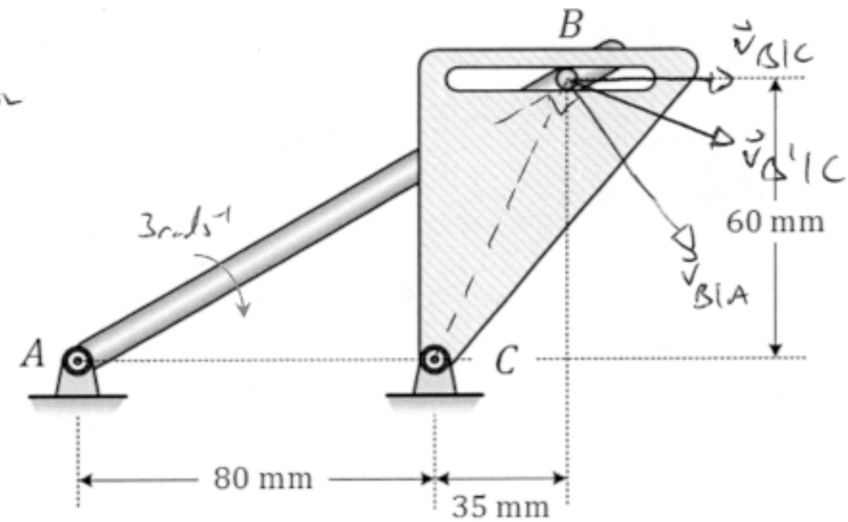
Question 1 [10 marks]

At the instant shown bar *AB* has an angular velocity of 3 rad/s in the clockwise direction.



$\vec{\omega}_{BC} = ?$, $\vec{v}_{B|C} = ?$

Figure Q1

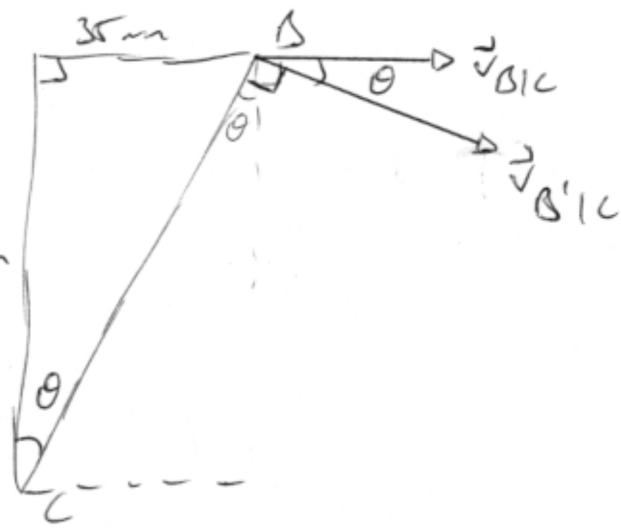
(a) Using relative velocity analysis, determine the angular velocity (magnitude and direction) of the plate rotating about point *C* and the velocity (magnitude and direction) of point *B* relative to the plate at the instant shown.

$$\vec{v}_{B'|C} + \vec{v}_{B|C} = \vec{v}_B - \vec{v}_C$$

Body BC:

$\vec{v}_{B'|C} = \vec{\omega}_{BC} \overline{BC}$

$\vec{v}_{B|C} =$

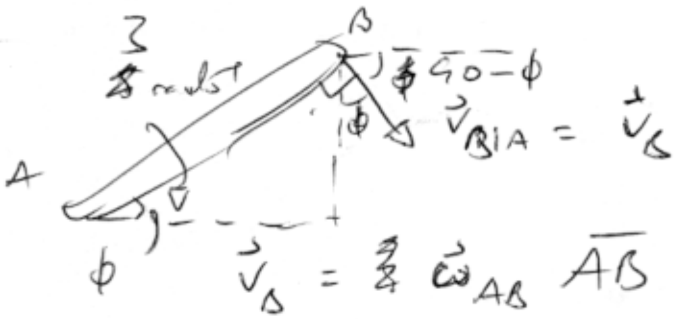


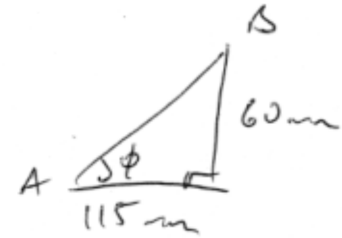
$$BC = \sqrt{60^2 + 35^2} = 69.46... \text{ mm} \rightarrow \text{`B'}$$

$$\theta = \tan^{-1}\left(\frac{35}{65}\right) = 28.3^\circ \rightarrow \text{`A'}$$

3AOFQ3N3 1

[redacted] AB:





$$\vec{v}_B = 3\,\vec{\omega}_{AB}\,\overline{AB}$$

$\phi = 27.55...° \rightarrow$ 'D'

$$\overline{AB} = \sqrt{115^2 + 60^2} = 129.71\ldots \text{ mm} \rightarrow \text{'C'}$$

$$\therefore \vec{v}_B = \begin{pmatrix} 3 \times 129.71 \times \cos(90 - \phi) \\ -3 \times 129.71 \times \sin(90 - \phi) \end{pmatrix}$$

$$= \begin{pmatrix} 180 \\ -345 \end{pmatrix} \text{ mms}^{-1}$$

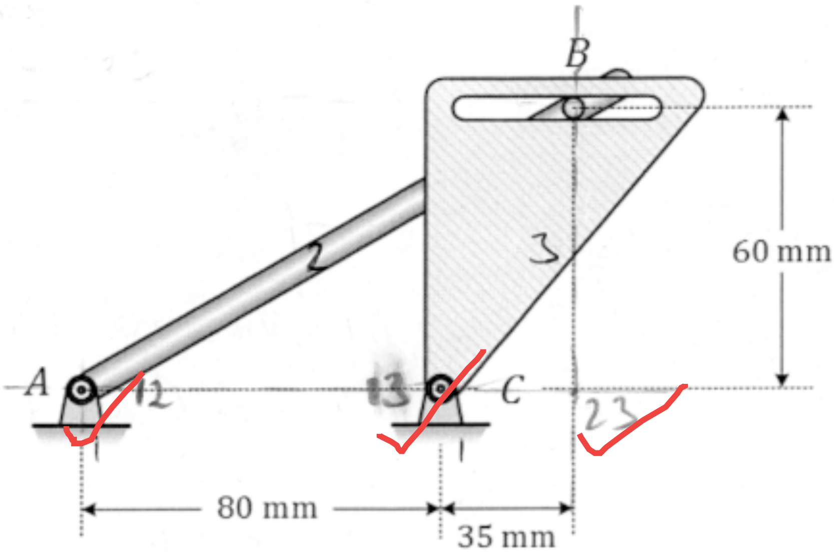
$$\vec{v}_{B'|C} + \vec{v}_{B|C} = \vec{v}_B$$

$$\begin{pmatrix} \omega_{BC}\,\overline{BC}\cos\theta \\ -\omega_{BC}\,\overline{BC}\sin\theta \end{pmatrix} + \begin{pmatrix} v_{B|C} \\ 0 \end{pmatrix} = \begin{pmatrix} 180 \\ -345 \end{pmatrix}$$

$$\therefore \vec{\omega}_{BC} = 10.476\ldots \text{ rads}^{-1}$$

$$\therefore \vec{v}_{B|C} = 2.7718\ldots \text{ mms}^{-1} \longrightarrow$$

(b) Locate all instant centres on Figure Q1 below and identify the instantaneous centres of zero velocity.



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Instantaneous centres of zero velocity are 12, 13

$\vec{\omega}_{BC} = ?,$

(c) Confirm the angular velocity of the plate in (a) using the method of instant centres.

$\vec{v}_{23|2} = \vec{v}_{23|3}$

$\vec{\omega}_2 \overline{A(23)} = \vec{\omega}_3 \overline{B(23)}$

$3 \times (60|15) = \vec{\omega}_3 \times \cancel{115}\ 60$

$\therefore \vec{\omega}_3 = \vec{\omega}_{BC} = \cancel{1150}\ 5.75 \ \text{rad s}^{-1}$

Extra Workspace – Question Number 2

~~Since system is under forced response~~
~~with $F_0 = 900 \sin(100\pi t)$ N~~

~~Assume , $\omega = \omega_d$~~

~~i.e. $r = \frac{\omega_d}{\omega_n}$, $\frac{\omega_d}{\omega_n} = \sqrt{1-\zeta^2}$~~

~~$\therefore r = \sqrt{1-\zeta^2}$~~

~~$\frac{MX}{m} = \frac{1-\zeta^2}{\quad}$~~

$$\frac{r^4}{r^4 - 1.9996 r^2 + 1} < (6.25 r^2)^2$$

$$\left((6.25 r^2)^2 - 1\right) r^4 - (6.25 r^2)^2 \, 1.9996 \, r^2 + (6.25 r^2)^2 > 0$$