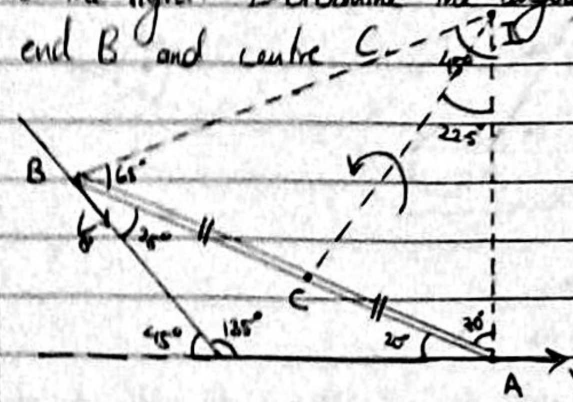
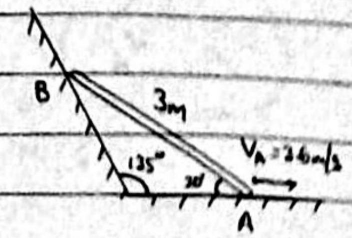
1

47_YASH SARANG

Assignment 7: Kinematics of Rigid Bodies (ICR)

1) A bar 3m long slides down the plane. The velocity of end A is 3.6m/s to the right. Determine the angular velocity of AB and velocity of end B and centre C.





→ When the end A moves right with a velocity 3.6m/s, end B also moves along the inclined plane with a velocity V_B.
ICR is a point of intersection of lines drawn perpendicular to velocity V_A & V_B.
Now, $\omega = \frac{V_A}{IA} = \frac{V_B}{IB} = \frac{V_C}{IC}$.

Using sine rule in ΔABI, $\frac{IA}{\sin 65} = \frac{IB}{\sin 70} = \frac{AB}{\sin 45}$ $\therefore IA = 3.845$ m
$\therefore IB = 3.987$ m.

$\therefore \omega = \frac{V_A}{IA} = \frac{3.6}{3.845} = 0.9363$ rad/s. $\omega = \frac{V_B}{IB} = \frac{V_C}{IC}$.

Using sine rule in ΔIAC, $\frac{IA}{\sin 77.5°} = \frac{AC}{\sin 22.5°} = \frac{IC}{\sin 70°}$. $\therefore IC = 3.683$ m.

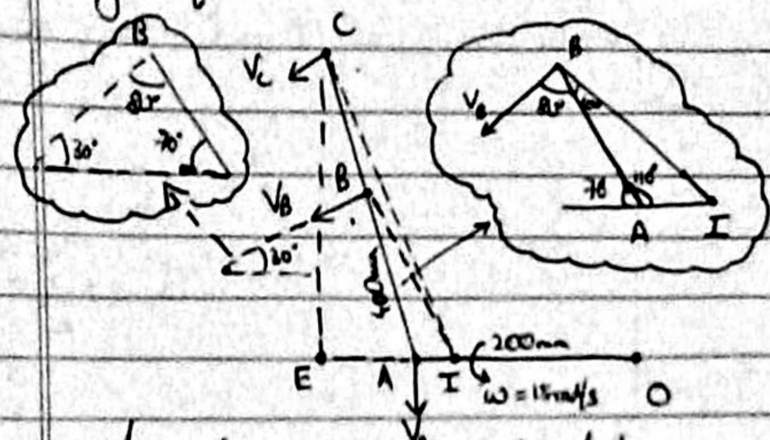
$\boxed{\therefore IC = 3.618 \text{ m (from cosine rule)}}$

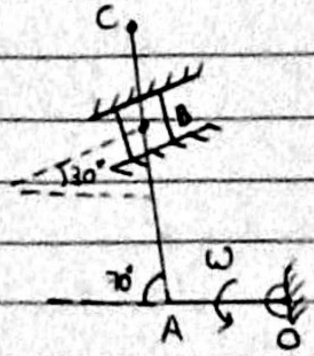
$\therefore V_B = IB \times \omega$, $V_C = IC \times \omega$.
$V_B = 3.987 \times 0.9363$ $V_C = \cancel{3.683 \times 0.9363}$. 3.618×0.9363

$\therefore \omega = 0.9363$ rad/s (↶), $V_B = 3.733$ m/s ($\perp^r$ to IB), $V_C = 3.388$ m/s. ($\perp^r$ to IC)

47_ Yash Sarang

2) Locate the instantaneous centre of ~~gravity~~ rotation for the link ABC and determine velocity of plane B and C. Angular velocity of rod OA is 15 rad/sec counter clockwise. length of OA is 200mm. AB is 400mm and BC is 150mm.





→ As rod OA moves counter clockwise i.e downwards with a vertical velocity V_A, hinge B moves down the incline with a velocity V_B.
ICR is a point of intersection of lines drawn perpendicular to V_A and V_B.
As a result, point c moves with a velocity V_C ⊥r to IC

OA is rotating anticlockwise, $\therefore V_A = OA \times \omega = 0.2 \times 15 = 3$ m/s.

Using sine rule to ΔABI, $\frac{AB}{\sin 60°} = \frac{AI}{\sin 10°} = \frac{BI}{\sin 110°}$ $\therefore AI = 0.0802$ m
$\therefore BI = 0.4340$ m.

$\therefore \omega = \frac{V_A}{IA} = \frac{V_B}{IB} = \frac{V_C}{IC}$, $\omega = \frac{3}{0.0802} = 37.41$ rad/s

$\therefore V_B = \omega \times IB$, $V_C = \omega \times IC$. ~~In ΔACI, $IC = \sqrt{IA^2 + AC^2}$ ∴ IC = 0.5558 m.~~

$= 37.41 \times 0.434$

$\therefore V_B = 16.24$ m/s , ~~$V_C = 20.79$ m/s (⊥r to IC)~~

In ΔABI, Using cosine rule

$IB = \sqrt{IA^2 + AB^2 - 2IA \times AB \cos 110°}$

In ΔACE, $AE = AC \cos 70°$.

$EC = AC \sin 70° = 0.5168$, $\therefore IB = 0.434$ m.

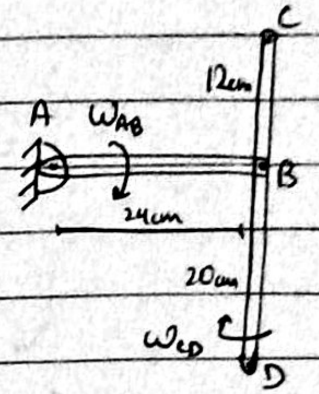
$\therefore IE = AE + IA = 0.1881 + 0.0802 = 0.2683$ m.

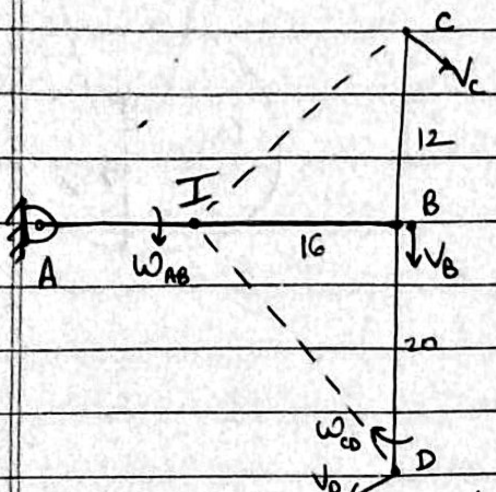
$\therefore IC = \sqrt{IE^2 + EC^2} = 0.5823$ m.

$\therefore V_C = 21.78$ m/s

47_YASH SARANG

3) A bar AB is 24 cm long and is hinged to a wall at A. Another bar CD = 32 cm long is connected by a pin at B such that CB = 12 cm and BD = 20 cm. At that instant shown (AB ⊥ CD) the angular velocities of the bars are $\omega_{AB} = 4$ rad/s $\omega_{CD} = 6$ rad/s. Determine the linear velocities of point C & D. Note that bar CD is in plane motion.





$V_B = AB \times \omega_{AB} = 96$ cm/sec ↓ $\qquad \omega_{CD} = \dfrac{V_C}{ID} = \dfrac{V_B}{ID} = \dfrac{V_D}{ID}$

$6 = \dfrac{96}{IB} = \dfrac{V_C}{IC} = \dfrac{V_D}{ID}$ $\qquad IB = 16$ cm.

$IC = \sqrt{IB^2 + BC^2} = 20$ cm. $\qquad ID = \sqrt{IB^2 + BD^2} = 25.612$ cm

$\omega = \dfrac{V_C}{IC} = \dfrac{V_D}{ID}$ $\qquad V_C = 6 \times IC$

$V_C = 120$ cm/s (⊥r to IC)

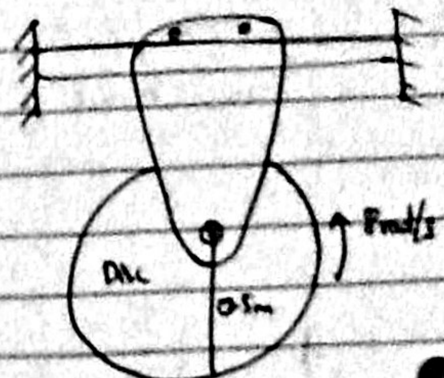
Similarly

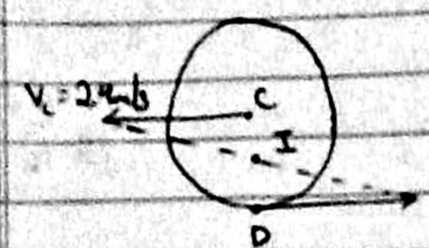
$V_D = 6 \times ID$

$V_D = 153.672$ cm/s. (⊥r to ID)

47_Yash Sarang

Q.4) The trolley shown moves to the left along a horizontal pipe at a speed of 2.4 m/s. The angular velocity of 0.5m disc is 8 rad/s anti-clockwise. Determine the velocity of point D on the disc.





$V_c = IC \times \omega$

$\therefore IC = 0.3m$

$V_D = ID \times \omega$

$V_D = (CD - IC)\,\omega$

$\therefore V_D = 1.6 m/s \ (\longrightarrow)$.

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