Unit 12

HYDROGRAPHY/OCEANOGRAPHY – WAVES AND TIDES

Basic terms

• *Oceans* • *Seas* • *Waves* • *Currents* • *Tides* • *winds* • *Coastal lines* • *wavelength*	• *Wave effect on the ship* • *Environmental protection* • *Sea state* • *Swell* • *Rogue wave* • *Crest and trough of a wave* • *Significant wave* • *Phenomenal wave*
• *tides* • *spring tide* • *neap tide* • *low tide/water* • *high tide/water* • *slack water* • *tidal range* • *(tidal) stand*	• *flood* • *ebb* • *trade winds* • *setting (of current)* • *drift* • *tidal stream*

Hydrography is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection. (https://www.iho.int/)

In the past few decades, the following important factors have emphasized the need for adequate hydrographic survey coverage and the production of nautical charts and publications as required by SOLAS Chapter V;

- the advent of exceptionally deep draught VLCC ships
- the need to protect the marine environment
- changing maritime trade patterns
- the growing importance of seabed resources
- and the U.N. Law of the Sea Convention affecting areas of national jurisdiction.

Oceanography, also known as **oceanology**, is the study of the physical and biological aspects of the ocean. It is an Earth science, which covers a wide range of topics, including ecosystem dynamics; ocean currents, waves, and geophysical fluid dynamics; plate tectonics and the geology of the sea floor; and fluxes of various chemical substances and physical properties within the ocean and across its boundaries. (https://en.wikipedia.org/wiki/Oceanography)

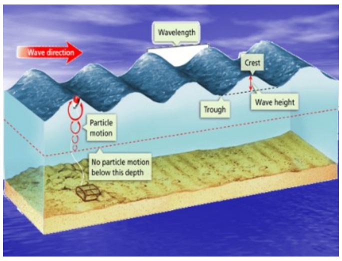
Wave terms:
Sea (or wind) waves are generated by the local prevailing wind and vary in size according to the length of time a particular wind has been blowing, the fetch (distance the wind has blown over the sea) and the water depth.
Swell waves are the regular longer period waves generated by distant weather systems. There may be several sets of swell waves travelling in different directions, causing a confused

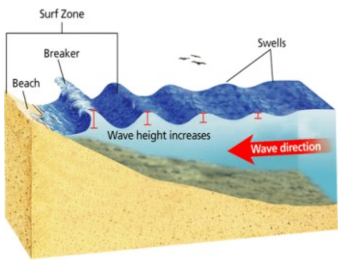
sea state.
Combined sea and swell is also known as total wave height, or significant wave height. Combined sea and swell describes the combined height of the sea and the swell that mariners experience on open waters. The height of the combined sea and swell refers to the average wave height of the highest one third of the waves.
Sea state describes the combination of sea (wind) waves and swell.
Wave height (trough to crest) for both sea and swell refers to 'significant wave height' which represents the average height of the highest one-third of the waves. Some waves will be higher and some lower than the significant wave height. **The probable maximum wave height can be up to twice the significant wave height.**
King or rogue waves are waves typically greater than twice the significant wave height. These very large waves are known to occur in areas where ocean currents run opposite to the prevailing sea and swell and where waves overrun each other, generating steep and dangerous seas. Mariners should be prepared for a rogue wave encounter.
Wave length: The mean horizontal distance between successive crests (or troughs) of a wave pattern.

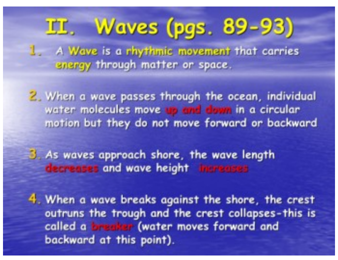
Sea and swell terms

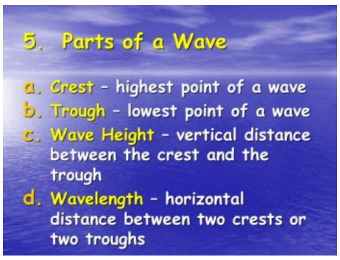
Sea waves: waves generated by the wind blowing at the time, and in the recent past, in the area of observation.
Peak wave period: Period in seconds between the swells of the primary swell component. The larger the time difference, the greater the amount of energy associated with the swells.
Primary swell: Height and direction of the swell with the highest energy component. This is sometimes referred to as the dominant swell.
Secondary swell: Height and direction of the swell with the second highest energy component.
Swell period: See Peak Wave Period.
Swell waves: waves which have travelled into the area of observation after having been generated by previous winds in other areas. These waves may travel thousands of kilometres from their origin before dying away. There may be swell present even if the wind is calm and there are no 'sea' waves.
Wave period: the average time interval between passages of successive crests (or troughs) of waves.
Wave height: Generally taken as the height difference between the wave

http://www.bom.gov.au/marine/knowledge-centre/reference/waves.shtml









Effects on ship that occurs because of encountering rogue waves at sea:

https://www.marineinsight.com/marine-navigation/effects-of-rogue-wave-on-ships/

Bow Slamming:

When a ship encounters high waves (especially in head seas), high amplitude pitching and heaving combined, produces an effect that sends the bow out of the water. As the wave passes aftward, the bow falls onto the surface (or slams the surface), with high acceleration, resulting in tremendous slamming forces in the f**Formation and Propagation of Cracks:**

Due to high slamming and pounding forces in the forward structure, the hull at the bow section is often prone to cracks that can propagate over the entire depth of the bow section.

Buckling of plates:

The shell plates at the bow and the bottom plating upto 25 percent of the ship's length aft of the forward perpendicular is subject to effects of slamming which result in buckling of these plates. Especially the bottom plating in the forward region, because in most lading cases, the ship is in hogging condition, which maintains the bottom shell in a state of compression. Major augment of stresses in the bottom plating therefore result in exceeding the buckling stress of the material, which may be much lower than the ultimate tensile stress.

Ultimate Failure

When forward structures have been subjected to large number of cycles of freak waves or slamming forces over a longer period of time, the structure undergoes fatigue. If scantling and structural surveys are not carried out regularly, then ultimate failure, leading to complete rupture of bow sections is not an impossibility when encountered with freak waves.

So designers have over the years, developed methods to combat freak waves by incorporating various factors of safety in structural design. Broadly, we will discuss them under the following distinctions:

Inclusion in Structural Formulae:

When the scantlings of a ship are calculated in preliminary design phase, designers use empirical formulae suggested and tested by classification societies. These formulae have been developed over extensive observation and analyses of statistical data of stressed that ships are subjected to at sea, and accordingly, factor of safety are considered in determing the scantlings, so as to prevent failure due to waves that are above the significant height.

Additional Strengthening against Slamming:

The hull girder is additionally strengthened at the bow. Some of the additional structures that are included are discussed below:

- **Panting stringers** that run longitudinally, are welded to the sideshell forward of the collision bulkhead. The height between subsequent stringer is usually 2 to 2.5 meters
- **Panting Beams** run transversely inside the deck shell, joining the panting stringer to the centreline wash bulkhead
- **Angled pillars** are used to support the panting beams at the centreline
- **Panting web sections** or perforated flats are used after between every one or two panting stringers. The side frames are end connected to these and the panting stringers via tripping brackets to ensure smooth stress flow
- **Plate floors** are used at every frame space ahead of the collision bulkhead forward structure of the ship.

Navigational Measures Taken On-Board:

Navigational measures are also taken on board a ship, to combat rogue waves, especially in high sea states. Remember the initial paragraphs of this article where we discussed about pitching and heaving motions induced onto a ship? The idea of navigational measures is just to reduce the pitching amplitudes.

The pitching amplitudes depend on the encountering angle and the encounter frequency. The encounter frequency is changed by changing the speed of the ship, and the encounter angle is altered by changing the heading of the ship. Though the latter may not always be feasible on fixed routes, the former is mostly used to reduce unwanted motions on the higher side.

How Ships Survive a Hurricane at Sea

For oceangoing ships, hurricanes are a threat long before they make landfall. This is how they prepare.

Storms at sea are harrowing experiences. Towering walls of water, driven by powerful winds, slam into the ship. A major storm can batter even the largest, sturdiest vessels. And they're an unavoidable part of life on the water.

Storms are part of life at sea, however. "If a ship is in the ocean, you're going to have heavy weather," says Fred Pickhardt, chief meteorologist at Ocean Weather Services. Captains can't dodge every storm, because, as Pickhardt explained, "ships are typically on a very tight schedule. Just the fuel alone on ships can be tens of thousands of dollars a day, so a two or three day delay or deviation can cost big bucks, so they always want to minimize it."

Most modern cargo ships are designed to tough out all but the heaviest weather and stay on schedule, but hurricanes are the largest and among the most dangerous storms on the ocean, and no crew wants to find itself in the midst of one.

Getting the Weather Report

To steer clear of hurricanes, mariners need good weather information. A century ago, weather updates at sea were limited to Morse code messages, but since the 1980s, weather updates have come to printers or fax machines right on the ship's bridge. U.S. cargo ships are required to carry a Navigational Telex (NAVTEX) machine, a radio receiver that picks up medium-frequency radio signals and converts them into a text printout. Another system called Weatherfax uses higher frequency radio waves to send black-and-white images to shipboard fax machines.

Today, captains can also receive weather maps, satellite images, and other information by email. Some vessels have more high-tech tools aboard, like onboard computer systems that help plan routes based on weather forecasts. "Anything you can get on a computer at home, you can probably get at sea through a satellite connection," Pickhardt says.

Ballast

The most dangerous ship in a hurricane is an empty one. That's because the weight of cargo helps stabilize the ship against the waves. Ballast provides a little stabilizing weight when ships sail empty, but not always enough.

"It can get kind of hairy, especially if you don't have cargo," former sea captain Max Hardberger tells Popular Mechanics. "When you have only ballast water way down in the bottom of the ship, the ship has a very wicked roll to it. I've been on ships, for example, where we would go from thirty degrees heeled over on one side, and we would whip across to thirty degrees heel on the other side in a matter of three and a half seconds, so you can imagine something like that will roll your eyeteeth out."

The rolling is hard for the crew, but the worst thing for a ship is the repeated impact of the hull slamming into the troughs between waves. Modern cargo ships are constructed of thick steel, but if the waves are large enough and their battering lasts long enough, the pounding of those impacts can still break a ship apart.

Any Port in a Storm?

Cargo ships don't always head for the nearest port when a hurricane approaches, because not all ports offer the same kind of shelter.

"If you have a choice," Hardberger says, "you obviously want to find what's known as a hurricane hole, which is going to be a port with very good holding and with high cliffs or mountains around the harbor to protect you from the winds."

Once in port, crews anchor the ship, leaving plenty of slack in the anchor chain to prevent the motion of the waves from snapping the chain. They might also put the ship's engine in reverse to put pressure on the anchor. "Once you've done those things and you're at anchor, there's not much else you can do except just hope and pray," Hardberger says.

Being caught in the wrong port can be dangerous. "After Katrina, there was a ship I went on in Lake Charles that had hammered its side against the docks during the hurricane and sustained some pretty heavy damage to its side," he says. That kind of battering takes a toll on the dock, too, and port authorities may order ships to leave ahead of a storm. "There are some ports that are so dangerous that ships will actually go out to sea, thinking that they'll be safer riding out the hurricane at sea than they are in port," Hardberger says.

Of course, the best plan is to get out of a hurricane's way. "At a modern ship speed of 14 knots, you should be able to outrun a hurricane," he says. But, Pickhardt says, "the later you leave, the less options you have. When you cut it too close, sometimes you get in trouble."

If All Else Fails

What if a ship must face a hurricane at sea? "You would try to steer for the area of the ocean that is going to see the shallowest waves and the lowest winds," Hardberger says. The "low side" or "clean side" of the storm is usually the side counterclockwise from its leading edge.

In the teeth of the storm, a ship's survival depends on two things: sea room and steering-way. Sea room means that the ship is a safe distance from anything it might crash into, like a coastline. Cargo ships try to stay well offshore if they must face a major storm at sea. If a ship is on a "lee shore," with land close by downwind, the storm can drive the ship onto the land and wreck it. Steering-way means that the ship is moving forward with enough power to steer rather than just getting pushed around by waves and wind. The ship must keep its bow (the front end) pointing into the waves to plow through them safely, since a massive wave striking the ship's side could roll the vessel over and sink it. Wind and waves will try to turn the vessel, and pushing against them requires forward momentum.

Information on tides and currents for piloting in the port

PEEL PORTS GREAT YARMOUTH GENERAL PORT AND PILOTAGE INFORMATION

The River Port at Great Yarmouth is situated on the lower 2.6 miles reach of the River Yare seaward of the Yare/Bure confluence that lies just north of Haven Bridge and handles ships up to 123 metres with drafts up to 5.7 metres on spring tides

The Port uses its own tidal harmonics and declares a spring range of 2 metres and a neap of 1 metre. Mean low water springs (MLWS) is 0.75 metres above datum (datum = 1.56 metres below ODN). Predicted times of high and low water can be obtained from the Port's website and from the Admiralty Tide Tables.

Local Conditions
Both the Outer Harbour and River Port operate on a 24-hour basis and vessels may enter at most times. Due to the strong tides at the entrances, vessels with limited manoeuvrability should enter during the high and low water slack periods. During periods of strong south-easterly winds, heavy seas may be experienced near to the port entrances and in the River Port entrance seas can be confused with wind against tide and reflections from the southern breakwater arm. The prevailing wind in the port area is offshore. The largest seas and swells are from an easterly or south easterly direction. North Sea swells penetrate as far south as Great Yarmouth, swell waves will also build up locally after sustained winds from the easterly quadrants. Wind and swell waves from the easterly quadrants will have the greatest effect on the harbour entrances and on occasions penetrate into the Outer Harbour, such swells do not generally penetrate more than 300 metres into the River Port.

From the Admiralty Chart 1534 at the Tidal Diamond position, about 1 mile north-east of the port entrances the tidal streams set as follows:

Time from HW Dover	Remarks
+0600	South-going stream begins -0020
	North-going stream begins.

Spring rate in each direction 2¼ kn.

From local information at the Port, off Brush Quay the tidal streams set as follows:

Local Tidal Times		Remarks
Local LW	+ 2 hours	In-going stream begins. At full flow it rarely exceeds 3 knots except at Haven Bridge.
Local HW	+ 1½ hours	Out-going stream begins. Full flow normally 3 to 4 knots but can reach 6 knots with accelerated flows between the buttresses of Haven Bridge.

Slack water normally occurs at local HW+1½ and LW+2 hours. The streams begin later upriver.

Flood Stream
Inside the offshore banks the south going stream (flood) tends to run parallel to the shore line. Close inshore the stream is deflected along the Outer Harbour north breakwater arm and after passing the end of the breakwater arm the stream swings south again past the Outer Harbour entrance, accelerating as it does so and re-joining the main southerly stream. There is a tidal flow into the Outer Harbour but the tidal currents inside the breakwater entrance tend to be weak, generally with a weak clockwise rotation within the basin on the flood tide and counter-clockwise on the ebb.
Vessels entering the Outer Harbour on either the flood or ebb streams, approach from the east counteracting the tide (and wind) so that the vessel is making good a course that will take them through the Outer Harbour entrance. Ship's Masters should be aware that when inbound on a strong tidal flow, as the vessel's bow passes through the entrance into the weak tidal flows within the basin, the vessel will lose the strong tidal flows that were being experienced outside the breakwaters. This will tend to swing the vessel, as part of the vessel will be in the tidal stream and part in the near still water of the Outer Harbour Basin.
Once through the entrance action will need to be taken to counteract any swing and to take way off the vessel. Masters should be aware that the swept path of the vessel will increase for approaches during the stronger tidal flows. During the early period of the south going stream, the stream passing the Outer Harbour entrance follows the Outer Harbour south breakwater and enters the River Port; part of the stream splits and continues south and south west past the Gorleston Pier and then along the coast.
After the first hour, the stream has increased in rate and more of the flow will continue south and southwest past the River Port entrance before turning inshore and then back in a north westerly direction into the River Port entrance. As

the strength of the stream increases further the north westerly flow passing the Gorleston Pier, develops a more northerly component that now runs strongly past the entrance and then splits as it encounters the North Wall of the entrance, with part continuing west, to flow into the river (to the west) and part forming an eddy current that runs to the east along the southern arm of the Outer Harbour breakwater, this easterly stream turns south and joins the main south going stream. Vessels can experience a strong set to the north from 1-2 cables off the River Port entrance with the strength of the northerly set increasing as the vessel closes the entrance. Vessels should take care
to take appropriate action to counteract this set. These sets are much stronger during the spring tidal cycle.

Ebb Stream
The out-going stream (ebb) runs out of the River Port entrance and along the Outer Harbour south breakwater arm before joining the main north going stream. Before the main coastal stream has gathered pace, a part of the out-going stream at the River Port entrance has a south easterly component that joins the main north easterly going coastal stream that runs just south and south east of the Gorleston Pier.
At the peak of the northerly ebb stream an area of confused eddies can develop just south of the south breakwater arm outside of the River Port entrance. These eddies disappear or are poorly developed when the streams are weaker. Vessels entering the River Port from the east can stem the outgoing easterly stream, by running along about 0.5 cables south of the south breakwater watching for any element of a northerly set. If entering from the southeast vessels will be set to the north until the vessel encounters the outgoing stream when the northerly set will reduce. Once through the entrance vessels should stem the outgoing stream and adjust speed and heading in preparation for rounding Brush Bend. During and after heavy rain the duration and rate of the out-going stream from the River Port is increased and the in going stream correspondingly reduced. Under these circumstances, on occasions, the out-going stream may attain 5/6 knots off Brush Quay and there may be a continuous out-going stream for 18 hours; the range of tide in these conditions will generally be reduced.

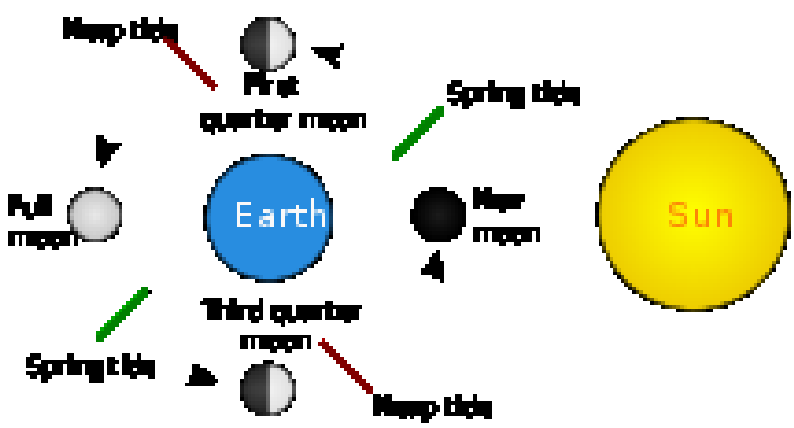
Tidal Anomalies
Prolonged strong winds or heavy rainfall may cause these times to vary and also alter the tidal range by more than 1 metre; the following can be expected in the aforementioned conditions: HW Slack LW Slack Tidal Height Northerly wind later earlier increased Southerly wind earlier later decreased Heavy rainfall earlier later increased The tidal ranges in Great Yarmouth are small (1 metre on neaps and 2 metres on springs) but the above wind and rain (or snow) effects can cause noticeable differences to the tidal heights causing tidal surges up to 2 metres.

https://www.peelports.com/media/2394/p16-general-port-pilotage-information.pdf

Tides are caused by **gravitational pull** of the moon and the sun. They are the cyclic rising and falling of Earth's ocean surface caused by the tidal forces of the Moon and the Sun acting on the Earth.

Tides are very long-period waves that move through the oceans in response to the forces exerted by the moon and sun. Tides originate in the oceans and progress toward the coastlines where they appear as the regular rise and fall of the sea surface.

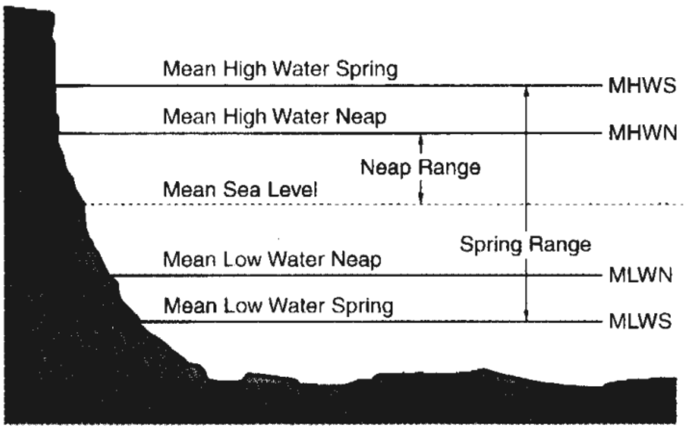
When the highest part, or crest, of the wave reaches a particular location, high tide occurs; low tide corresponds to the lowest part of the wave, or its trough. The difference in height between the high tide and the low tide is called the tidal **range**. https://oceanservice.noaa.gov/facts/tides.html



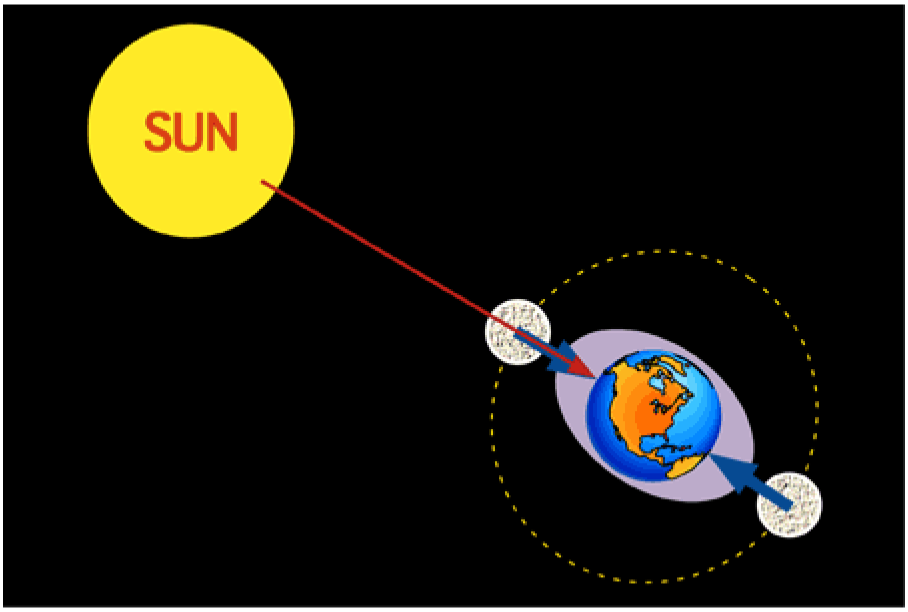
Four elements **cause tides**:
- the attractive force of the Moon;
- the pull of the Sun;
- gravity;
- the centrifugal forces caused by the rotation of the Earth.

Of these the **force of the moon** is the greatest. If the sea were of equal depth and if there were no land masses, the tides would follow the movement of the Moon around the Earth and vary slightly according to the relative positions of the Earth, the Sun and the Moon. However, the sea varies in depth, and continents and islands have an effect on the general pattern, thus there can be tides which occur once a day in some places and four times a day in others. A **daily or diurnal tide** occurs in a 24-hour period of oscillation, that is, one high water and one low water a day. A 12-hour period of oscillation means two high and two low waters a day; while a 6-hour period produces four high and four low waters a day. These differences may occur at places quite close together.
Sometimes high water is very high and low water is very low. When this happens the tides are known as spring tides. These occur when the moon is either **new or full** and its attractive force is **combined** with the pulling power of the Sun.

Tidal Range



When the Moon is in its **first or last quarter**, however, it is at right angles to the Sun, so that some of its pull is neutralised. This condition produces the neap tides, when the high waters are lowest and the low waters are highest.
Between these two tides the height of the waters will either increase or diminish progressively.

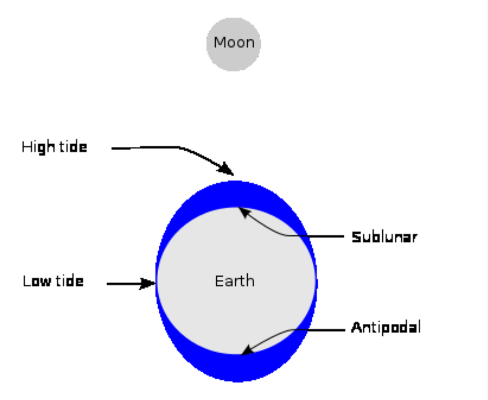


https://earthsky.org/earth/tides-and-the-pull-of-the-moon-and-sun

We have **high slack water** when the tide is at its highest and just about to turn. An ebb tide and flood tide (the reflux and rising of water flux) are words indicating low and high waters, respectively. The tide is said to be at its flood when it is at its highest, and therefore slack.

The **range** of any particular tide is the difference between the levels at low and high waters while its stand is the period recorded when no rise or fall in the height of water can be detected.

Low tide at the same fishing port in Bay of Fundy, 1972



In Maine (U.S.), low tide occurs roughly at moonrise and high tide with a high moon, corresponding to the simple gravity model of two tidal bulges; at most places however, the Moon and tides have a phase shift.

Ebb is the **tidal** phase during which the water level is falling and **flood** the **tidal** phase during which the water level is rising;

Ebb is the **tidal** phase during which the **tidal** current is flowing seaward (**ebb**current) and **flood** is the **tidal** phase during which the **tidal** current is flowing inland (**flood** current)

The world's largest tidal range of 16.3 metres (53.5 feet) occurs in Bay of Fundy, Canada,[2][4] and the United Kingdom regularly experiences tidal ranges up to 15 metres (49 feet) between England and Wales in the Severn Estuary. The Mediterranean Sea's tidal range is only a few centimeters on average.

Tide tables can be used to find the predicted times and amplitude (or "**tidal range**") of tides at any given locale. The predictions are influenced by many factors including the alignment of the Sun and Moon, the phase and amplitude of the tide (pattern of tides in the deep ocean), the amphidromicsystems of the oceans, and the shape of the coastline and near-shore bathymetry (see *Timing*). They are however only predictions, the actual time and height of the tide is affected by wind and atmospheric pressure. Some shorelines experience a **semi-diurnal** tide—two nearly equal high and low tides each day. Other locations experience a **diurnal** tide—only one high and low tide each day. A "mixed tide"—two uneven tides a day, or one high and one low—is also possible.[1][2][3]

Tides vary on timescales ranging from hours to years due to a number of factors, which determine the lunitidal interval. To make accurate records, tide gauges at fixed stations measure water level over time. Gauges ignore variations caused by waves with periods shorter than minutes. These data are compared to the reference (or datum) level usually called **mean sea level**.[4]

While tides are usually the largest source of short-term sea-level fluctuations, sea levels are also subject to forces such as wind and barometric pressure changes, resulting in storm surges, especially in shallow seas and near coasts. https://en.wikipedia.org/wiki/Tide

Tide changes proceed via the following **stages**:

- Sea level rises over several hours, covering the intertidal zone; **flood tide**.
- The water rises to its highest level, reaching **high tide**.
- Sea level falls over several hours, revealing the intertidal zone; **ebb tide**.
- The water stops falling, reaching **low tide**.

Oscillating currents produced by tides are known as **tidal streams**. The moment that the tidal current ceases is called **slack water** or **slack tide**. The tide then reverses direction and is said to be turning. **Slack water** usually occurs near high water and low water. But there are locations where the moments of slack tide differ significantly from those of high and low water.[5]

Tides are commonly ***semi-diurnal*** (two high waters and two low waters each day), or ***diurnal*** (one tidal cycle per day). The two high waters on a given day are typically not the same height (the daily inequality); these are the *higher high water* and the *lower high water* in tide tables. Similarly, the two low waters each day are the *higher low water* and the *lower low water*. The daily inequality is not consistent and is generally small when the Moon is over the Equator.[6]

The **Douglas Sea Scale** is a scale which measures the height of the waves and also measures the swell of the sea.
The WMO sea state code largely adopts the 'wind sea' definition of the Douglas Sea Scale. See *Marine Meteorology* (unit 11) and *Meeting Heavy Weather* (Unit 20)

IMO STANDARD MARTNE COMMUNICATION PHRASES

III/6.2.1.5 - *Hydrographic Information*

Abnormally high tides expected in position... at about... UTC/within ... hours, Abnormally low tides expected in position... at about... UTC/within... hours.
Tide rising, It is ... hours before high water.
Tide rising. It is ... hours after low water.
Tide rising, It is ... metres below high water.
Tide rising, It is ... metres above low water.
Tide falling, It is ... hours after high water.
Tide falling, It is ... hours before low water.
Tide falling, It is ... metres below high water.
Tide falling, It is ... metres above low water.
Tide slack.
Present height of tide above datum... metres in position....
Tide... metres above prediction,
Tide ... metres below prediction.
Tidal stream... knots in position....
Current... knots in position....
Tide setting in direction... degrees.
Sufficient depth of water in position....
No sufficient depth of water in position....
Charted depth increased by ... metres due to winds/sea state.
Charted depth decreased by ... metres due to winds/sea state.

A. Comprehension & vocabulary

A.1 *State whether the following statements are true or false*

	TRUE	FALSE
1. Tides are the inflow and outflow of the sea in coastal harbours and bays primarily due to the attractive force of the Moon and the Sun.		
2. The tide that produces one high and one low water a day is called the semidiurnal tide.		
3. A neap tide is the result of the combined attractive force of the Moon and the Sun.		
4. Spring tides result when the Sun is opposing the Moon, as at the first quarter.		
5. The movement of water in a vertical direction is called the current.		
6. A current in the ocean is often called a stream.		
7. The period between the flood and ebb or ebb anti flood with a strong current is called slack water.		
8. The period when the tidal current is flowing towards the land is called the ebb.		
9. The outflowing current is called the ebb tide (stages: first of the ebb, strength, last of the ebb).		
10. The difference between the extreme levels of the ebb and flood tide is called the range of the tide.		

A.2 *Complete these sentences:*

1. The tide is the result of the attractive forces of ____________________ .
2. Spring tides occur when _____________________ .
3. Neap tides occur when ____________________ .
4. The influence of the Moon upon the tide is two and a half times greater than ______________________.
5. The Mean Sea Level (M.S.L.) is the average level of the surface of the sea between ____________________.
6. The horizontal movement of the water as the tide rises and falls is known as ______________________.
7. Inland seas, such as the Mediterranean and Baltic, are tideless because ______________________.
8. The chart datum is the point from which we measure ______________________.

A.3 *Supply the missing words:*

• trough • tidal current • tidal harbour • bench mark • tide tables • tidal stream • crest • tidal datums • vertical datum

1. A horizontal movement of the water caused by the gravitational interaction between the Sun, the Moon and the Earth is called ______________ in American English.

2. In British English the same horizontal component of a tidal wave, i.e. tidal current, is called _______________ .
3. A _______________ is a port affected by the tides as opposed to non-tidal ports, basins or berths.
4. High water is a _______________ of a tidal wave and low water is the _______________ of the tidal wave.
5. The tables which give the predicted times and heights of a high and low water for every day and year for a number of world areas are called _______________.
6. A _______________ is a base elevation used as a reference from which to reckon the heights and depths.
7. _______________ are the vertical datums defined by a certain phase of the tide.
8. A _______________ is a fixed physical object used as a reference for a vertical datum.

***A.4** Fill in the following missing terms reffering to the tides:*

• *spring* • *neap*

l. _______________ tides are those tides, which rise highest and fall lowest from the mean tide level, as compared with 2. _______________ tides, which are those which rise lowest and fall highest. 3. _____________ tides occur when the pull of the Sun and the Moon act in opposition, either 90° or 270° apart. 4. _____________ tides occur when the pull of the Moon and the Sun act together (i.e. 0° or 180°) apart. There are two *5.* _______________________ tides and two 6. _______________ tides every ninety days.

B. Grammar

***B.1** Supply the link words such as:*

• *then* • *before* • *during* • *because* • *until*

1. ______________ one day, (24 hours) Poole harbour actually gets four separate high waters. From low water the tide starts, to make (i.e. rise) and continues 2. ______________ it reaches its peak point. 3. ______________, like any normal tide, it starts to ebb. However, 4. ______________ it can complete the ebb cycle to low water, the tide starts to make once more, bringing a second high water with it. This occurs 5. ________________ Poole harbour lies at the meeting point of two separate tidal streams.

***B.2** Find all the nouns in Exercise A.3 which are qualified by the adjective*

tidal:
EXAMPLE
tidal *stream*

tidal __________________
tidal __________________
tidal __________________
tidal __________________

B.3 *Transform the following **wh-questions** into **yes/no questions:***

1. What are the elements causing tide?
2. Why do the tides vary greatly?
3. What is a diurnal and semi-diurnal tide?
4. What is the difference between the neap and the spring tide?
5. When does the high slack and the low slack water occur?
6. What is the difference between the ebb tide and the flood tide?
7. What is the range and stand of the tide?