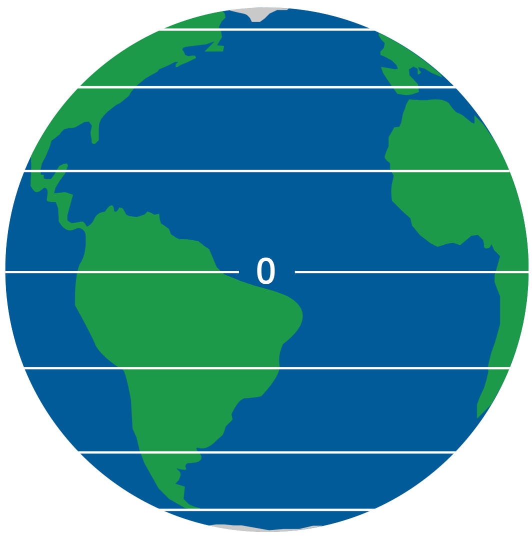
Chapter 1

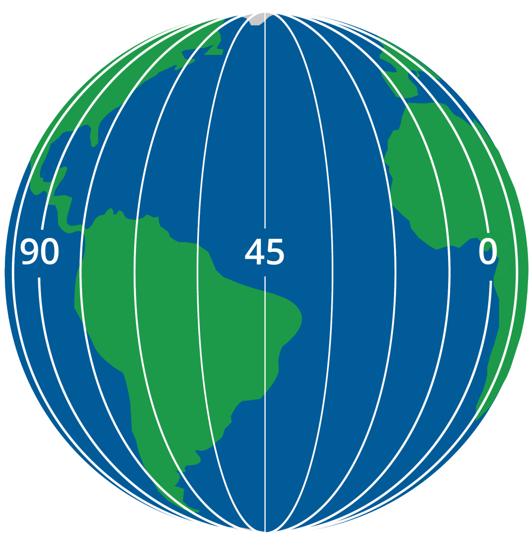
Longitude and Latitude

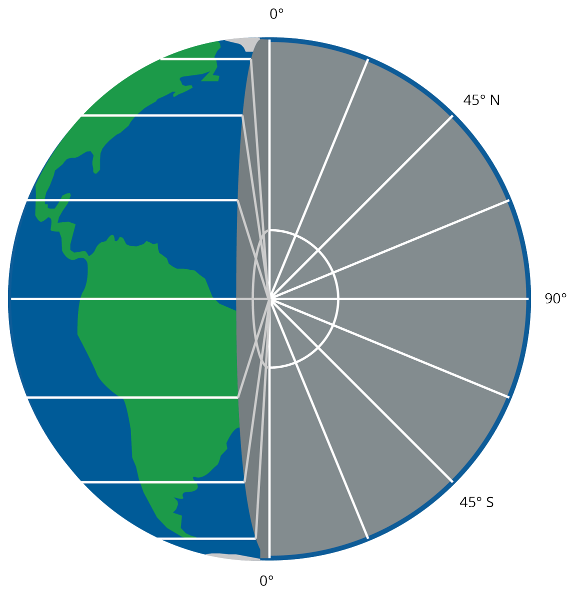
The Earth can be represented as a sphere, and the position of a point on its surface can be described using two coordinates: latitude and longitude.

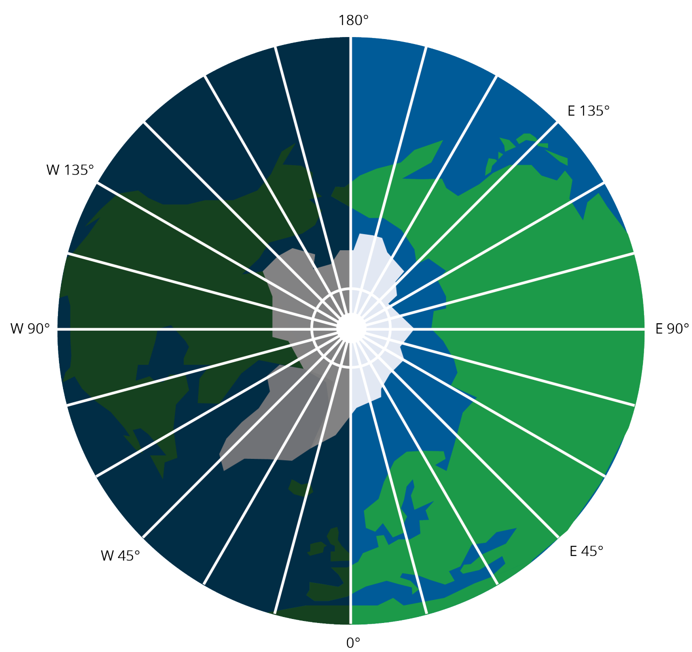
Latitude is a measure of a point's distance north or south of the Equator, expressed in degrees. It ranges from $-90°$ at the South Pole to $+90°$ at the North Pole, with $0°$ representing the Equator.



Longitude, on the other hand, measures a point's distance east or west of the Prime Meridian (which passes through Greenwich, England). It ranges from $-180°$ to $+180°$, with the Prime Meridian represented as $0°$.





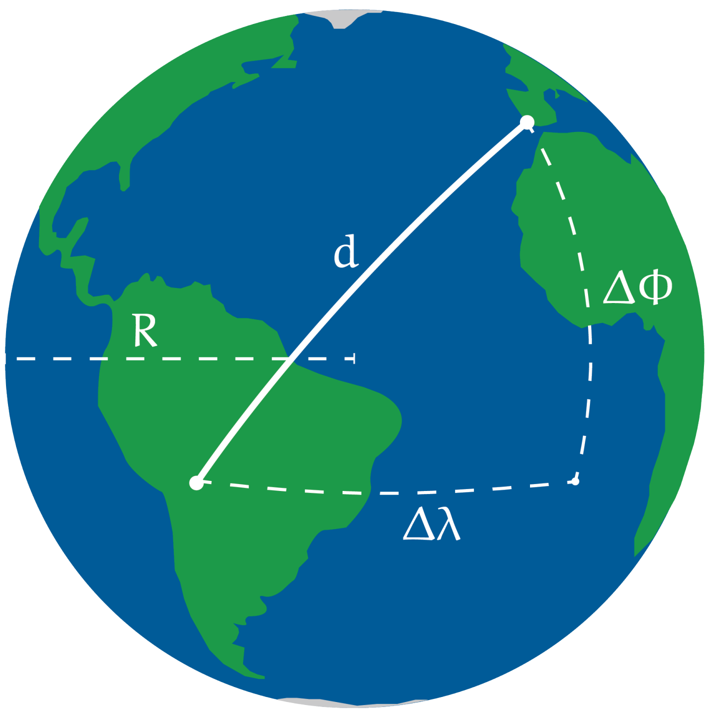


1.1 Nautical Mile

A nautical mile is a unit of measurement used primarily in aviation and maritime contexts. It is based on the circumference of the Earth and is defined as one minute $(1/60°)$ of latitude. This makes it directly related to the Earth's geometry, unlike a kilometer or a mile, which are arbitrary in nature. The exact value of a nautical mile can vary slightly depending on which type of latitude you use (e.g., geodetic, geocentric, etc.), but for practical purposes, it's often approximated as 1.852 kilometers or 1.15078 statute miles.

1.2 Haversine Formula

The haversine formula is an equation important in navigation for giving great-circle distances between two points on a sphere from their longitudes and latitudes. It's especially useful when it comes to calculating distances between points on the surface of the Earth, which we represent as a sphere for simplicity.



In its basic form, the haversine formula is as follows:

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\Delta\lambda}{2}\right)$$

$$c = 2 \cdot \operatorname{atan2}\left(\sqrt{a}, \sqrt{1-a}\right)$$

$$d = R \cdot c$$

Here, ϕ represents the latitudes of the two points (in radians), $\Delta\phi$ and $\Delta\lambda$ represent the differences in latitude and longitude (also in radians), and R is the radius of the Earth. The result, d, is the distance between the two points along the surface of the sphere.

Appendix A

Answers to Exercises

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