ME316 Tutorial 3

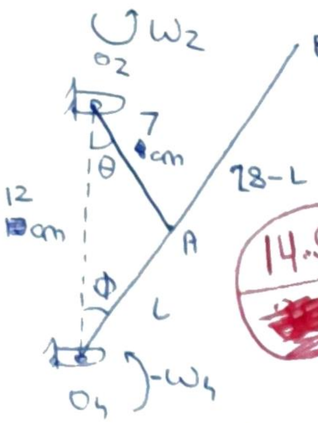
Q4.1

Ameya Halarnkar
200020023

q^3 1.5

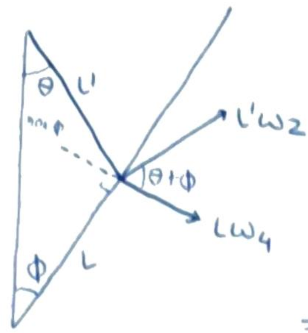
14.5

Q4)



constant

At the instant, $\frac{d\theta}{dt} = 60\,RPM = 2\pi$ rad/s (ω_2)



$L' = 7$cm , $\theta = 15°$

Link 3 moves along rod BO_4

$\Rightarrow$ Net $\perp$ velocity $= 0$

$\Rightarrow L'\omega_2 \cos(\theta+\phi) + L\omega_4 = 0$

$\Rightarrow \omega_4 = -\frac{L'\omega_2 \cos(\theta+\phi)}{L} = -\frac{\omega_2 \sin\phi \cos(\theta+\phi)}{\sin\theta}$

$\omega_4 = \frac{d\phi}{dt}$

$\alpha_4 = \frac{d^2\phi}{dt^2}$

$\Rightarrow \alpha_4 = -\frac{\omega_2}{\sin\theta} \frac{d}{d\phi}\left[\sin\phi \cos(\theta+\phi)\right] \frac{d\phi}{dt}$

Sine Rule:

$\frac{L'}{\sin\phi} = \frac{L}{\sin\theta}$

V_{rel} is needed. Coriolis acceleration

$\Rightarrow \alpha_4 = -\frac{\omega_2\omega_4}{\sin\theta}\left[\cos\phi\cos(\theta+\phi) - \sin\phi\sin(\theta+\phi)\right]$

(1) $= -\frac{\omega_2\omega_4}{\sin\theta}\cos(\theta+2\phi)$. Hence no change.

At instant,

$\frac{\sin(\theta+\phi)}{12} = \frac{\sin\phi}{7}$

$\alpha_4 = \frac{\omega_2^2 \sin\phi \cos(\theta+\phi)\cos(\theta+2\phi)}{\sin^2\theta}$

$\Rightarrow 7(\sin\theta\cos\phi + \cos\theta\sin\phi) = 12\sin\phi$

$\Rightarrow 7\sin\theta + 7\cos\theta\tan\phi = 12\tan\phi$ $\Rightarrow \tan\phi = \frac{7\sin 15°}{12 - 7\cos 15°} = 0.345$

$\Rightarrow \phi = 0.33297 \times \frac{180}{\pi} = 19.077°$

CRIBS : The same Q. was there in previous tut and the same method used was given full marks. So here also full should be given.

$\Rightarrow \omega_4 = -\frac{(2\pi)\sin(19.077)\cos(34.077)}{\sin 15} = \boxed{6.572 \text{ rad/s anticlockwise}}$

$\alpha_4 = \frac{4\pi^2 \sin(19.077)}{\sin^2 15}\cos(34.077)\cos(53.154) = \boxed{95.673}$

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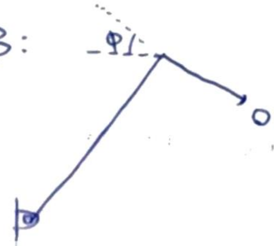
Angular velocity and acceleration of link 4

Answers are incorrect

Velocity of B:

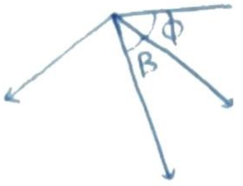


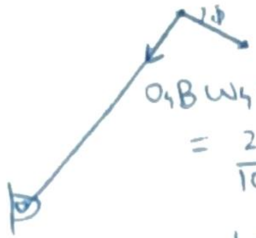
$\omega_4 = 0.564$ rad/s

→ 47.87 cm/s

$O_4B\,\omega_4 = \frac{28}{100} \times (-6.572) = \boxed{1.84 \text{ m/s along}}$

Acceleration of B





$O_4B\alpha_4 = \frac{28}{100} \times 95.673 = 26.788$

$O_4B\omega_4^2 = \frac{28}{100} \times (16.572)^2 = 12.093$

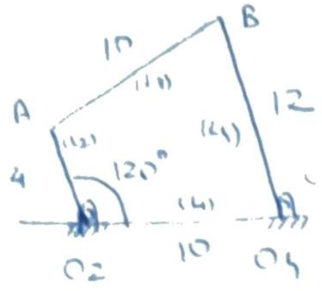
$\tan\beta = \frac{12.093}{26.788} \Rightarrow \beta = 24.296°$

$a = \sqrt{(26.788)^2 + (12.093)^2}$

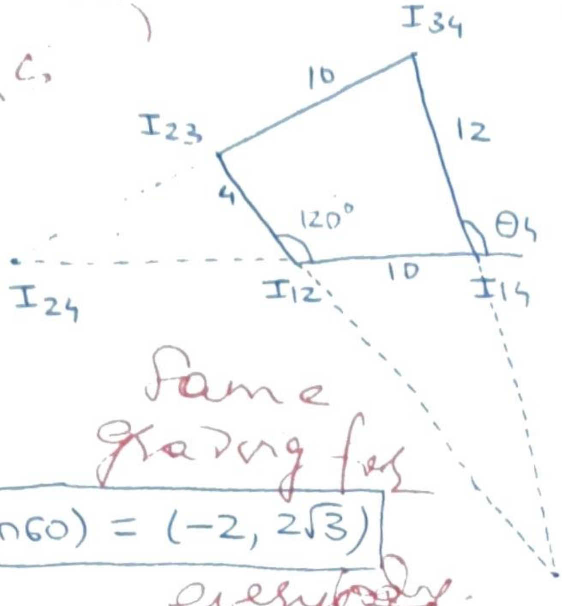
$\Rightarrow \boxed{a = 29.3911\ m/s^2 \text{ along } 43.373°}$

23.658

Q3)



$a = 4,\ b = 10,\ c = 12,\ d = 10$



velocity:

$V_B = \omega_3 BI_{13} = \omega_4 BI_{14}$

$\omega_3 \times (12 + x) = \omega_4 \times 12$

Locations obtained using the Aronhold Kennedy Theorem

Total ICOV $= {}^4C_2 = 6$

Given $O_2 = (0,0) = I_{12}$

$I_{14} = (10, 0)$

$I_{23} = (-4\cos 60, 4\sin 60) = (-2, 2\sqrt{3})$

Same grading for everybody. So no change.

★ CRIBS ICOV calculation was very hectic so more marks should be awarded for the same.

using the equation derived in class,

$\cos(\theta_4)(240 - 96\cos 120) - 96 \times \frac{\sqrt{3}}{2}\sin\theta_4 + (160 - 80\cos 120) = 0$

$288\cos\theta_4 - 83.138\sin\theta_4 + 200 = 0$

$\frac{1-t^2}{1+t^2} \qquad \frac{2t}{1+t^2} \qquad \left(t = \tan\frac{\theta_4}{2}\right)$

I_{24}
I_{13}
ω_3, ω_4

$288(1 - t^2) + (-166.277)t + 200(1 + t^2) = 0$

$-88t^2 - 166.277t + 488 = 0$

$\Rightarrow t^2 + 1.8895t - 5.545 = 0$

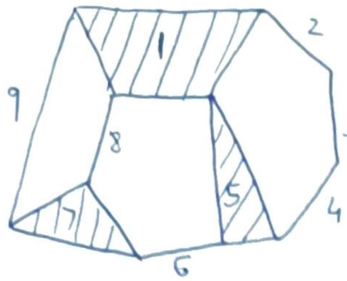
$t = \frac{-1.8895 \pm \sqrt{(1.8895)^2 + 4(5.545)}}{2} = \frac{\pm 5.0746 - 1.8895}{2}$

→ 1.59257
→ −3.48205

$\Rightarrow \frac{\theta_4}{2} = 57.874$ or -73.9766

$\Rightarrow \theta_4 = 115.968$ OR -147.95 → As in the given instant $\theta_2 > 0$, θ_4 must also be > 0

a)



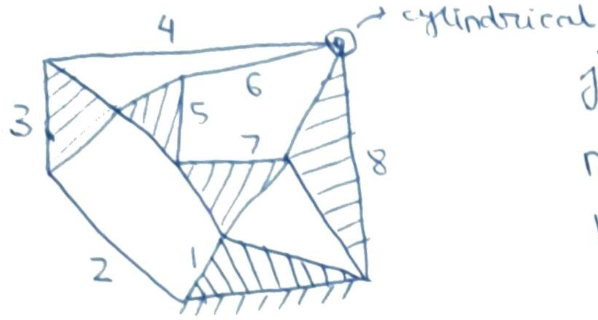
$j = 11$ (lower pairs/revolute joints)

$n = 9$ (no. of links)

$h = 0$ (higher pairs)

$$DOF = 3(n-1) - 2j - h = 3(8) - 2\times 11 = \boxed{2}$$

b)



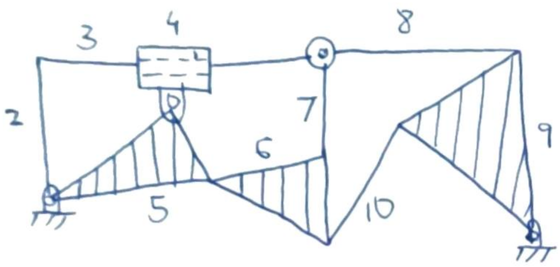
$j = 11$ (cylindrical counted as 2 lower pairs)

$n = 8$ (no. of links)

$h = 0$ (higher pairs)

$$DOF = 3(n-1) - 2j - h = 21 - 22 = \boxed{-1}$$

c)



$n = 10$ (no. of links)

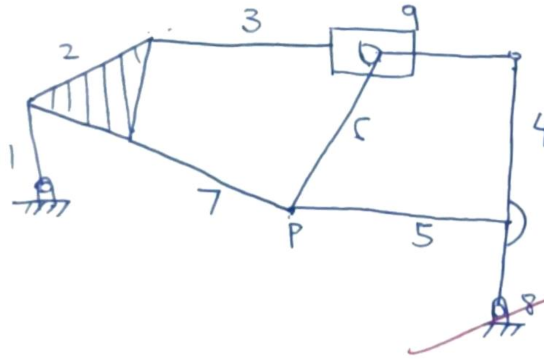
$h = 0$ (higher pairs)

$j = 13$ (cylindrical → 2, prismatic → 2)

$$DOF = 3(10-1) - 2(13) = \boxed{1}$$

10

d)



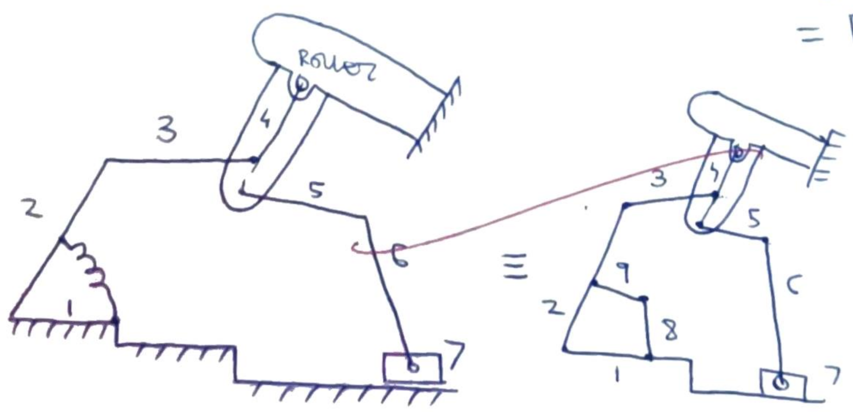
$n = 9$ (no. of links)

$h = 0$ (higher pairs)

$j = 11$ (lower pairs) Point P → 2

$$DOF = 3(9-1) - 2(11) - 0 = \boxed{2}$$

e)



$n = 9$

$j = 10$ (lower pairs 7 → 2)

$h = 1$ (Roller is higher pair)

$$DOF = 3(9-1) - 2(10) - 1 = \boxed{3}$$

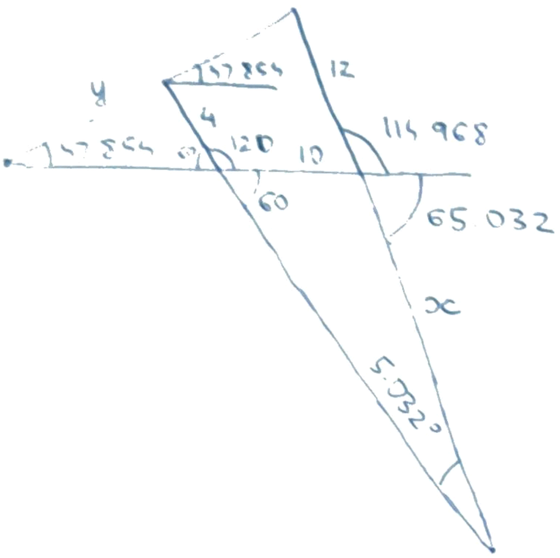
$\Rightarrow \theta_4 = 114.968°$

we also know, $a\sin\theta_2 + b\sin\theta_3 = c\sin\theta_4$

$$\Rightarrow 4 \times \frac{\sqrt{3}}{2} + 10\sin\theta_3 = 12\sin(114.968)$$

$$\Rightarrow \theta_3 = 47.854$$

$$\Rightarrow \theta_1 = 2\pi - \theta_2 - \theta_3 - \theta_4 = 77.178°$$



By sine Rule,

$$\frac{4}{\sin(47.854)} = \frac{y}{\sin 60} \Rightarrow y = 4.672\,cm$$

$$\frac{x}{\sin 60} = \frac{10}{\sin(5.032)} \Rightarrow x = 116.8\,cm$$

Location of $I_{24} = (0 - 4\cos 60 - y\cos(47.854), 0)$

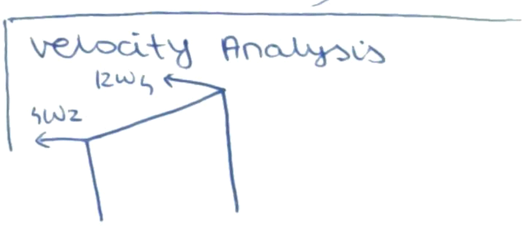
$$\Rightarrow \boxed{I_{24} \equiv (-5.135, 0)}$$

Location of $I_{13} = (10 + x\cos(65.032), -x\sin(65.032))$

$$\Rightarrow \boxed{I_{13} \equiv (61.677, -105.507)}$$

Location of $I_{34} = (10 - 12\cos(65.032), 12\sin(65.032))$

$$\Rightarrow \boxed{I_{34} \equiv (4.935, 10.878)}$$



Q2) $l_1 = 4, l_2 = 9, l_3 = 14, l_4 = 18$

$4 + 18 = 22 < 9 + 14 = 23 \Rightarrow$ Grashof's criterion satisfied.

If 4cm is fixed → Double crank mechanism 3

If 18cm is fixed → Double Rocker mechanism

If 9/14cm is fixed → Crank Rocker mechanism

Depend on Shortest link only