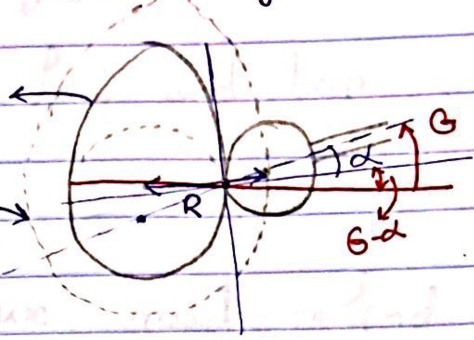
Disk cam with radial roller follower:-

at dwell:

$\alpha = 0$

$\rightarrow f'(\theta) = 0$

$R = R_o + f(\theta)$ (1)



α is between CT, CN

R_r = radius of roller (2)

Contact point C: $x = C_x = R\cos\theta - R_r\cos(\theta-\alpha)$

$y = C_y = R\sin\theta - R_r\sin(\theta-\alpha)$

$\alpha = \tan^{-1}\left(\frac{f'(\theta)}{R_o + f(\theta)}\right)$ ← اذا طلب α منعطفة مماسية مباشرة

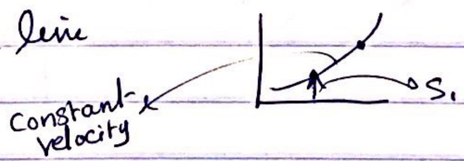
R_o = minimum distance between the center of rotation of the cam and the center of the Roller

To find α max:-

find $\frac{L}{R_o}$ → Local S

Given

if V is constant : take $f(\theta)$ at first point in line



$\tan^{-1}\left(\frac{\text{Slope}}{R_o + f(\theta)}\right)$

Cusp in radial roller follower

To avoid cusp find ρ_{min} and Keep:

$$R_r < \rho_{min}$$

· To find $(R_{r\,max})$ → we need to find ρ_{min}

① find $\frac{L}{R_o}$ as previously

Then find β

② use curve to obtain $\frac{\rho_{min}}{R_o}$

and multiply it with R_o $\xrightarrow{\text{to find } \rho_{min}}$ R_r

if constant velocity

$$\rho_{min} = \frac{\left[R^2 + f'(\theta)^2\right]^{3/2}}{R^2 + 2[f'(\theta)]^2 - R(f''(\theta))}$$

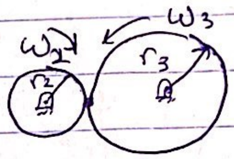
At dwell $\alpha = 0$ since $\Rightarrow$ $f'(\theta) = 0$

Gear trains:

Types:-

1- Rotation about a fixed axis:-

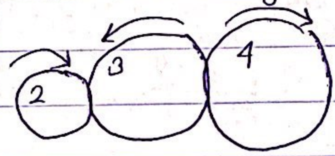
→ simple gear train : one gear per shaft.



Rolling with slipping

$$\frac{\omega_2}{\omega_3} = \frac{-r_3}{r_2}$$

If there are an additional gear (Idle gear)



$$\frac{\omega_2}{\omega_4} = \frac{r_4}{r_2}$$

$$\text{Velocity} = \frac{\omega_{in}}{\omega_{out}}$$

$$\text{train value } (e) = \frac{\omega_{out}}{\omega_{in}}$$

→ compound gear train

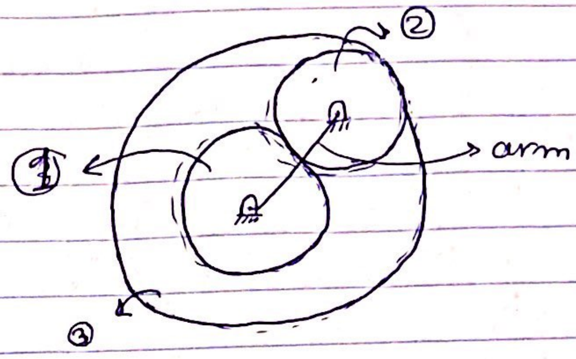
Gears on same shaft has same angular velocity

Planetary Gears :-

- If the arm is fixed

① Drives ②
② Drives ①

② is called planet gear



$$\frac{W_{out}}{W_{in}} = \underset{\text{external}}{\ominus} \frac{N_1 \times N_2}{N_2 \times N_3} \Big\} \text{internal} = \frac{-N_1}{N_3} = \frac{\omega_3}{\omega_1}$$

- If gear 1 is fixed

$$\frac{W_{out}/arm}{W_{in}/arm} = \frac{-N_1}{N_3}$$

$$\frac{W_3 - W_{arm}}{\cancel{W_1}^{0} - W_{arm}} = \frac{-N_1}{N_3}$$

$$\frac{W_3 - W_{arm}}{-W_{arm}} = \frac{-N_1}{N_3}$$

Notes:

- usually W_{arm} is given and we need to find W_1 or W_3

- If gear 3 is fixed

$$\frac{-W_{arm}}{W_1 - W_{arm}} = \frac{-N_1}{N_3}$$

Procedure of Analysis :-

1- Identify the Planet gear

2- " " gears directly in mesh with the planet (first , last)

Driver ↲ ↳ Driven

$$\frac{\omega_{F/arm}}{\omega_{L/arm}} = \frac{\Pi \text{ driven}}{\Pi \text{ drivers}}$$

CCW ⇒ +

CW ⇒ −

Standard gears

• Diametral pitch: number of teeth of a gear per inch of it's pith diameter

English standard :- $P = \frac{N}{D}$

SI metric " :- $m = \frac{D}{N}$

to mesh the gears they must have same m or P

• (e) train value can be found using teeth

$$e = \frac{\omega_{out}}{\omega_{in}} = \frac{\text{Product of number of teeth of driver gear}}{\text{Product of number of theeth of driven gear}}$$

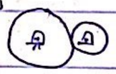
$$= \frac{\Pi \text{ Driver}}{\Pi \text{ Driven}}$$

• التسنين

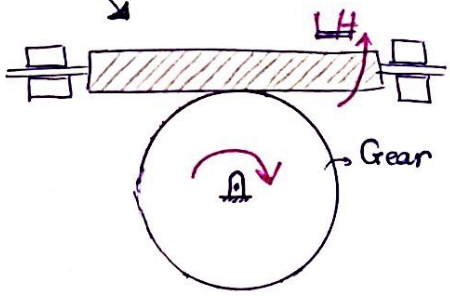
داخلي : يكونو يدورو بنفس الاتجاه والنسبة $\frac{\omega_2}{\omega_1} = \frac{N_1}{N_2}$ بدون سالب

خارجي : يكون في اشارة سالب في النسبة لأنهم بدورو بعكس الاتجاه

$$\frac{\omega_2}{\omega_1} = -\frac{N_1}{N_2}$$



Warm Gear:



Number of teeth N:

- Single : $N=1$
- Double : $N=2$
- Trible : $N=3$

$$\frac{\omega_G}{\omega_w} = \frac{N_w}{N_G}$$

Lead $= N_w \times P$ → circular pitch

- if the gears turns one complete revolution the contact point burns $= N_G \times P$

if N_w, N_G are not Given :-

$$\frac{\omega_G}{\omega_w} = \frac{N_w}{N_G} = \frac{L}{\pi D_G}$$

L → lead

D_G → diameter of pitch circle

- Rotation and direction

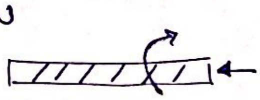
Worm can be :
LH or RH

Gear Rotation :-
ω_G :- CW
or CCW

- Now if worm is LH :-

ω_G : CW

Warm :



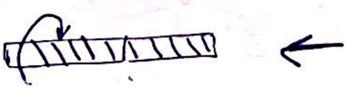
ω_G : CCW

warm

- If warm is RH :

ω_G : CCW

Worm



ω_G : CW

Worm :

Scanned with CamScanner

Balancing

Static Balancing :- masses rotate in one plane

→ one mass used to balance

$$(m_b R_b)_x = -\sum m_i R_i \cos\theta_i$$

$$(m_b R_b)_y = -\sum m_i R_i \sin\theta_i$$

$$m_b R_b = \sqrt{(m_b R_b)_x^2 + (m_b R_b)_y^2}$$

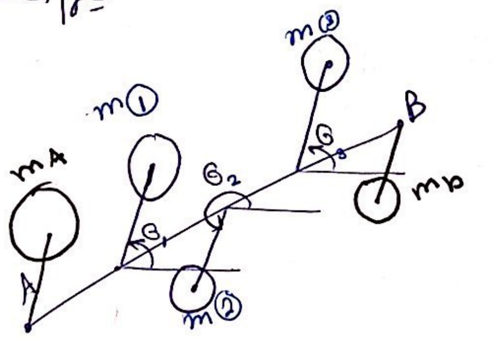
$$\theta_b = \tan^{-1}\left(\frac{m_b R_b\, y}{m_b R_b\, x}\right)$$

- If you want to find m_b alone you need to find $(m_b R_b)_x$ then $(m_b R_b)_y$ Then find $m_b R_b$ Then divide by R_b

Dynamic Balancing : two masses required to balance

one for forces — one for moments

نستخدم كتلة عشان نوازن الـ moments عند النقطة B مثلاً . هاي الكتلة تخلي
مجموع الـ moments حوالين A يصير صفر بتبين لحط كتلة عند A توازن قوى الشكل الناشئة عا
فيهم الكتلة اللي حطيتها عند B



- **Signs** $\sum M_y = -m_i R_i \cos\theta_i\, \omega^2 L_i$ (Because $\cos\theta$ can be neg or pos refering to the Qudrant the mass is in)

  if theta → Q2 or Q3 → $\cos\theta$ = neg → moment is pos

  if theta → Q1 or Q4 → $\cos\theta$ = pos → " " neg

$$(m_B R_B)_x = \frac{-\sum m_i R_i \cos\theta_i L_i}{L_B}$$

$$(m_B R_B)_y = \frac{-\sum m_i R_i \sin\theta_i L_i}{L_B}$$

$$m_B R_B = \sqrt{(m_B R_{Bx})^2 + (m_B R_{By})^2}$$

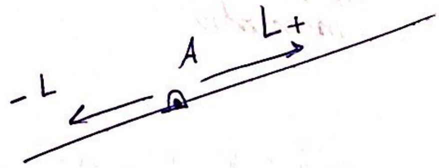
$$\tan\theta_B = \frac{m_B R_{By}}{m_i R_{ix}}$$

* Balancing of forces

$(m_A R_A)_x = -\sum m_i R_i \cos\theta_i$ (including $m_B R_B \cos\theta_B$)

$(m_A R_A)_y = -\sum m_i R_i \sin\theta_i$

Additional Note:



- If point A is not on the side, the only difference is that L now has signs

Fly wheels

Applications: 1- Presses
2- Engines

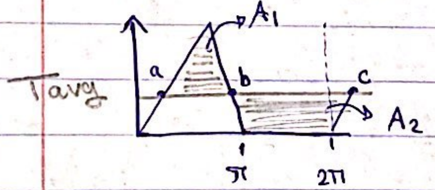
Steam engine → single acting cylinder, double acting cylinder
internal combustion engine

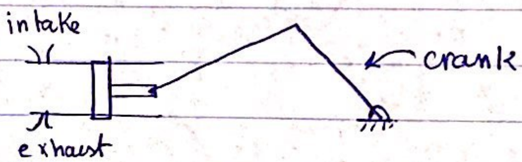
single acting cylinder — crank angle = 360
2 single acting cylinder — crank.A = 180
3 single acting cylinder — crank angle = 120

- Crank angle = $\frac{\text{duration of one cycle}}{\text{number of pistons}}$

Steam engine

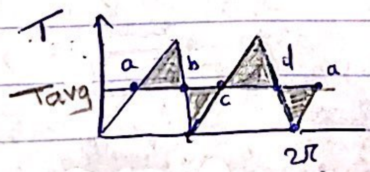
Single acting cylinder

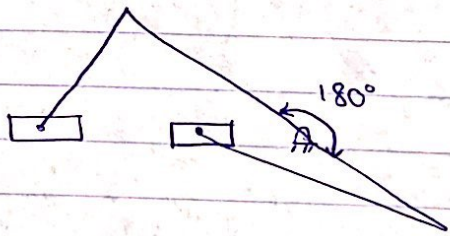




$A_1 = A_2$

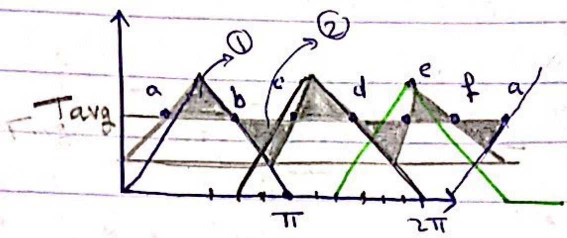
- 2 single acting cylinder
  crank angle = 180

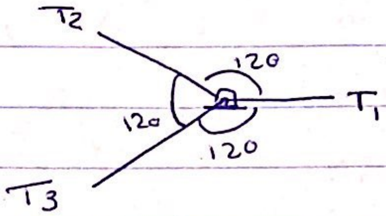




مجموع مساحة مافوق الخط
=
مجموع مساحة ماتحت الخط

3 single acting cylinders
crank angle $= 120°$





energy at a
$= H$

energy at b
$= H + \text{Area}①$

energy at c
$= H + \text{Area}① - \text{Area}① = H$

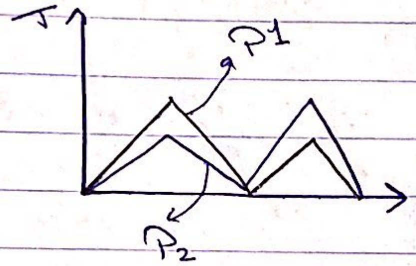
energy at d
$= H + \text{Area}\ 3$

— —— ——

untill you reach a again where energy $= H$

Tavg مجموع ما فوق Tavg = مجموع ما تحت الـ Tavg

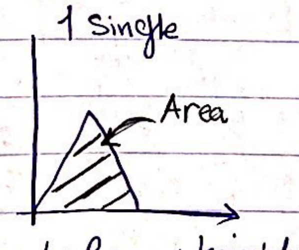
Double acting cylinder (2 pistons)



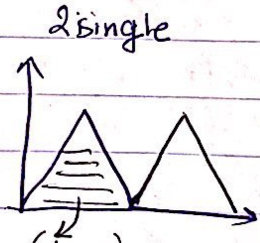
يشتغلو عكس بعض

Basic defenitions

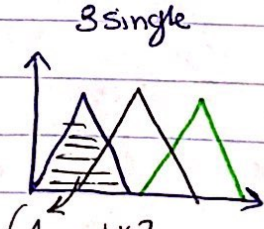
H: Total energy = Total area under the curve
= * of pistons * area under one curve



$= \frac{1}{2} \times \text{Base} \times \text{height}$
using rad



(Area) X2



(Area) X3

T_{avg} = Total energy / duration of (period) one cycle

e: Maximum fluctuation of energy $= H_{max} - H_{min}$

$e = \frac{1}{2} I \left(\omega_1^2 - \omega_2^2 \right)$ = energy supplied by flywheel

Max Ang Vel (ω_1), min Ang Vel (ω_2)

$\omega = \frac{\omega_1 + \omega_2}{2}$

Avg Ang Vel (ω)

E = energy of the flywheel at mean speed $= \frac{1}{2} I \omega^2$

K = coefficient of fluctuation of speed

$= \frac{\omega_1 - \omega_2}{\omega}$

$K = \frac{e}{2E}$

احياناً تعطينا السرعة ب m/s تبع V

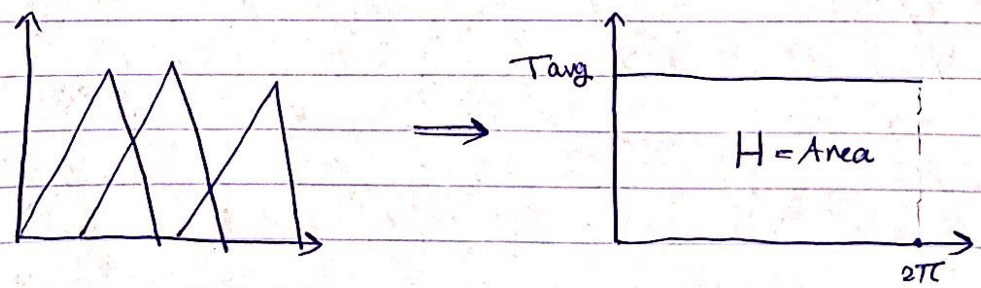
$E = \frac{1}{2} \underset{\text{mass}}{m} V^2 \leftarrow E$ هون نضر

Inertia

K_G: Radius of Gyration

$I = m K_G^2$

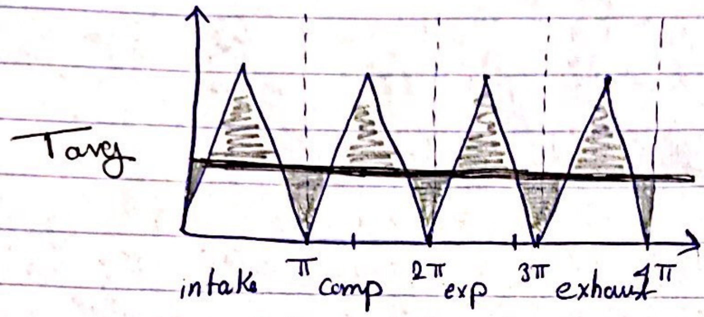
When you calculate T_{avg}:



Power $= T_{avg} \times \omega$

Internal combustion engines (4- Stroke engine)
= gas engine

cycle duration = 4π



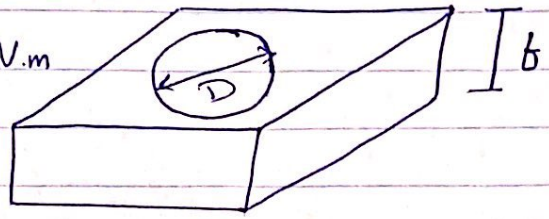
Area above = Area under

- If the energy is Given by mm^2 you multiply it by scales ($1 mm \to 5 n\text{-}m$, $1 mm \to 1°$ → for example) and then by $\frac{\pi}{180}$
- If the Question asks for percentage fluctuation of speed → K

Punching machine (مكبس)

Scale: $1\ mm^2 \rightarrow n\ N.m$

يعني كل mm^2 بده n من ال energy



Power of motor $= \dfrac{\text{energy}}{\text{Time}}$

energy required to shear one hole = area $\times\ n$

$= \pi D t \times n$

Actual cutting time $= \dfrac{t}{\text{Stroke}} \times$ (time needed to cut one hole$/2$)

energy of fly wheel = e of shearing one hole − e of cutting time