# Planetary Gear Trains

- Are used because they can obtain very large or small gear ratios and are able to transmit more power than ordinary gear trains.
- They are also used because they can have two degrees of freedom

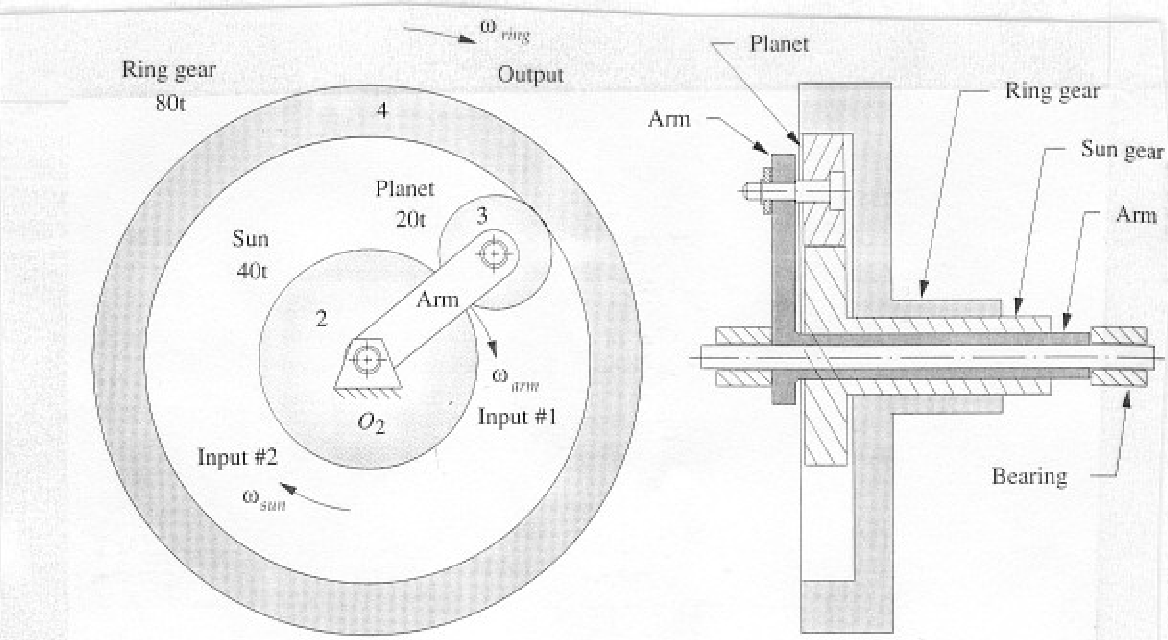
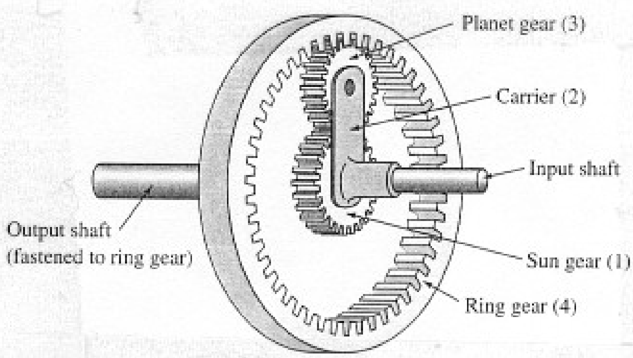



**FIGURE 9-34**

Planetary gearset with ring gear used as output




(a)

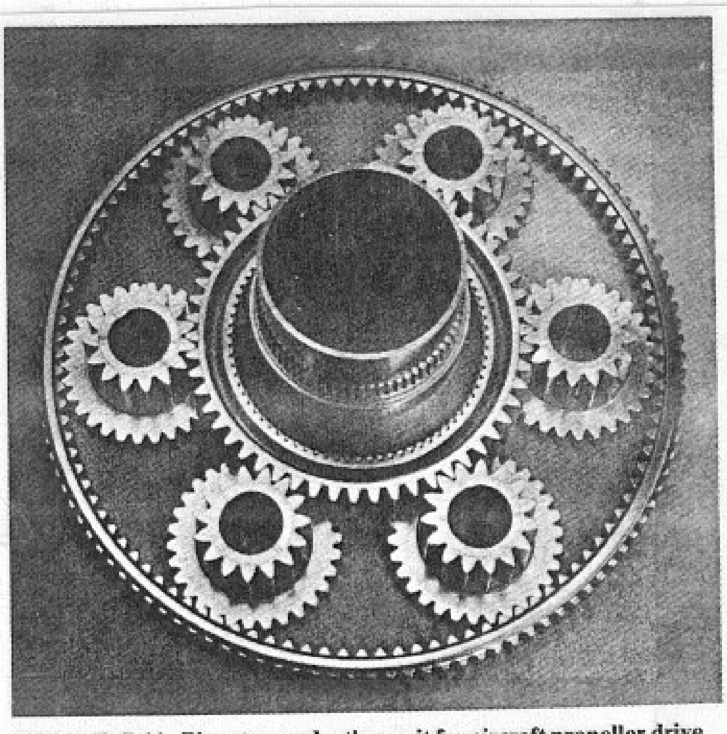


**FIGURE 7.11 Planetary reduction unit for aircraft propeller drive. (Courtesy of Foote Brothers Gear & Machinery Corp.)**

## The Formula Method

$\omega_F$ = Absolute angular velocity of the first gear

$\omega_L$ = Absolute angular velocity of the last gear

$\omega_A$ = Absolute angular velocity of the arm

$\omega_{FA}$ = Angular velocity of the first gear wrt. the arm

$\omega_{LA}$ = Angular velocity of the last gear wrt. the arm

$$\omega_{FA} = \omega_F - \omega_A \qquad \omega_{LA} = \omega_L - \omega_A$$

$$\frac{\omega_{LA}}{\omega_{FA}} = \frac{\omega_L - \omega_A}{\omega_F - \omega_A} = (-1)^{\text{\# of external mesh}} \left\{ \frac{\text{\# of teeth on Driver gears}}{\text{\# of teeth on Driven gears}} \right\}$$

### Example

Determine the angular velocity of gear 5

Given: $\omega_{21} = 50\ r/s$ and $\omega_{61} = 75\ r/s$ both counter-clockwise when viewed from the right

Solution: $\omega_2 = 50\ r/s$, $\omega_6 = 75\ r/s$

There are two inputs and one output (gear 5).

Let's choose gear # 2 as the first gear

gear # 6 is the arm

gear # 5 is the last gear

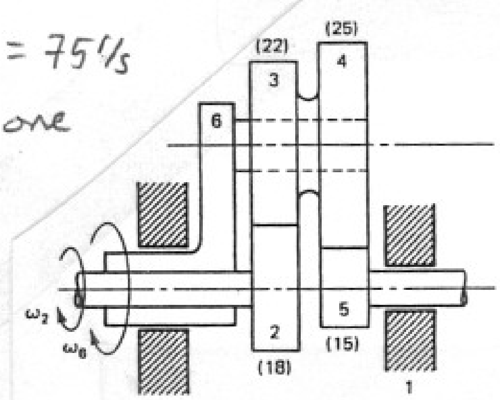



**Figure 7.31** Compound planetary gear train with two inputs and one output (see Examples 7.3 and 7.6). See Fig. 7.36 for an end view sketch of this gear train.

$$\frac{\omega_{LA}}{\omega_{FA}} = \frac{\omega_{56}}{\omega_{26}} = \frac{\omega_L - \omega_A}{\omega_F - \omega_A} = \frac{\omega_5 - \omega_6}{\omega_2 - \omega_6} = (-1)^2 \left( \frac{N_2 N_4}{N_3 N_5} \right)$$

$$\frac{\omega_5 - 75}{50 - 75} = + \frac{(18)(25)}{(22)(15)} \rightarrow \omega_5 = -34.09 + 75 = 40.91 \text{ r/s}$$

$$\boxed{\omega_5 = 40.91 \text{ r/s}}$$

## Example

For the planetary gear system shown, gear 2 and gear 5 are the inputs rotating counter-clockwise from right

$\omega_2 = 500$ rpm ; $\omega_5 = 300$ rpm   Find $\omega_6 = \omega_{61} = \omega_{ARM}$

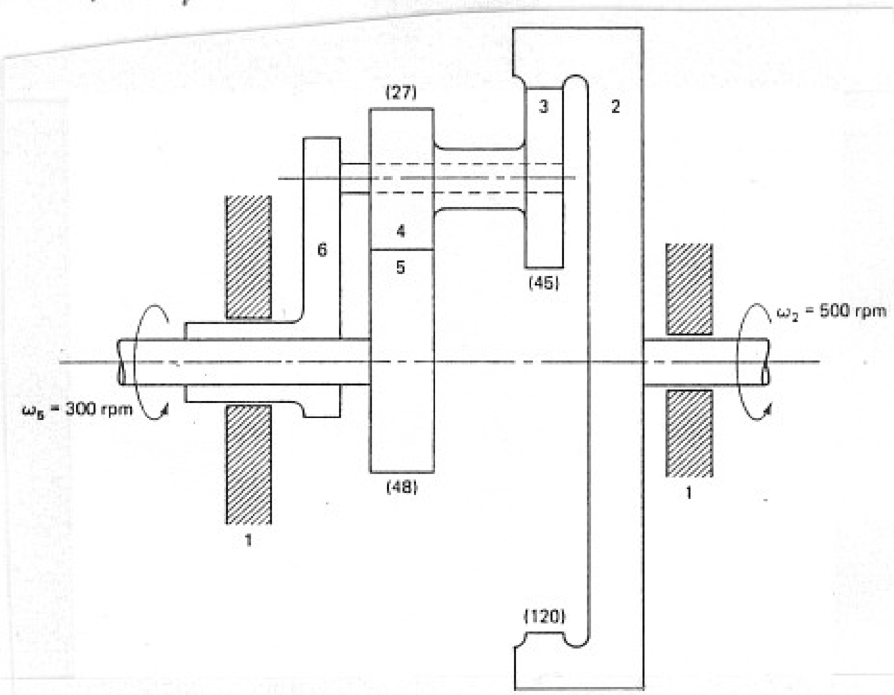



**Figure 7.32** Two-degree-of-freedom planetary gear train; 2 and 5 are inputs, 6 is output (see Examples 7.4, 7.7, and 7.9). See Fig. 7.37 for an end view sketch of this gear train.

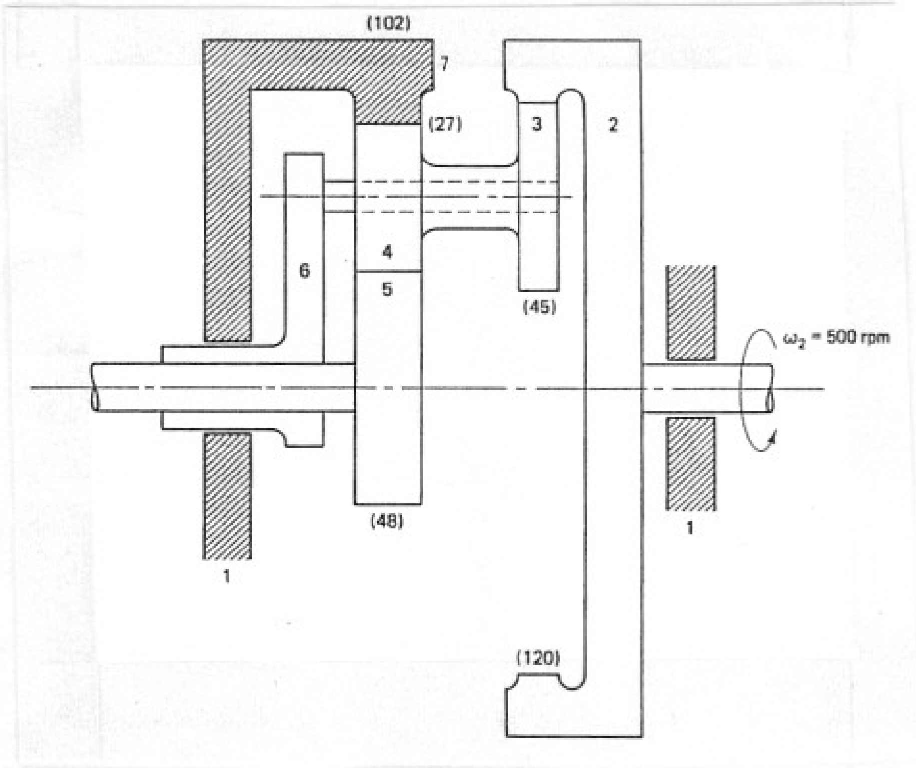
Choose the first gear to be gear # 5, Arm= gear 6, the last gear is gear # 2.

$$\frac{\omega_{LA}}{\omega_{FA}} = \frac{\omega_{26}}{\omega_{56}} = \frac{\omega_L - \omega_A}{\omega_F - \omega_A} = \frac{\omega_2 - \omega_6}{\omega_5 - \omega_6} = (-1)\frac{N_5 N_3}{N_4 N_2}$$

$$\frac{500 - \omega_6}{300 - \omega_6} = - \frac{(45)(48)}{(27)(120)} \rightarrow 500 - \omega_6 = \frac{2}{3}\omega_6 - 200 \rightarrow -\frac{5}{3}\omega_6 = -700$$

$$\boxed{\omega_6 = 420 \text{ rpm}}$$

Example Let's solve the same problem except let's add a stationary ring gear. Gear 2 is the only input gear rotating at 500 rpm ccw from the right. Find the speed of gear 5.




Choose the first gear to be gear # 2, arm = # 6, the last gear is gear # 5.

$$\frac{\omega_{LA}}{\omega_{FA}} = \frac{\omega_{56}}{\omega_{26}} = \frac{\omega_L - \omega_A}{\omega_F - \omega_A} = \frac{\omega_5 - \omega_6}{\omega_2 - \omega_6} = (-1)^1 \frac{N_2 N_4}{N_3 N_5}$$

$$\frac{\omega_5 - \omega_6}{500 - \omega_6} = -\frac{(120)(27)}{(45)(48)} = -\frac{3}{2} \rightarrow \text{unknowns } \omega_6 + \omega_5$$

We need another equation!

choose the first gear to be gear # 2, arm = # 6, the last gear is gear # 7

$$\frac{\omega_{LA}}{\omega_{FA}} = \frac{\omega_{76}}{\omega_{26}} = \frac{\omega_L - \omega_A}{\omega_F - \omega_A} = \frac{\omega_7 - \omega_6}{\omega_2 - \omega_6} = (-1)^0 \frac{N_2 N_4}{N_3 N_7}$$

$$\frac{0-\omega_6}{500-\omega_6} = \frac{(120)(27)}{(45)(102)} \rightarrow -\omega_6 = 352.94 - 0.706\,\omega_6$$

$$-0.294\,\omega_6 = 352.94 \rightarrow \omega_6 = -1200 \text{ rpm}$$

combining with the previous equation

$$\omega_5 + 1200 = -\frac{3}{2}(500 + 1200) \rightarrow \boxed{\omega_5 = -3750 \text{ rpm}}$$

Example The sun gear B rotates at 100 rpm cw as viewed from the right. Determine the angular velocity of gear G as viewed from the bottom.