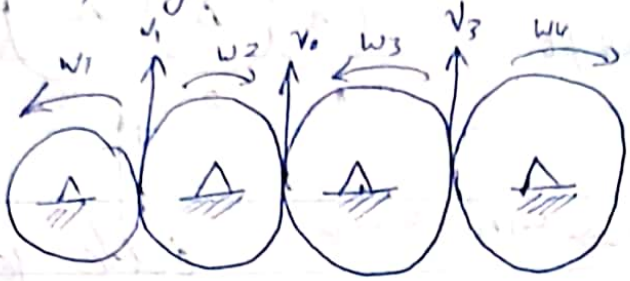
Gear Trains.

* simple gear train



$w_1 r_1 = w_2 r_2$

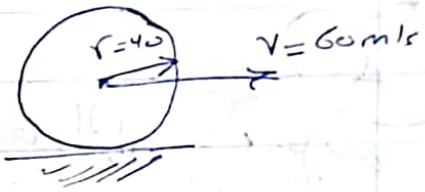
$w_2 r_2 = w_3 r_3$

$\frac{9000}{60}$ rpm $= 150 \frac{rev}{s}$

مثلاً سرعة دوران عجل السيارة :-

220 km/h ??

$= 60 m/s$



$w = \frac{v}{r} = \frac{60}{0.4} = 152 \text{ rad/s} * \frac{rev}{2\pi \text{ rad}}$

$= \boxed{24 \text{ rev/s}}$

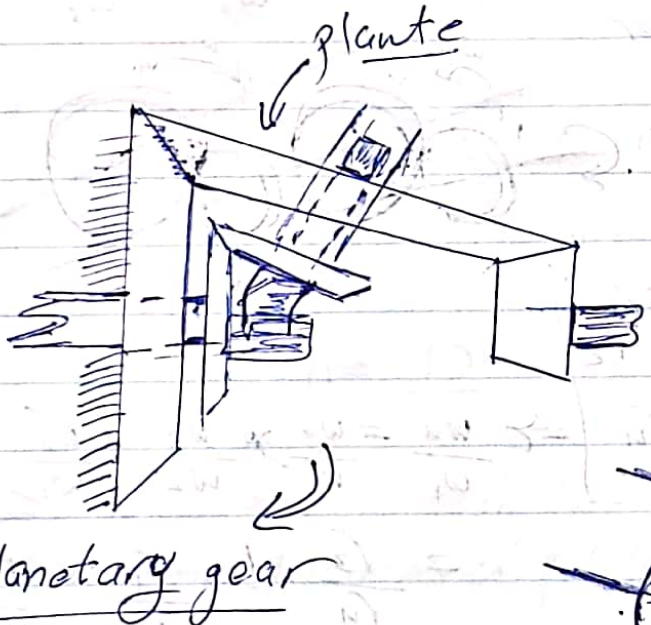
$w_1 : w_2 \Rightarrow \frac{r_2}{r_1} = 10$

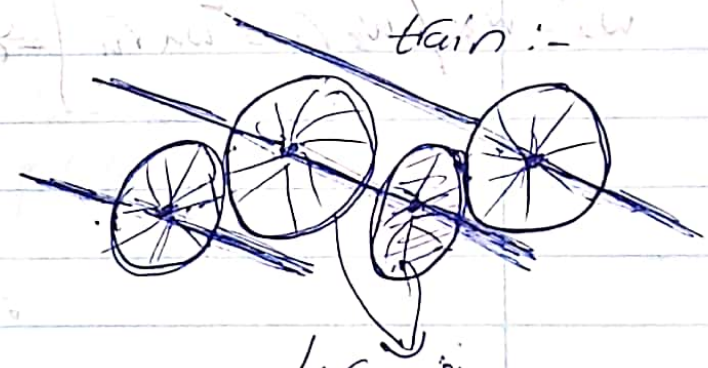
10 : 1

in the simple gear reduction

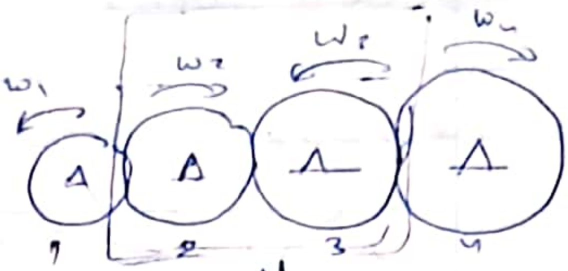
وهذا غير مقبول في السيارات لذلك

مثال ما يسمى Compound gear train :-





▤ Simple gear Train.



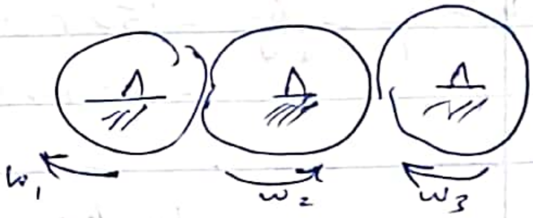
⇒ One gear per shaft

$$w_1 r_1 = -w_2 r_2$$
$$w_2 r_2 = -w_3 r_3$$
$$w_3 r_3 = -w_4 r_4$$

$\Rightarrow w_1 r_1 = w_4 r_4$

⇓ idle gears → اي انها لا تأثر على الحركة ويتم وظيفها اذا كانت هنالك مسافة مثلاً بين الاول والرابع / او لعكس اتجاه الحركة

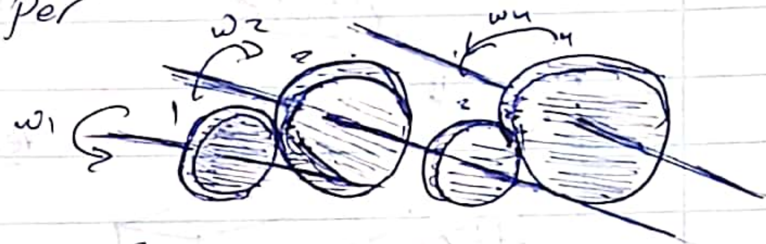
← لجعل يدور بنفس الاتجاه



▤ Compound gear train.

⇒ More than one gear per shaft.

* see videos.



$$w_1 r_1 = -w_2 r_2 \Rightarrow \frac{w_2}{w_1} = -\frac{r_1}{r_2}$$

$$w_2 = w_3 \quad / \quad w_3 r_3 = -w_4 r_4$$

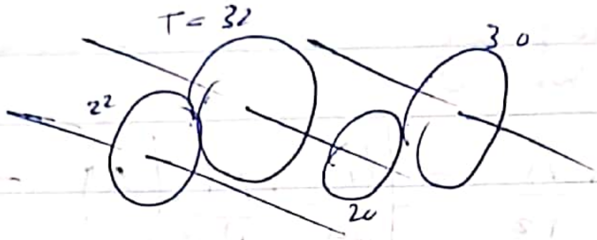
$$\Rightarrow \frac{w_4}{w_1} = \frac{w_4}{w_3} * \frac{w_3}{w_2} * \frac{w_2}{w_1}$$

$$= \frac{r_3}{r_4} \cdot 1 \cdot \frac{r_1}{r_2} = \frac{r_3 r_1}{r_4 r_2}$$

← اي هنا اصبح هناك فائدة من reduction.

لأن

$$\frac{r_1}{r_2} = \frac{D_1}{D_2} = \frac{N_1}{N_2} \Leftarrow \boxed{\frac{N_1}{D_1} = \frac{N_2}{D_2}} \quad \frac{r_2}{r_1} = \frac{N_2}{N_1}$$



$$\frac{\omega_4}{\omega_1} = \frac{N_1}{N_2} \cdot \frac{N_3}{N_4} = \frac{22 \times 20}{32 \times 30} = \frac{44}{96} = \frac{22}{48} = \boxed{0.45} = \frac{\omega_4}{\omega_1}$$

اي اذا input يدور دورة واحدة
فان output يدور 0.45 دورة :-

- velocity Ratio :-

$$\text{velocity Ratio} = \frac{\omega_{out}}{\omega_{in}} = \frac{\omega_4}{\omega_1} = VR$$

$$VR = \frac{\omega_{out}}{\omega_{in}} = \frac{\text{Product of number of teeth of Driver gears}}{\text{Product of number of teeth of Driven gears}}$$

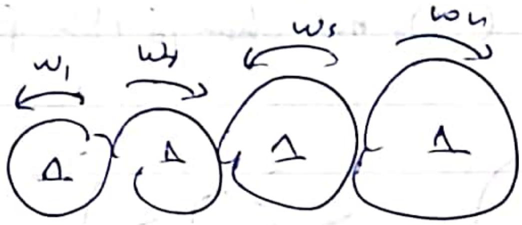
اي العلاقة عكسية ←

$$\frac{\omega_4}{\omega_1} = \frac{\Pi \text{ Driver}}{\Pi \text{ Driven}} = \frac{N_1 \times N_3}{N_2 \times N_4}$$

(Driver) ↑ اي في compound gear ← 1 يقود 2 و 3 تقود 4

(Driven) و 2 ينتج 1 و 4 ينتج 3

ولذلك بالنسبة لـ simple gear



اي دائماً عند هناك mesh نضع negative sign

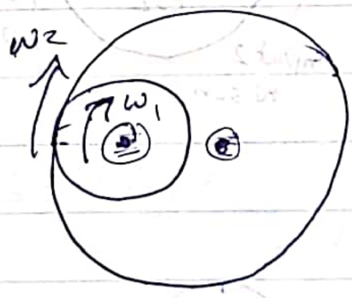
$$\frac{w_4}{w_1} = \frac{-N_1 \times -N_2 \times -N_3}{N_2 \times N_3 \times N_4} = \boxed{\frac{-N_1}{N_4}}$$

$$e = \frac{W_{in}}{W_{out}} = \frac{\Pi \text{ Driven}}{\Pi \text{ Driver}}$$

⇒ العلاقة الثابتة نحطها بالحلقة ونكمل في عالسنة gear

Internal gears

⇐ يتم استخدام نفس العلاقة السابقة ولكن لا يوجد negative sign لانها بنفس الاتجاه.

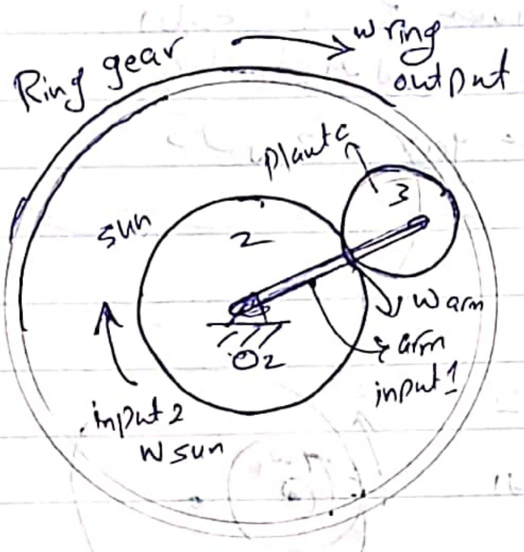


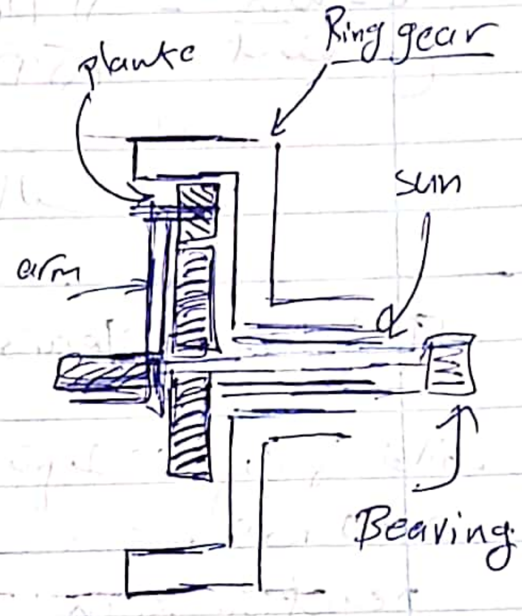
* Remarks:- in all previous example all axes of rotation are fixed! (Do not change it's position)

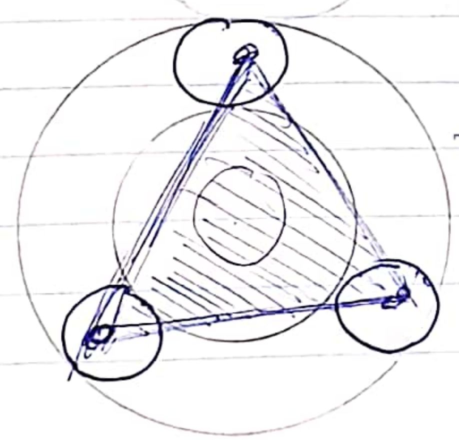
⇒ To increase velocity ratio:-

→ * Moving axes of Rotation

→ * Planetary Gears.







* هنا صار ع planet 3

⟹ بعطي ثلاثة أضعاف

Torque ولكن [illegible]

عملية التحليل و[illegible]

يكفي

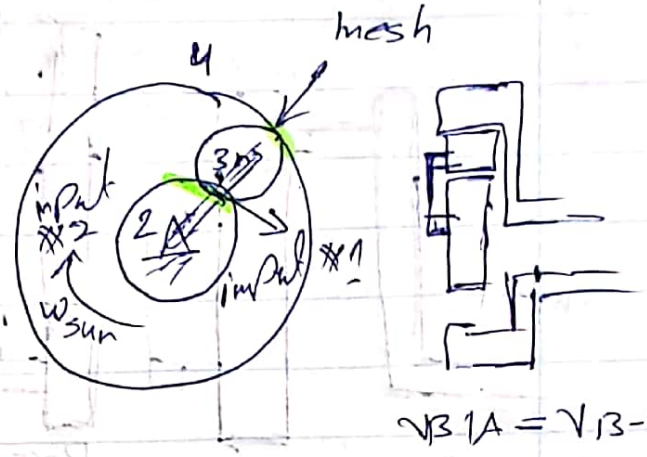
10/5/2021

Planetary gears:-

Procedure of analysis:-

1. Identify the plant gear and the arm (gears)
2. Identify the gears that are directly in mesh with the planet (gears 2 & 4)

* Relation to the arm all gears are rotating about a fixed axis.



$$\Rightarrow (VR)_{arm} = \frac{\omega_{out/arm}}{\omega_{in/arm}}$$

$$= \frac{\text{\# of driver}}{\text{\# of driven}}$$

$$= \frac{\omega_{out} - \omega_{arm}}{\omega_{in} - \omega_{arm}} = \frac{\text{\# Driver}}{\text{\# Driven}}$$

$$\vec{V}_{B/A} = \vec{V}_B - \vec{V}_A$$

$$\vec{\omega}_{3/2} = \vec{\omega}_3 - \vec{\omega}_2$$

Exp:-

$\omega_{arm} = 2$ rad/s ccw

gear 2 is fixed $\Rightarrow$ Determine ω_4 ??

$$\frac{\omega_{out} - \omega_{arm}}{\omega_{in} - \omega_{arm}} = \frac{\text{\# Driver}}{\text{\# Driven}} = \frac{\omega_4 - \omega_{arm}}{\omega_2 - \omega_{arm}} = -\frac{N_2 * N_3}{N_3 * N_4}$$

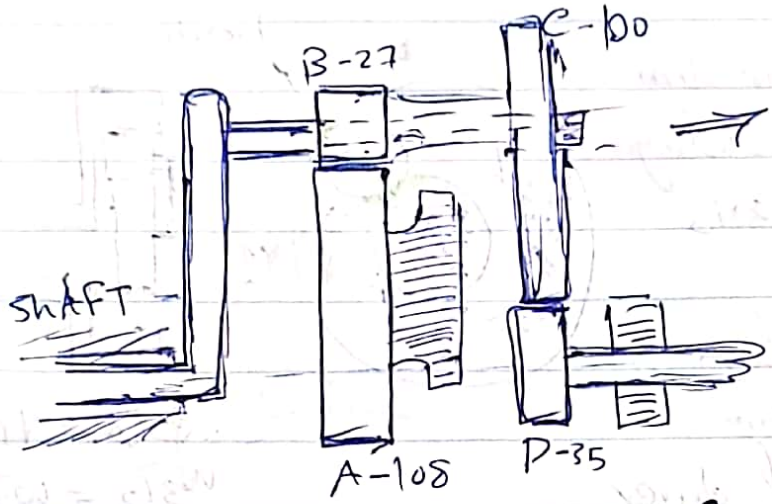
(ω_{arm}: 2 rad/s; ω_2: fixed = zero; $\omega_2 - \omega_{arm}$: 2 rad/s)

$\omega_4 =$ ____

في اي حل لهذه الاسئلة :-

* يجب معرفة اي gear هو fixed axis و اي arm هو غير ذلك.

* اي الرموز يجب ان نستعيض بكلمة arm .



planetary gears (planetes)

B C

in mesh with:

B	C
A	D

input- output

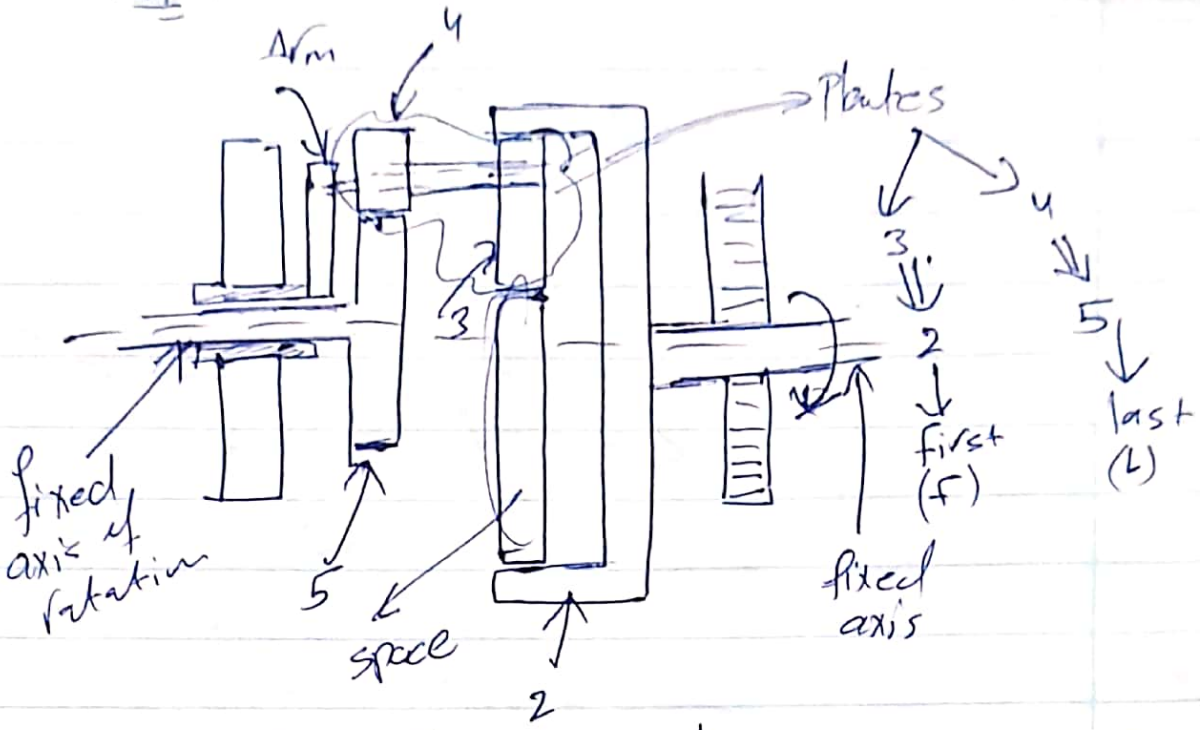
$$\frac{W_D/arm}{W_A/arm} = \frac{w_{out}/arm}{w_{in}/arm} = \frac{T\ Driver}{T\ Driven} = -\frac{N_A}{N_B} * \frac{N_C}{N_D} = \frac{W_D - W_{arm}}{W_A - W_{arm}}$$

external gear

zero fixed

given

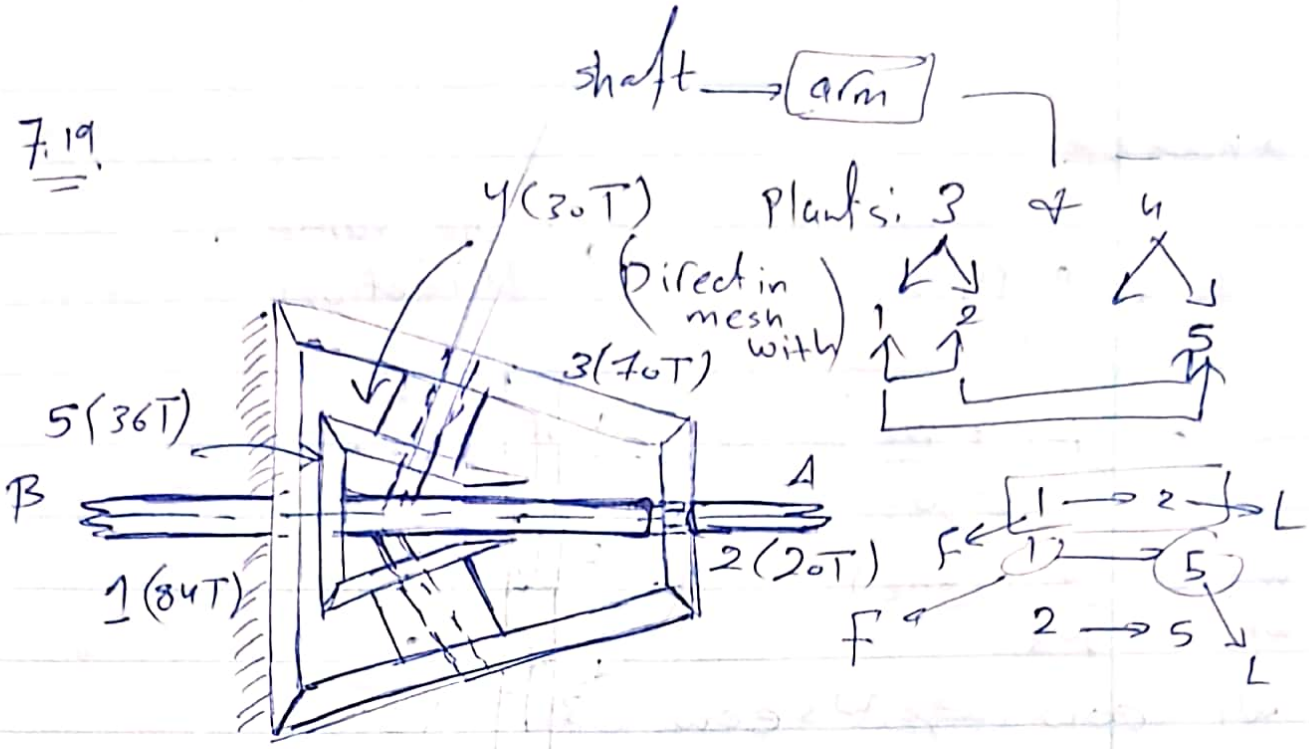
Exp:



$$\frac{W_{2/arm}}{W_{F/arm}} = \frac{\text{Driver}}{\text{Driven}} = \frac{-N_5}{N_4} * \frac{N_3}{N_2} = \frac{W_2 - W_{arm}}{W_5 - W_{arm}}$$

17/5/2021

7.19.



$$\frac{\omega_{L/arm}}{\omega_{F/arm}} = \frac{\text{No. of Driver}}{\text{No. of Driven}}$$

$$\frac{\omega_2 - \omega_{arm}}{\omega_1 - \omega_{arm}} = \frac{\omega_{2/arm}}{\omega_{1/arm}} = \frac{\omega_{L/arm}}{\omega_{F/arm}} = \frac{\text{No. of Driver}}{\text{No. of Driven}} = \frac{-N_1}{N_3} * \frac{-N_3}{N_2}$$

ω_1 fixed $= 0$ zero $= \frac{-N_1}{N_2}$

Remember

ω_A & ω_6

$$\frac{\omega_A - \omega_6}{0 - \omega_{arm}} = \frac{\omega_L - \omega_{arm}}{\omega_1 - \omega_{arm}} = \frac{-N_1}{N_2}$$

By $(1 \to 5)$

$$\frac{\omega_B - \omega_6}{0 - \omega_6} \quad \frac{\omega_5 - \omega_{arm}}{\omega_1 - \omega_{arm}} = \frac{\omega_{L/arm}}{\omega_{F/arm}} = \frac{\text{No. of Driver}}{\text{No. of Driven}} = \frac{-N_1}{N_3} * \frac{-N_4}{N_5}$$

Sh ω_B & ω_6

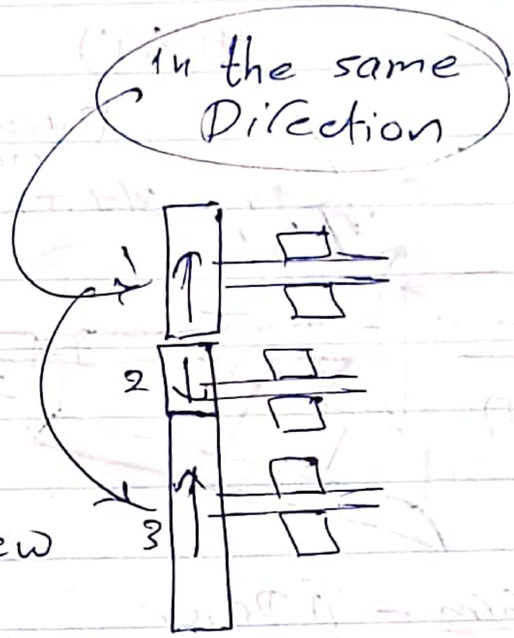
$$= \frac{N_1 N_4}{N_3 N_5}$$

*note:-

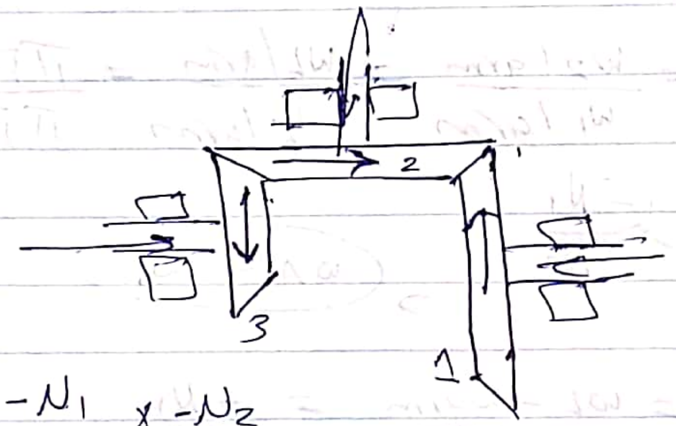
$$\frac{\omega_3}{\omega_1} = \frac{\Pi \text{ Driver}}{\Pi \text{ Driven}} = \frac{-N_1 * N_2}{N_2 * N_3}$$

$$\frac{\omega_3}{\omega_1} = \frac{N_1}{N_3} \quad (+ve)$$

ω_1 ccw ⇒ ω_3 ccw



⇐ وتسمى حالة bevel gear :



$$\frac{\omega_3}{\omega_1} = \frac{-N_1}{N_2} \times \frac{-N_2}{N_3}$$

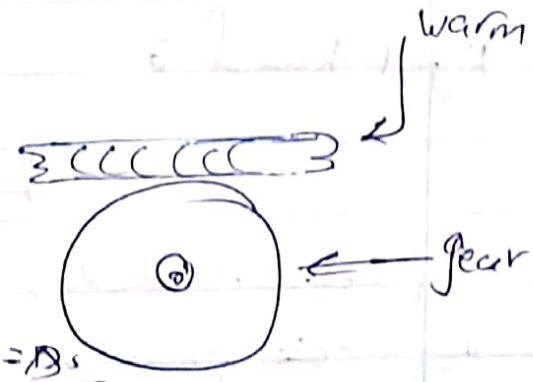
$$\frac{\omega_3}{\omega_1} = \left(\frac{N_1}{N_3}\right)$$

↳ are ω_1 & ω_3 in the same direction ??

* لذلك ليست بنفس الاتجاه ← لا

في هذه الحالة كانت العلاقة لوحدها والاتجاه الاشارة السالبة

Worm gears:-



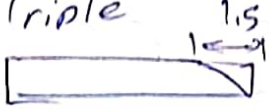
⇒ in mechanical Drawing:-

* single — one teeth


⇒ lead = P = Ds/one turn w

* Double — one term

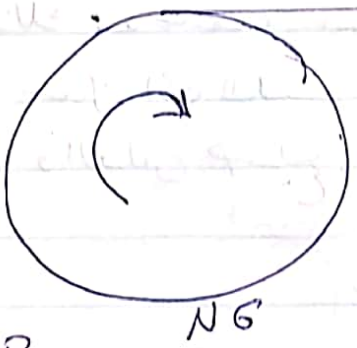

⇒ lead = 2P = Ds/one turn w

* Triple


⇒ one term
lead = 3P = Ds/one turn w

---

1 turn ⇒ DsG = circumference = NG * P



$$DsG = \frac{NG * P}{\text{turn } G}$$

$$\text{turn } \theta = \frac{NG * P}{DsG}$$

$$* \; WG = \frac{NG\,P}{VG}$$

$$1 \text{ turn } w = \frac{Nw * P}{Dsw}$$

$$* \; W_w = \frac{Nw * P}{Vw}$$

$$Vw = VG$$

$$\frac{Nw * P}{Ww} = \frac{NG * P}{WG} \Rightarrow \boxed{\frac{WG}{Ww} = \frac{Nw}{NG}}$$

NG = 40

Nw = 2

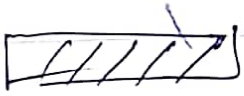
$$\frac{WG}{Ww} = \frac{2}{40} = \frac{1}{20}$$

warm لل 1 و gear لل 20

Right hand :-

* عند تدوير مع عقارب الساعة سيتقدم لذلك عندضغط عند التقدم ⇐ سيسحب gear الى الخلف والعكس صحيح.

left hand :-



* عند تدوير عكس عقارب الساعة سيتقدم لذلك عندضغط عند التقدم ⇐ سيسحب gear الى الخلف والعكس صحيح.