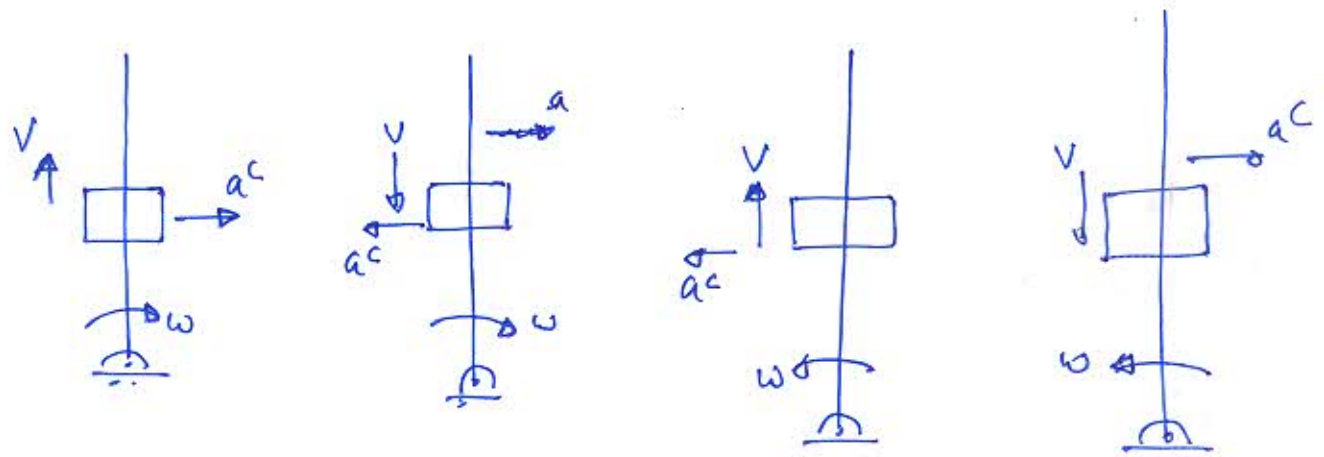
NME-502, ST-2, SOL, Odd, 2017-18

Section-A

Question: 1 What is the Coriolis Component of acceleration? Also give the direction sense.

An acceleration caused by Coriolis force, Coriolis force is apparent force experienced by a body moving relative to rotating body.



Turn velocity vector by 90° in the same sense as 'ω'.

Question-2 Name the different mechanism which are used for exact & approximate straight line motion.

→ Exact straight line Mechanism

1. Peaucellier Mechanism.
2. Hart's Mechanism.

→ Approximated Straight Line

1. Watt's Mechanism.
2. Modified Scott-Russel mechanism.

Que-3 Define the terms:
(a) Module (b) Pressure angle (c) Circular Pitch (d) addendum

(a) Module: It is the ratio of pitch circle diameter in mm to number of teeth

$$m = \frac{D(mm)}{T}$$

(b) Pressure angle: It is the angle b/w the common normal to two gear teeth at the point of contact & the common tangent at pitch point.

(c) Circular Pitch: It is distance measured on the circumference of the pitch circle from a point of one tooth to the corresponding point on the next tooth.

$$P_c = \frac{\pi D}{T}$$

(d) addendum; It is radial distance of a tooth from pitch circle to the top of the tooth

Question-4: The driving & driven shafts connected by Hook's joint are inclined an angle α, Write for Maximum, Minimum & eaual speed.

Condition for maximum speed: → $\omega_{max} = \frac{\omega}{\cos\alpha}$

for Minimum $\omega_{min} = \omega \cos\alpha$

for eaual, $\tan\theta = \pm\sqrt{\cos\alpha}$

ω = driver shaft speed

α = Misalignment b/w shaft

Question-5; Explain the term Interference and how it is Prevented.

The Phenomenon when the tip of tooth undercuts the root on its mating gear is known as interference

Method to Prevent.

(i) By Maintaining Minimum Number of teeth

(ii) By increasing Pressure angle

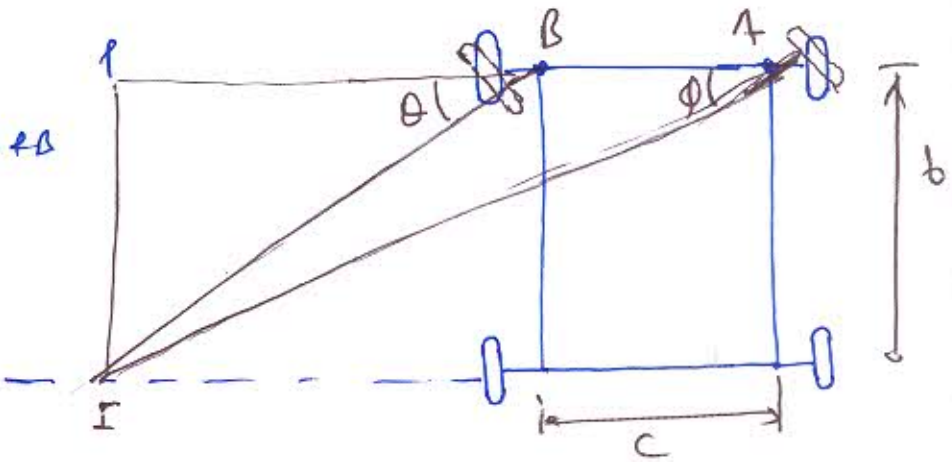
(iii) By stubing the tooth

: Section-B :

Question-6 ; What is the condition for correct steering? Sketch & show the two main types of steering gears & discuss their relative advantage?

b = Wheel base

C = Distance b/w the Pivot A & B of front axle.



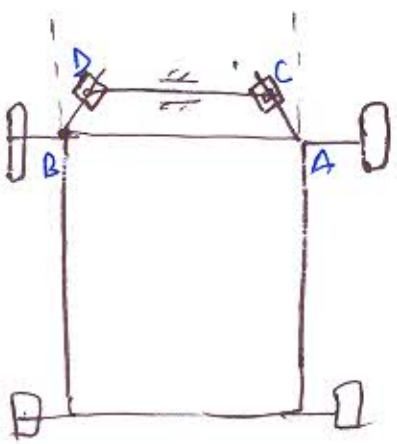
In Δ IBP & IAP

$$\cot\theta = \frac{BP}{IP}$$

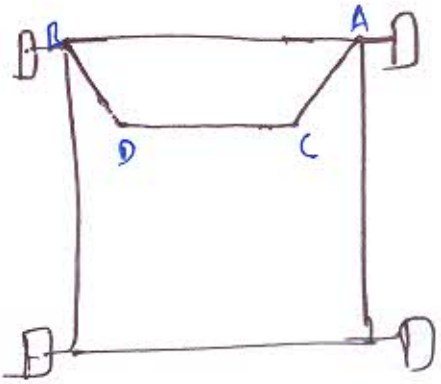
$$\cot\phi = \frac{AP}{IP} = \frac{AB+BP}{IP}.$$

$$\boxed{\cot\phi - \cot\theta = \frac{C}{b}}$$ → Condition for correct steering

Davis steering



Ackerman steering



Davis Steering	Ackerman steering
① Fulfil Condition for correct steering at all position	① fulfil condition for correct steering at mid & extreme point only
② 2 Turning & 2 Sliding Pairs	② 4 Turning Pair
③ Wear & tear is high	③ Less wear & tear

Question-7: Two shafts are connected by Hook's Joint the driving shaft revolves uniformly at 500 rpm if total permissible variation in speed of the driven shaft is not to exceed ± 6% of mean speed find the greatest permissible angle b/w centre lines & shaft axis.

Given $N = 500$ rpm $\quad \omega = \frac{2\pi \times 500}{60} = 52.4$ rad/s

Let α = Greatest Permissible angle.

$q = \pm 6\% \Rightarrow 12\%$ of mean $\omega = 0.12\,\omega$

$$0.12\,\omega = \omega \frac{1-\cos^2\alpha}{\cos\alpha} \qquad \cos^2\alpha + 0.12\cos\alpha - 1 = 0$$

$$\cos\alpha = \frac{-0.12 \pm \sqrt{(0.12)^2 + 4}}{2} = \frac{-0.12 \pm 2.0036}{2}$$

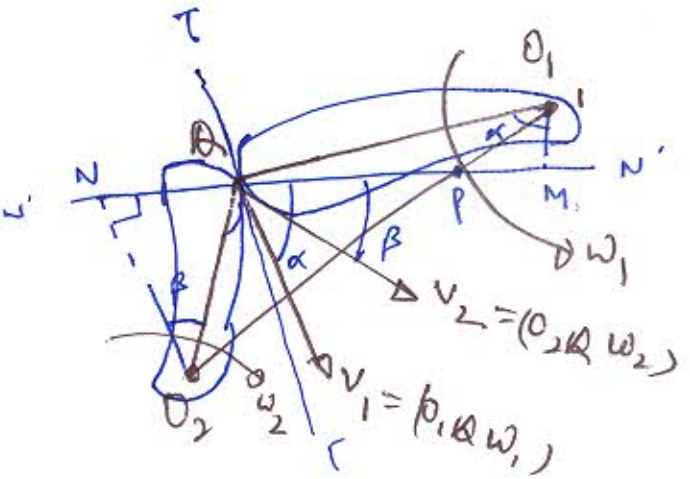
$\alpha = 19.64°$ Ans

Question-8: State & Prove the law of gearing. Derive expressions for the velocity of sliding.

Statement: "The line of action at every moment should always pass through the fixed point (pitch point) on line joining the centre of rotation of gears"

Prove:

O_1 O_2 fixed centre of gear
Q → Point of Contact



For Proper Contact

$V_1 \cos\alpha = V_2 \cos\beta$

$O_1Q\,\omega_1 \cdot \frac{O_1M}{O_1Q} = O_2Q\,\omega_2 \cdot \frac{O_2N}{O_2Q}$

$$\boxed{\frac{\omega_1}{\omega_2} = \frac{O_2N}{O_1M}}$$

from similar ΔO_2NP & O_1PM

$$\frac{\omega_1}{\omega_2} = \frac{O_2N}{O_1M} = \frac{O_2P}{O_1P} = \frac{PN}{PM} = \text{Constant}$$

Velocity of sliding:

$$V_{sliding} = |V_1 \sin\alpha - V_2 \sin\beta|$$

$$= \left[O_1 \omega_1 \frac{QM}{O_1} - O_2 \omega_2 \frac{QN}{O_2} \right]$$

$$= \omega_1 (QP + PM) - \omega_2 (PN - QP)$$

$$= \omega_1 QP + \omega_1 PM - \omega_2 PN + \omega_2 QP$$

$$V_{sliding} = (\omega_1 + \omega_2) QP$$

Question: Derive the expression for minimum number of teeth required on the pinion in order to avoid interference in involute gear teeth, when it meshes with wheel.

From figure:

$BE = (BF)^2 + (FE)^2$ → length of Maximum possible Lagh

$$(BF)^2 + (FP + PE)^2$$

$$= (R\cos\phi)^2 + (R\sin\phi + r\sin\phi)^2$$

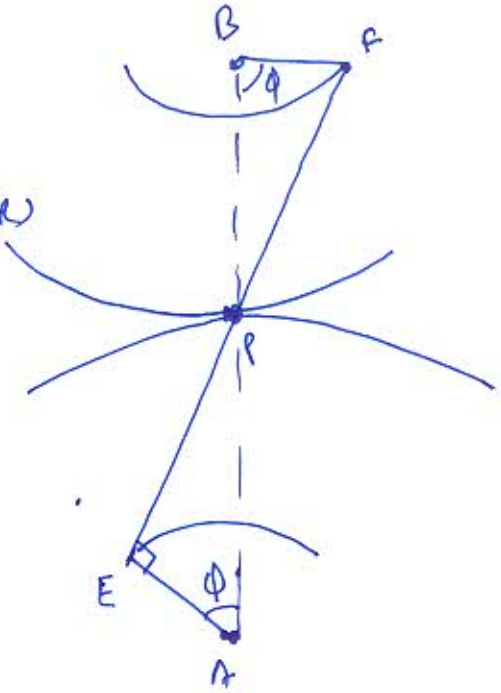
$$= R^2\cos^2\phi + R^2\sin^2\phi + \lambda^2\sin^2\phi + 2\lambda R\sin^2\phi$$

$$= R^2(\cos^2\phi + \sin^2\phi) + \sin^2\phi(\lambda^2 + 2\lambda R)$$

$$= R^2 + (\lambda^2 + 2\lambda R)\sin^2\phi$$

$$= R^2\left[1 + \frac{(\lambda^2 + 2\lambda R)}{R^2}\sin^2\phi\right]$$

$$= R^2\left[1 + \left(\frac{\lambda^2}{R^2} + \frac{2\lambda}{R}\right)\sin^2\phi\right].$$



$$BE = R\sqrt{1 + \frac{\lambda}{R}\left(\frac{\lambda}{R} + 2\right)\sin^2\phi}$$

Maximum value of the addendum

$$a_{w\max} = R\sqrt{1 + \frac{\lambda}{R}\left(\frac{\lambda}{R} + 2\right)\sin^2\phi} - R$$

$$= R\left[\sqrt{1 + \frac{\lambda}{R}\left(\frac{\lambda}{R} + 2\right)\sin^2\phi} - 1\right]$$

$$R = \frac{MT}{2}$$

$$T \geq \frac{2a_{w\max}}{\sqrt{1 + \frac{1}{q}\left(\frac{1}{q} + 2\right)\sin^2\phi} - 1}$$

Ans

Question-10 A Pinion having 30 teeth drives a gear having 80 teeth. The Profile of the gears is involute with 20° Pressure angle, 12 mm module & 10 mm addendum. Find the length of Path of contact, arc of contact and contact ratio.

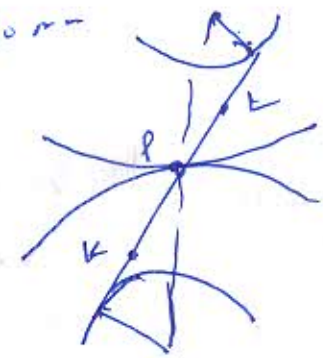
Given: $t = 30$; $T = 80$, $\phi = 20°$

$m = 12$ mm & Addendum = 10 mm

Length of Path of Contact

$$r = \frac{mt}{2} = \frac{12 \times 30}{2} = 180 \text{ mm}$$

$$R = \frac{m \cdot T}{2} = \frac{12 \times 80}{2} = 480 \text{ mm}$$



$$r_A = r + 10 = 190 \text{ mm}$$

$$R_A = 490 \text{ mm}$$

$$KP = \sqrt{(R_A)^2 - R^2\cos^2\phi} - r\sin\phi$$

$$= 191.5 - 164.2 = 27.3 \text{ mm}$$

$$PL = \sqrt{r_A^2 - r^2\cos^2\phi} - r\sin\phi$$

$$= \sqrt{(190)^2 - (180)^2\cos^2 20} - 180\sin 20 = 86.6 - 61.6$$

$$= 25 \text{ mm}$$

$$\boxed{KL = KP + PL = 52.3 \text{ mm Ans}}$$

Length of Arc of Contact

$$= \frac{\text{Length of Path of Contact}}{\cos\phi} = 55.66 \text{ mm Ans}$$

We Know that Circular Pitch

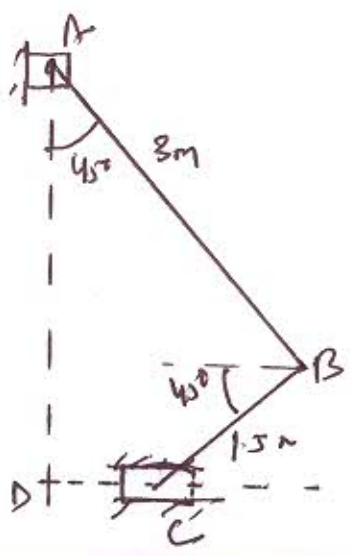
$$P_c = \pi m = \pi \times 12 = 37.7 \text{ mm}$$

$$\text{Contact Ratio} = \frac{\text{Length of arc of Contact}}{P_c}$$

$$= \frac{55.66}{37.7} = 1.5 \quad \text{Ans}$$

Section – C

Question-11 In the mechanism shown in figure 1, the slider C is moving to the right with a velocity of 1 m/s and an acceleration of 2.5 m/s². The dimension of various links are AB = 3 m inclined at 45° with vertical and BC = 1.5 m & inclined at 45° with horizontal Determine: 1. Magnitude of vertical & horizontal component of acceleration of the Point B and 2. the angular acceleration of the link AB & BC

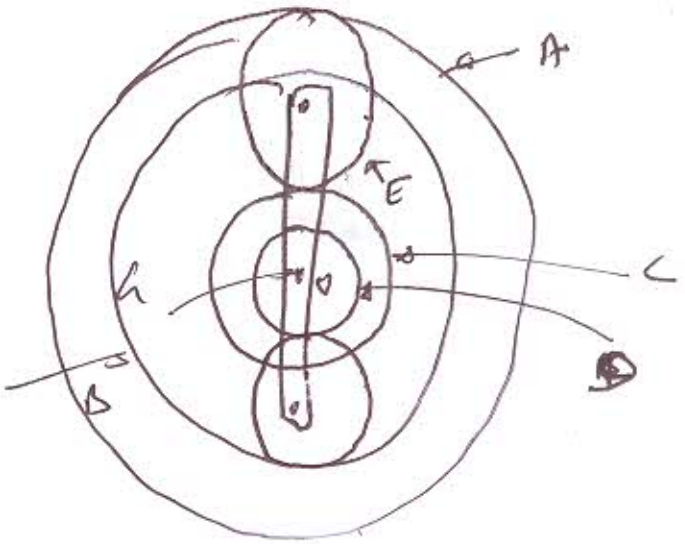


$$\alpha_{AB} = \frac{1.41}{3} = 0.47 \text{ rad/s}^2$$

$$\alpha_{DC} = \frac{1.94}{1.5} = 1.3 \text{ rad/s}^2$$

Ans

Question-12 In an epicyclic gear train as shown in figure 2, the internal wheels A & B & compound wheels C & D rotate independently about axis O. The wheel E & F rotate on pins fixed to arm G. E gear with A & C and F gear with B & D. All the wheel have the same module and number of teeth are: $T_C = 28$, $T_D = 26$, $T_E = 18$. ① Sketch the arrangement ② Find the number of teeth on A & B if arm G make 100 rpm clockwise and wheel A makes 10 rpm. Counter clockwise, Find speed of wheel D.



Given: $T_C = 28$, $T_D = 26$

$T_E = T_F = 18$

Let Number of teeth on wheels A & B

T_A & T_B

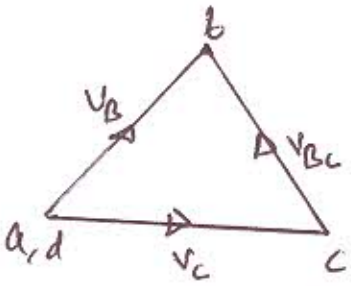
$$d_A = d_C + 2d_E$$

$$d_B = d_D + 2d_F$$

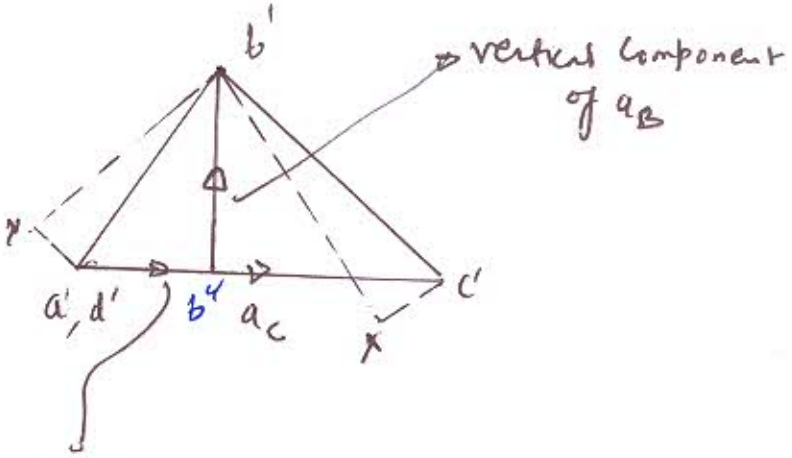
or $$T_A = T_C + 2T_E = 28 + 2 \times 18 = 64$$

Scale: $1 m/s = 3.5$ cm

Scale $2.5 m/s^2 = 5$ cm



Velocity diagram



Acceleration diagram

given $V_C = 1 m/s$ $\quad a_C = 2.5 m/s^2$

$\vec{V}_{CD} = 1 m/s$

$V_{BA} = \vec{ab} = 0.72 m/s$

$V_{BC} = 0.72 m/s$

$$a^n_{BC} = \frac{V_{BC}^2}{CB} = \frac{(0.72)^2}{1.5} = 0.346 m/s^2$$

$$a^n_{BA} = \frac{V_{BA}^2}{AB} = \frac{(0.72)^2}{3} = 0.173 m/s^2$$

Magnitude of horizontal & vertical Component

$a'b'' = 0.9 m/s^2$ — Horizontal

$b'b'' = 1.13 m/s^2$ — vertical

Angular Acceleration of AB & BC

$$\alpha t_{BA} = 1.41 m/s^2$$

$$\alpha t_{BC} = 1.94 m/s^2$$

$T_B = T_D + 2T_F = 26 + 2\times 18 = 62$ Ans

Condition of motion	Arm G	Wheel A	Wheel E	Compound Wheel C-D	Wheel F	Wheel B
Arm fixed Wheel A +1 rev	0	+1	$+\frac{T_A}{T_E}$	$-\frac{T_A}{T_E}\times\frac{T_E}{T_C} = -\frac{T_A}{T_C}$	$+\frac{T_A}{T_C}\times\frac{T_D}{T_F}$	$+\frac{T_A}{T_C}\times\frac{T_D}{T_B}$
Arm fixed Wheel A +x rev.	0	+x	$+x\frac{T_A}{T_E}$	$-x\frac{T_A}{T_C}$	$+x\frac{T_A}{T_C}\times\frac{T_D}{T_F}$	$+x\frac{T_A}{T_C}\times\frac{T_D}{T_B}$
Added +y rev. to all elemen	+y	x+y	$y+x\frac{T_A}{T_E}$	$y-x\frac{T_A}{T_C}$	$y+x\frac{T_A}{T_C}\times\frac{T_D}{T_F}$	$y+x\frac{T_A}{T_C}\times\frac{T_D}{T_B}$

Since, G makes 100 rpm (clock)

$y = -100$ rpm

$x+y = 0$ $\quad x = -y = 100$ rpm

Speed of $B = y + x\frac{T_A}{T_C}\times\frac{T_D}{T_B} = -100 + 100\frac{64}{28}\times\frac{26}{62} = -100 + 95.8$

$= -4.2$ rpm $= 4.2$ rpm (Clock) Ans

When G makes 100 rpm Clock & A 10 rpm anti-clock

$x+y = 10$ & $y = -100$

$x = 10 - y = 110$

Speed of B $= -100 + 110\times\frac{64}{28}\times\frac{26}{26} = -100 + 105.4$

$= +5.4$ rpm $= 5.4$ rpm (Counter clock) Ans