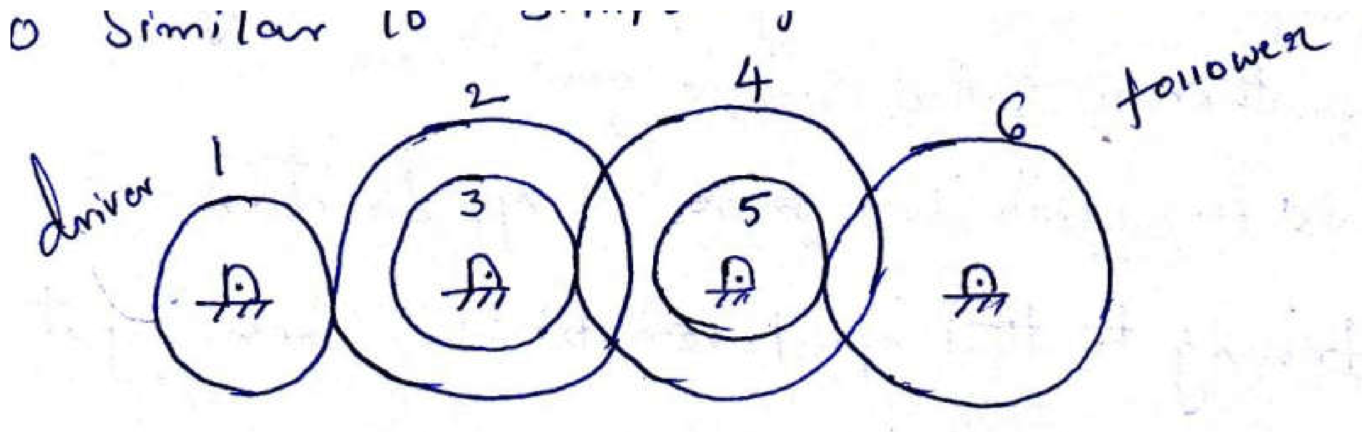
Gear ratio for simple gear train

- From the diagram of simple gear train, we observed that gear 1 is connected to gear 2, gear 2 is connected to gear 3 and so on..
- So it is also obvious that all the gears will have their individual shafts on which these gears are being mounted.
- Gear 1 – driver, gear 5 – driven
- When 2 gears are meshed, we know their speed ratio is inverse to their teeth ratio.
  - i.e. $\frac{N_2}{N_1} = \frac{T_1}{T_2}$
- Here we need to find the ratio of speeds between driven and driver i.e. $\frac{N_5}{N_1}$.
  - i.e. $\frac{\boldsymbol{N_5}}{\boldsymbol{N_1}} = \frac{N_5}{N_4} \times \frac{N_4}{N_3} \times \frac{N_3}{N_2} \times \frac{N_2}{N_1} = \frac{T_4}{T_5} \times \frac{T_3}{T_4} \times \frac{T_2}{T_3} \times \frac{T_1}{T_2} = \frac{\boldsymbol{T_1}}{\boldsymbol{T_5}}$

Compound Gear Train



Compound Gear Train

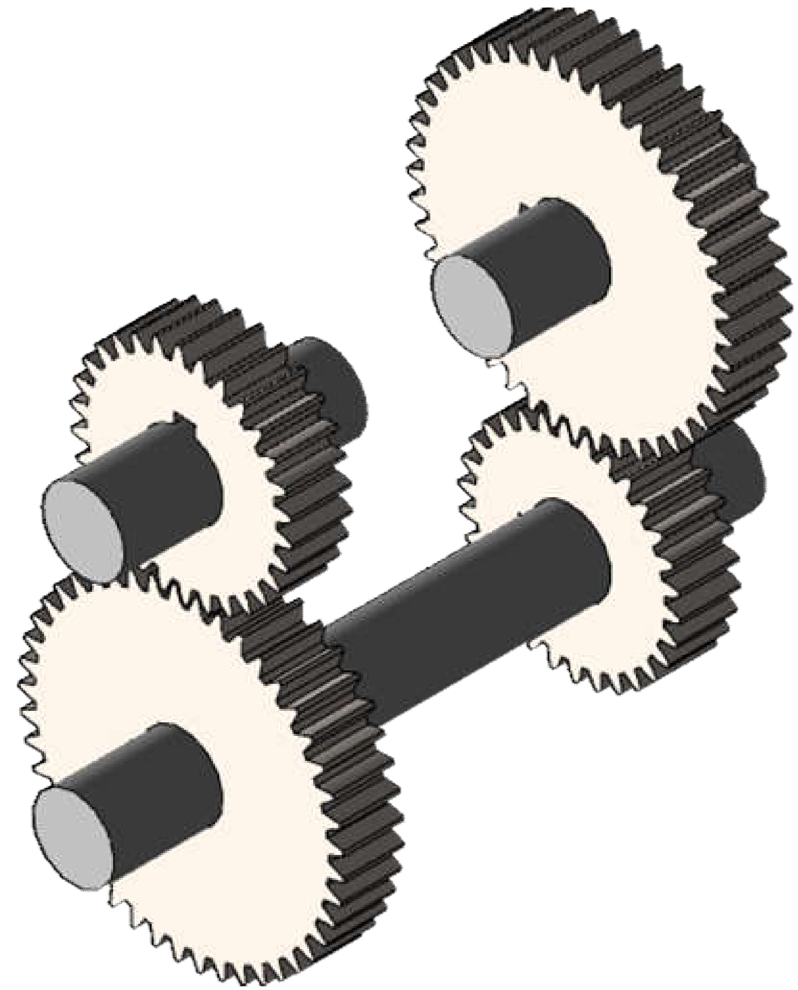


- This is similar to simple gear train, whereas two or more gears are being mounted on same shaft.
- So in the fig. gears 2 & 3, 4 & 5 are being mounted on same shafts. So as they are mounted on same shafts their speeds are same. (i.e. $N_2 = N_3$ and $N_4 = N_5$)
- Now we need to find the Gear ratio for this gear train.

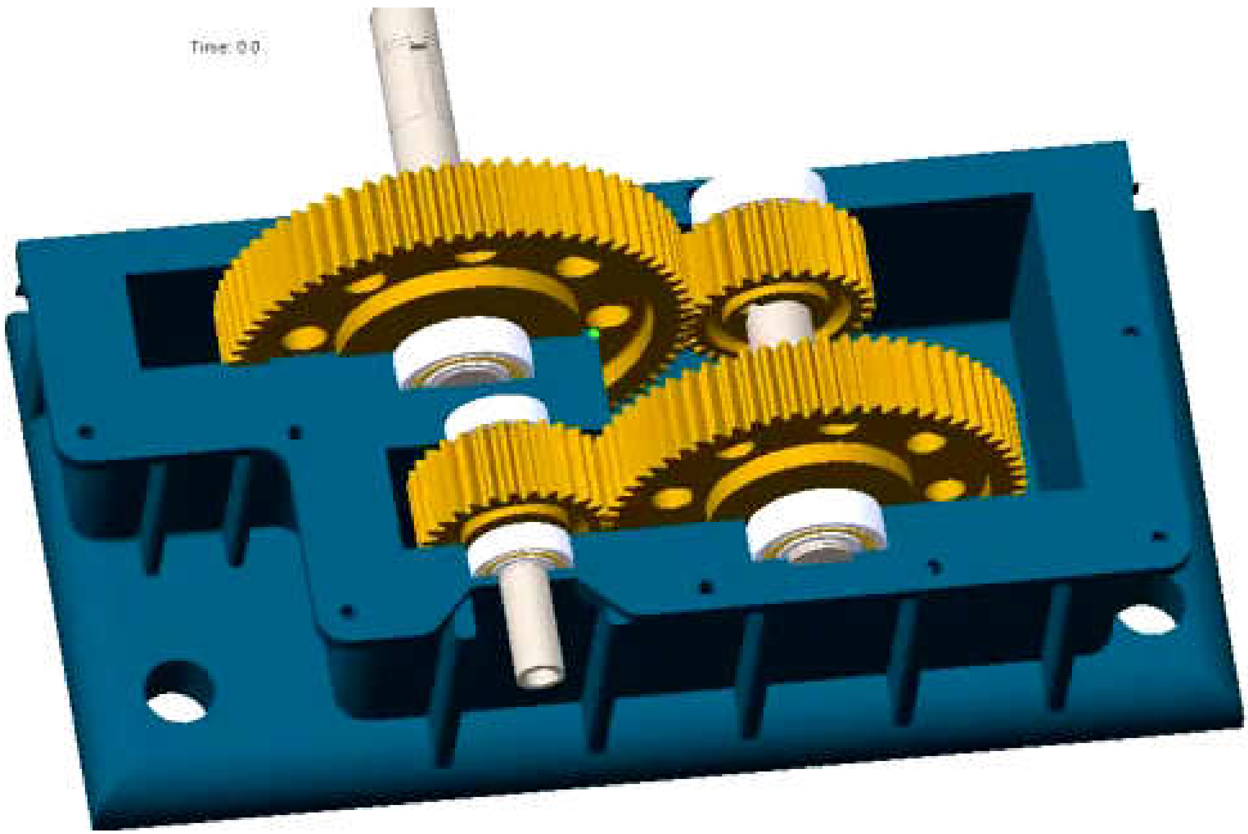
Gear ratio of compound gear train

- Velocity ratio = $\frac{\boldsymbol{N_6}}{\boldsymbol{N_1}} = \frac{N_6}{N_5} \times \frac{N_5}{N_4} \times \frac{N_4}{N_3} \times \frac{N_3}{N_2} \times \frac{N_2}{N_1}$
- But in case of compound gear system as two gears mounted on same shaft their speeds are same, so $N_2 = N_3$ and $N_4 = N_5$
- Therefore the formula is modified as $\frac{\boldsymbol{N_6}}{\boldsymbol{N_1}} = \frac{N_6}{N_5} \times \frac{N_4}{N_3} \times \frac{N_2}{N_1} = \frac{T_5}{T_6} \times \frac{T_3}{T_4} \times \frac{T_1}{T_2}$

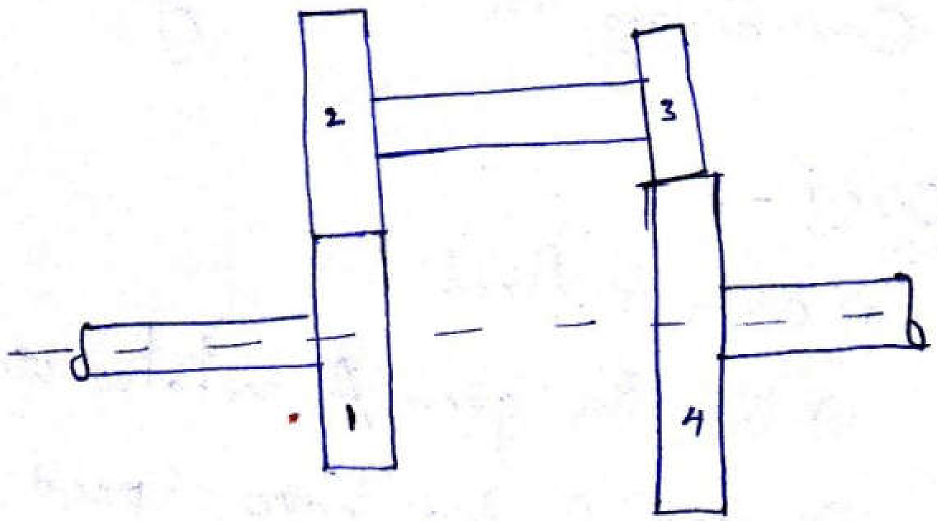
Reverted gear train



Reverted Gear Train animation

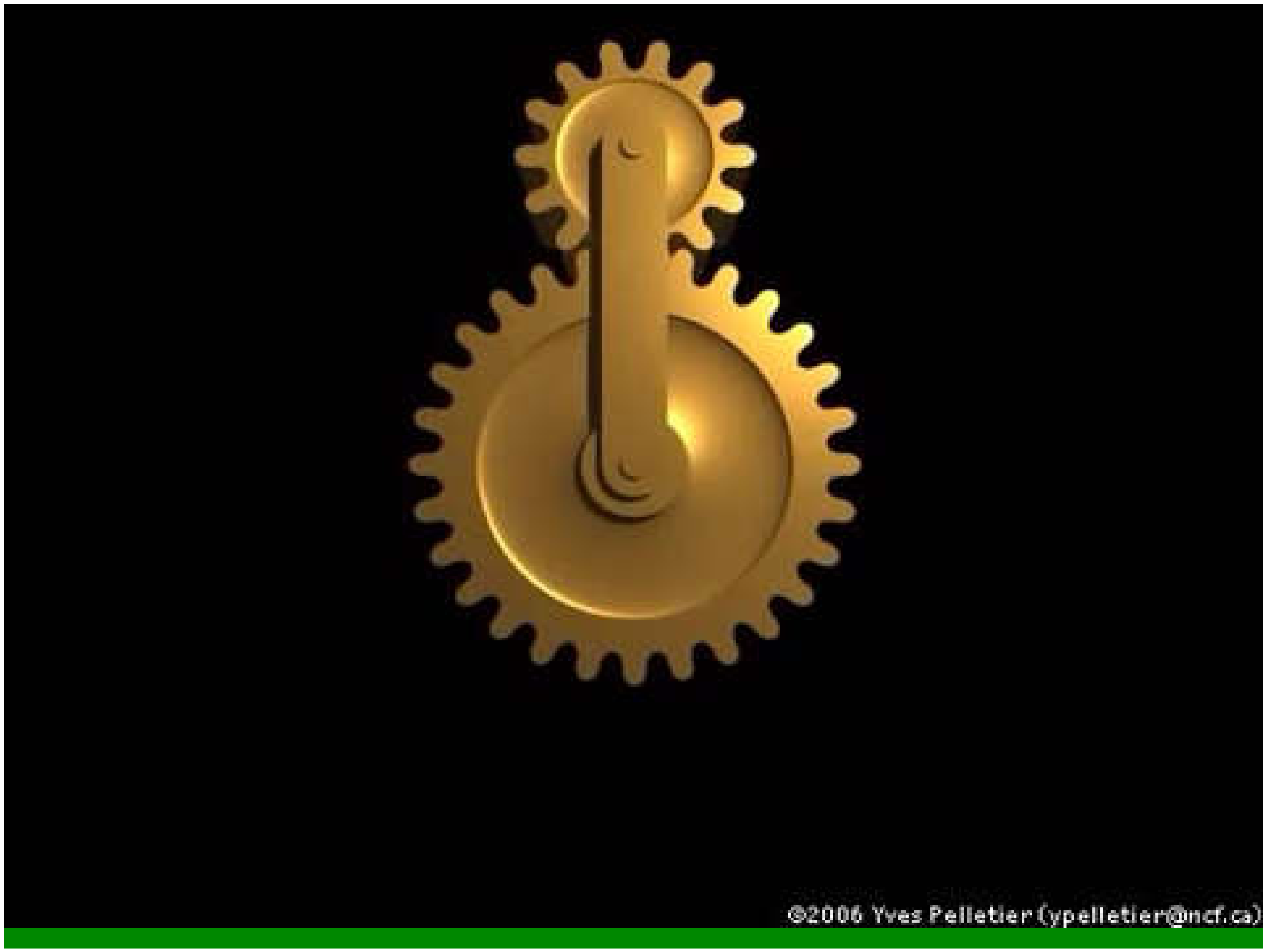


Reverted Gear Train



- If the axis of first and last gear wheels are collinear, then such compound gear train can be called as reverted gear train.
- It is a special case of compound gear train.
- Aim: To find Gear ratio

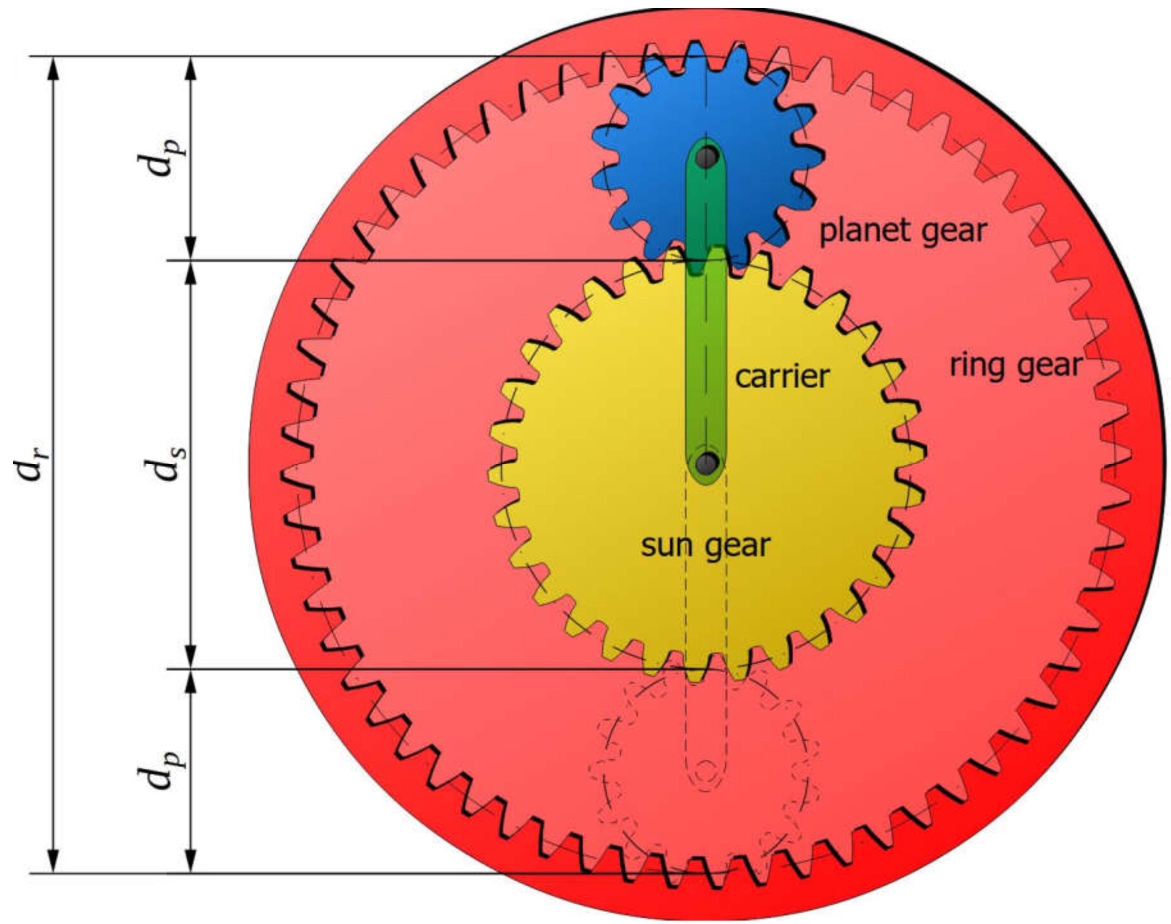
Epicyclic gear train



Epicyclic gear train

- A gear train having relative motion to the gear axis is called as epicyclic gear train.
- So the axis of one gear will move relative to the axis of other.
- This gear train can be also called as planetary gear train.
- Larger speed reductions can be possible using this gear train.
- So, from the animation we can see that there is a large gear, small gear, a connector connecting both these.
- These components are called as sun gear, planet gear, arm.
- So Now as per our Aim, we need to find the velocity ratio. For finding that we have two methods
  - Algebric method
  - Tabular method.

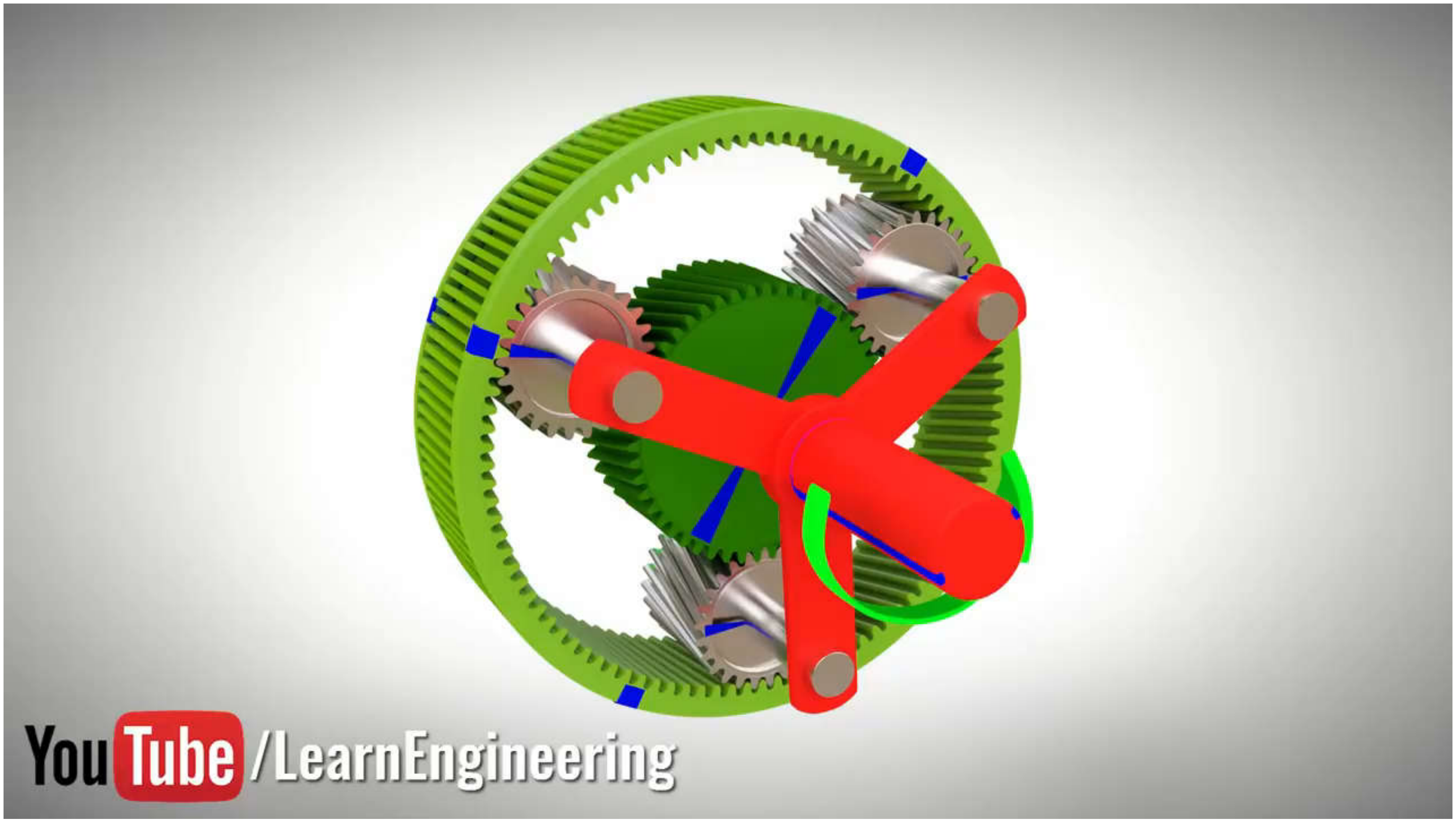
Planetary gear train Analysis



Tabular column method

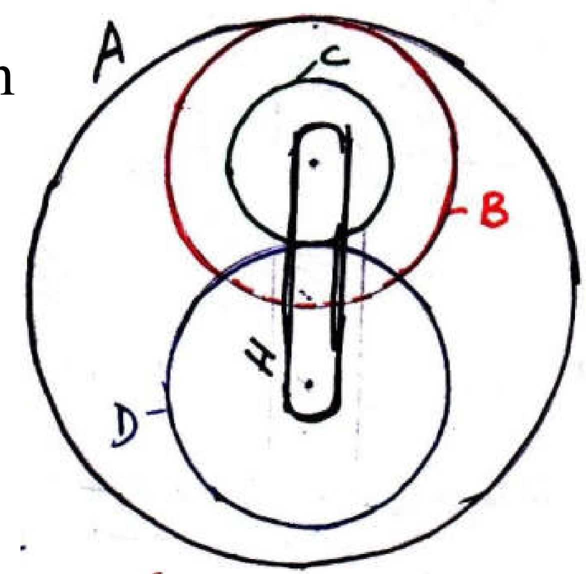
Conditions of motion	Revolution of Elements		
	Arm	Gear A	Gear B
Arm fixed, $+x$ revolution to gear A anticlockwise	0	$+x$	$-x\frac{T_A}{T_B}$
All elements rotated with + y revolutions	+y	+y	+y
Total Motion	+y	x+y	$y-x\frac{T_A}{T_B}$

Compound epicyclic gear train



Compound epicyclic gear train

- This system consists of 4 gears and an arm
  - Compound gear B-C,
  - Sun gear D
  - Gear A
  - Arm H
- Outer gear A is known as annulus gear
- Annulus gear has internal teeth
- So our Aim is to find the speed of different elements of the system.



Tabular column method-Compound epicyclic gear train

Conditions of motion	**Revolution of Elements**			
	Arm	Gear D	Gear B-C	Gear A
Arm fixed, $+x$ revolution to gear A anticlockwise	0	$+x$	$-x\frac{T_D}{T_C}$	$-x\frac{T_D}{T_C}\frac{T_B}{T_A}$
All elements rotated with + y revolutions	+y	+y	+y	+y
Total Motion	+y	x+y	$y-x\frac{T_D}{T_C}$	$y-x\frac{T_D}{T_C}\frac{T_B}{T_A}$