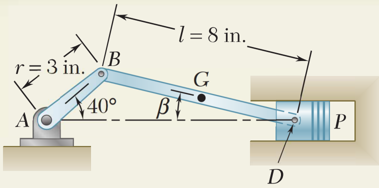
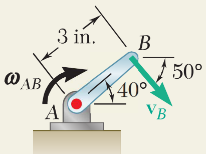


In the engine system shown, the crank AB has a constant clockwise angular velocity of 2000 rpm. For the crank position indicated, determine (*a*) the angular velocity of the connecting rod BD, (*b*) the velocity of the piston P.



Motion of Crank *AB*. The crank AB rotates about point A. Expressing ω_{AB} in rad/s and writing $v_B = r\omega_{AB}$, we obtain

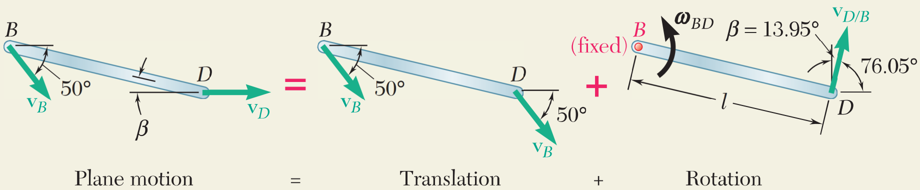
$$\omega_{AB} = \left(2000\frac{\text{rev}}{\text{min}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right)\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right) = 209.4\text{ rad/s}$$

$$v_B = (AB)\omega_{AB} = (3\text{ in.})(209.4\text{ rad/s}) = 628.3\text{ in./s}$$
$$\mathbf{v}_B = 628.3\text{ in./s} \measuredangle 50°$$

Motion of Connecting Rod *BD*. We consider this motion as a general plane motion. Using the law of sines, we compute the angle β between the connecting rod and the horizontal:

$$\frac{\sin 40°}{8\text{ in.}} = \frac{\sin\beta}{3\text{ in.}} \qquad \beta = 13.95°$$

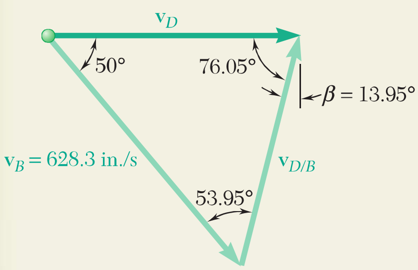
The velocity $\mathbf{v}_D$ of the point D where the rod is attached to the piston must be horizontal, while the velocity of point B is equal to the velocity $\mathbf{v}_B$ obtained above. Resolving the motion of BD into a translation with B and a rotation about B, we obtain



Expressing the relation between the velocities $\mathbf{v}_D$, $\mathbf{v}_B$, and $\mathbf{v}_{D/B}$, we write

$$\mathbf{v}_D = \mathbf{v}_B + \mathbf{v}_{D/B}$$

We draw the vector diagram corresponding to this equation. Recalling that $\beta = 13.95°$, we determine the angles of the triangle and write



$$\frac{v_D}{\sin 53.95°} = \frac{v_{D/B}}{\sin 50°} = \frac{628.3\text{ in./s}}{\sin 76.05°}$$

$$v_{D/B} = 495.9\text{ in./s} \qquad \mathbf{v}_{D/B} = 495.9\text{ in./s} \measuredangle 76.05°$$
$$v_D = 523.4\text{ in./s} = 43.6\text{ ft/s} \qquad \mathbf{v}_D = 43.6\text{ ft/s} \rightarrow$$
$$\mathbf{v}_P = \mathbf{v}_D = 43.6\text{ ft/s} \rightarrow$$

Since $v_{D/B} = l\omega_{BD}$, we have

$$495.9\text{ in./s} = (8\text{ in.})\omega_{BD} \qquad \boldsymbol{\omega}_{BD} = 62.0\text{ rad/s} \circlearrowleft$$