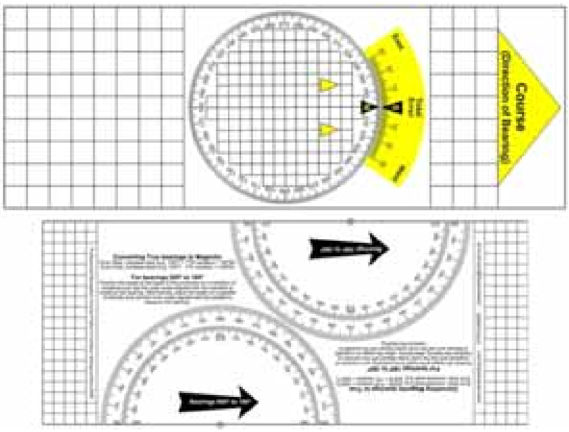
Latitude and Longitude

If you turned around and kept on turning until you were facing in the same direction again you would have turned through an angle of 360 degrees. A circle is made up of 360 degrees which is usually written as 360º. Degrees are then subdivided into minutes and there are 60 minutes in each degree. Although minutes can again be subdivided into seconds and there are 60 seconds in each minute, in marine navigation we use degrees, minutes and decimals of minutes instead of degrees, minutes and seconds.

Any position on the earth's surface can be expressed by two co–ordinates, (1) latitude up to 90 degrees north or south of the equator and (2) longitude up to 180 degrees east or west of the prime meridian, also known in the UK as the Greenwich meridian.

Latitude is always written before longitude, e.g. 50°13'.90N 005°37'.10W and never the other way around, e.g. 005°37'.10W 50°13'.90N.

Marine course plotters



There are a bewildering number of designs of course plotter available for marine navigation.

The most common type is the Breton type of plotter (the top one in the illustration). The base is a rectangular piece of perspex with grid lines and an "error" scale. On this base is mounted a 360° rotating protractor made of the same material. A common complaint about this type of plotter is that the rotating protractor tends to "stick", and then "jump" too far to get exactly the bearing required, thereby making it difficult to achieve consistent plotting accuracy.

We have visited the bridge on a number of commercial ferries operating between the UK and the continent and noted on the chart table a different design of course plotter, with no moving parts. Navigating officers told us that this type of plotter is more accurate than any other that they have used. We thought this to be quite an endorsement of the design from professional navigators but it couldn't be sourced in the UK. So now we have the plotter specially manufactured for our RYA courses. Naturally we'll be showing you how to use it as we consider it is the best and most accurate tool for the job.

Understanding latitude

If lines were drawn from the centre of the earth to: (1) the equator and (2) another position, the vertical angle in degrees between those 2 lines at the centre of the earth would be the latitude of the position at (2).

Let's take an example and say the angle is 50°. Since the position is north of the equator, latitude is said to be 50°N. If all the points with a latitude of 50°N were joined by a continuous line, such a line would be parallel to the equator and is called a parallel of latitude, in this case the 50th parallel.

Each degree is subdivided into 60 minutes, so if the angle shown was 50.5°, the latitude would be expressed as 50°30'N. Each minute may be further subdivided into tenths of a minute e.g. 50°30'·5N if it was half a minute and not 50°30'30"N.

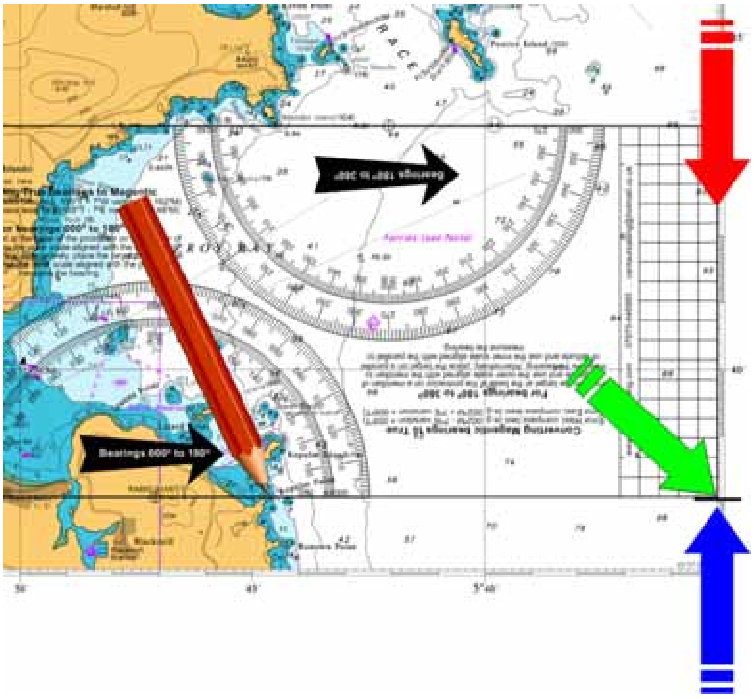
NB: If latitude is less than 10 degrees it is correctly expressed with a single leading zero, e.g. 09ºN. There can only be one leading zero since latitude will never exceed 90 degrees although for zero degrees, almost on the equator, to be correct there would be two zeroes, e.g. 00ºN.

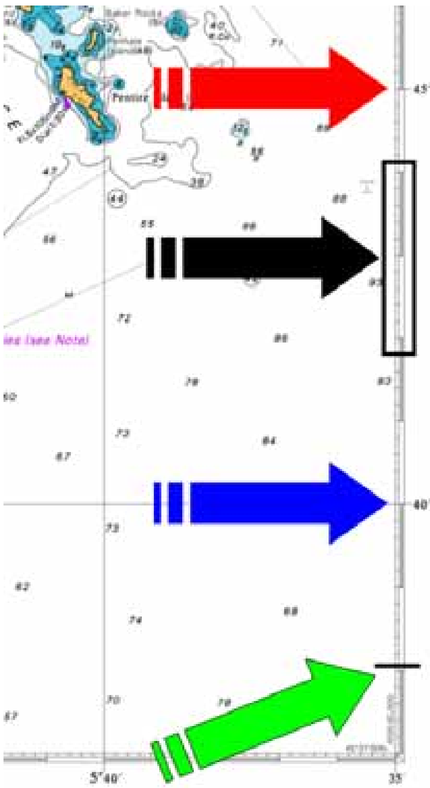
Plotting latitude

Open up RYA Training Chart 3, perhaps folding it conveniently, so you can see the bottom right hand corner, this is why navigators like big tables, or small charts!

Take your pencil and place the point at the centre of the symbol for the rock that is awash at the level of Chart Datum (just off Repulse Point) and hold the pencil point there as shown. Next take your plotter and slide it up against the pencil point so that one of the grid lines on the base of the plotter exactly lines up with the latitude scale, i.e. from the red to the blue arrow. If the total length of the grid line on the plotter is in line with the latitude scale then the plotter must be exactly perpendicular to the scale.

Hold the plotter firmly with one hand and make a pencil mark across the latitude scale as indicated by the green arrow. Place your pencil and plotter out of the way and you are ready to read the latitude of the rock.





Reading latitude

Locate two adjacent numbers on the latitude scale, we'll use the 45' mark indicated by the red arrow and the 40' mark indicated by the blue arrow. Degrees are not shown with every minute mark, e.g. 45' and 40' are shown instead of 45°45' and 45°40' respectively.

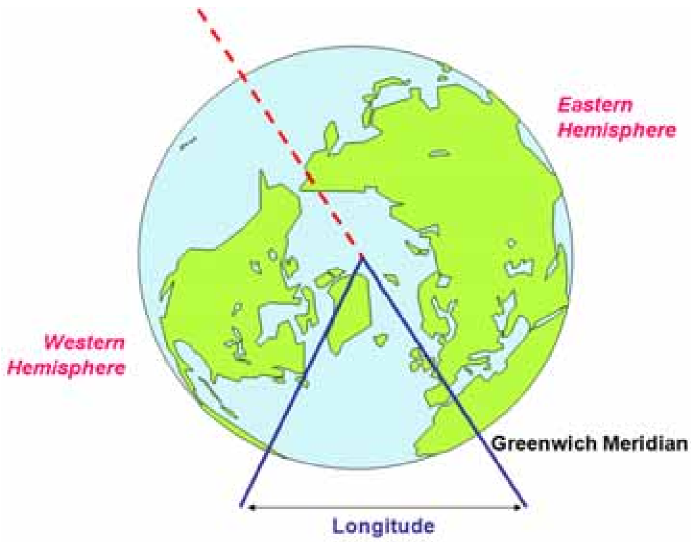
Identifying the 5 divisions between the 45' and 40' marks shows that in the black frame there are 2 minutes of latitude and that each of the 5 sub-divisions represents 0.2 minutes of latitude. This is a very important discipline, since the scale and sub-divisions used will differ from chart to chart or to put it another way, don't take it for granted that it'll be what you expect.

With this information we can see that the latitude of our rock is a quarter of a division up from 38' so it is 38'.05N (remember that each sub-division equals 0.2'). A glance further up the latitude scale will reveal the degrees part of the latitude, alternately you can look in a corner of the chart where the latitude is given, for example the bottom right has a latitude of 45º37'.00N. So the latitude of our rock is 45º38'.05N.

Understanding longitude

When looking down at the Earth from over the north pole, if lines were drawn from the centre of the earth to: (1) the prime (Greenwich) meridian and (2) another position, the angle in degrees between those 2 lines at the centre of the earth is the longitude of the position.

Let's again take an example and say the angle is 50°. Since the position is west of the prime (Greenwich) meridian the longitude is said to be 050°W. Note that if the position were east of the prime (Greenwich) meridian the longitude would be said to be 050°E. If all the points with a longitude of 050°W were joined by a continuous line, it would run from pole to pole and be called a meridian of longitude.



As for latitude, each degree is subdivided into 60 minutes, so if the angle shown was 50.5°W, the longitude would be expressed as 050°30'W. Again, each minute may be further subdivided into tenths of a minute e.g. 050°30·5'W if it was half a minute and not 050°30'30"W.

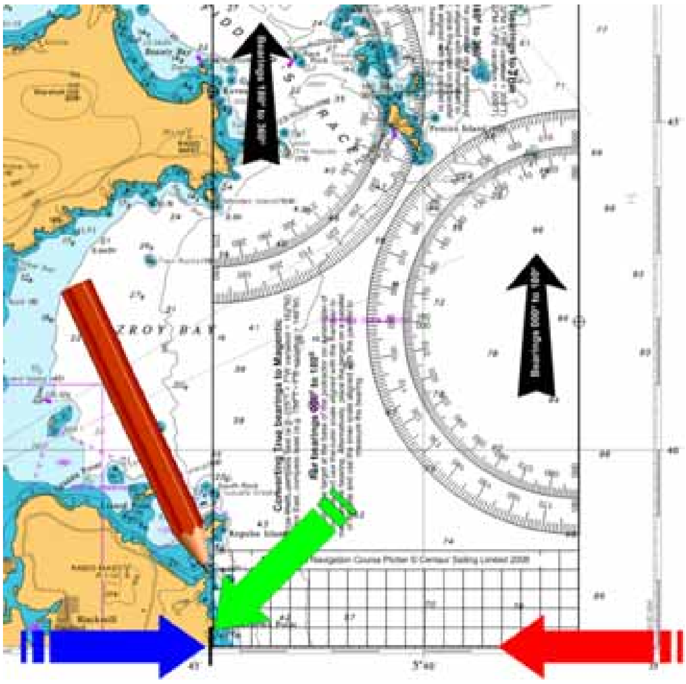
NB: If longitude is less than 100 degrees it is correctly expressed with a single leading zero, e.g. 099ºW and if less than 10 degrees it is correctly expressed with a double leading zero, e.g. 009ºW. Longitude can never exceed 180 degrees although for less than one degree, almost on the prime meridian (Greenwich Meridian), to be correct there would have to be three zeroes, e.g. 000ºW unlike latitude for which the maximum is two.

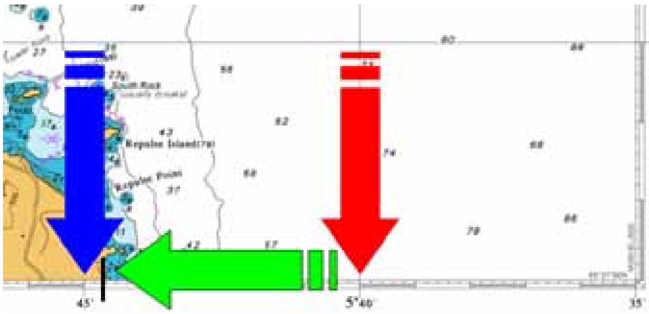
Plotting longitude

Open up RYA Training Chart 3 again so you can see the bottom right hand corner.

Take your pencil and place the point at the centre of the symbol for the rock that is awash at the level of Chart Datum (just off Repulse Point) and hold the pencil point there again. Next take your plotter and slide it up against the pencil point so that one of the grid lines on the base of the plotter exactly lines up with the longitude scale, i.e. from the red to the blue arrow. If the total length of the grid line on the plotter is in line with the longitude scale then the plotter must be exactly perpendicular to the scale.

Hold the plotter firmly with one hand and make a pencil mark across the longitude scale as indicated by the green arrow. Place your pencil and plotter out of the way and you are ready to read the longitude of the rock.





Reading longitude

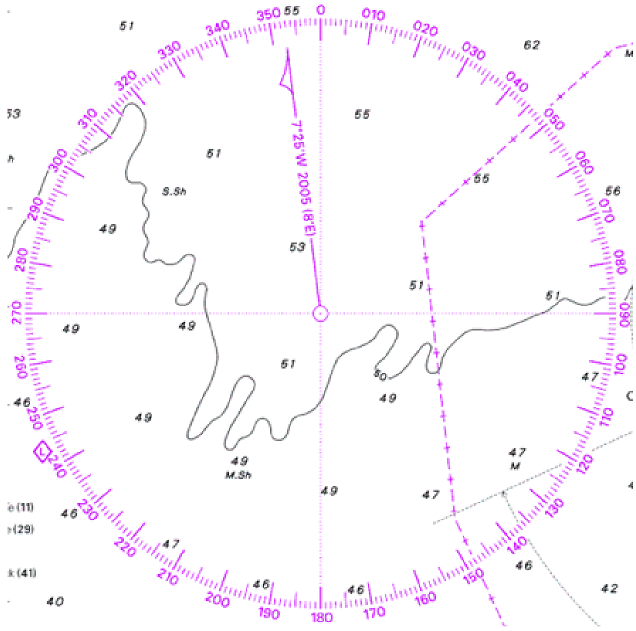
Locate two adjacent numbers on the longitude scale, we'll use the 45' mark indicated by the red arrow and the 5º40' mark indicated by the blue arrow. Degrees are not shown with every minute mark, e.g. 45' is shown instead of 005°45'. Please note that the omission of the 2 leadings zeroes by the publishers, in order to avoid filling the chart with detail thus making it busier and harder to read, doesn't make it good practice for us to do the same. As we said for latitude, this is a very important discipline, since the scale and sub-divisions used will differ from chart to chart or to put it another way, don't take it for granted that it'll be what you expect.

With this information we can see that the longitude of our rock is just under 2 sub-divisions right from 45' (don't forget that each sub-division equals 0.2') and that longitude west increases the further west it goes from the prime meridian. A glance at a corner of the chart where the longitude is given, for example the bottom right has a longitude of 005º35'.00W, so the longitude of our rock is 005º44'.62W.

The co-ordinates of the rock are therefore: 45º38'.05N 005º44'.62W.

Bearing & Distance

As well as using latitude and longitude to find a position, the bearing and distance from a landmark, or other charted object, can be used. In this section we'll start using the navigational plotter and pencil holding compasses for plotting both bearings and distances respectively.

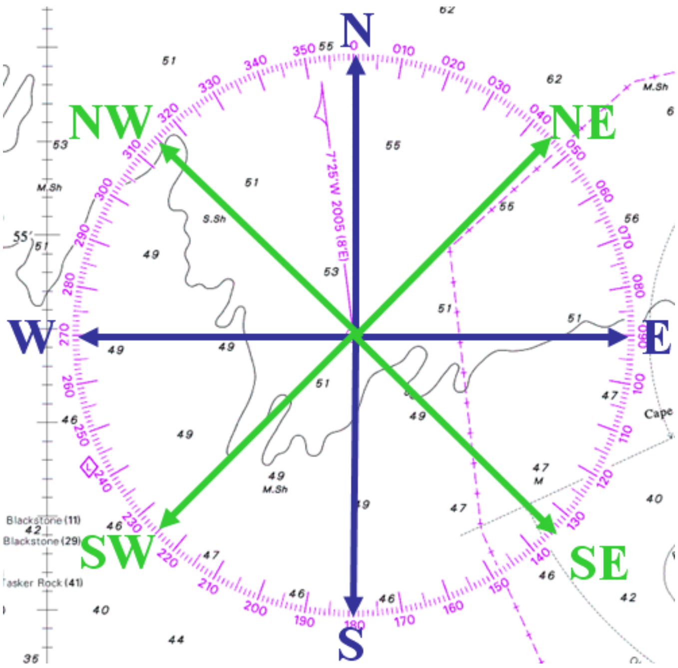


The illustration to the right is the compass rose between Southern Peninsula and Slade Island on RYA Training Chart 3. We'll be using this compass rose to confirm bearings that we'll plot with a navigational course plotter.

The compass rose is simply a protractor where the figures around it give the bearing, in degrees related to TRUE north, from the centre of the compass rose.

The line from the centre of the compass rose pointing towards 353°T ("T" = TRUE) is the direction of MAGNETIC north from that part of the chart. From the text along the arrowed line we can see that in 2005, MAGNETIC north was 7°25' to the west of TRUE north. This difference between TRUE north and MAGNETIC north is called VARIATION. The 8' E (in brackets) tells us that following 2005, variation decreases by 8 minutes per annum.

Please note that you need to recognise how easily confusion can be caused with an ambiguous bearing such as 353° because it could mean either 353°T or 353°M, i.e. a difference of 7°, which after a 60 mile run would mean an error of 7 miles!



Cardinal points of the compass

We'll start with North, which is often expressed as "due North". As we know, a circle is divided into 360 degrees, so North may be expressed as either 000°T or 360°T – either is acceptable.

The blue arrows and letters show the 4 cardinal points of the compass, it is from these "cardinal" directions that the cardinal system of buoyage is named. NCM is the abbreviation for north cardinal mark, a buoy or other mark that marks the northern end of an underwater hazard and the safe water is to the north of the NCM. An "east cardinal" would mark the eastern extremity of the hazard with safe water to the east of it, and so on.

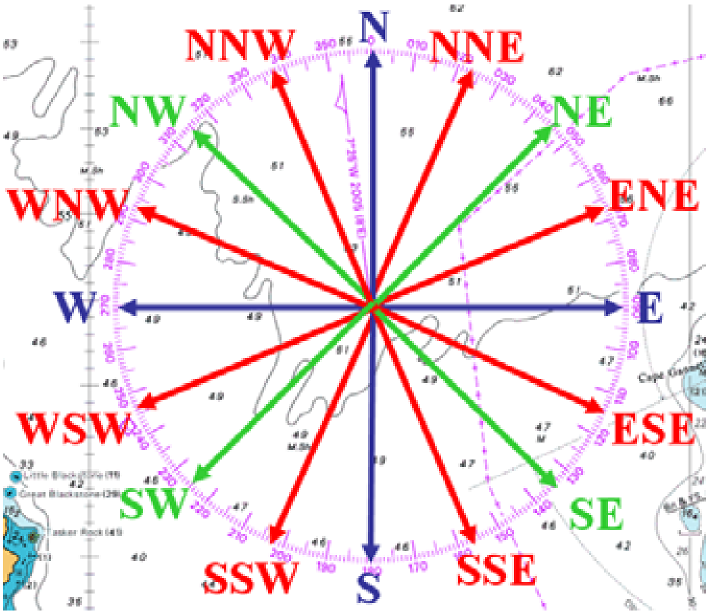
Adding, or subtracting, 180° to or from a bearing gives what is called the "reciprocal" bearing. South at 180°T is the "reciprocal" bearing of North at 000°T, in other words if a straight line were drawn heading towards North, the reciprocal would be along the same line but going in the opposite direction. West at 270°T is the "reciprocal" bearing of East at 090°T. In each case the reciprocal must differ by 180°.

In naming the green intermediate directions, we can take the relative importance of the 4 cardinal directions as being (1) North, (2) South, (3) East and West. Now it's easy! NE is named with N first so it can't be EN as North is more important than East. SE is named with S first so it can't be ES as South is more important than East. SW is named with S first so it can't be WS as South is more important than West. Finally, NW is named with N first so it can't be WN as North is more important than West.

We've seen that a complete circle involves a complete rotation of 360°T, you may also encounter the term 720°. This is used in racing, where it means to perform 2 complete circles with the boat, as a penalty for infringing a rule, before continuing on with the race.

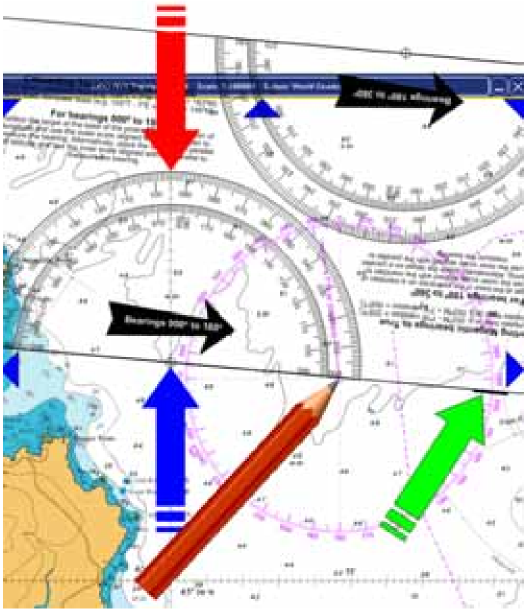
Bearings can go up to 360° and are always written with 3 digits, so where there are less than 3 digits, leading zeroes are used to make up the number. In addition, to avoid any ambiguity, and thereby misunderstanding, they must always be defined as: T for True, M for Magnetic or C for Compass. We'll discuss these terms for bearings further in module DS04.

In naming the intermediate directions shown in red, we continue taking the relative importance of directions to guide us: (1) North, (2) South, (3) East and West, (4) North-East and North-West, (5) South-East and South-West. NNE is named with N first as North is more important than North-East. ENE is named with E first as East is also more important than North-East. ESE is named with E first as East is more important than South-East. Finally, SSE is named with S first as South is also more important than South-East. It's the same on the West side of the compass rose, can you work it out using this method?



In marine navigation we only use these cardinal based directions for the wind, on all other occasions we use bearings. When describing a wind as a westerly we mean that it is coming FROM the West towards the centre of the compass rose, and when describing a boat direction or perhaps the direction of a tidal stream with a bearing of 270°T, which is West, the direction is always TOWARDS the bearing and away from the centre of the compass rose.

Please note that decimals of degrees of bearings aren't used in marine navigation, they are always rounded to the nearest whole number of degrees e.g. 022.5°T becomes 023°T.



Plotting a bearing less than 180°T using a meridian of longitude

As with latitude and longitude, so much of the later material in this course depends on your ability to draw or to measure an accurate bearing, so it is both wise and necessary to take care to develop good practice at this stage.

We'll start with plotting a bearing of 095ºT. First we'll use a meridian of longitude (vertical lines going from the top to the bottom of the chart). Since the bearing is less than 180ºT, we'll be using the protractor on the plotter with the black arrow marked "Bearings 000º to 180º".

Place the point of your pencil in the centre of the compass rose. Lay the plotter on the chart so that the edge of the plotter is up against the pencil, i.e. passes through the centre of the compass rose. Manipulate the plotter so that while the edge is kept up against the pencil, both the "target" (the small circle indicated by the blue arrow) and 095ºT on the outer scale (indicated by the red arrow) are accurately aligned with a meridian of longitude (a vertical line) on the chart.

Holding the plotter so that it cannot move, draw a line that intersects the bearing scale surrounding the compass rose at the position indicated by the green arrow. Remove the plotter and examine where the pencil line intersects the scale on the compass rose to confirm it is 095ºT.

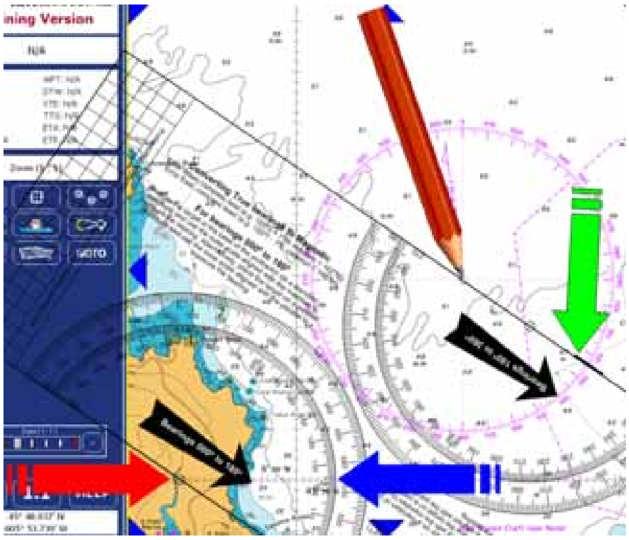
There is a strip of clear plastic between the line against the pencil in the illustration and the physical edge of the plotter which cannot be seen in the illustration, ensuring the target is placed as described above simply use the edge of the plotter instead of the line shown.

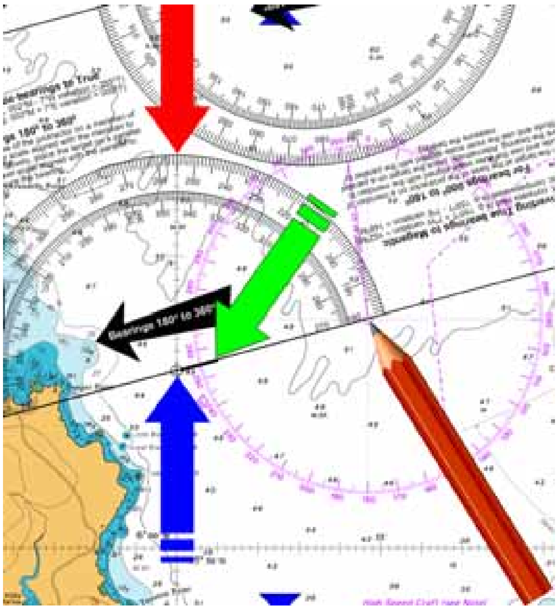
Plotting a bearing less than 180°T using a parallel of latitude

Now we'll plot a bearing of 124ºT using a parallel of latitude (horizontal lines going from the one side of the chart to the other). As we are still working with a bearing that is less than 180ºT, we'll again be using the protractor on the plotter with the black arrow marked "Bearings 000º to 180º".

As before, place the point of your pencil in the centre of the compass rose. Lay the plotter on the chart so that the edge of the plotter is up against the pencil, i.e. passes through the centre of the compass rose. Manipulate the plotter so that while the edge is kept up against the pencil, both the "target" (red arrow) and 124ºT on the inner scale (blue arrow) are accurately aligned with a parallel of latitude (a horizontal line) on the chart.

Holding the plotter so that it cannot move, draw a line that intersects the bearing scale surrounding the compass rose at the position indicated by the green arrow. Remove the plotter and examine where the pencil line intersects the scale on the compass rose to confirm it is 124ºT.





Plotting a bearing greater than 180°T using a meridian of longitude

Next we'll plot a bearing of 255ºT using a meridian of longitude (vertical lines). Since the bearing is greater than 180ºT, we'll be using the protractor on the plotter with the black arrow marked "Bearings 180º to 360º".

Just like we did before, place the point of your pencil in the centre of the compass rose. Lay the plotter on the chart so that the edge of the plotter is up against the pencil, i.e. passes through the centre of the compass rose. Manipulate the plotter so that while the edge is kept up against the pencil, both the "target" (blue arrow) and 255ºT on the outer scale (red arrow) are accurately aligned with a meridian of longitude (a vertical line) on the chart.

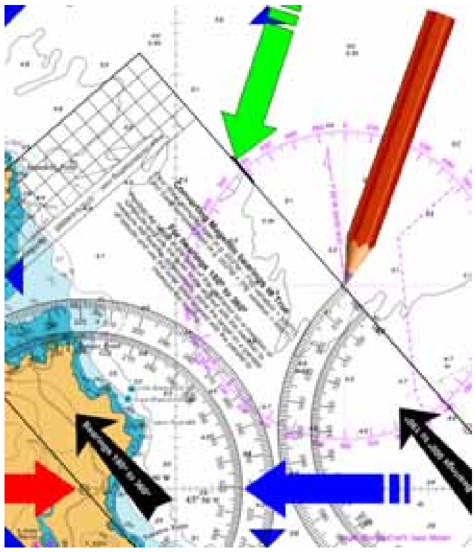
Holding the plotter so that it cannot move, draw a line that intersects the bearing scale surrounding the compass rose at the position indicated by the green arrow. Remove the plotter and examine where the pencil line intersects the scale on the compass rose to confirm it is 255ºT.

Plotting a bearing greater than 180°T using a parallel of latitude

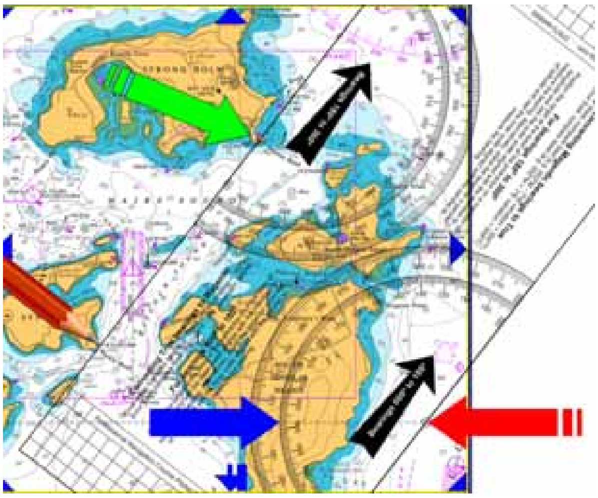
Now we'll plot a bearing of 319ºT using a parallel of latitude (horizontal lines). As we are still working with a bearing that is greater than 180ºT, we'll again be using the protractor on the plotter with the black arrow marked "Bearings 180º to 360º".

Once again place the point of your pencil in the centre of the compass rose. Lay the plotter on the chart so that the edge of the plotter is up against the pencil, i.e. passes through the centre of the compass rose. Manipulate the plotter so that while the edge is kept up against the pencil, both the "target" (red arrow) and 319ºT on the inner scale (blue arrow) are accurately aligned with a parallel of latitude (a horizontal line) on the chart.

Holding the plotter so that it cannot move, draw a line that intersects the bearing scale surrounding the compass rose at the position indicated by the green arrow. Remove the plotter and examine where the pencil line intersects the scale on the compass rose to confirm it is 319ºT.



Reading a bearing



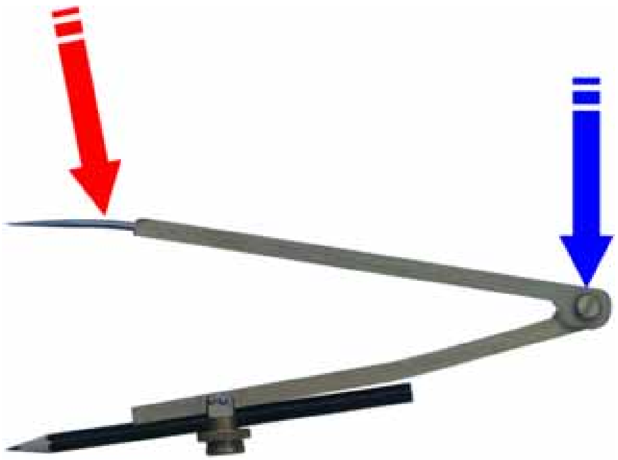
Sometimes as well as draw a bearing line, we need to be able to read the bearing between two charted features. Since we can see that the bearing (from the pencil point to the green arrow) is less than 180ºT, we'll be using the protractor on the plotter with the black arrow marked "Bearings 000º to 180º".

First the pencil point is placed in the centre of the open asterisk of the major light at Huckle Head on Synka. Then the plotter is placed onto the chart with the black arrow marked "Bearings 000º to 180º" pointing towards the asterisk marking the major light at Mutton Head on Strong Holm (the green arrow). Slide the plotter up against the pencil and adjust the position of the plotter so the edge passes almost through the centre of the asterisk marking the light at Mutton Head (allowing for another but imaginary pencil point).

Decide whether a meridian of longitude or a parallel of latitude is nearest to the "target" on the plotter (indicated by the red arrow), in this case a parallel of latitude involves least movement of the plotter. Re-adjust so that the plotter edge passes through both asterisks and the "target" is exactly on the parallel of latitude (red arrow) and read the bearing 038ºT, from the inner scale (blue arrow).

The tool for the job

To the right is the MOD pattern wide-span brass pencil-holding compasses used to measure distance. You could use a pair of dividers but they can damage a chart. This item, and an even better design that has an attachment that enables the pencil point to articulate for drawing smaller arcs/circles, is made by Weems & Plath. Either can be obtained from www.bookharbour.com.



You could use a pair of pliers to induce enough bend in the compass point, at the position indicated by the red arrow. This brings the points closer together and facilitates drawing of quite small arcs. These compasses can be a little stiff at first and may tend to stick when you try to adjust them and then they jump to anything but the distance desired. They can be "eased" quite easily. Using 2 flat-bladed screw-drivers, loosen the screws at the joint (indicated by the blue arrow) and squirt a little WD40 or other very light lubricant into the joint. Then tighten the joint again to your desired working tightness.

Setting the compass to the distance to be measured

Looking at the right hand side of the upper half of RYA Training Chart 3, we'll measure the distance between the major lights on Holm Point and Johnson Point.

Carefully set the compass point and the point of the pencil so that they touch the centre of the open asterisk symbol that marks the position of each of the major lights (or lighthouses). If you are using a 2B pencil, you can even describe an easily erasable arc through the second light to be sure the measurement is accurate.

Using the adjacent latitude scale to measure the distance

Take the compasses to the adjacent latitude scale and place the point on the 15' line and either lay the pencil on the scale above it or draw a small arc so you can clearly see where it cuts the scale. Here the pencil arc would cut the scale at 4½ sub-divisions up from the 20' line. Looking at the scale between 15' and 20' it is clear that there are 5 main divisions of 1' each, and that each minute has 5 sub-divisions of 0.2' each. Therefore, our arc crosses the latitude scale at 20.9' (5.9' from the 15' mark) so the distance between the major lights on Holm Point and Johnson Point is 5.9 miles.

On a Mercator chart the latitude axis down the side of the chart is the only axis where, in the vicinity of the boat's position, one minute of arc is equal to one sea mile (about 2000 yards or 1850 metres) – this is NOT true on the longitude axis. One tenth (0.1') of a nautical mile is called a "cable" and is about 200 yards. This makes it very important to measure distances using the latitude scale adjacent to the distance being measured.

Developing your best practice

To make absolutely sure that the compasses didn't open or close while you moved them from the chart to the latitude scale, just take them back and make sure they still measure the same distance. In this case they were still set at the correct distance, so we can be confident that the measured distance between the 2 lights is 5.9 miles.

We recommend that you adopt this double-check EVERY time you measure distance, then you can be confident in your plotting accuracy and by developing this "best practice" you are on your way to becoming a competent navigator.

If you measure the distance of 5 minutes of latitude at the top of the chart (the top left hand corner of the chart is at a latitude of 46º30'N) it won't be the same as 5 minutes of latitude at the bottom (the bottom right hand corner of the chart is at a latitude of 45º37'N). So there's even a demonstrable difference in less than one degree of latitude.