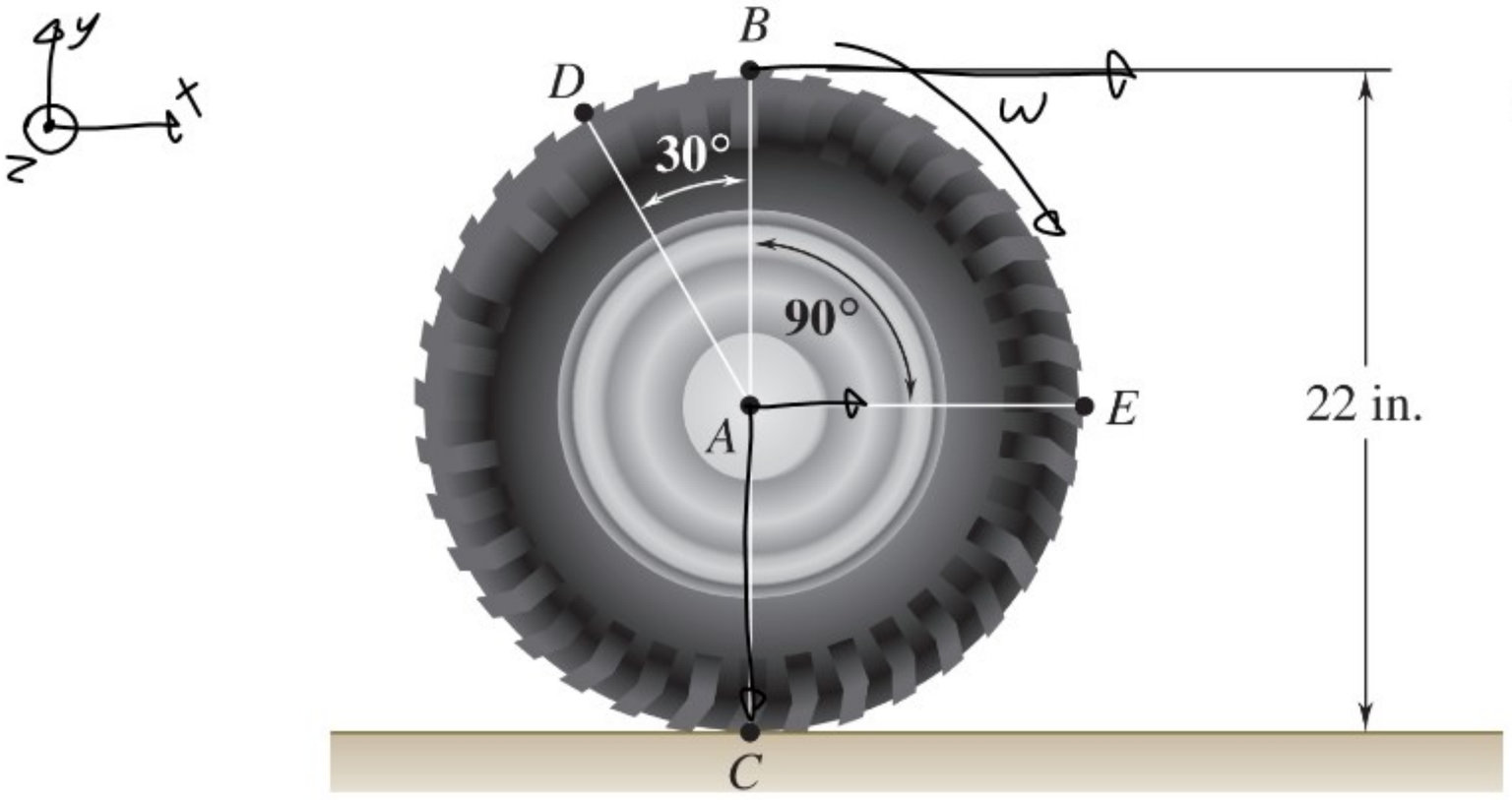
15.38 An automobile travels to the right at a constant speed of 48 mi/h. If the diameter of a wheel is 22 in., determine the velocities of points *B*, *C*, *D*, and *E* on the rim of the wheel.



$V_A = 48\,i$ mph

$= 48\,i \frac{mi}{h} \frac{1\,h}{3600\,s} \frac{5280\,ft}{1\,mi}$

$= 70.4\,i\ ft/s \frac{12\,in}{1\,ft}$

$= 845\,i\ in/s$

$V_C = V_A + V_{C/A}$

$\omega = \frac{V}{C} = \frac{V}{\pi d}$

$= \frac{845\ in/s}{\pi\ 22\ in/rev} = 12.22\ rev/s \frac{2\pi\ rad}{1\ rev} = 76.8\ rad/s$

$V_B = V_A + V_{B/A} = V_A + \omega \times r_{B/A}$

$= 845\,i - 76.8\,k \times 11\,j$

$= 845\,i + 845\,i = \boxed{1690\ in/s = V_B}$

$$\begin{vmatrix} i & j & k & i & j \\ 0 & 0 & -76.8 & 0 & 0 \\ 0 & 11 & 0 & 0 & 11 \end{vmatrix} = 11(-76.8)i = 845\,i$$

$$\begin{vmatrix} i & j & k & i & j \\ 0 & 0 & -76.8 & 0 & 0 \\ 11 & 0 & 0 & 11 & 0 \end{vmatrix} = -11(76.8)j$$

$$V_C = V_A + V_{C/A} = V_A + \omega \times r_{C/A} = 845i - 76.8k \times -11j = 845i - 845i = 0 = V_C$$

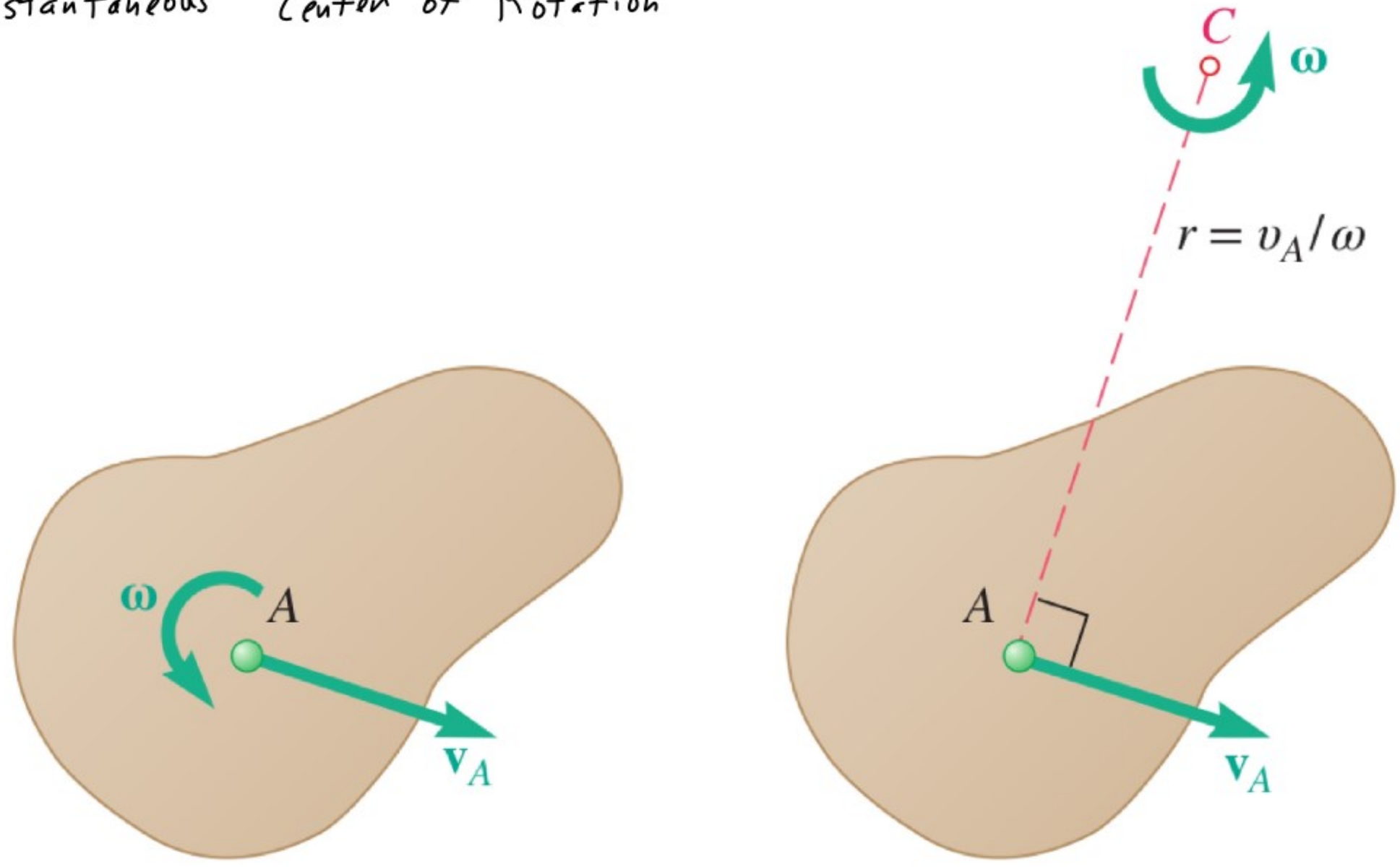
$$V_E = V_A + V_{E/A} = V_A + \omega \times r_{E/A} = 845i - 76.8k \times 11i = 845i - 845j \ \text{in/s}$$

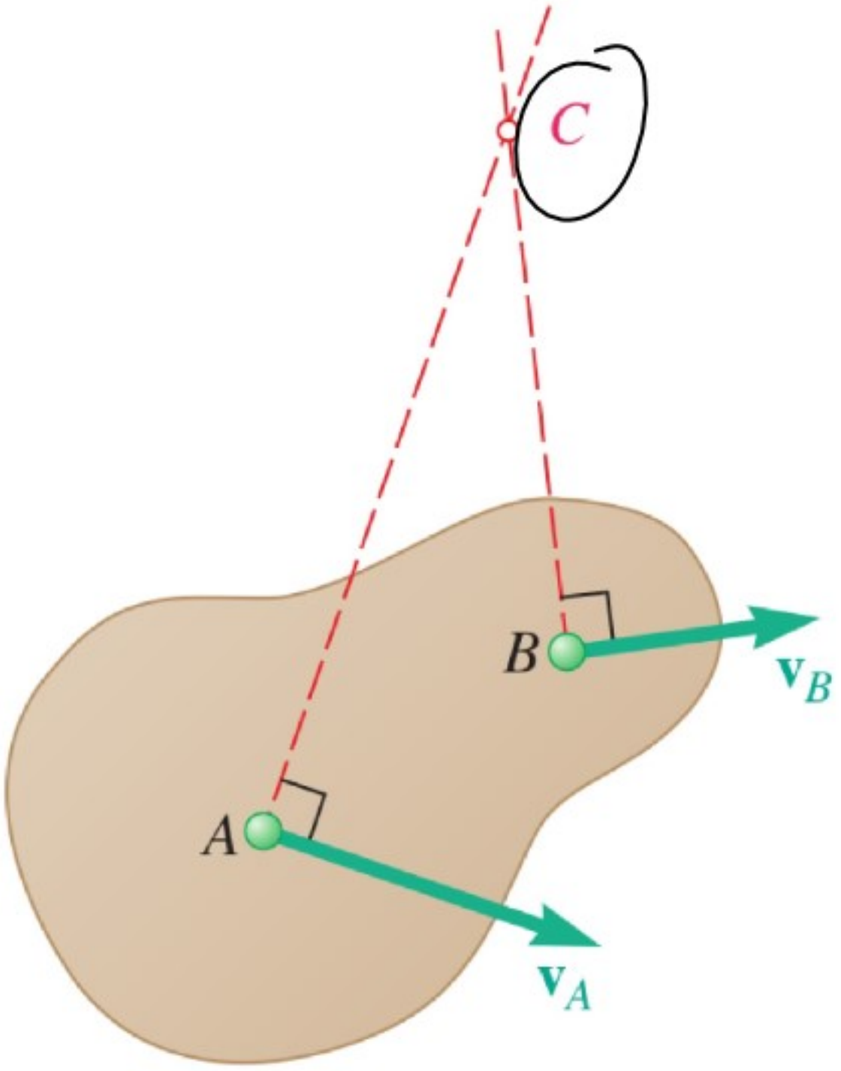
$$r_{D/A} = -11\sin 30\,i + 11\cos 30\,j = -5.5i + 9.5j$$

$$V_D = V_A + \omega \times r_{D/A}$$

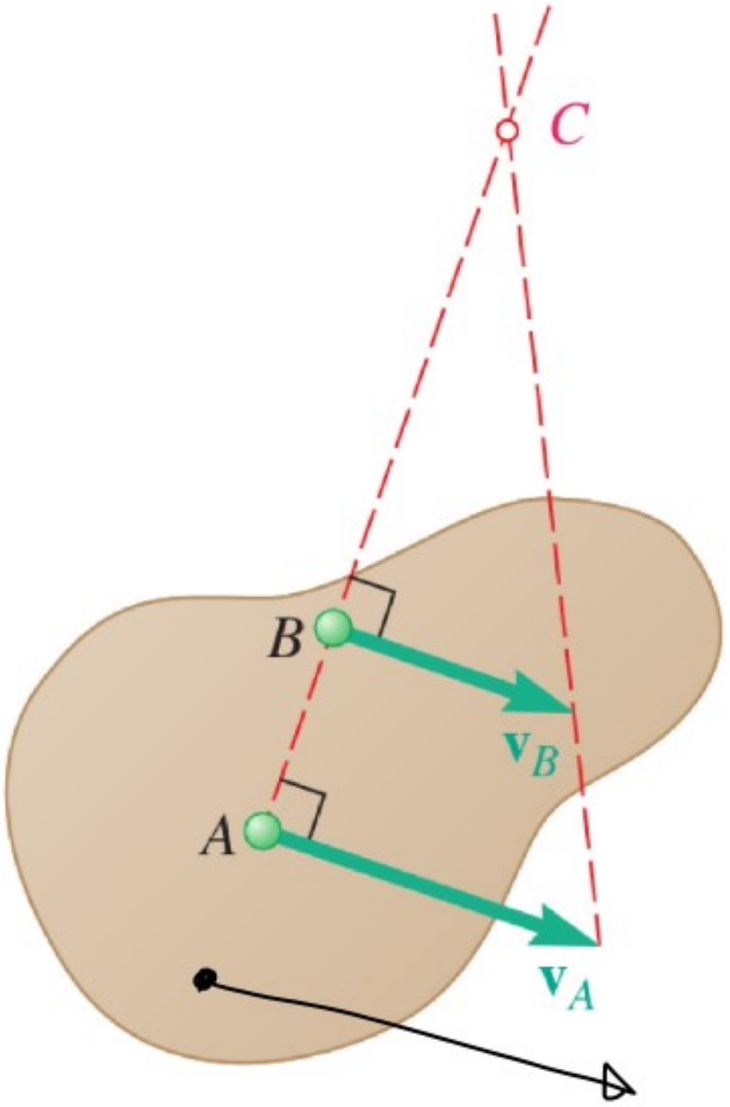
$$\begin{vmatrix} i & j & k & i & j \\ 0 & 0 & -76.8 & 0 & 0 \\ -5.5 & 9.5 & 0 & -5.5 & 9.5 \end{vmatrix} = 5.5(76.8)j + 9.5(76.8)i$$

Instantaneous Center of Rotation

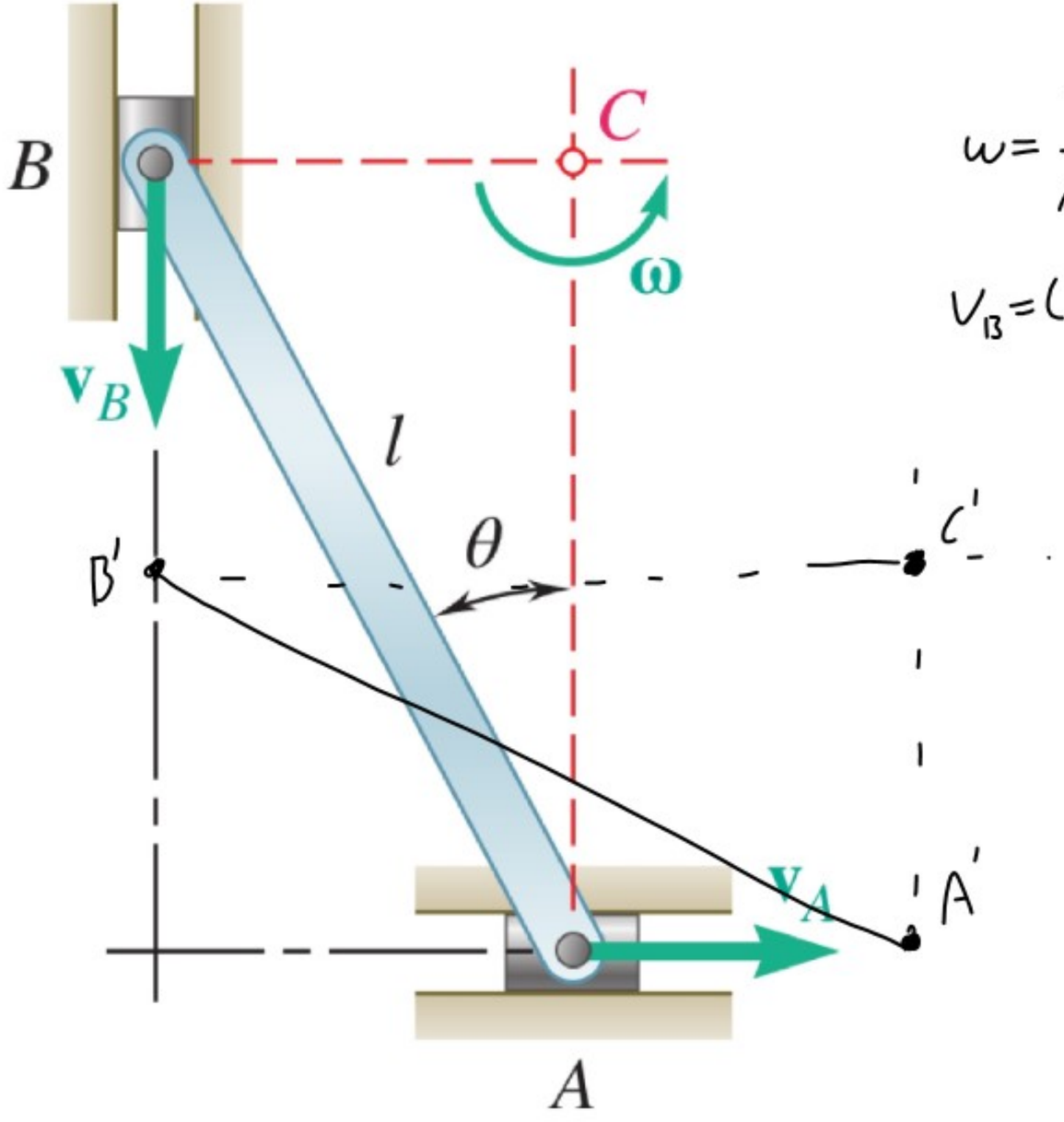




(a)



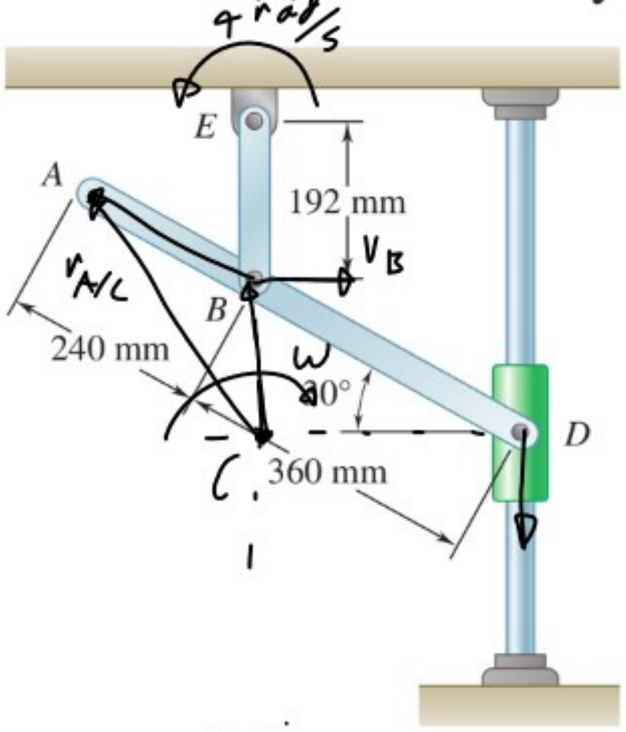
(b)



$$\omega = \frac{V_A}{AC} = \frac{V_A}{l\cos\theta}$$

$$V_B = (BC)\omega = l\sin\theta \frac{V_A}{l\cos\theta} = V_A \tan\theta$$

Knowing that at the instant shown the angular velocity of rod BE is 4 rad/s counterclockwise, determine (*a*) the angular velocity of rod AD, (*b*) the velocity of collar D, (*c*) the velocity of point A.



$$r_{A/C} = r_{A/D} + r_{B/C}$$

$$= -290\cos 30\, i + 290\sin 30\, j + 360\sin 30\, j$$

$$= -208\, i + 300\, j$$

$$V_A = \vec{\omega} \times \vec{r}_{A/C} = -4.27k \times (-208\, i + 300\, j)$$

$$= \begin{vmatrix} i & j & k \\ 0 & 0 & -4.27 \\ -208 & 300 & 0 \end{vmatrix} \quad \begin{matrix} i & j \\ 0 & 0 \\ -208 & 300 \end{matrix}$$

$$= 300 \cdot 4.27\, i + 208 \cdot 4.27\, j$$

$$= 1231\, i + 888\, j \ \text{mm/s}$$

$$V_D = \omega_{EB} = 4 \cdot 192 = 768 \ \text{mm/s}$$

$$\omega = \frac{V_B}{BC} = \frac{768 \ \text{mm/s}}{360 \ \text{mm} \sin 30} = 4.27 \ \text{rad/s}$$

$$V_D = \omega_{CD} = 4.27 \cdot 360 \cos 30$$

$$= 1330 \ \text{mm/s}$$