Mathematics of Flight

Crosswinds

Crosswinds

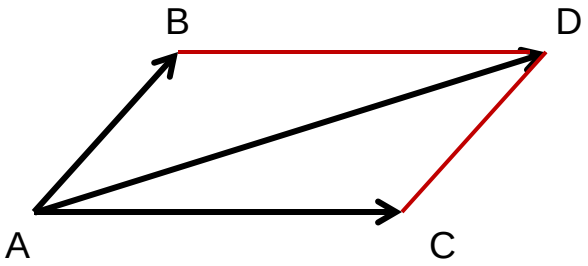
Wind often causes an aircraft to drift from its heading or direction. Pilots must calculate the effect the wind will have on the aircraft so they can remain on course.

Crosswinds

In still air, an aircraft would travel due east along AC.

With a crosswind blowing in the direction of AB, the aircraft actually travels in the direction of AD.

AD represents the course of the aircraft. $\angle CAD$ is called the drift angle.



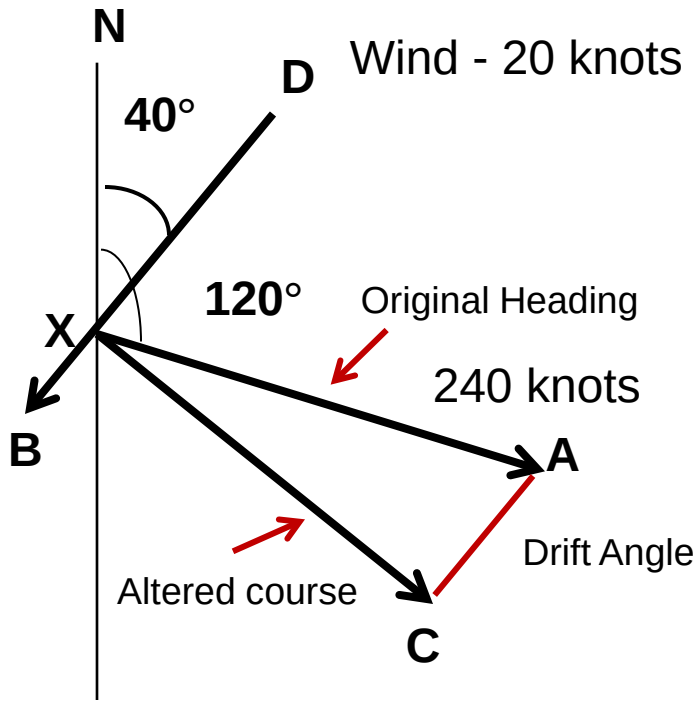
Crosswinds

Find the course, the speed of the wind and the drift angle of an aircraft headed at 120° when flying at 240 knots in still air if there is a crosswind of 20 knots blowing from the direction 40°.

Crosswinds

Solution:

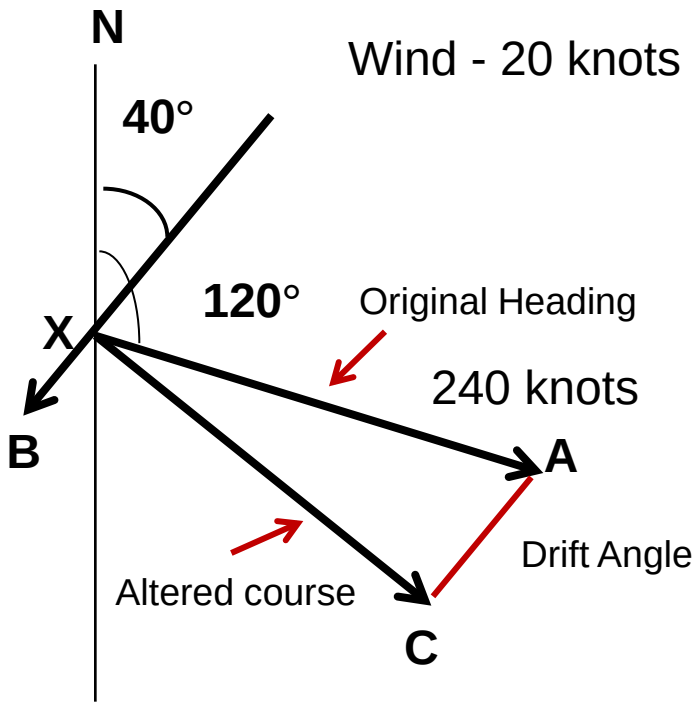
Draw a diagram to illustrate the problem.



Crosswinds

∠AXC is the drift angle.
∠AXD + ∠AXB = 180°
∠AXD = 120°- 40° = 80°
80° + ∠AXB = 180°
∠AXB = 100°

Using alternate interior angles:
∠CAX = ∠AXD
∠AXD = 180° - ∠AXB
∠AXD = 180° - 100°
∠AXD = 80°
∠CAX = 80°



Crosswinds

Using the Law of Sines:

$$\frac{\sin\angle AXC}{AC} = \frac{\sin\angle CAX}{XC}$$

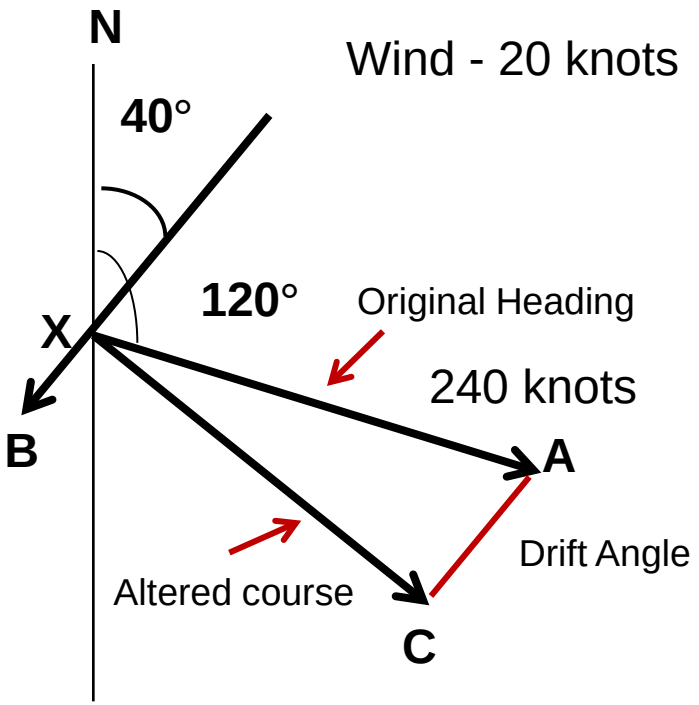
$$\frac{\sin\angle AXC}{20} = \frac{\sin 80°}{237.35} = \frac{0.9848}{237.35}$$

$$\sin\angle AXC = \frac{20\ (.09848)}{237.35}$$

$$\sin\angle AXC = 0.0830$$

$$\angle AXC = \sin^{-1}(0.0830)$$

$$\angle AXC = 4.76°$$



Crosswinds

Using ΔXAC and the Law of Cosines: $c^2 = a^2 + b^2 - 2ab\cos\Theta$

$$\overrightarrow{XC}^2 = \overrightarrow{AC}^2 + \overrightarrow{XA}^2 - 2\overrightarrow{AC}\,(\overrightarrow{XA}\cos\angle CAX)$$

$$\overrightarrow{XC}^2 = 20^2 + 240^2 - (2 \times 20)(240\cos 80°)$$

$$\overrightarrow{XC}^2 = 400 + 57{,}600 - 9{,}600\,(0.1736)$$

$$\overrightarrow{XC}^2 = 400 + 57{,}600 - 1667$$

$$\overrightarrow{XC}^2 = 56{,}333$$

$$\overrightarrow{XC} = 237.35$$

Crosswinds

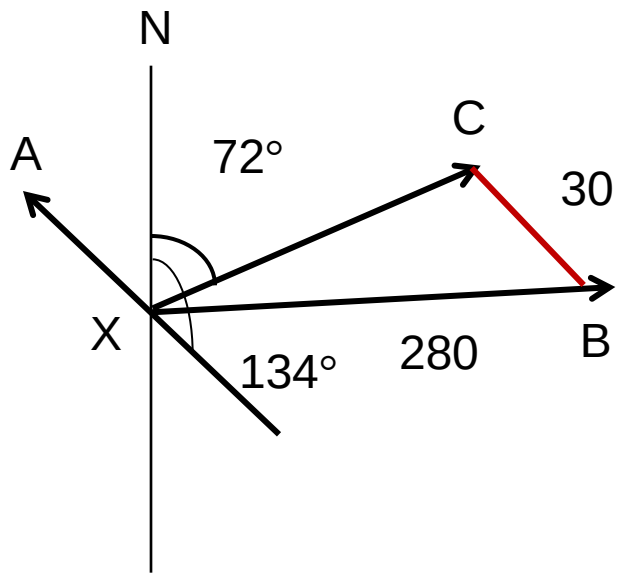
Exercise 1:

A pilot is to fly on course 72° in a wind blowing 30 knots from a direction of 134°. If the aircraft's speed is 280 knots, in what direction must the pilot head the aircraft and what will be the speed of the aircraft in the wind?

Crosswinds

Solution:

Draw a diagram to illustrate the problem.



$\angle CXB = ?$
$\overline{XC} = ?$
$\overline{BC} = 30$
$\overline{XB} = 280$

$\angle AXN + 134° = 180°$
$\angle AXN + 134° - 134° = 180° - 134°$
$\angle AXN = 46°$

$\angle AXC = \angle AXN + 72°$
$\angle AXC = 46° + 72°$
$\angle AXC = 118°$

Crosswinds

$\angle BCX = \angle AXC = 180° - (134° - 72°) = 118°$

$$\frac{\sin\angle BXC}{\overrightarrow{BC}} = \frac{\sin\angle BCX}{\overrightarrow{XB}}$$

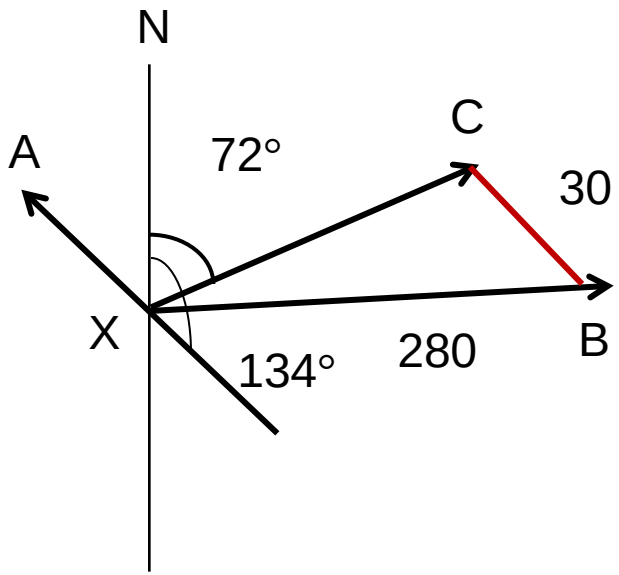
$$\frac{\sin\angle BXC}{30} = \frac{\sin\angle BCX}{280}$$

$$\frac{\sin\angle BXC}{30} = \frac{\sin 118°}{280} = \frac{0.8829}{280}$$

$$\sin\angle BXC = \frac{30\,(0.8829)}{280} = 0.0946$$

$\angle BXC = \sin^{-1}(0.0946)$

$\angle BXC = 5.43°$



The aircraft heading must be 72° + 5.4° = 77.4°

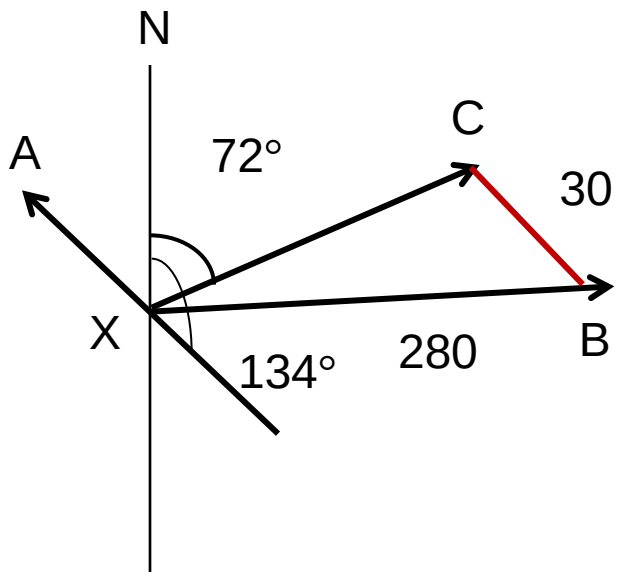
Crosswinds

To find the speed in the wind,

$\angle XBC = 180° - \angle BCX - \angle BXC$

$\angle XBC = 180° - 118° - 5.43°$

$\angle XBC = 56.57°$



Crosswinds

Using the Law of Sines:

$$\frac{\sin\angle XBC}{\overline{XC}} = \frac{\sin\angle BXC}{\overline{BC}}$$

$$\frac{\sin\angle XBC\,(XC)}{\overline{XC}} = \frac{XC\sin\angle BXC}{\overline{BC}}$$

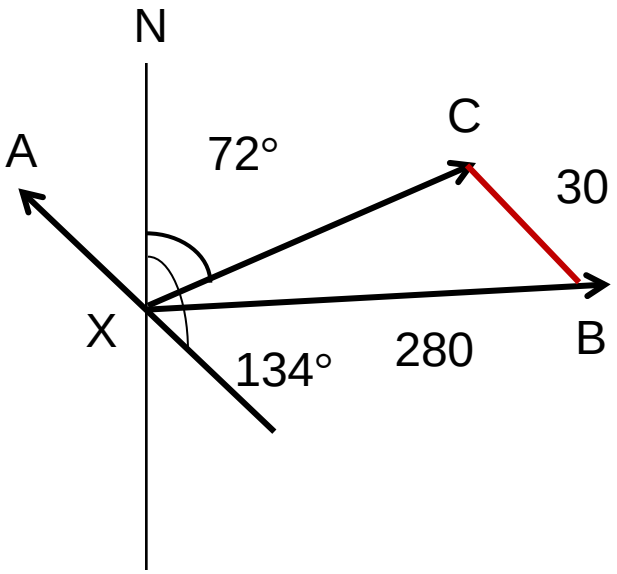
$$\frac{\overline{BC}\sin\angle XBC}{\sin\angle BXC} = \overline{BC}$$

$$\frac{\overline{BC}\,(\sin\angle 56.57°)}{\sin\angle 5.43°)} = \overline{BC}$$

$$\frac{30\,(0.8345)}{0.0946} = 264.58$$

The aircraft will travel at 264.58 knots.

BC = 30



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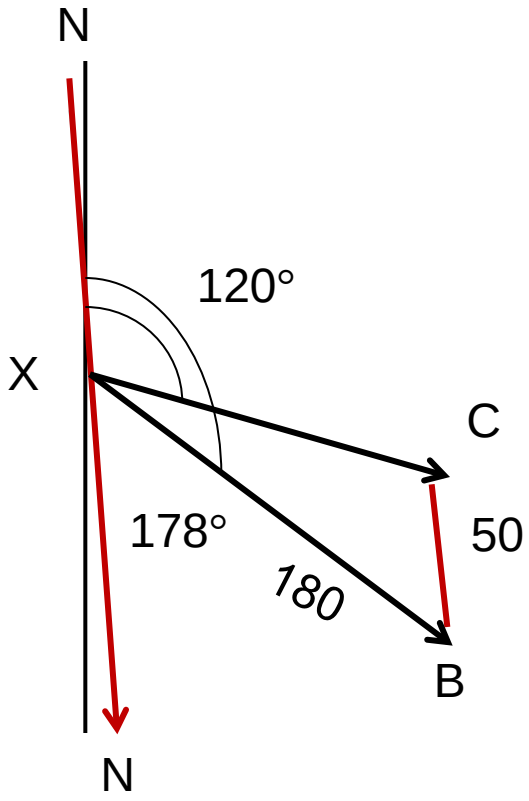
Crosswinds

Exercise 2

An aircraft is headed in direction 120° with a speed of 180 knots in still air. The wind is blowing from 178°at 50 knots. What will be the course of the aircraft? What will be the speed of the aircraft in the wind?

(Round answer to the nearest hundredth.)

Crosswinds



Crosswinds

Using the Law of Sines:

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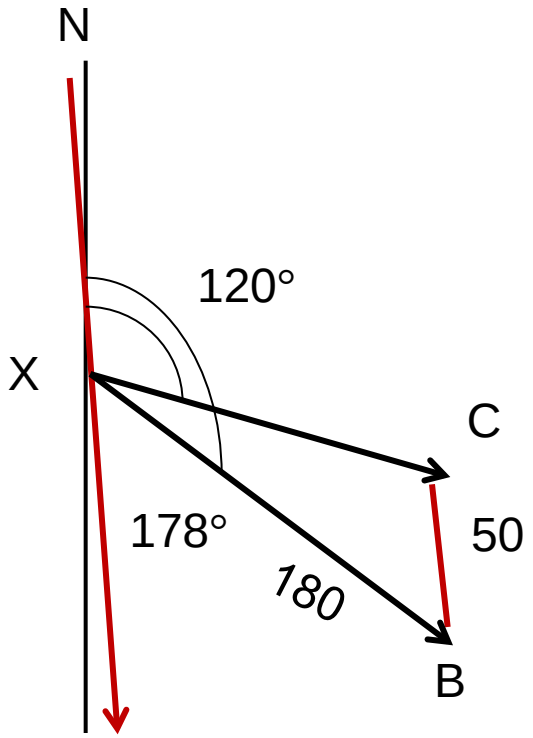


Crosswinds

Using alternate interior angles:

$\angle CBX = \angle AXB = 178° - 120° = 58°$

Using $\angle BXC$ and the Law of Cosines: $c^2 = a^2 + b^2 - 2ab\cos\Theta$

$\rightarrow \quad \rightarrow \quad \rightarrow \quad \rightarrow \quad \rightarrow$

$XC^2 = BC^2 + XB^2 - 2BC\ (XB \cos \angle CBX)$

$\rightarrow$

$XC^2 = 50^2 + 180^2 - (2 \times 50)\ (180 \cos 58°)$

$\rightarrow$

$XC^2 = 2{,}500 + 32{,}400 - 18{,}000\ (0.5299)$

$\rightarrow$

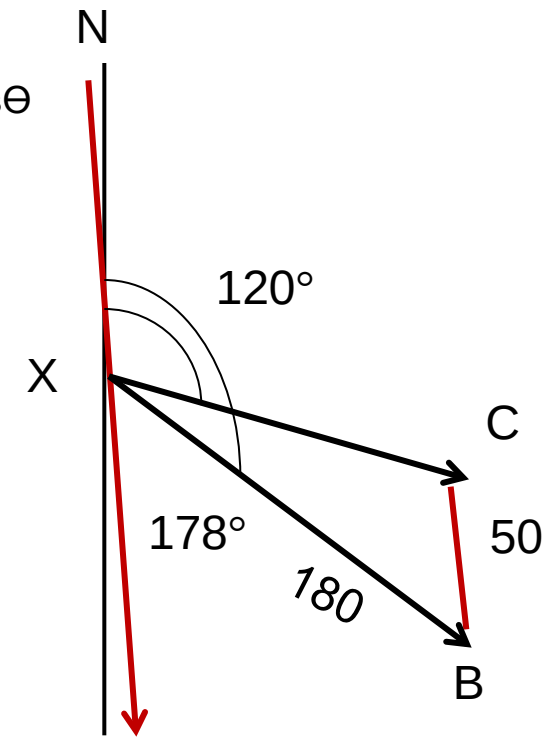
$XC^2 = 2{,}500 + 32{,}400 - 9{,}538.20$

$\rightarrow$

$XC^2 = 25{,}361.80$

$XC = 159.25$

The aircraft will travel at 159.25 knots.



More Resources

Additional Resources
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