Measurement of Distance and Direction

Geographical Poles Two points on the surface of the earth through which the axis of rotation of the earth passes.

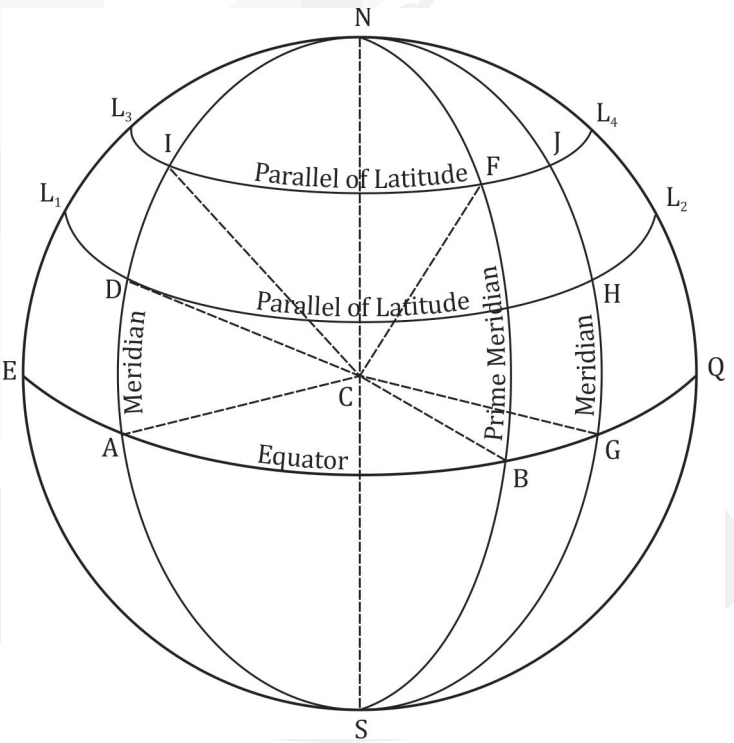
Great Circle Any circle drawn on the surface of a sphere, of which the plane of the circle passes through the centre of the sphere. It is the largest circle that can be drawn on a sphere passing two given points.

Small Circle Any circle on the surface of a sphere, the plane of which does not pass through the centre of the sphere.

The Equator A great circle on the surface of the earth, the plane of which is perpendicular to the axis of rotation of the earth.

Meridian A semi-great circle on the surface of the earth that connects the two geographical poles.

Prime Meridian The meridian that passes through an arbitrary point which is Greenwich, UK.



ACD	Latitude of D	BCA	Longitude of A, D and I
ACI	Latitude of I	BCG	Longitude of G, H and J
DCI	D. Lat. between D and I	IF	Dep. between I and F
DH	Dep. between D and H		
ACG	D. Long. between D and H or I and J		

Parallel of Latitude — Small circle on the surface of the earth parallel to the equator.

Latitude — The latitude of any particular position is the arc of any meridian contained between the equator and the parallel of latitude through that particular position.

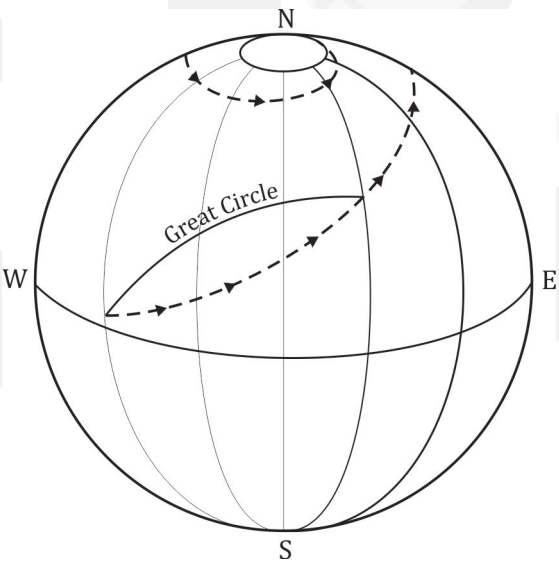
Difference of Latitude (D. Lat.) — The difference of latitude between any two positions is the arc of a meridian contained between the parallels of latitude through the positions.

Longitude — The longitude of any particular position is the arc of the equator contained between the prime meridian and the meridian passing through that particular position.

Difference of Longitude (D. Long.) — The difference of longitude between any two positions is the lesser arc of the equator contained between the two meridians that pass through the positions.

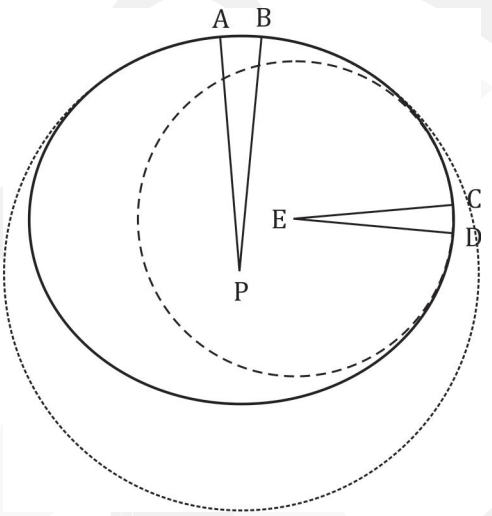
Departure — The departure between two positions is the distance in nautical miles between meridians passing through the two positions, measured along parallel latitude.

Rhumb Line or Loxodrome — The rhumb line is the line that cuts every meridian at the same angle. If the rhumb line cuts the meridians at an angle of 90°, then it is a part of a parallel of latitude. If the rhumb line cuts the meridians at an angle other than 90°, the line is a spiral that converges on the pole. The rhumb line course is used for steering from one position to another because it is convenient, but it is not the shortest distance between two positions. The shortest distance between two positions is along the arc of a great circle.



Measurement of Distance

The nautical mile is the unit used to measure distance at sea. It is the unit of angle of the great circle of a meridian. The length of one nautical mile is defined as the length of a meridian which subtends an angle of one minute at the centre of the curvature of that part. The earth is not a true sphere, but is an oblate spheroid, flattened at the poles and bulged at the equator. Therefore, the radius of the curvature at the poles is greater than the radius at the equator, so the linear distance of one nautical mile at the pole is greater than the linear distance of one nautical mile at the equator. Thus, the exact length of a mile varies along the meridian.



In the figure: $APB = CED = \theta°$ $AP > CE \therefore AB > CD$

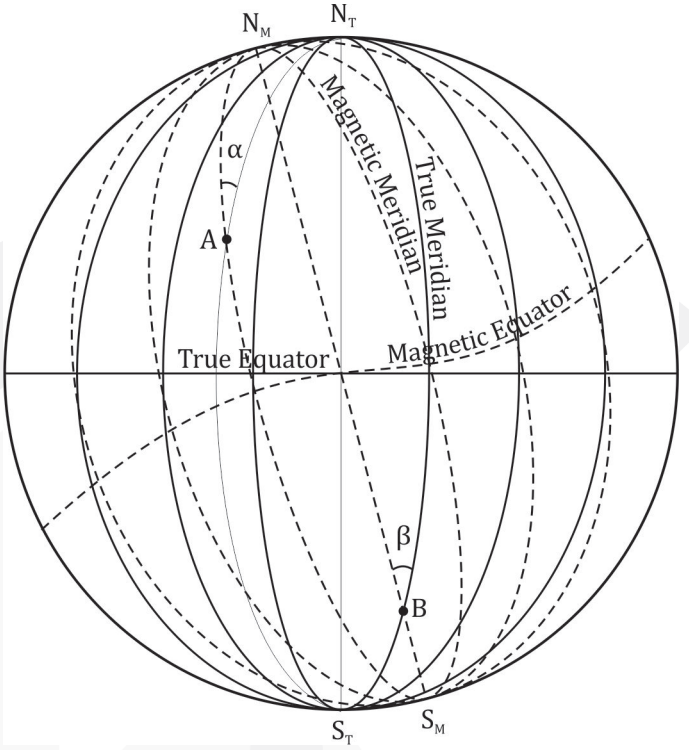
One nautical mile at the equator is approximately 1842.9 metres (6046.4 feet) and one nautical mile at the poles is approximately 1861.7 metres (6107.8 feet). For practical navigation, the value of 1852 metres (6080 feet) is adopted as the International Nautical Mile.

Measurement of Direction

Measurement of direction is used to express the course, which is the direction of a movement or the direction of a bearing. This expression uses the direction of the north as the reference. There are two directions of north: true north, and magnetic north. True north is the geographical North Pole, through which all the chart's meridians pass, and magnetic north is the earth's magnetic north pole.

Variation is the difference between True North and Magnetic North

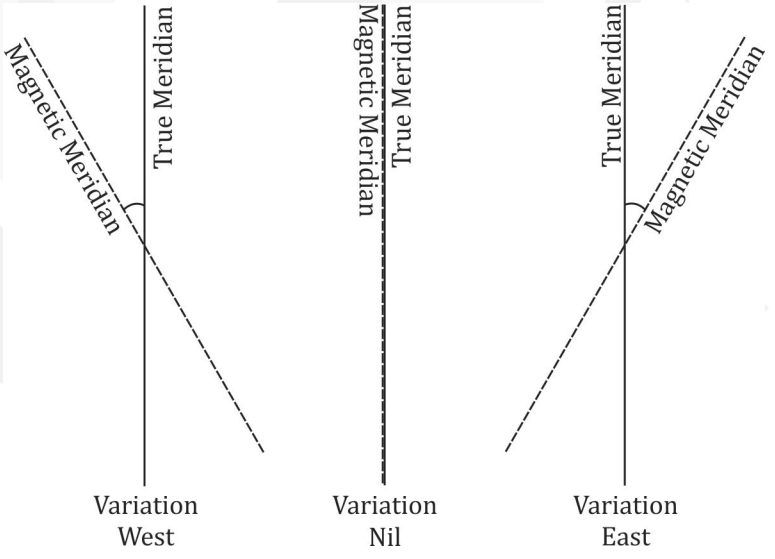
The magnetic north does not coincide with true north, but slowly rotates around true north. The angle between the magnetic meridian and the true meridian is called **Variation**. The variation changes with position, e.g., as shown in the next figure at position A, the variation is θ; at position B, the variation is β.



If the variation is west, then the magnetic north is greater than the true north, and if the variation is east, then the magnetic north is less than the true north.

Variation **WEST**
Magnetic **BEST**

Variation **EAST**
Magnetic **LEAST**

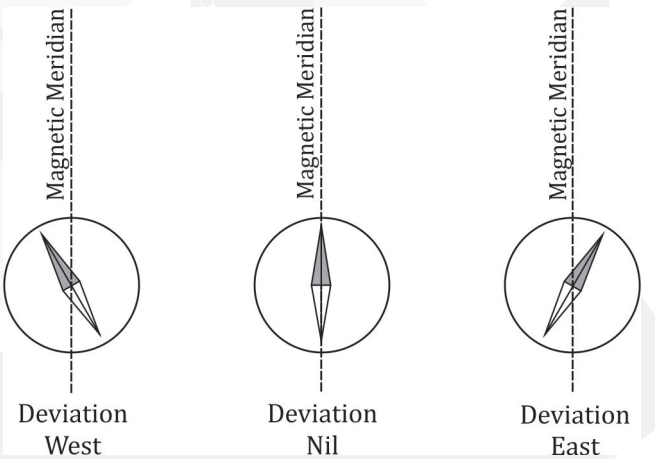


Magnetic Compass

The magnetic compass basically consists of a magnetic needle suspended at a point. As per the effect of the earth's magnetic field, this needle is rotated until its length is parallel with the magnetic meridian if there is no other force in the vicinity to affect the needle. The magnetic needle is usually attached to a compass card, which is marked with directions; when the magnetic field effect on the needle causes rotation of the needle, then the card rotates also; when the needle settles down, with its length parallel to the magnetic meridian, the observer can read the direction on the compass card. The ship's magnetic compass usually consists of four or eight needles under the compass card, and is designed so as to be free from friction and working under conditions of the rolling of the ship. The magnetic needle is also affected by the local magnetic field, especially on today's steel ships. Magnetic bars are placed in the compass to correct the effect of the local magnetic field. The effect of the local magnetic field can never be eliminated completely, and whatever remains is called **Deviation**. Deviation is therefore the angle between the direction of the needle and the magnetic meridian. Deviation changes its value when the ship's head changes direction. Deviation is named WEST if the compass needle points left of magnetic meridian, and named EAST if the compass needle points to the right of the magnetic meridian.

Deviation is the difference between Magnetic North and Compass North

If the deviation is west, then the compass north is greater than the magnetic north, and if the deviation is east, then the compass north is less than the magnetic north.



Deviation **WEST**
Compass **BEST**

Deviation **EAST**
Compass **LEAST**

Compass Error

Compass error is the difference between the True North and Compass North

Compass error is the angle between the true north and the direction in which the compass card is pointing. It is the combination of the variation and deviation. If the variation and deviation have the same name; then the compass error is the sum of variation and deviation. If they have a different name, then the compass error is the difference between variation and deviation, and will be named as the greater one.

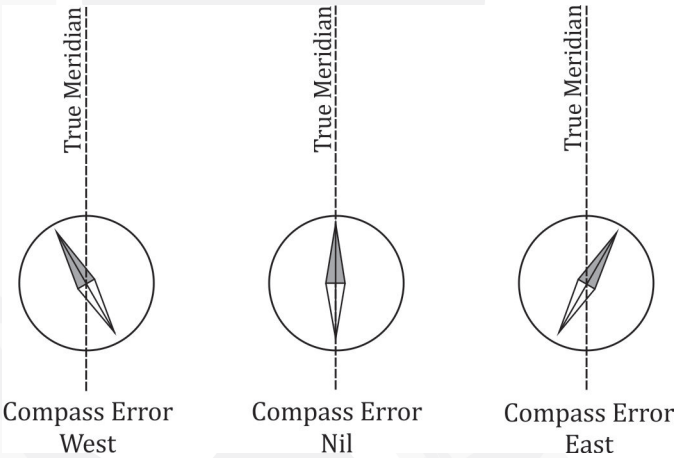
If the compass error is west, then the compass north is greater than the true north, and if the compass error is east, then the compass north is less than the true north.

Example 1

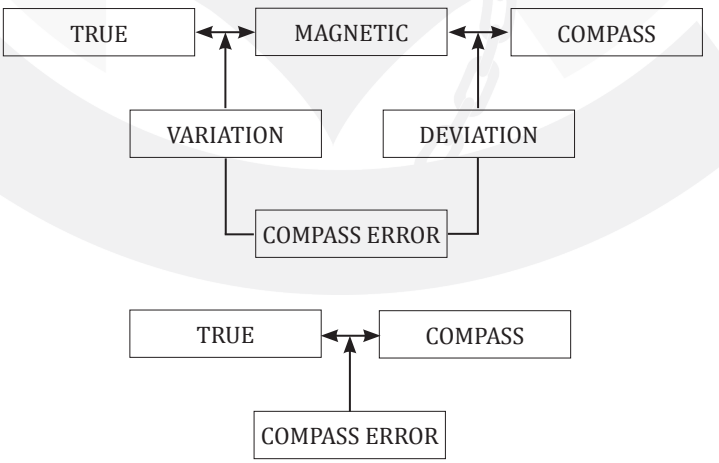
Dev. 10°W	Var. 25°E	⇒	CE = 15°E
Dev. 10°E	Var. 21°W	⇒	CE = 11°W
Dev. 4°E	Var. 15°E	⇒	CE = 19°E
Dev. 9°W	Var. 11°W	⇒	CE = 20°W

Compass error **WEST**
Compass **BEST**

Compass error **EAST**
Compass **LEAST**



Summary



Example 2

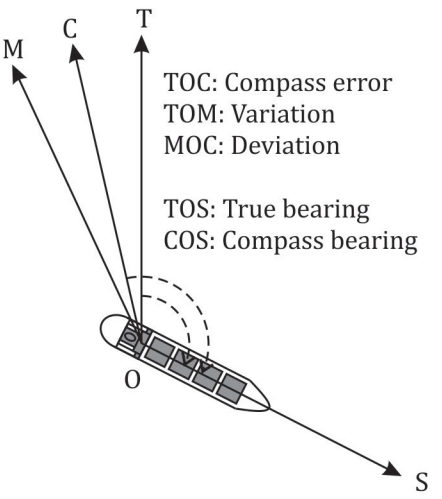
Given compass bearing, find true bearing

A ship is steaming 130° by the compass, deviation is 12°E, and variation is 25°W. Find the true course:

Compass course	130°C
Deviation	12°E
Magnetic course	142°M
Variation	25°W
True course	117°T

or

Variation	25°W
Deviation	12°E
Compass error	13°W
Compass course	130°C
True course	117°T



Example 3

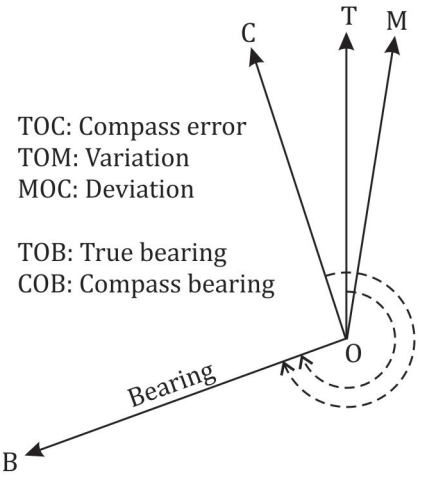
Given true bearing, find compass bearing

The true bearing of a shore structure is 250°T, deviation is 27°W, and variation is 9°E. Find the compass bearing of the structure:

True bearing	250°T
Variation	9°E
Magnetic bearing	241°M
Deviation	27°W
Compass bearing	268°C

or

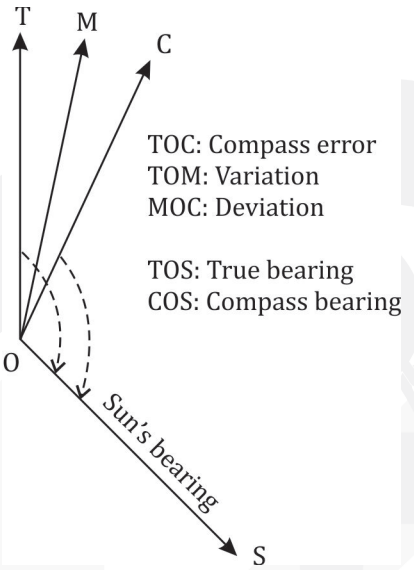
Variation	9°E
Deviation	27°W
Compass error	18°W
True bearing	250°T
Compass bearing	268°C



Example 4

Given true bearing, compass bearing and variation, find deviation

The sun bears 130°T and 105°C. Find compass error and deviation if variation in the area is 12°E:



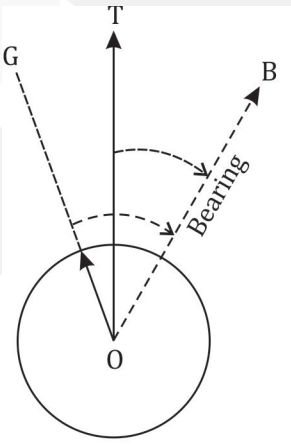
True bearing	130°T
Compass bearing	105°C
Compass error	25°E
Variation	12°E
Deviation	13°E

Gyro Compass

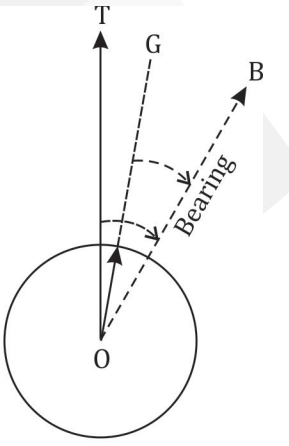
Compass error **HIGH** *is* **NEGATIVE**

Compass error **LOW** *is* **POSITIVE**

The gyroscopic compass is designed to indicate the true heading of the ship so that no correction will be required for variation and deviation. The gyro compass also bears small errors, which should never exceed 1° or 2°. This small error is said to be a HIGH or LOW reading. The error is said to be HIGH when the north point of the gyro compass card is pointing to the left of the true north. The correction is negative, because all the direction taken from the compass card will be greater than the true value. Therefore, all the readings on the compass must be subtracted from the error to obtain the true value.



Compass HIGH



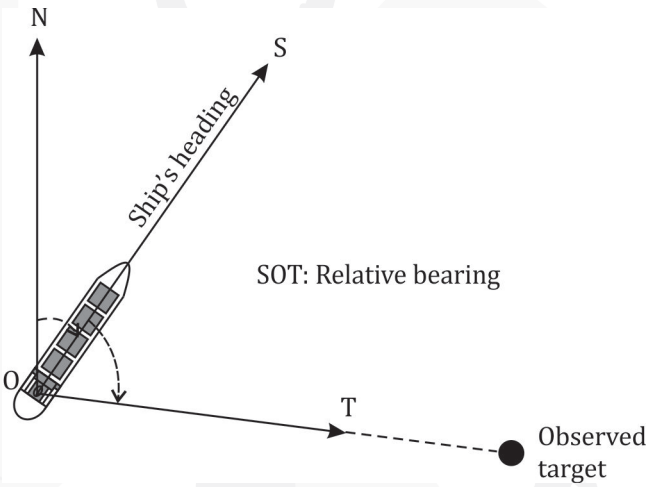
Compass LOW

The error is said to be LOW when the north point of the gyro compass card is pointing to the right of true north. The correction is positive, because all direction taken from the compass card will be less than the true value. Therefore, the error must be added to the compass reading in order to get the true value.

Relative Bearing

Relative bearing is the angle at the observer, measured clockwise from the direction of ship's heading to the direction of the observing target.

True bearing = Ship's true heading + Relative bearing



Example 5 Ship's heading at the time of observing is 030°T; a relative bearing of a target is 075°. Find the target's true bearing:

$$\begin{aligned}\text{True bearing} &= \text{Ship's true heading} + \text{Relative bearing}\\ &= 030° + 075°\\ &= 105°\text{T}\end{aligned}$$

Example 6 A target is bearing 125° relatively on the starboard bow; the ship's heading is 265°T. Find the true bearing of the target.

$$\begin{aligned}\text{True bearing} &= \text{Ship's true heading} + \text{Relative bearing}\\ &= 265° + 125°\\ &= 390°\\ &= 390° - 360°\\ &= 030°\text{T}\end{aligned}$$