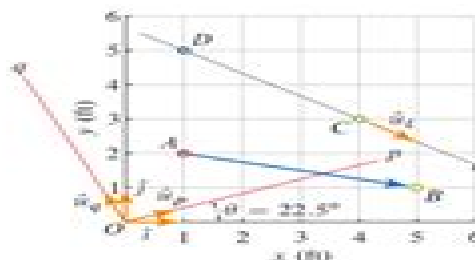


Problem 1.4 i

Determine expressions for the vector $\vec{r}_{B/A}$ using both the xy and the pq coordinate systems. Next, determine $|\vec{r}_{B/A}|$, the magnitude of $\vec{r}_{B/A}$, using both the xy and the pq representations and establish whether or not the two values for $|\vec{r}_{B/A}|$ are equal to each other.



Solution

Using the component system formed by the unit vectors $\hat{i}$ and $\hat{j}$, the vector $\vec{r}_{B/A}$ can be written as $\vec{r}_{B/A} = (x_B - x_A)\hat{i} + (y_B - y_A)\hat{j}$, where (x_A, y_A) and (x_B, y_B) are the Cartesian coordinates of points A and B relative to the xy coordinate system, respectively. By inspection we have $(x_A, y_A) = (1.000, 2.000)$ ft and $(x_B, y_B) = (5.000, 1.000)$ ft. Therefore, we have

$$\vec{r}_{B/A} = (4.000\hat{i} - 1.000\hat{j}) \text{ ft}, \quad (1)$$

which, when expressed to three significant figures, gives

$$\vec{r}_{B/A} = (4.00\hat{i} - 1.00\hat{j}) \text{ ft}.$$

Now we find the unit vectors $\hat{u}_p$ and $\hat{u}_q$, which are the unit vectors orienting the p and q axes, respectively,

$$\hat{u}_p = \cos \theta_p \hat{i} + \sin \theta_p \hat{j} \quad \text{and} \quad \hat{u}_q = \cos \theta_q \hat{i} + \sin \theta_q \hat{j}, \quad (2)$$

where θ_p and θ_q are the angles formed by the p and q axes with the positive x axis, respectively, and therefore are given by $\theta_p = \theta = 22.5^\circ$, $\theta_q = (\theta + 90^\circ) = 112.5^\circ$. Consequently, Eqs. (2) and (3) become

$$\hat{u}_p = 0.9239\hat{i} + 0.3827\hat{j} \quad \text{and} \quad \hat{u}_q = -0.3827\hat{i} + 0.9239\hat{j}. \quad (3)$$

Then, using Eqs. (1) and (3), the expression for $\vec{r}_{B/A}$ in the pq component system is

$$\begin{aligned} \vec{r}_{B/A} &= (\hat{u}_p \cdot \vec{r}_{B/A})\hat{u}_p + (\hat{u}_q \cdot \vec{r}_{B/A})\hat{u}_q \\ &= \{[(4.000\hat{i} - 1.000\hat{j}) \text{ ft}] \cdot (0.9239\hat{i} + 0.3827\hat{j})\}\hat{u}_p \\ &\quad + \{[(4.000\hat{i} - 1.000\hat{j}) \text{ ft}] \cdot (-0.3827\hat{i} + 0.9239\hat{j})\}\hat{u}_q \\ &= (3.313\hat{u}_p - 2.455\hat{u}_q) \text{ ft}, \end{aligned} \quad (4)$$

which, when expressed to three significant figures gives

$$\vec{r}_{B/A} = (3.31\hat{u}_p - 2.46\hat{u}_q) \text{ ft}.$$

Engineering Mechanics Gray Solution

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