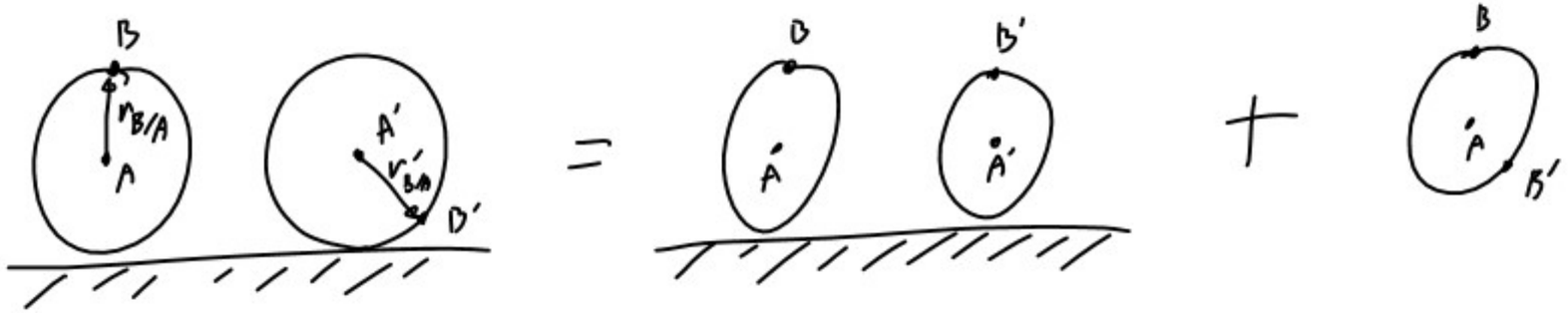
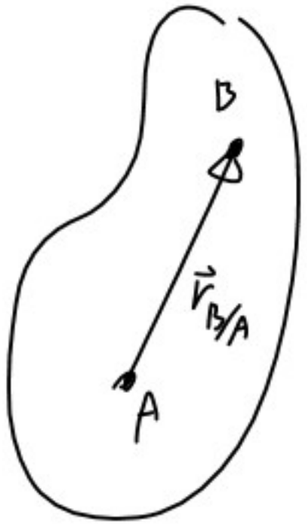
General Plane Motion





$$\vec{V}_B = \vec{V}_A + \vec{V}_{B/A}$$

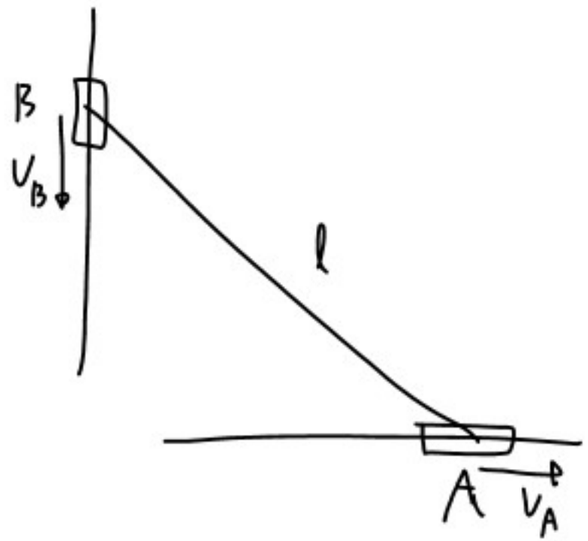
$$\vec{V}_B = \vec{V}_A + \omega k \times \vec{r}_{B/A}$$

$$\vec{V}_{B/A} = \vec{\omega} \times \vec{r}_{B/A} \quad 3D$$

$$= \omega k \times \vec{r}_{B/A}$$

$$V_{B/A} = r_{B/A}\,\omega$$

$$V_B = V_A + V_{B/A}$$



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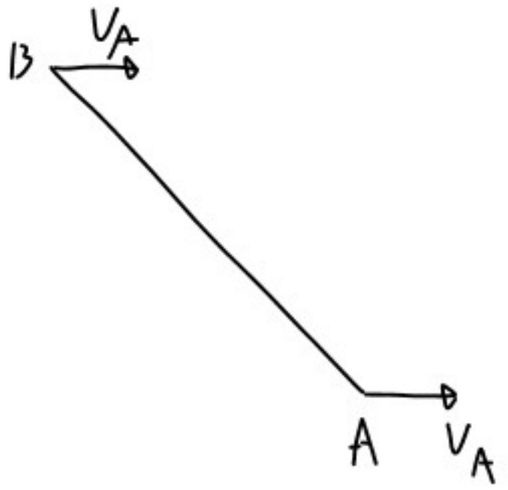

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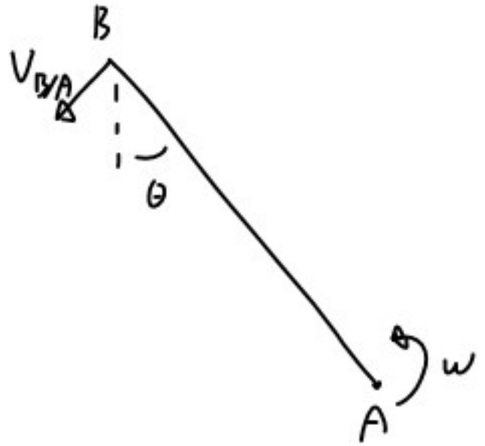
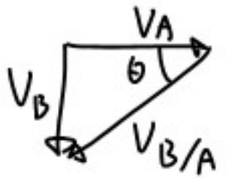
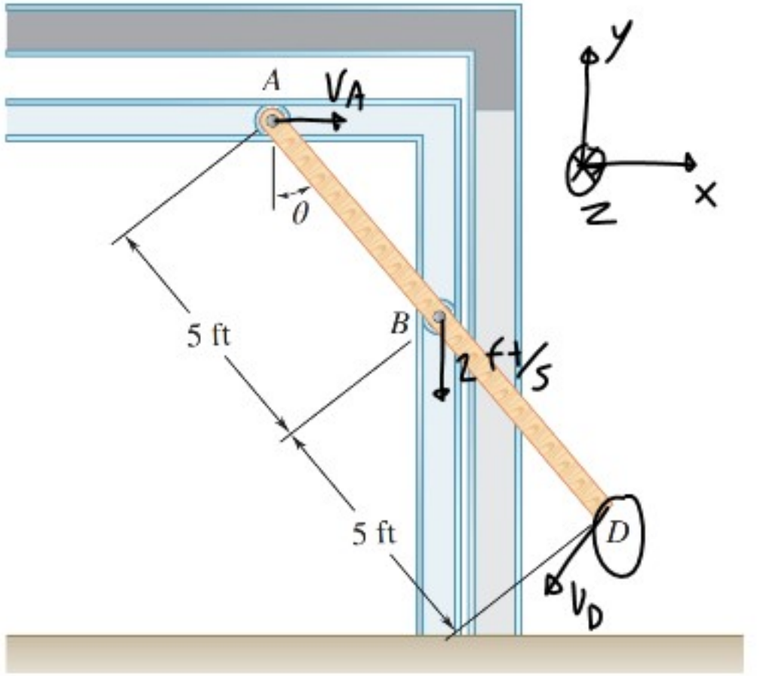




$$\frac{V_B}{V_A} = \tan\theta \qquad V_B = V_A \tan\theta$$

$$V_{B/A} = r_{B/A}\,\omega \qquad \frac{V_{B/A}}{l} = \omega = \frac{V_A}{l\cos\theta}$$

15.39 An overhead door is guided by wheels at A and B that roll in horizontal and vertical tracks. Knowing that when $\theta = 30°$ the velocity of wheel B is 2 ft/s downward, determine (a) the angular velocity of the door, (b) the velocity of end D of the door.



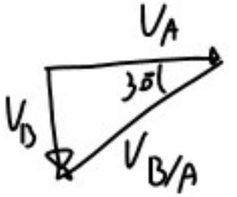
$V_{B/A} = r\omega$

$V_{B/A} = 5\omega$

$\frac{V_B}{5} = \omega$

$\omega = \pm 0.8$ rad/s

$\frac{V_B}{V_A} = \tan 30$



$V_A = \frac{V_B}{\tan 30} = \frac{2}{\tan 30} = 3.46$ ft/s

$\sin\theta = \frac{V_B}{V_{B/A}}$

$V_{B/A} = V_B / \sin 30 = 2/\sin 30 = 4$ ft/s

$\vec{V}_D = \vec{V}_A + \omega k \times \vec{r}_{D/A}$

$= 3.46 i - (0.8 k \times 10 \sin 30\, i - 10 \cos 30\, j)$

$$V_{D/A} = -0.8K \times 10\sin 30\, i - 10\cos 30\, j$$

$$= -0.8K \times 5i - 8.66j$$

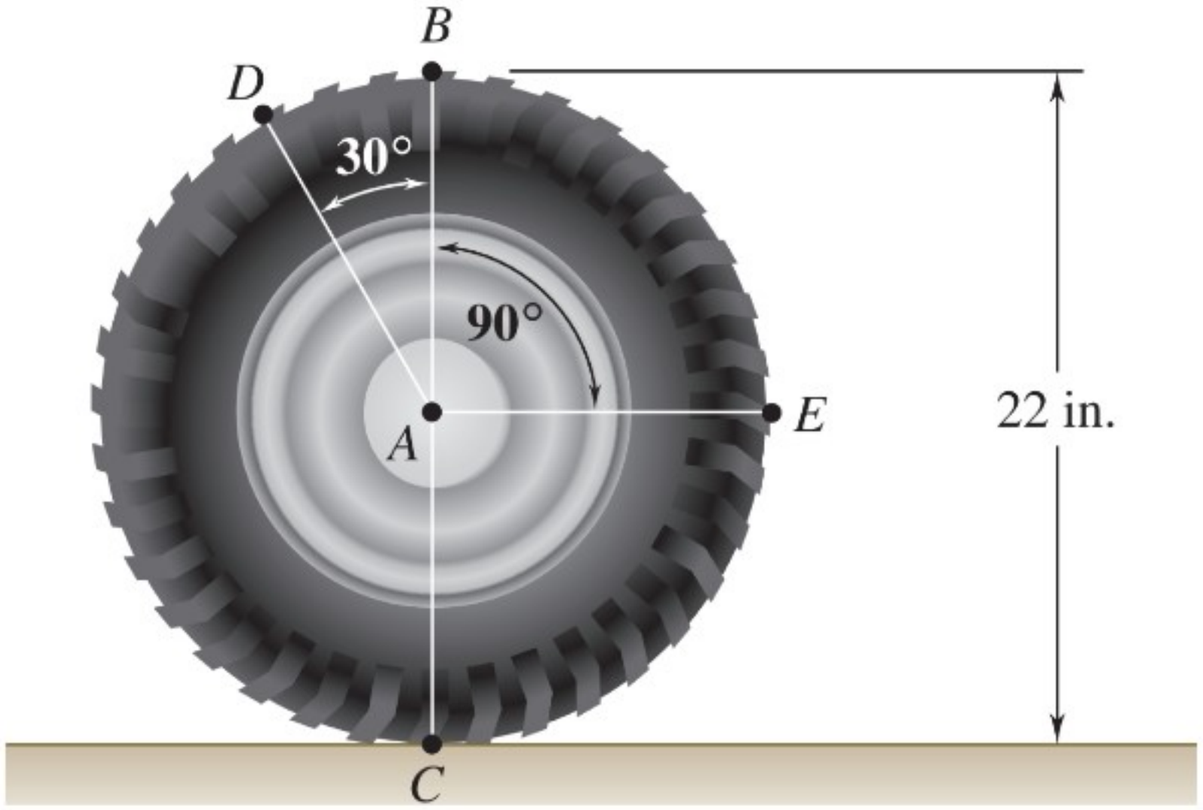
$$= \begin{vmatrix} i & j & K \\ 0 & 0 & -0.8 \\ 5 & -8.66 & 0 \end{vmatrix} \quad \begin{matrix} i & j \\ 0 & 0 \\ 5 & -8.66 \end{matrix}$$

$$= -0.8 \cdot 5\, j - (-0.8)(-8.66)i$$

$$= -6.93i - 4j \text{ ft/s}$$

$$\vec{V}_D = \vec{V}_A + V_{D/A}$$

$$= 3.46i - 6.93i - 4j = \boxed{-3.47i - 4j = V_D}$$

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.

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