

1.3 Magnetic Compass and Compass Error

A basic magnetic compass makes use of a light weight bar magnet, balanced on an almost frictionless pivot point, to find directions relative to the Earth's magnetic poles. The magnet (usually called a compass needle) is marked 'N' for north, which means that the marked end points to the magnetic north pole.

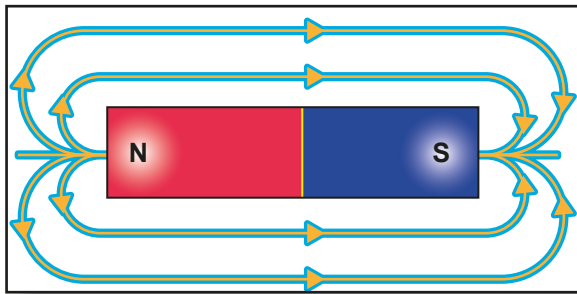


Figure 1.14 - Magnetic Field

In order to understand the working limitations and errors of a magnetic compass, navigators must understand the principle of magnetism and the relationship between the Earth's magnetism and the magnet used. Errors can be due to faults in the equipment or caused by failing to apply corrections before using the compass bearing obtained for navigation.

1.3.1 Principle of Magnetism

A magnet is a ferrous metal (ie iron or steel) that has a magnetic field around it, enabling it to attract other metals. The strength of this magnetic field is stronger towards the ends of the magnet, these are called poles. The bar magnet shown in Figure 1.14 has two poles with opposite polarity (ie one positive and one negative). These two poles are connected to each other with magnetic lines of force that travel from one pole to the other. The pole from where these lines of force emanate in a bar magnet is called the red or north pole and the pole where they enter the magnet is called the blue or south pole, as shown in Figure 1.14.

If an ordinary iron bar is placed in the Earth's magnetic field, it will become a temporary magnet. This is often unnoticed due to the weakness of the magnetic field created in the steel. This type of magnetism is called induced magnetism. The potential of an iron bar to retain induced magnetism depends on its hardness and the strength of the magnetic field to which it is subjected. If a hard iron bar is subjected to a strong magnetic field it may retain magnetism for longer durations, in which case it will be known as permanent magnetism.

Induced magnetism is known as soft iron magnetism and permanent magnetism as hard iron magnetism.

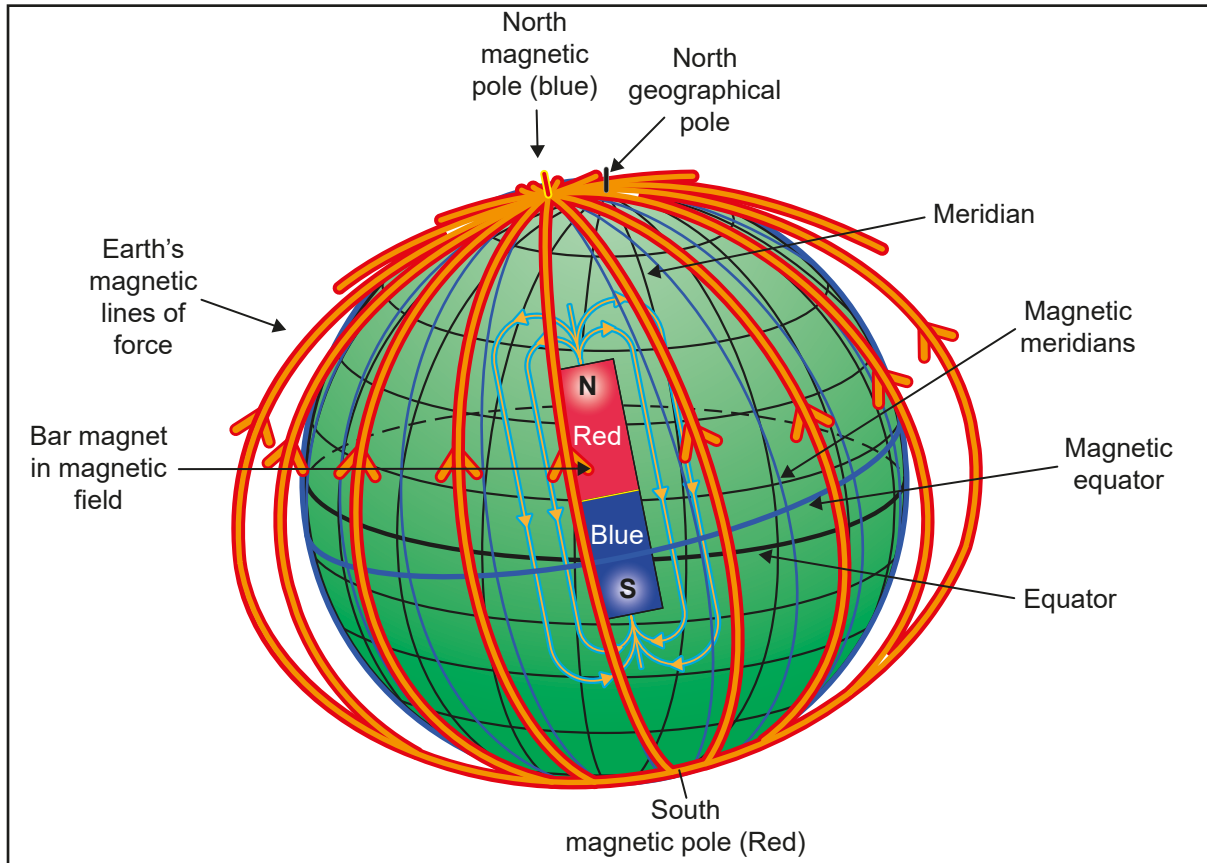


Figure 1.15 - Magnet and the Earth
 (Note: the red end of the magnet is attracted to the blue pole)

All magnetic compasses work on the law of magnetism, which states that 'like poles repel and opposite poles attract', ie red poles will attract blue poles, but will repel red poles and vice versa. This means that, for an ordinary bar magnet to provide directions, its red pole must be attracted by a blue pole. Fortunately, the Earth acts like a huge magnet with a magnetic field around it. If a bar magnet is allowed to rotate freely in a horizontal direction, it will settle as shown in Figure 1.15. Traditionally, the names of the poles on a compass needle are reversed by identifying the end of the compass that points to the north magnetic pole as north and the other as south.



It is worth observing that the north magnetic pole is not in proximity to the geographical North Pole, but is currently located in the north of Canada.

1.3.2 Variation

The Earth's north magnetic pole where the magnetic lines of force enter is called the blue pole and south magnetic pole where the magnetic lines of force emanate is called the red pole. The lines joining the north and south magnetic poles are called

magnetic meridians. This means that the red end of a bar magnet in a compass will be attracted to the Earth's north magnetic pole (as different poles attract each other) to align itself with the magnetic lines of force. However, the north magnetic pole is not situated exactly at the geographical north pole (as shown in Figure 1.15) leading to an error known as 'variation'.

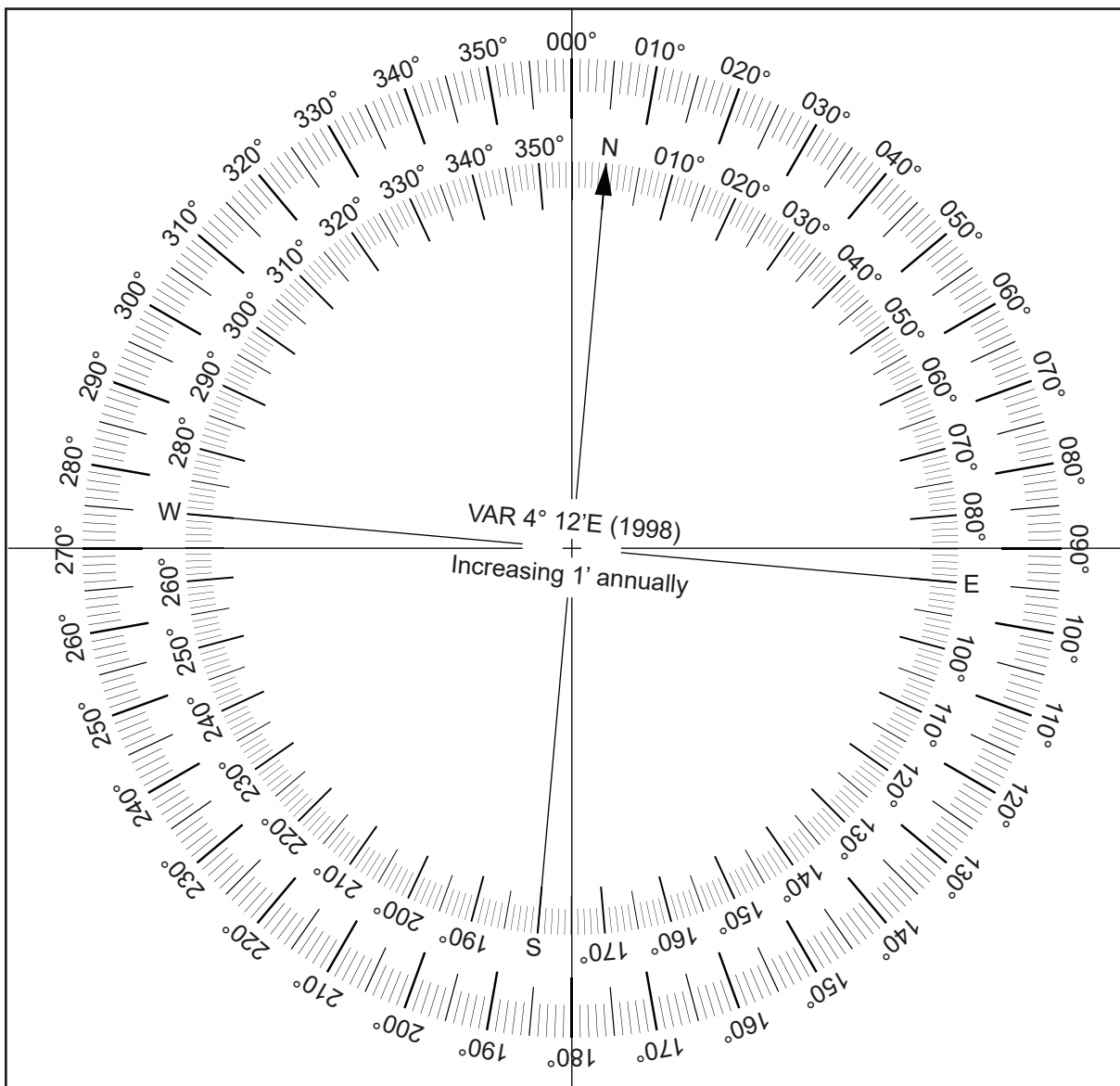


Figure 1.16 - Compass Rose with Variation

Variation is defined as the angle (measured in degrees and fractions) between the direction in which a compass needle points and true north. Variation is named east if the compass needle is deflected to the east of true north, and west if the compass needle is deflected to the west of true north. Variation is not constant as the Earth's magnetic strength varies from place to place and with time.

The local variation, along with the annual changes for any place, is given on the compass rose (shown in Figure 1.16) on navigational charts. Variation changes as an observer moves on the surface of the Earth.



Lines of equal variation are called 'Isogonic lines' and lines of equal annual change in variation are called 'Isoporic lines'.

1.3.3 Deviation

From the discussion above, it has been established that:

- Variation may change from place to place
- a ship constructed of steel can have two types of magnetism, permanent and induced.

Induced magnetism must also be considered due to the effect of placing a ship in the Earth's magnetic field and because of changes in the structure of a ship, ie changes in the amount of 'iron' surrounding the compass needle on the ship. If a magnetic compass is placed away from a ship, it will point in a slightly different

direction to a compass on the ship. This difference is called 'deviation' and is caused by the effect of the ship's steel structure on the compass needle. Deviation is defined as the angle between the magnetic meridian and the compass meridian, as shown in Figure 1.17.

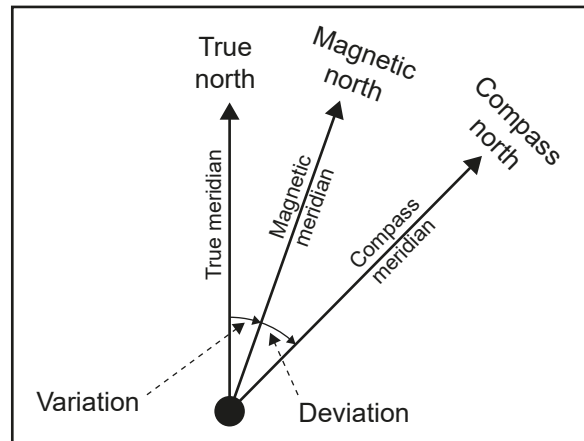


Figure 1.17 - Variation and Deviation

Deviation is different for each ship and may also vary for different headings on the same ship due to the distribution of different amounts of 'iron' in the structure. For example, if a piece of metal is placed near the compass, it will attract the north end of the compass needle, causing a change in deviation. The presence of materials like radars, electronic and electrical equipment have an effect on the magnetic compass. Unlike variation, which varies from place to place, deviation can even vary on the same ship as it ages, through the addition of new equipment (eg radar/GPS), alterations in the structure of the ship, repairs in dry dock or even by loading/discharging cargo with a significant amount of steel. The specialist compass adjuster(s) can eliminate most of the deviation, but it is not possible to remove it completely and so the navigator should know the residual deviation for the magnetic compass. The residual deviation is calculated by a process called 'swinging the compass' (discussed later in this chapter), and given either in the form of a 'deviation card' (Figure 1.18) or a deviation curve

(Figure 1.19). Both the card and graph show the deviation for compass headings from 000°–360°, which can be applied by the navigator when using a compass.



In practice, the magnetic compass is referred to as the compass, or ship's compass. A gyrocompass is referred to as the gyro, or gyrocompass.

In a manner similar to variation, if the compass points to the east of the magnetic meridian, deviation is east (Figure 1.20) and if it points to the west of the compass meridian, deviation is west (Figure 1.21).

Deviation Card	
Compass Heading	Deviation
0°	2.5°E
20°	3.5°E
40°	4.0°E
60°	3.0°E
80°	2.5°E
100°	2.0°E
120°	1.5°E
140°	1.0°E
160°	0.5°E
180°	1.0°W
200°	2.0°W
220°	3.0°W
240°	3.5°W
260°	2.5°W
280°	1.5°W
300°	0.5°W
320°	1.5°E
340°	2.0°E
360°	2.5°E

Figure 1.18

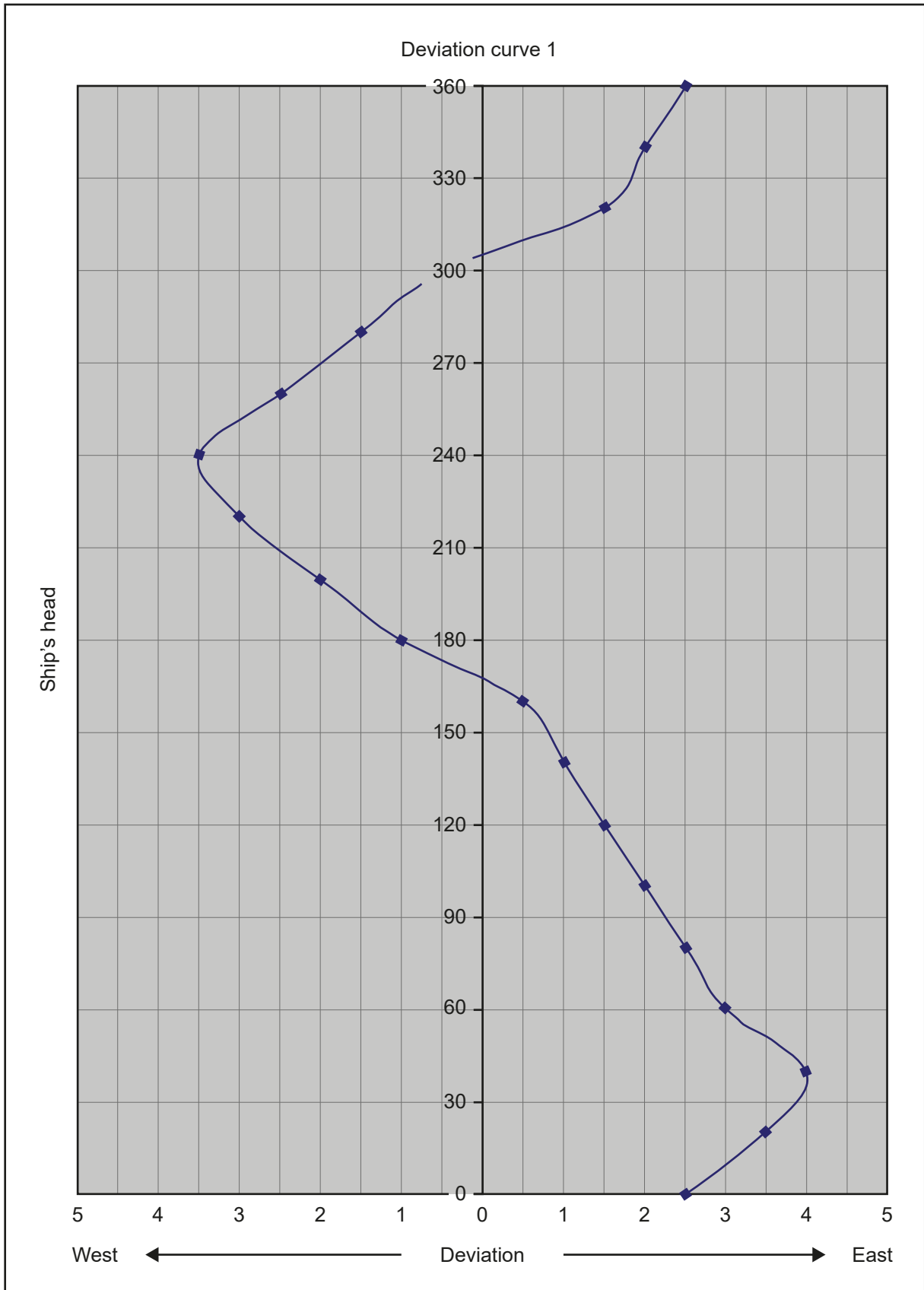


Figure 1.19

1.3.4 Compass Error

The sum or difference of variation and deviation is called 'the compass error'. This is applied to the compass bearings to convert them to true bearings before plotting on navigational charts.



Remember it is only the true bearings or courses that should be plotted on the charts!

The compass error is named east or west and it is the angle between true north and compass north. Figures 1.20 to 1.23 show various combinations of variation and deviation and also show the compass error.

1.3.5 Compass on the Ship

The magnetic compass has been discussed as if it took the form of a bar magnet or a compass needle, but in reality a ship's magnetic compass is much more complex than that. Instead of placing a compass needle in a suspension mechanism, a magnetic compass consists of a card (Figure 1.24) with magnetised needles attached to its underside. These are aligned to the north and south line marked on the card. Until recently, the traditional marine magnetic compass was marked with cardinal, inter-cardinal, intermediate and by-points (shown in Figure 1.24), along with three digit notations. In modern magnetic compasses, the marking is only with three-digit notations (0° – 360° clockwise), with 000° being north.

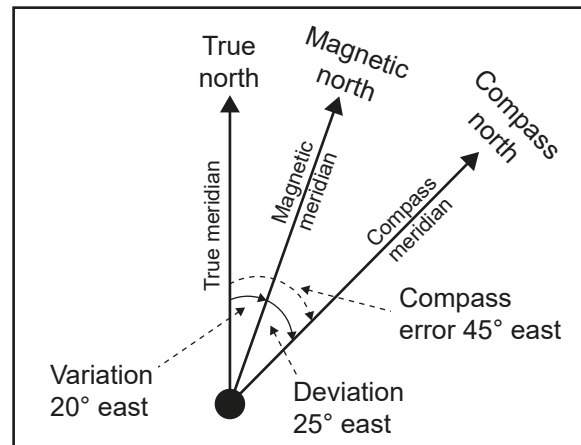


Figure 1.20

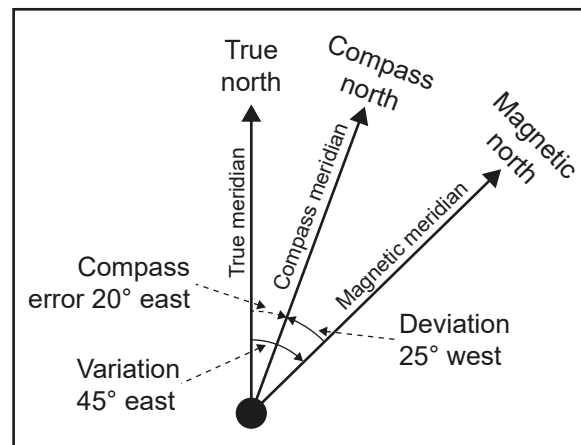


Figure 1.21

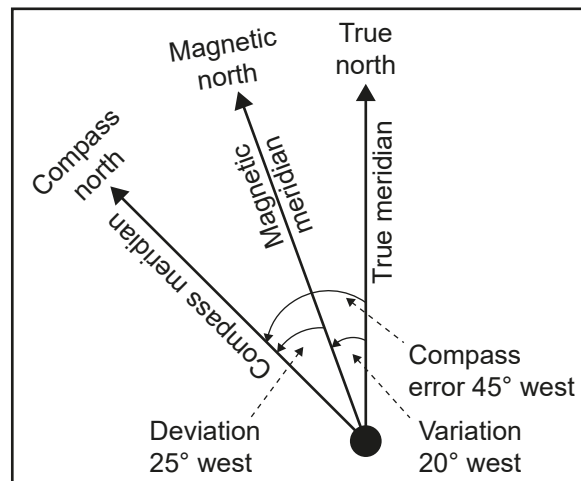


Figure 1.22