24AG401 THEORY OF MACHINES

UNIT IV NOTES

2.5 Gear Train

A gear train is a collection of gear wheels that transmit motion from one shaft to another. Ordinary gear trains consist of simple and compound gear trains. The epicyclic gear trains, which allow relative motion between gear axes, are the other types of gear trains. The gear trains are necessary when-

- A significant reduction in velocity or mechanical advantage is desired.
- The distance between two shafts is not excessively long but not short enough to allow for the use of a single big gear.
- When a particular velocity ratio is desired

2.5.1. **Types of Gear Trains**

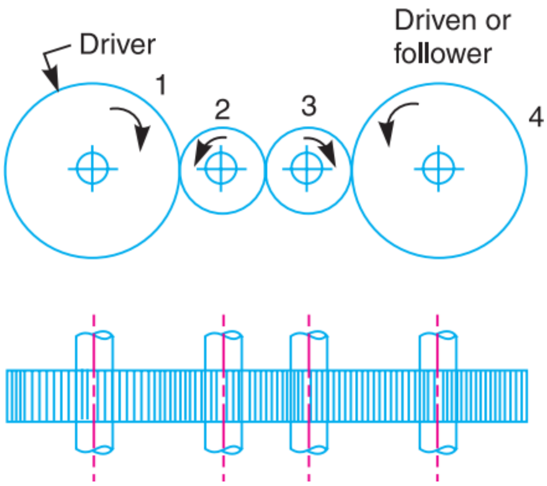
Depending on how the wheels are arranged, there are several different types of gear trains. Below we have mentioned four types of gear trains where the axes of the shafts on which the gears are mounted are fixed relative to each other in the first three types of gear trains. Knowing the types of gear trains is helpful in **designing gears** as well. It is essential to know **gear terminologies** as well before going further. The axes of the shafts on which the gears are mounted may, however, move relative to a fixed axis in epicyclic gear trains. The types of gear trains are:

- Simple gear train
- Compound gear train

- Reverted gear train
- Epicyclic gear train

Simple Gear Trains

This is the simplest type of gear train for conveying motion from one shaft to the other, as the name implies. All of the gear axes stay locked in position with respect to the frame, and each gear is mounted on its own shaft, which is a distinct feature of this type of train. A simple gear train is one that has only one gear on each shaft, as shown in Figure. Pitch circles are used to depict the gears.



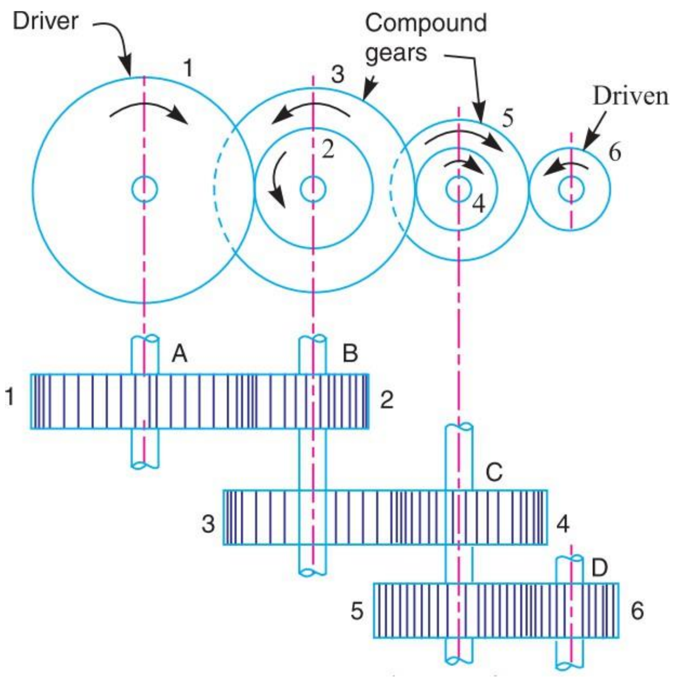
The two gears 1 and 2 mesh with each other to transmit motion from one shaft to the other when the distance between the two shafts is minimal, as shown in Figure. Because gear 1 drives gear 2, it is referred to as the driver, while gear 2 is referred to as the driven or follower. The motion of the driving gear is the opposite of the motion of the driving gear.

Because the gear train's speed ratio (or velocity ratio) is the driver's speed to the driver's or follower's speed. **The train value of a gear train is** defined as the ratio of the driver's or follower's speed to the driver's speed.

Compound Gear Train

A compound train of gears is when there are multiple gears on a shaft, as seen in Figure. In a simple train of gears, we know that idle gears have no effect on the system's speed ratio. On the other hand, these gears are useful for bridging the gap between the driver and the driven. When the distance between the driver and the driven or follower must be bridged by intermediate gears while still requiring a large (or much smaller) speed ratio, the advantage of intermediate gears is amplified by using compound gears on intermediate shafts. Each intermediate shaft has two gears rigidly attached to it in this scenario, allowing them to rotate at the same speed. As seen in Figure, one of these two gears meshes with the driver, while the other meshes with the driven or follower linked to the next shaft.

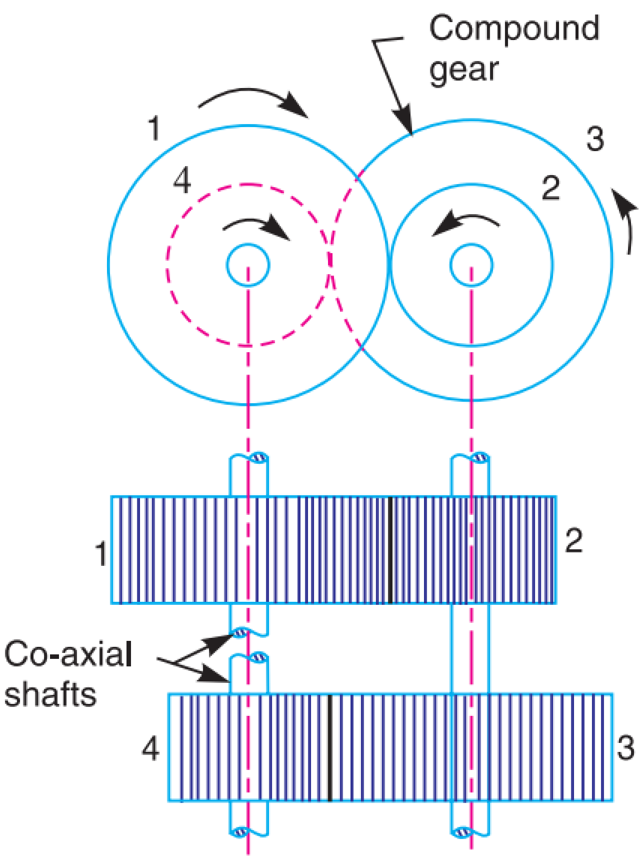
The driving gear is positioned on shaft A in a compound train of gears, as shown in Figure, while the compound gears 2 and 3 are mounted on shaft B. Gears 4 and 5 are compound gears that are mounted on shaft C, whereas gear 6 is the driven gear that is located on shaft D.



Reverted Gear Train

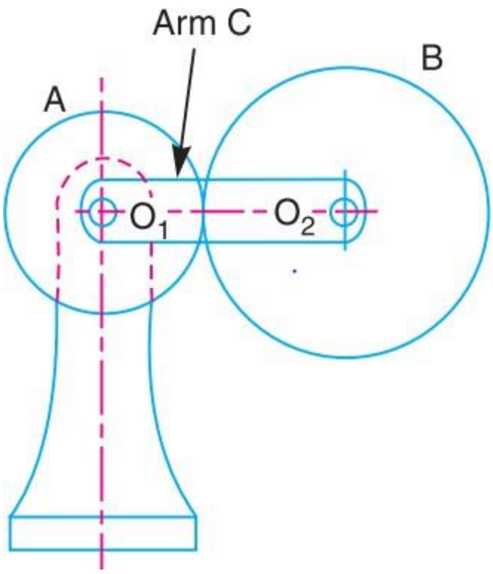
A reversed gear train is one in which the first and last gear axes are co-axial, as seen in Figure.

Gear 1 appears to be driving gear 2 in the other direction. Because gears 2 and 3 are attached to the same shaft, they create a compound gear, which means that gear 3 rotates in the same direction as gear 2. The third gear pushes the fourth gear in the same direction as the first. As a result, we can see that the motion of the first and last gears are similar in a reversed gear train.



Epicyclic Gear Train

The axes of the shafts over which the gears are mounted can move relative to a fixed axis in an epicyclic gear train. The figure shows a simple epicyclic gear train with a common axis at O1 around which the gear A and the arm C can rotate. The gear B meshes with the gear A and rotates about its axis on the arm at O2. The gear train is simple if the arm is stationary, and gear A can drive gear B or vice versa; however, if the arm is fixed and rotated around the axis of gear A, the gear B is forced to spin on and around gear A. Epicyclic motion is defined as gear trains constructed in such a way that one or more of their members travel over and around another member. The epicyclic gear trains may be simple or compound.



Problem

. Example 13.2. Two parallel shafts, about 600 mm apart are to be connected by spur gears. One shaft is to run at 360 r.p.m. and the other at 120 r.p.m. Design the gears, if the circular pitch is to be 25 mm.

Solution. Given : $x = 600$ mm ; $N_1 = 360$ r.p.m. ; $N_2 = 120$ r.p.m. ; $p_c = 25$ mm

Let d_1 = Pitch circle diameter of the first gear, and

d_2 = Pitch circle diameter of the second gear.

We know that speed ratio,

$$\frac{N_1}{N_2} = \frac{d_2}{d_1} = \frac{360}{120} = 3 \quad \text{or} \quad d_2 = 3d_1$$

and centre distance between the shafts (x),

$$600 = \frac{1}{2}(d_1 + d_2) \quad \text{or} \quad d_1 + d_2 = 1200$$

From equations *(i)* and *(ii)*, we find that

$$d_1 = 300 \text{ mm, and } d_2 = 900 \text{ mm}$$

∴ Number of teeth on the first gear,

and number of teeth on the second gear,

$$T_2 = \frac{\pi d_2}{p_c} = \frac{\pi \times 900}{25} = 113.1$$

Since the number of teeth on both the gears are to be in complete numbers, therefore let us make the number of teeth on the first gear as 38. Therefore for a speed ratio of 3, the number of teeth on the second gear should be 38 × 3 = 114.

Now the exact pitch circle diameter of the first gear,

$$d_1' = \frac{T_1 \times p_c}{\pi} = \frac{38 \times 25}{\pi} = 302.36 \text{ mm}$$

and the exact pitch circle diameter of the second gear,

$$d_2' = \frac{T_2 \times p_c}{\pi} = \frac{114 \times 25}{\pi} = 907.1 \text{ mm}$$

∴ Exact distance between the two shafts,

$$x' = \frac{d_1' + d_2'}{2} = \frac{302.36 + 907.1}{2} = 604.73 \text{ mm}$$

Hence the number of teeth on the first and second gear must be 38 and 114 and their pitch circle diameters must be 302.36 mm and 907.1 mm respectively. The exact distance between the two shafts must be 604.73 mm.

Problem

An epicyclic gear consists of three gears A, B and C as shown in Fig. 13.10. The gear A has 72 internal teeth and gear C has 32 external teeth. The gear

B meshes with both A and C and is carried on an arm EF which rotates about the centre of A at 18 r.p.m.. If the gear A is fixed, determine the speed of gears B and C.

We know that the speed of the arm is 18 r.p.m. therefore,

$$y = 18 \text{ r.p.m.}$$

and the gear A is fixed, therefore

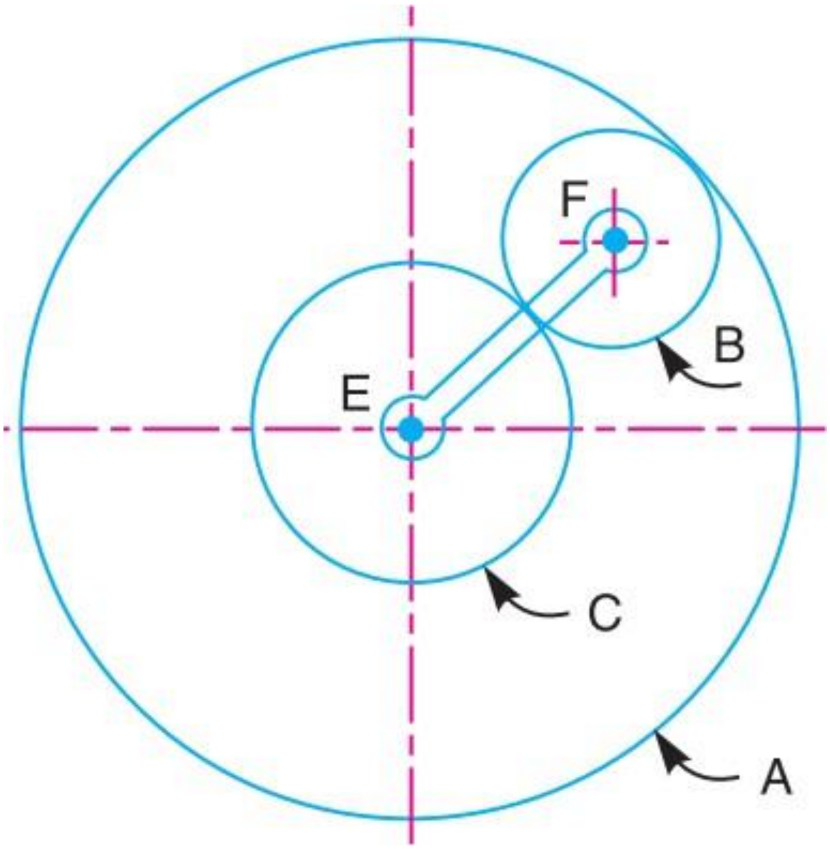
$$y - x \times \frac{T_C}{T_A} = 0 \quad \text{or} \quad 18 - x \times \frac{32}{72} = 0$$

$\therefore$ $x = 18 \times 72 / 32 = 40.5$

$\therefore$ Speed of gear C $= x + y = 40.5 + 18$

$= + 58.5$ r.p.m.

$= 58.5$ r.p.m. in the direction of arm.



Let d_A, d_B and d_C be the pitch circle diameters of gears A, B and C respectively. Therefore, from the geometry of Fig. 13.10,

$$d_B + \frac{d_C}{2} = \frac{d_A}{2} \quad \text{or} \quad 2\,d_B + d_C = d_A$$

Since the number of teeth are proportional to their pitch circle diameters, therefore

$$2\,T_B + T_C = T_A \quad \text{or} \quad 2\,T_B + 32 = 72 \quad \text{or} \quad T_B = 20$$

$\therefore$ Speed of gear B $= y - x \times \frac{T_C}{T_B} = 18 - 40.5 \times \frac{32}{20} = -46.8$ r.p.m.

= 46.8 r.p.m. in the opposite direction of arm.