Rod BC of length 24 in. is connected by ball-and-socket joints to a rotating arm AB and to a collar C that slides on the fixed rod DE. Knowing that length of arm AB is 4 in. and that it rotates at a constant rate \( \omega_1 = 10 \text{ rad/s} \), determine the velocity of collar C when \( \theta = 90^\circ \).

**Solving Problems on Your Own**

1. **Determine velocities in a body rotating about a fixed axis:**
   In vector form, the velocity of a point in the body is given by:
   \[
   \mathbf{v} = \mathbf{\omega} \times \mathbf{r}
   \]
   Where \( \mathbf{v} \), \( \mathbf{\omega} \), and \( \mathbf{r} \) are the velocity of the point, the angular velocity of the body, and the position vector from the axis to the point.
2. Determine velocities in general motion of a rigid body

\[ \mathbf{v}_B = \mathbf{v}_A + \mathbf{\omega} \times \mathbf{r}_{B/A} \]

Where \( \mathbf{v}_B \) is the velocity of point B, \( \mathbf{v}_A \) is the (known) velocity of point A, \( \mathbf{\omega} \) is the angular velocity of the body with respect to a fixed frame of reference, and \( \mathbf{r}_{B/A} \) is the position vector of B relative to A.

**Problem 15.256**

**Solving Problems on Your Own**

Rod BC of length 24 in. is connected by ball-and-socket joints to a rotating arm AB and to a collar C that slides on the fixed rod DE. Knowing that length of arm AB is 4 in. and that it rotates at a constant rate \( \omega_1 = 10 \text{ rad/s} \), determine the velocity of collar C when \( \theta = 90^\circ \).

**Problem 15.256 Solution**

Determine velocities in a body rotating about a fix axis.

Determine the velocity of point B when \( \theta = 90^\circ \):

\[ \mathbf{\omega}_1 = 10 \mathbf{k} \text{ rad/s} \]
\[ \mathbf{r}_{B/A} = -4 \mathbf{j} \text{ in} \]
\[ \mathbf{v}_B = \mathbf{\omega}_1 \times \mathbf{r}_{B/A} \]
\[ \mathbf{v}_B = 10 \mathbf{k} \times (-4 \mathbf{j}) \]
\[ \mathbf{v}_B = (-40 \text{ in/s}) \mathbf{i} \]
Determine velocities in general motion of a rigid body.

Consider rod BC:

\[ v_B = (40 \text{ in/s}) \mathbf{i} \]
\[ v_C = v_C \mathbf{k} \]
\[ \omega = \omega_x \mathbf{i} + \omega_y \mathbf{j} + \omega_z \mathbf{k} \]
\[ r_{CB} = 4 \mathbf{i} - 12 \mathbf{j} + 20.4 \mathbf{k} \]

\[ v_C = \mathbf{v}_B + \omega \times r_{CB} \]
\[ v_C \mathbf{k} = (40 \text{ in/s}) \mathbf{i} + \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ \omega_x & \omega_y & \omega_z \\ 4 & -12 & 20.4 \end{vmatrix} \]

\[ v_C \mathbf{k} = (40) \mathbf{i} + (20.4 \omega_y + 12 \omega_z) \mathbf{i} + (-20.4 \omega_x + 4 \omega_z) \mathbf{j} + (-12 \omega_x - 4 \omega_y) \mathbf{k} \]

Equate coefficients of \( i, j, k \):

\[ 0 = 40 + 20.4 \omega_y + 12 \omega_z \]
\[ 0 = -20.4 \omega_x + 4 \omega_z \]
\[ v_C = -12 \omega_x - 4 \omega_y \]

Solve for \( v_C \): (First eliminate \( \omega_z \) and then eliminate \( 3 \omega_x + \omega_y \).)

\[ v_C = 7.84 \text{ in/s} \]

\[ v_C = 7.84 \mathbf{k} \text{ in/s} \]