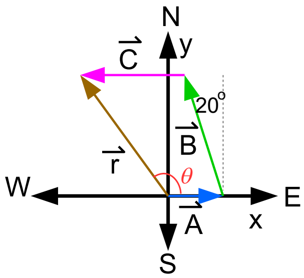
Chapter 4 Problem 21 †



Given
$\vec{A} = 5.0\ \hat{\imath}\ km$
$\vec{B} = 10.0\ km\ \angle 20°$ west of north
$\vec{C} = -8.0\ \hat{\imath}\ km$

Solution
What is the final displacement of the cylist?

First break vector B into scalar components using unit vectors. Since the angle is west of north, the opposite side of the angle corresponds to the negative x-axis. Therefore, the sine function is used to determine the x-component. The vector is pointing in the positive y-direction and this side corresponds to the adjacent side of the angle. Therefore, cosine is used for the y-component.

$$\vec{B} = \{-10.0\sin(20°)\ \hat{\imath} + 10.0\cos(20°)\ \hat{\jmath}\}\ km$$

$$\vec{B} = \{-3.42\ \hat{\imath} + 9.40\ \hat{\jmath}\}\ km$$

Adding the vectors together gives

$$\vec{r} = \vec{A} + \vec{B} + \vec{C}$$

$$\vec{r} = 5.0\ \hat{\imath}\ km + \{-3.42\ \hat{\imath} + 9.40\ \hat{\jmath}\}\ km - 8.0\hat{\imath}\ km$$
$$\vec{r} = \{-6.42\ \hat{\imath} + 9.40\ \hat{\jmath}\}\ km$$

The magnitude of this vector is

$$r = \sqrt{r_x^2 + r_y^2} = \sqrt{(-6.42)^2 + (9.40)^2} = 11.4\ km$$

The angle of travel is

$$\theta = \tan^{-1}\left(\frac{r_y}{r_x}\right) = \tan^{-1}\left(\frac{9.40\ km}{-6.42\ km}\right) = -55.7°$$

Since the x-component is negative and the y-component positive, the vector should be in the 2nd quadrant, not the 4th. Add 180° and the answer is

$$\theta = -55.7° + 180° = 124.3°$$

If you want to express this angle with regard to the geography, then it is 56° north of west or 34° west of north.

---

†Problem from University Physics by Ling, Sanny and Moebs (OpenStax)