TIDAL THEORY

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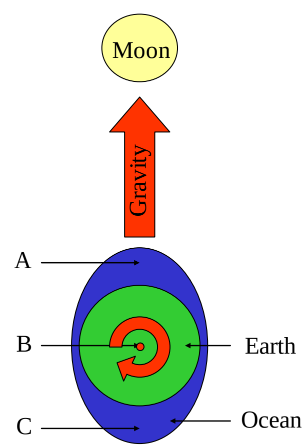
Tide is one of those areas that the more you learn about it, the more you realise you don't know. As sea kayakers (and dinghy sailors) and not necessarily scientists, we don't have to know every detail but a simplified understanding can help us to understand and predict what we might expect to see when we are out on the water.

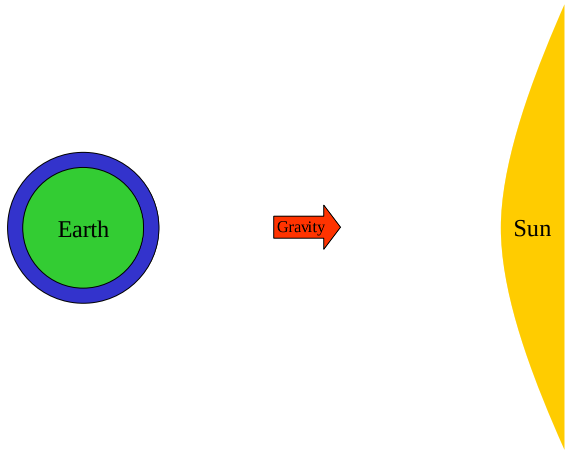
Causes of Tide

To understand tide it is convenient to imagine the earth with an envelope of water all around it, spinning once every 24 hours on its north-south axis with the moon on a line parallel to the equator.

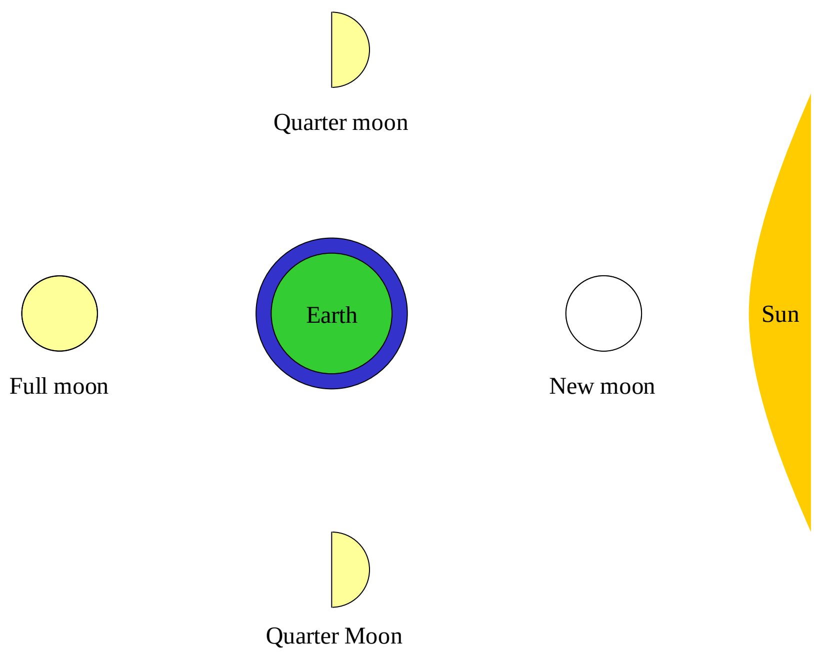


The tides are primarily caused by the gravitational attraction of the moon. Simplifying a bit, at point A the gravitational pull is the strongest causing a **high tide**, point B experiences a medium pull towards the moon, while point C has the weakest pull causing a second high tide. Because the earth spins once every 24 hours, at any location on its surface there are two high tides and two low tides a day. There are approximately six hours between high tide and low tide. One way of predicting the approximate time of high tide is to add 50 minutes to the high tide of the previous day.

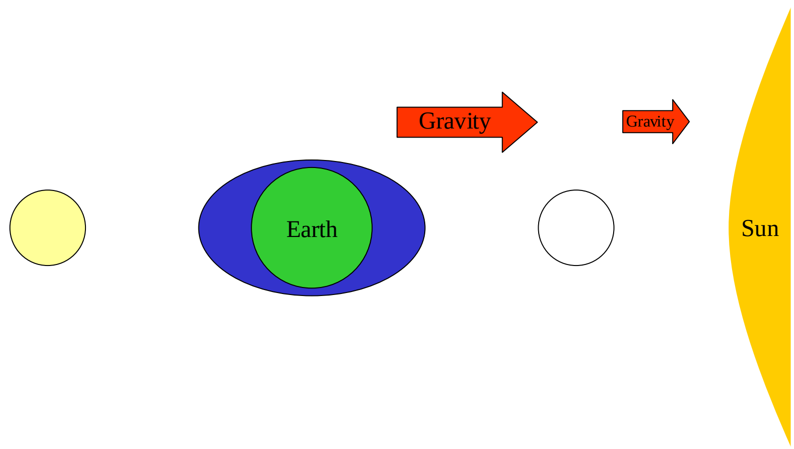
The sun has a similar but weaker gravitational effect on the tides. On average this is about 40 percent of that of the moon. The main importance of the sun is the effect of either reinforcing the moon's force or reducing it depending on their positions relative to each other.



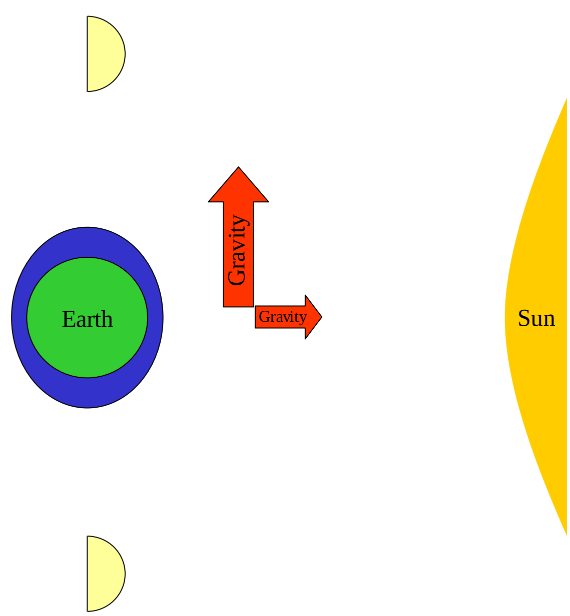
The moon orbits around the earth once every lunar month or 29 ½ days, this changes its position in relation to the sun. You can tell where the moon is in relation to the sun by its phase.



When the sun and moon are in line both their forces work together to create **spring tides**. Spring tides have higher 'high water' and lower 'low water' (i.e. the greatest **tidal range**). The word spring is derived from the Norse word sprungen, meaning big.



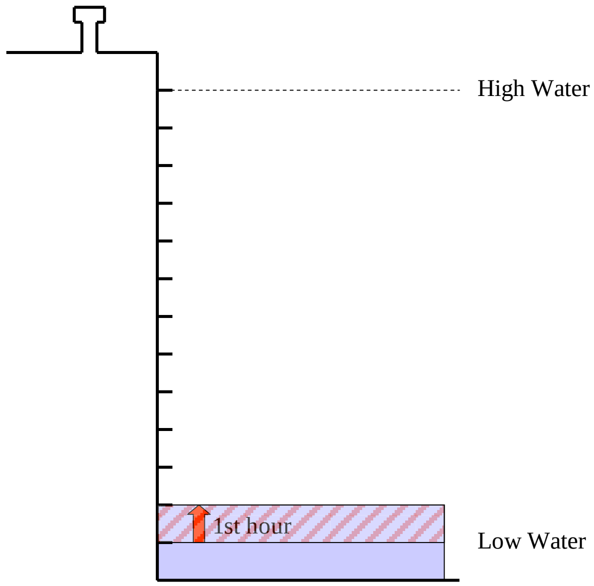
Neap tides occur when the sun and moon's forces oppose each other. They have lower 'high tides' and higher 'low tides' (i.e. the smallest range). There are two spring tides every lunar month and two neaps. There are approximately seven days between springs and neaps. The spring and neap tides lag the lunar phase by approximately two days (i.e the spring tide is two days after the full moon).



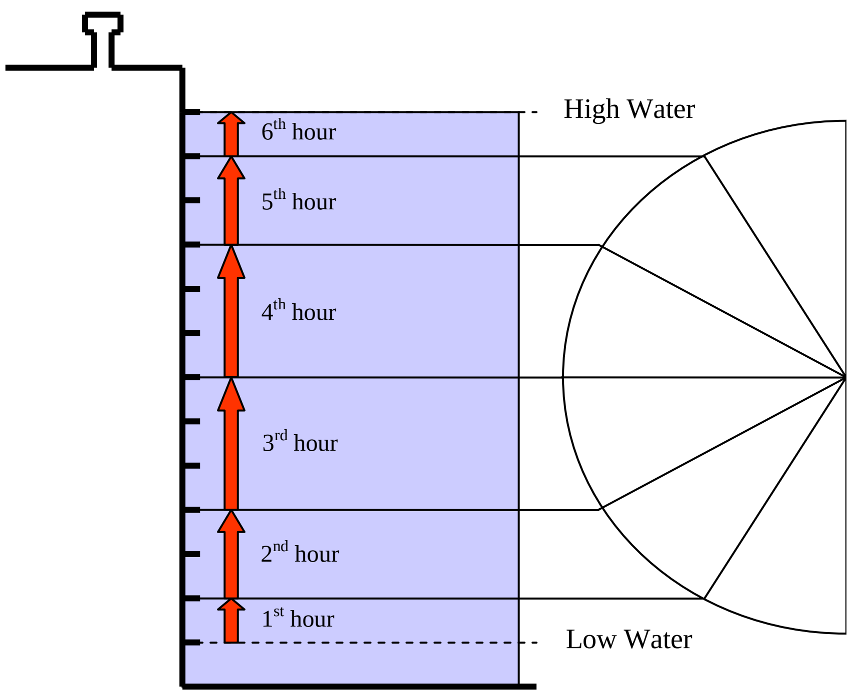
Rate of Vertical Movement

The following diagrams depict a dockside with a ladder with twelve rungs running up its side. Starting from low tide we will look at the rate the tide rises over the six hours till high tide.

In the first hour the tide rises one twelfth of its overall range.



In the second hour it rises two twelfths on top of the twelfth it has already risen. During the third and fourth hour; three twelfths, the fifth; two twelfths, and the sixth; one twelfth. The half clock face depicts the cyclical nature of this movement.



This is called the 'Rule of Twelfths'. Once the tide reaches high tide it starts to drop in exactly the same way. The two important points to note are that in the third and fourth hour there is a lot of tidal movement, and in the first and sixth hour there is very little.

Rule of 1/12ths

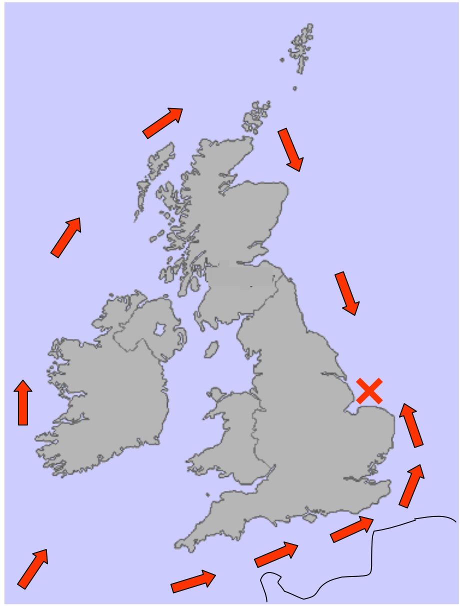
Time since low water	Water level rise
1st hour	1/12th
2nd hour	2/12th
3rd hour	3/12th
4th hour	3/12th
5th hour	2/12th
6th hour	1/12th

This is a rule of thumb of the tide height. The height of the tide at any time can be determined by multiplying the tidal range by the number of twelfths since or until high water and subtracting this from the height at high water.

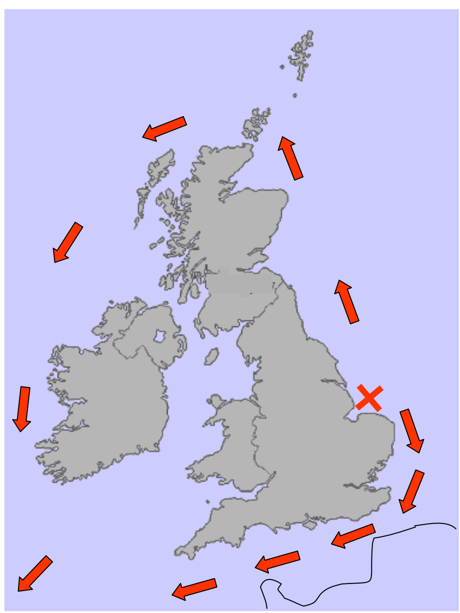
For example, if the height of the tide at high water is 5m and at low water 1.2m, then the range is: 5-1.2 = 3.8m. The height of the tide at two hours after high water will have dropped: 1/12 + 2/12 = 3/12. Multiply the range by number of twelfths dropped: 3.8 x 3/12 = 0.95m. And subtract this from the height at high water: 5 – 0.95 = 4.05m.

Tidal Streams

When the moon causes high tide, water has to flow in from elsewhere to make up the extra volume of water. The diagram is a very simplified version of the direction the flood tidal streams around the UK. The **flood tide** is the rising tide from low water to high water. Each arrow approximately represents one hour of movement.



The **ebb tide** or falling tide flows in the opposite direction.

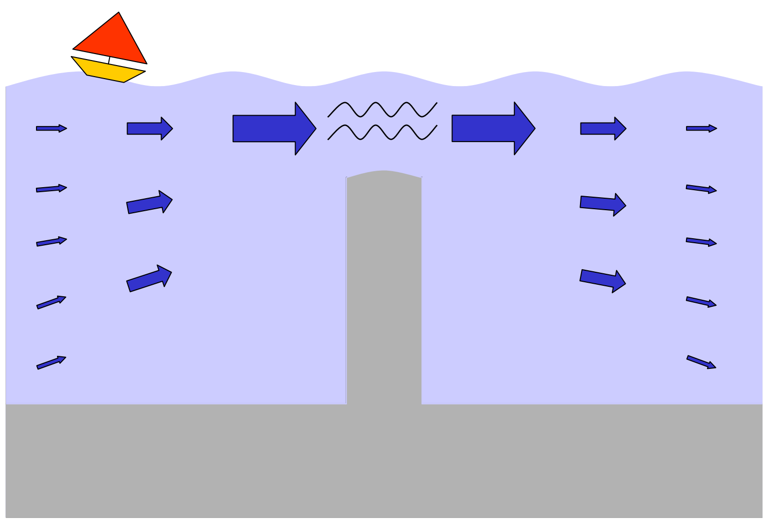


The time between the ebb and the flood and the flood and the ebb is called **slack water**. In the same way that the rate of vertical movement starts slowly and builds up, before slowing down, so does the speed of the flow. There are a couple of rules of thumb that help you predict this. The rule of thirds is related to the rule of twelfths, but only refers to the speed of flow, and the 50/90 rule which also only refers to flow but generally gives a more accurate representation of what really happens.

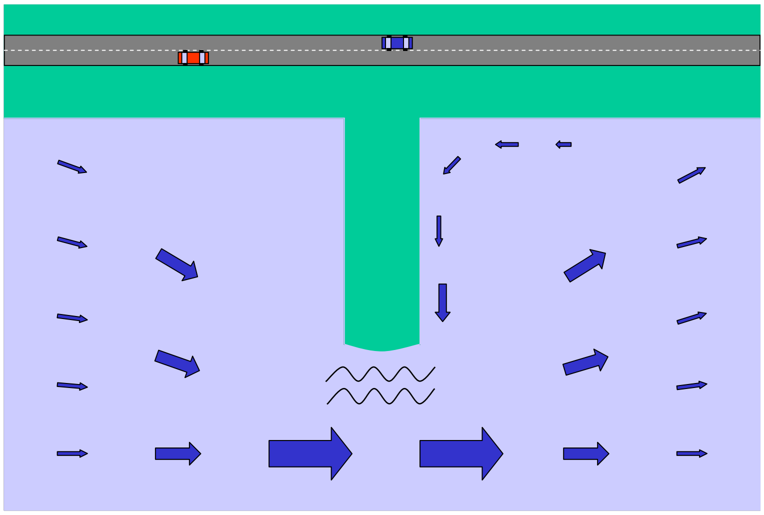
	Hours after slack	1	2	3	4	5	6
Rule of Thirds	Thirds of max rate	1/3	2/3	3/3	3/3	2/3	1/3
	Speed in Knots	1	2	3	3	2	1
50/90 Rule	Percentage of max rate	50	90	100	100	90	50
	Speed in Knots	1.5	2.7	3	3	2.7	1.5

Races and overfalls

When the tide flows along the coast and comes across an obstacle that constricts its flow it speeds up as it goes around or over the obstacle. If it goes over the obstacle it is called an **overfall**.



If it goes around the obstacle it is called a **tidal race**. In practice a tidal race is often also an overfall as the sea bed around a headland or island tends to be shallow. An **eddy** (area of still water) or back eddy (area of water flowing against the main flow) will often form behind the obstacle.



Theses areas of fast flowing water can potentially form waves and rough water if combined with wind and or waves. If the wind is blowing in the same direction as the tide it reduces the wave height and increases the wave length, if it is blowing against the tide it increases the wave height and reduces the wave length. River mouths can produce similar effects to tide races.

Reference Sources

Information concerning tides can be found on Tide tables, Charts, Tidal stream atlases and Pilots.

Tide tables for specific locations are published in a variety of literature sources and on the internet. They show times and heights of high and low water daily.

Charts show positions where tidal streams have been measured by a letter within a diamond. An associated table shows the direction and speed of spring and neap rate of the streams at these positions for each hour before and after high water at the standard port (Fig Tidal diamond with annotations).

Tidal atlases have a separate page for each hour before and after high water at the standard port. The direction and the speed of the flow is shown by arrows with numbers alongside to indicate the mean rate in tenths of a knot. The first pair of numbers show the rate at neaps and the second at springs.

Pilots, in their sections on tidal streams, describe the tidal streams directions and speeds in words.

Other Effects

As well as the moon and the sun, other things can affect the tide.

Atmospheric pressure – This can increase high tide levels by several meters. 10 millibars can result in a difference of 0.1 meters on the tide level, the change takes time to develop and applies to the average pressure over a large area of the sea.

Wind – A wind that has been blowing for some time over open water will set up a current in line with the direction of the wind. A wind of ten knots blowing for ten hours can create a current of up to one knot. Also if the wind blows into an enclosed channel and then drops, a current flowing back out of the channel can occur. In the English Channel when the wind blow from the west for a long lime the ebb tides get later and later and smaller and smaller than predicted. When the wind stops the next ebb tidal stream is usually about 20% more than predicted.

Landmass - The shape of the coastline and the sea bed can dramatically affect the tide heights, times and flows giving each location a unique tidal pattern. Some examples are: The highest tide range in the UK is at Bristol with over 15m, while many other parts of our coastline have less than 3 meters range. Southampton experiences a double-high water, a high water peak followed by a small drop, then a second high water peak followed by low water. In the Menai Straits the time of high and low water and the coinciding change in direction of flow, slack water, can vary by over two hours.

Inshore – The friction between the land and water means that really close inshore the flow of water is slower.

Eddies – There are eddies behind almost every obstruction in tidal streams, some only form areas of still water but some can cause powerful back eddies. In a bay where the tide flows strongly past the entrance, a back eddy will form. The flow of the eddy will lag behind the main flow and the fastest area of the eddy flow will be at the upstream entrance of the bay.

Turn of the tide – The tidal stream turns inshore first. If you are paddling/sailing against the tide you want to be close in because the streams are slower and you will pick up the flow going with you earlier. If you are paddling with the flow you don’t want to head in too early as the flow closer in will turn against you earlier.