## Gear trains:

External spur gear:

Single pair

$$\frac{\omega_p}{\omega_g} = \frac{n_p}{n_g} = \frac{-d_g}{d_p} = \frac{-N_g}{N_p}$$

$-ve$ → indicates that spur gear with external teeth rotate in opposite direction.

Internal gear:

$$d = -ve$$

$$\frac{\omega_p}{\omega_g} = \frac{d_g}{d_p}$$ — rotate in the same direction.

Normally:

Pinion: Driver

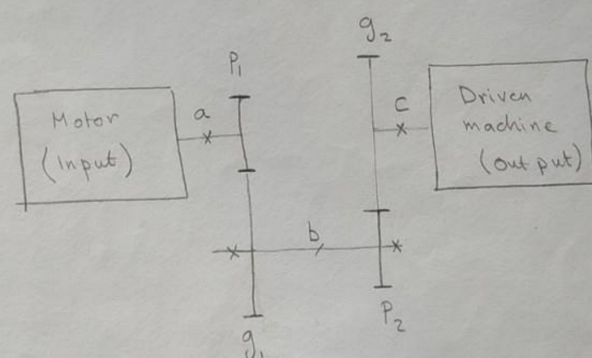
Gear: Driven

⇒ $\frac{\omega_p}{\omega_g}$ → reduction ratio.

There are some exceptions: Engine driven supercharger
Centrifugal compressor for Air conditioning.

## Gear trains:

Duoble reduction gear train




Input shaft = a

Counter shaft = b

Output shaft = c

Velocity ratio:

$$\frac{\omega_a}{\omega_c} = \frac{\omega_a}{\omega_b} \times \frac{\omega_b}{\omega_c} = \frac{-d_{g_1}}{d_{p_1}} \times -\frac{d_{g_2}}{d_{p_2}} = \frac{d_{g_1}\, d_{g_2}}{d_{p_1}\, d_{p_2}} = \frac{N_{g_1}\, N_{g_2}}{N_{p_1}\, N_{p_2}}$$

For gear train with $l$ gears:

$$\text{train value} = e = \frac{\text{Product of driving tooth number}}{\text{Product of driven tooth number}}$$

2020/6/5 18:04

STUDENTS-HUB.com Uploaded By: anonymous

$\Rightarrow \quad n_L = e\, n_F$

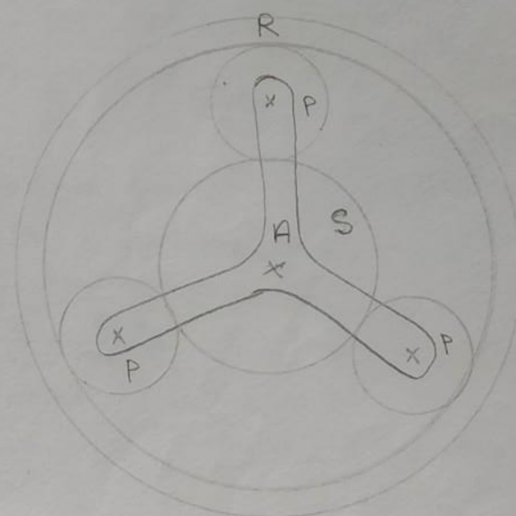
$n_L = \omega_L$ = Speed of last gear

$n_F = \omega_F$ = Speed of first gear.

$e = +ve$ if first and last gears rotate in the same dire

$e = -ve$ if $\omega_L$ and $\omega_F$ rotate in opposite direction.

## Planetary Gear train:




S = Sun gear [at the Center]

P = Planets

A = Carrier or arm

R = Ring or Annulus [Internal]

### Function:

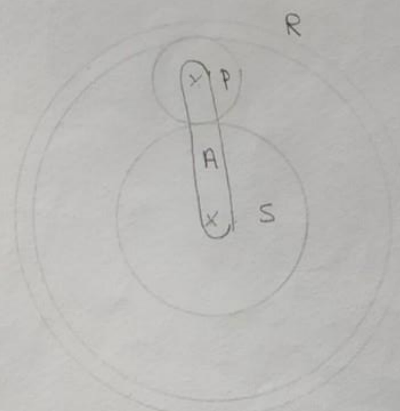
One of the members S, R, A

Input, fixed Reaction member

out put.

Automatic transmission uses combination of planetary gear train with a clutch to hold on of the members fixed.

### let:




R, S, P = diameters, No. of theeth of Ring, sun, planet.

velocity of Ring with respect to the arm:

$\omega_{RA} = \omega_R - \omega_A$

velocity of Sun with respect to the arm:

$\omega_{SA} = \omega_S - \omega_A$

$$\frac{\omega_{RA}}{\omega_{SA}} = \frac{\omega_R - \omega_A}{\omega_S - \omega_A}$$

For fixed arm: $\omega_{RA}$ $\omega_R$ $\left(-S\right)\left(P\right)$ $-S$

2020/6/5 18:04

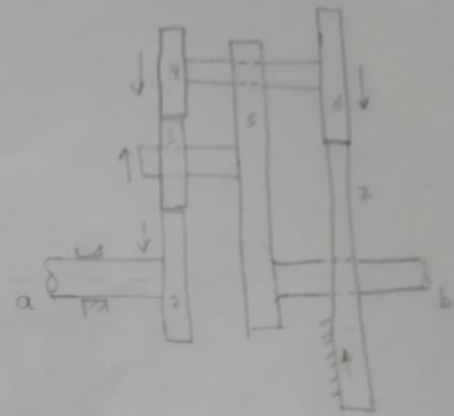
STUDENTS-HUB.com Uploaded By: anonymous

$N_2 = 24$ , $N_3 = 18$ , $N_4 = 30$

$N_6 = 36$ $N_7 = 54$

Gear 7 is fixed

If $w_b = 5$ revolution find $w_a$.





__Solution:__

$w_F = w_7$

$w_L = w_a = w_2$

$$\frac{w_L - w_A}{w_F - w_A} = \frac{w_2 - w_5}{w_7 - w_5} = -\frac{N_7 \; N_4 \; N_3}{N_6 \; N_3 \; N_2}$$

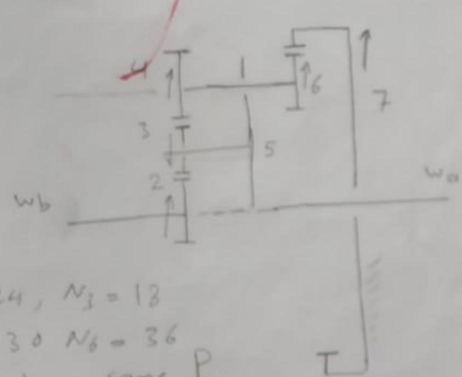
$$\frac{w_2 - w_5}{0 - w_5} = -\frac{54 \times 30}{36 \times 24} = -1.875$$

$w_5 = w_b = 5$

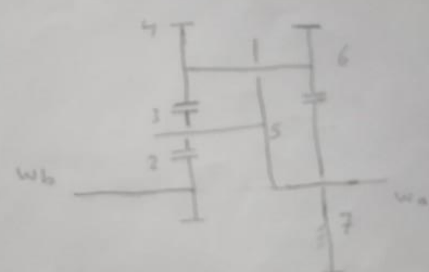
$w_2 = 2.875 \, w_5 = 14.375$ rev. in same direction of $w_b$

$w_a = 2.875 \, w_b$ in same direction

__Ex__









$N_2 = 24$ , $N_3 = 18$

$N_4 = 30$ $N_6 = 36$

All gear have same P.

Find wb for if $w_a = 5$ rev

$$\frac{d_2}{2} + d_3 + \frac{d_4}{2} = \frac{d_7 - d_6}{2} \rightarrow$$

$N_2 + 2N_3 + N_4 = N_7 - N_6$

$N_7 = N_2 + 2N_3 + N_4 + N_6$

$= 126$

$$\frac{w_2 - w_a}{w_7 - w_a} = +\frac{N_7 \; N_4}{N_6 \; N_2} \Rightarrow$$

2020/6/5 18:05

STUDENTS-HUB.com Uploaded By: anonymous

In general:

Identify: the Input, output, Reaction member.

members: X, Y, A = arm.

$$e = \frac{\omega_X}{\omega_Y} = \frac{\omega_X - \omega_A}{\omega_Y - \omega_A}$$

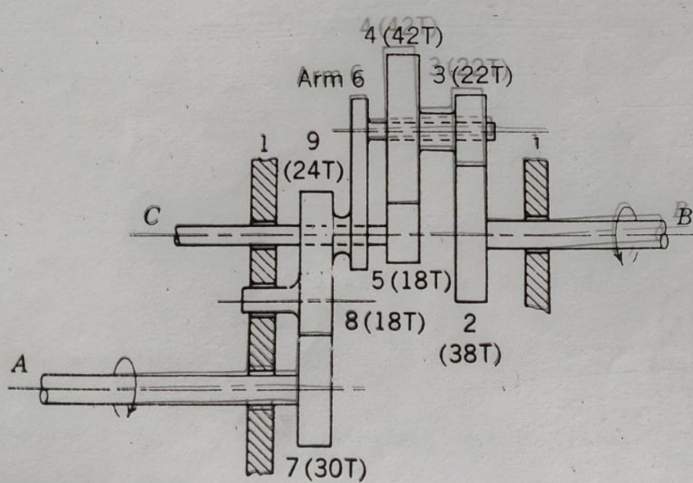



FIGURE 7.43

2020/6/5 18:05

STUDENTS-HUB.com

Uploaded By: anonymous

shaft A , $\omega_A = 300$ rpm

$\omega_B = 600$ rpm

Find $\omega_c$ and its direction of rotation.

Solution:

Planetary gear train:

Gears : 5, 4, 3, 2 , arm = 6

$\omega_{arm} = \omega_9$

let $\omega_F = \omega_2$

$\omega_L = \omega_5$   $\omega_{arm} = \omega_6$

$$\frac{\omega_L - \omega_{arm}}{\omega_F - \omega_{arm}} = + \frac{N_2 \; N_4}{N_3 \; N_5} = \frac{38 \times 42}{22 \times 18} = 4.030$$

$\omega_{arm} = \omega_9$

Gears : 7, 8, 9 simple gear train.

$$\frac{\omega_L}{\omega_F} = e \longrightarrow \begin{matrix} L = 9 \\ F = 7 \end{matrix}$$

$$\frac{\omega_9}{\omega_7} = + \frac{N_7 \; N_8}{N_8 \; N_9} = \frac{N_7}{N_9} \Rightarrow \omega_9 = \omega_7 \frac{N_7}{N_9} = 300 \times \frac{30}{24}$$

$= 375$ rpm

$\omega_9 = 375$ rpm ccw looking from right

$$\frac{\omega_5 - \omega_{arm}}{\omega_2 - \omega_{arm}} = 4.030$$

Take ccw looking from right +ve.

$\omega = +ve$ ccw ←

$$\frac{\omega_5 - 375}{\omega_2 - 375} = + 4.030 \rightarrow \frac{\omega_5 - 375}{600 - 375} = 4.030$$

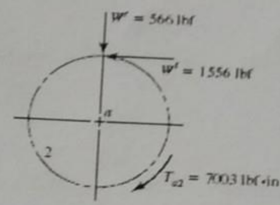
$\omega_2 = \omega_B = {}^{+}600$ rpm ccw ←

$\rightarrow \omega_5 = {}^{+}1281.82$ rpm

2020/6/5 18:06

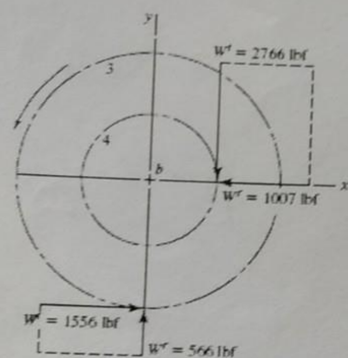
STUDENTS-HUB.com Uploaded By: anonymous

*Gear 2*




$$T_{a2} = 63\,025(200)/1800 = 7003 \text{ lbf} \cdot \text{in}$$
$$W^t = 7003/4.5 = 1556 \text{ lbf}$$
$$W^r = 1556 \tan 20° = 566 \text{ lbf}$$

*Gears 3 and 4*




$$W^t(4.5) = 1556(8), \quad W^t = 2766 \text{ lbf}$$
$$W^r = 2766 \tan 20° = 1007 \text{ lbf}$$

*Ans.*

---

$\omega = 1800$ rpm   $hp = 200$

$P = 2$ teeth/in

$\phi = 20°$

$N_2 = 18$

$N_3 = 32$

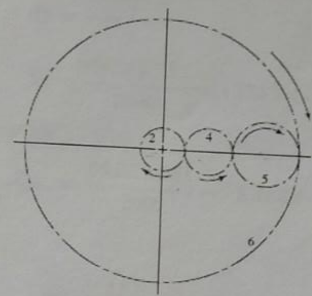
$N_4 = 18$

$N_5 = 48$

$hp = \frac{F_t V}{33000}$

2020/6/5 18:03

STUDENTS-HUB.com Uploaded By: anonymous




$$d = \frac{N}{6}$$

$d_2 = 4$ in, $d_4 = 4$ in, $d_5 = 6$ in, $d_6 = 24$ in

$$e = \frac{24}{24}\left(\frac{24}{36}\right)\left(\frac{36}{144}\right) = 1/6, \quad n_P = n_2 = 1000 \text{ rev/min}$$

$n_L = n_6 = 0$

$$e = \frac{n_L - n_A}{n_F - n_A} = \frac{0 - n_A}{1000 - n_A}$$

$n_A = -200$ rev/min

$N_2 = 24$ $\quad$ $P = 6$

$N_3 =$ arm $\quad$ $\phi = 20^\circ$

$N_4 = 24$ $\quad$ $\omega_2 = 1000$ rpm (cw)

$N_5 = 36$ $\quad$ hp $= 25$

$N_6 = 144$

2020/6/5 18:04

STUDENTS-HUB.com Uploaded By: anonymous

Input torque:

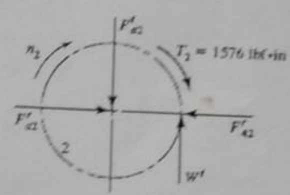
$$T_2 = \frac{63\,025H}{n}$$

$$T_2 = \frac{63\,025(25)}{1000} = 1576 \text{ lbf} \cdot \text{in}$$

For 100 percent gear efficiency

$$T_{arm} = \frac{63\,025(25)}{200} = 7878 \text{ lbf} \cdot \text{in}$$

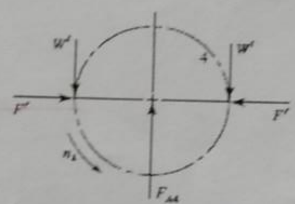
*Gear 2*




$$W^t = \frac{1576}{2} = 788 \text{ lbf}$$

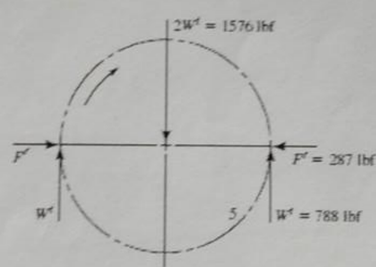
$$F_{32}^r = 788 \tan 20° = 287 \text{ lbf}$$

*Gear 4*

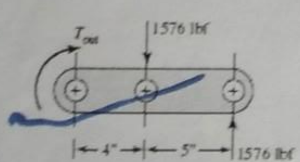


$$F_{A4} = 2W^t = 2(788) = 1576 \text{ lbf}$$

*Gear 5*




*Arm*




$$T_{out} = 1576(9) - 1576(4) = 7880 \text{ lbf} \cdot \text{in} \quad \textit{Ans.}$$

---

3-39 Given: $P = 2$ teeth/in, $n_P = 1800$ rev/min cw, $N_2 = 18T$, $N_3 = 32T$, $N_4 = 18T$, $N_5 = 48T$.

Pitch Diameters: $d_2 = 18/2 = 9$ in; $d_3 = 32/2 = 16$ in; $d_4 = 18/2 = 9$ in; $d_5 = 48/2 = 24$ in.

2020/6/5 18:05

STUDENTS-HUB.com Uploaded By: anonymous