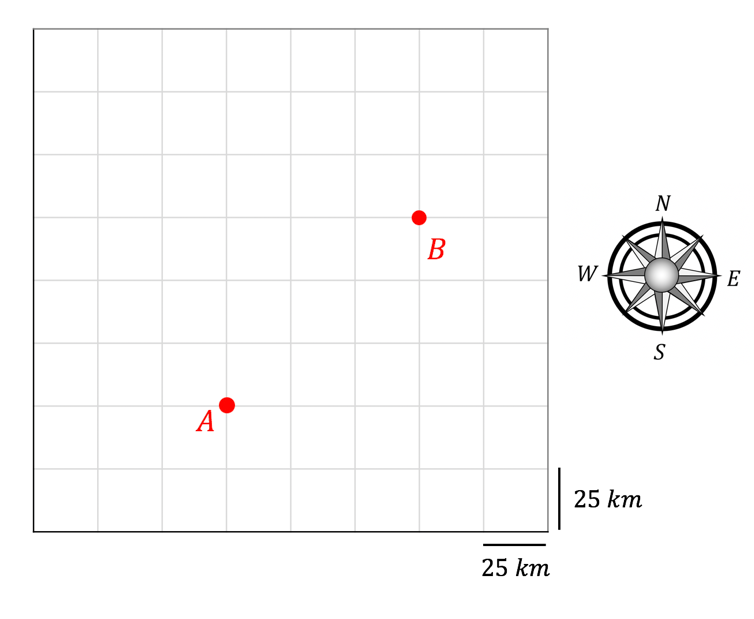
**2.3 Notes: Finding speed and bearing along a trajectory**

*The following note sheet describes how to calculate the speed and bearing along the trajectory of an object’s motion.*

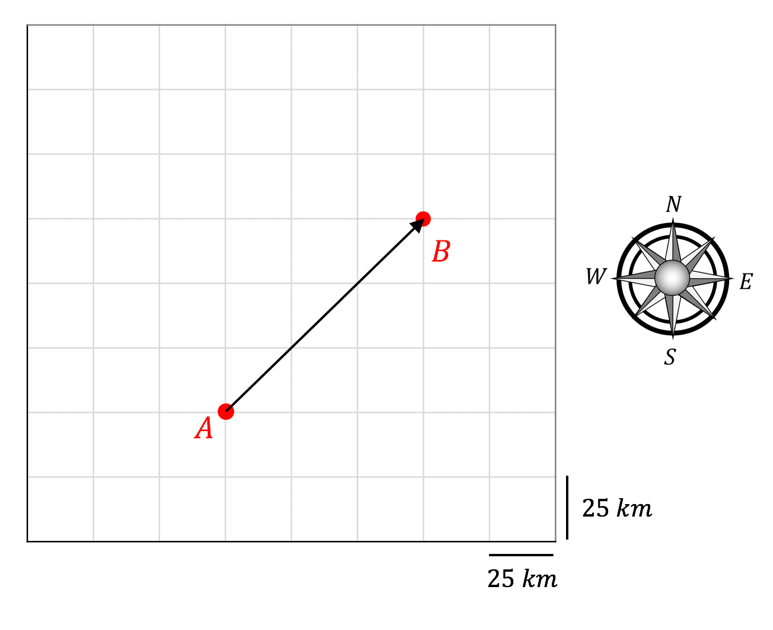
* **Speed** is the distance traveled over a given period of time.
* A **grid bearing** is the angle between a North-pointing ray and a ray pointing along a path of motion. Traditionally, the angle is measured clockwise from North to the ray of motion.

How does one calculate speed and bearing?

In the example below, we will find the speed and bearing of an object moving from location A to location B on a grid where each grid cell is each tall and wide. Let’s imagine that sea ice drifts from location A to location B over 15 days.



We can describe the average motion of the ice with a ray that points from A to B:



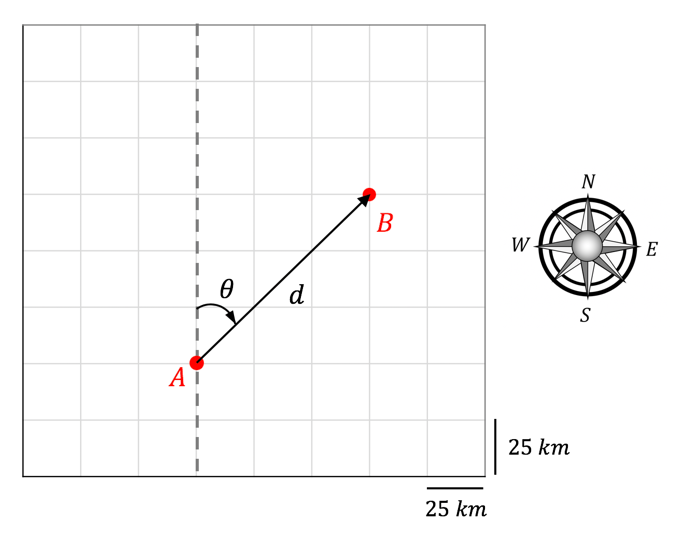
*Bearing:*

Using the compass next to the grid, we can see that the object moves North and East as it moves from A to B. However, we need a more clear way to define this direction, so we must find the grid bearing.

We begin by drawing a line along a meridional (north-south) grid line that passes through point A. The grid bearing, , is the angle measured clockwise from the dashed meridional line to the ray .

*Speed and distance:*

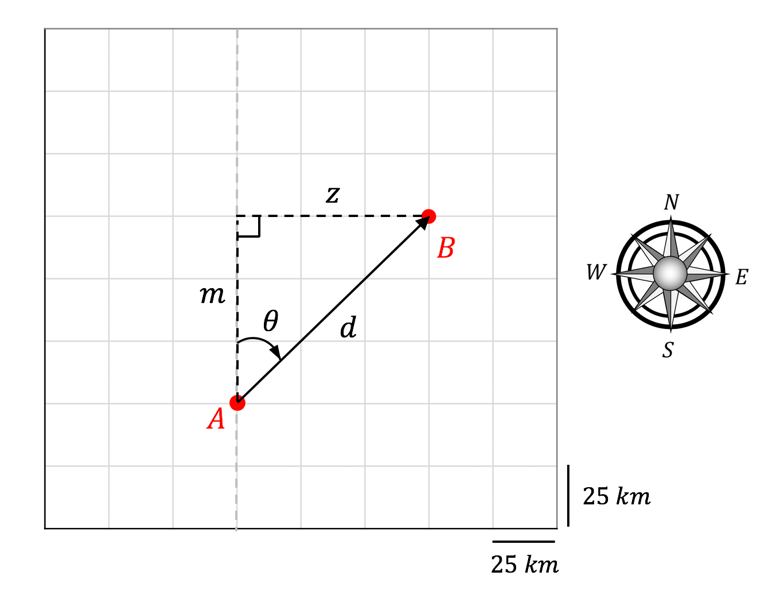
The distance traveled, is the length of the ray . The speed, , is this distance divided by the amount of time, it took to travel the distance ().



*Calculating speed, distance, and bearing:*

In order to calculate and , we will need to use triangular geometry.

We can make a right triangle with the meridional (north-south), , and zonal (east-west), , components of the ray . The hypotenuse of the right triangle has length

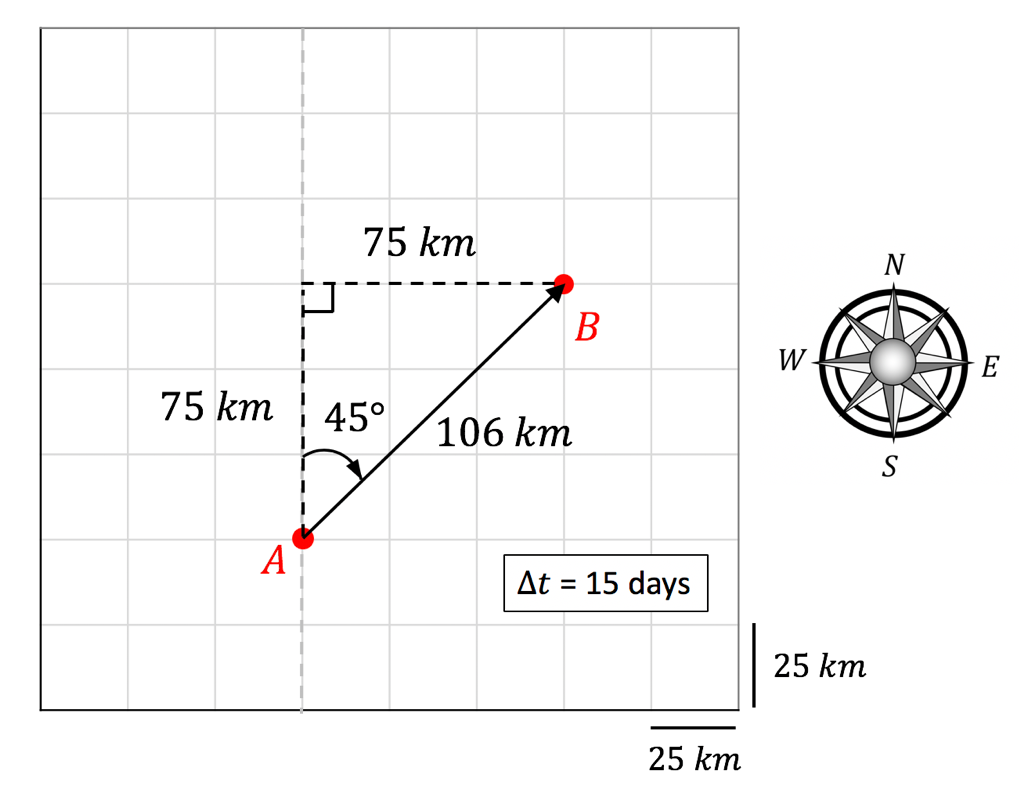


On this plot, each grid cell is in length, so the distances and can be calculated directly (they are each since they are three grid cells in length). However, in other problems, the length scale may not be given directly, and the distances and may need to be calculated using more creative methods.

For this simple case, and can be determined using known lengths and :

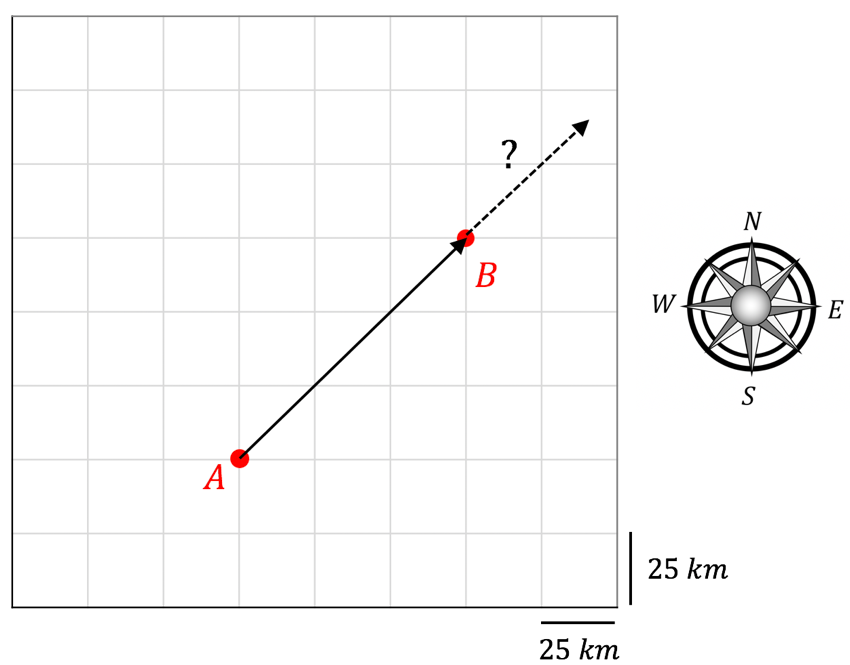
* The bearing can be found using:
* Pythagorean’s theorem can be used to solve for :
* Speed can be calculating once is known:

Since , , and are known, we can carry out the calculations:



*Forecasting ice drift:*

What can we do once we know the speed and bearing of the ice drift? We can use it to try to forecast where the buoy will drift in the future.



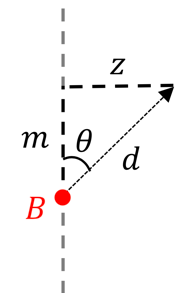
Let’s imagine the buoy continues to drift at the same speed and bearing at which it is currently drifting. Where will it be in 5 days?

We can calculate where it will be using the same math we used above – but in reverse. Before, we used the components of its path of travel ( and ) to determine its bearing and speed ( and ). Now, we can use and to predict the components of its future path, assuming they are all related to one another in the same way they were.

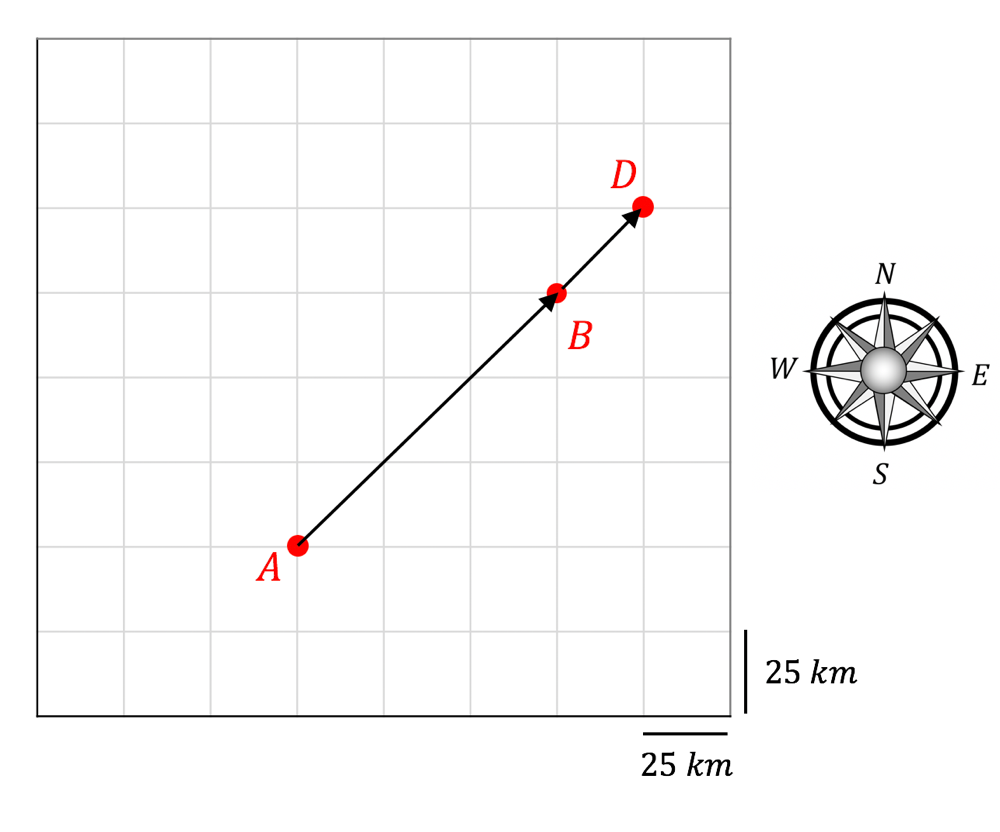
We know the current drift is described by:

From the known speed, the distance traveled in a given time can be calculated:

Over 5 days, the distance traveled by the buoy will be given by:

Knowing the distance traveled by the ice and the direction along which it travels, the zonal and meridional components of the travel can be calculated:

The distances traveled in either direction can be added onto the ice’s current location to find where it might end up after 5 more days of drift (shown as location D on the plot below)

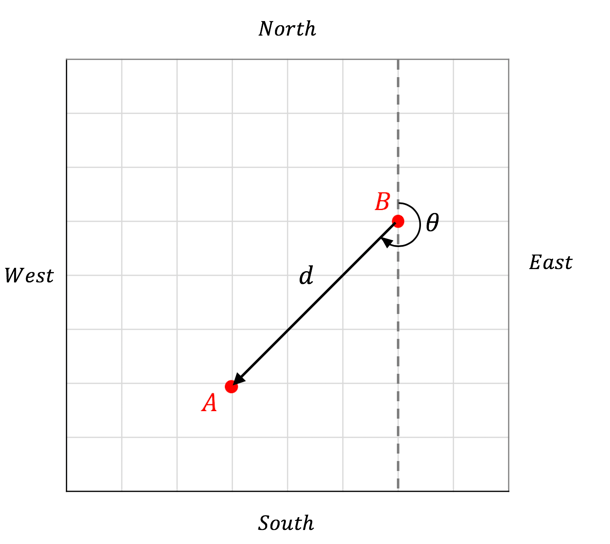


A note about the definition of bearing:

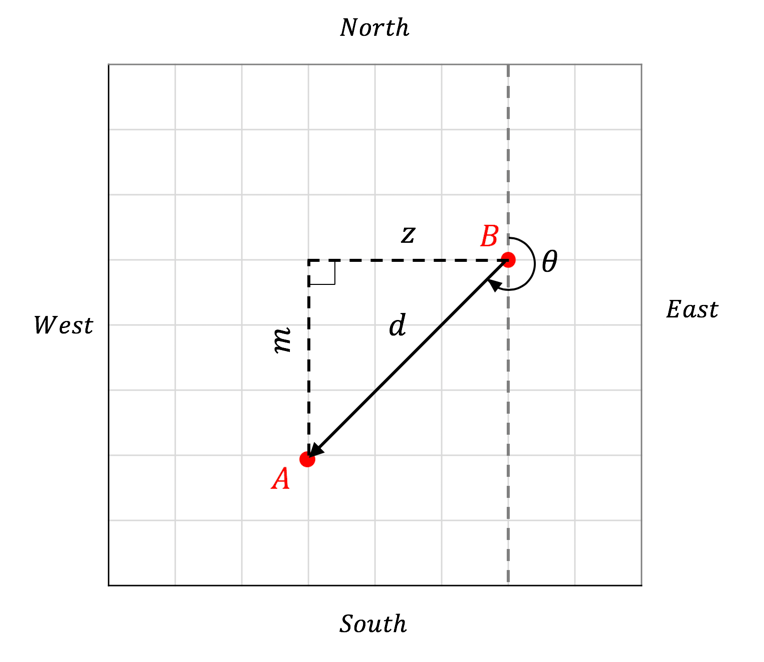
As mentioned before, bearing is traditionally measure *clockwise* from a North-pointing ray to the ray connecting two locations. So what happens if an objects moves West or South of its original location? We’ll demonstrate what this might look like by imagining the object in the example above moves from location B to location A.

*Bearing and distance B to A:*

When making a bearing estimate from B to A, the bearing angle must still be taken clockwise from North to the ray .



The distance traveled can be calculated again in terms of zonal and meridional components and will be the same distance as that traveled over ray .

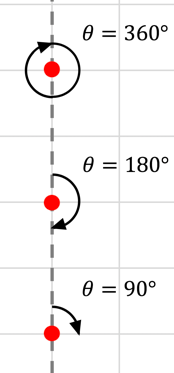


The bearing angle will be slightly more challenging to calculate, but we can do it using some well-known angles and angles within the triangle.

To calculate the bearing angle, we will use known angles. Right away, we can notice and label some right angles (). We can also label the angle we found in the previous calculation ().

* *The angles in any triangle add up to :*

Also, the angle made around one half and one fourth of a circle are 180 and 90 degrees, respectively.

* *The angle made around a full circle is*