Waves are one of the most beautiful and awe-inspiring natural phenomena. Glancing through the ocean, one can see innumerable waves as far as the vision can decipher.

They are in a continual set of motion – rising up, moving forward, splashing amongst themselves, losing their motion and then rising again. They are a treat to watch, and even better to play with. They are the reason why beach-goers and surfers visit otherwise boring sea beaches. Yes, you heard me right! Imagine a beach, with no waves at all.

Sand and water will be all you'd be left with, which would be…pretty…..boring!

Sea waves are one of the beautiful natural marvels that excite us. However, there are different types of waves that are formed according to different weather conditions.

While those calm and large waves come in regular intervals make beachgoers and surfers happy, for seafarers, it's a nightmare just because those monster rogue waves often result in causalities.

Similarly, there are small waves even on calm waters. Water appears moving in circular motion as the energy created by some forces pass through the water.

The surface water never travels, but the energy moves across if not obstructed by any obstacles.

How Sea Waves are Formed?

As discussed earlier, there are several types of waves and the forces behind them are also different. The most common cause of ocean waves is wind. Wind-driven waves, also known as surface waves, are formed due to the friction between surface water and wind.

When the wind is blowing on the sea, the surface exerts the gravitational force on the bottom layer of the wind. This, in turn, exerts the pull on the layer above it until it reaches the top-most layer.

With the gravitational pull being different at each layer, the wind moves at a different speed. The top-most layer tumbles, forming a circular motion. This creates a downward pressure at the front and upward pressure at the rear of the surface, causing a wave.

However, there are tidal waves that are created by the gravitational pull of the sun and moon on the earth. It should be noted that a tidal wave is a shallow water wave, not a tsunami.

While the above-mentioned waves are not dangerous in its impact, there are hazardous waves, including tsunami, that is caused by severe weather conditions such as a hurricane, typhoon as well as a tornado, and other natural calamities including earthquakes, landslides, and volcanic eruptions.

Waves are basically disturbances (termed oscillations) on the surface of the water, which can be formed on all types of water bodies like seas, oceans, rivers and even lakes. Although waves stem from some kind of external force, they are actually a restoring force, which counters the disturbance introduced in the water. They seem to transport water and debris as they move. But there is more to it than meets the eye.

Actually, waves are energy passing through the water, which makes the water to move in a circular motion. If you might have closely observed a boat encountering a wave, the wave lurches the boat upward and forward, swirls it, but then the boat comes down to its original position. This is evidence enough that waves do not make the water travel much, but are simply the manifestation of the transfer of kinetic energy through the water.

Some might argue that they have clearly seen waves moving forward and splashing on the shore. This happens because the inclined edge of the beach offers resistance and slows down the bottom portion of the wave. This creates an imbalance, and the upper portion of the wave, or the crest, topples forward and splashes on the beach.

Having established the fact that waves represent the movement of energy, the obvious question is that from where do waves get their energy?

While mild winds blowing over the surface of the water may create small surface waves, extreme weather conditions like hurricanes and cyclones produce strong winds and often create huge waves which may be potentially hazardous. Some adverse natural phenomena like underwater earthquakes, landslides or volcanic eruptions can create humongous series of waves known as tsunamis, which can cause unimaginable destruction to the coastal ecology and human inhabitations in the area of impact. Waves can also be caused by recurring natural phenomena like tides.

Waves are basically classified according to their formation, source of energy and behavior. Here we will be looking at the different types of sea waves and how they are formed.

Different Types of Sea Waves

As mentioned, the sea waves are categorized based on their formation and behaviour. The commonly used classification of ocean waves is based on the wave period.

Here are all the different types of sea waves.

Breaking Waves

The breaking waves are formed when the wave collapses on top of itself. The breaking of water surface waves happens anywhere on the surface of the seawater.

However, one can see breaking water surface waves most commonly on a coastline since wave heights are normally amplified in the shallower water areas.

When waves approach the shore, their profile is modified by the resistance offered by the sloping sea floor. The seafloor obstructs the motion of the base (or trough) of the wave, while the top part (or crest) continues to move at its usual speed. As a result, the wave begins to lean forward as it gradually approaches the shore.

At a point where the steepness ratio of the wave reaches 1:7, the crest outruns the slow-moving trough, and the entire profile of the wave collapses on itself, thus forming a breaking wave.

The breaking waves may further be classified into four types –

• Spilling waves – Also known as mushy waves in the beach-goers' terminology, these waves are formed at gentle inclinations of the ocean floor. If the shoreline is gently sloping, the energy of the waves is gradually expelled, the crest gradually spills and mild waves are formed. These waves take more time to break as compared to other types.

• Plunging Waves – When waves pass over a steeply inclined or rugged ocean floor, the crest of the wave curls and trap a pocket of air underneath it. As a result, the waves somewhat explode when they reach the steeper gradient of the shore, and all of the waves' energy is dissipated over a much shorter distance. Thus plunging waves are formed. Common during offshore winds, these waves have high energies and travel really swiftly, which may prove to be dangerous to unsuspecting beachgoers and surfers. They also result in tremendous erosion and deposition.

• Surging waves – They are produced when huge swells reach shorelines having a steep profile. They travel at high speeds and have no crest associated with them.

Although they might seem to be harmless because they don't break like other waves, they can be dangerous because of the strong backwash (pulling or sucking effect) associated with them.

• Collapsing waves – They are a blend of plunging and surging waves. Their crest does completely break, and the bottom profile gets vertically aligned and collapses, turning into whitewater.

Deep Water Waves

Deepwater waves, as the name suggests, have their origin where the depth of the water in the ocean is significant, and there is no shoreline to provide any resistance to their motion. Technically speaking, they are formed in areas where the depth of the water is more than half of the wavelength of the wave. The speed of the wave is a function of the wavelength of the wave. This means that waves having a longer wavelength travel at greater speeds as compared to waves with a shorter wavelength.

They are actually multiple waves of different wavelengths, which superimpose upon one another to form a combined larger wave. They are long and travel in straight lines, and have enough energy to traverse much greater distances as compared to other waves like breaking waves. The major force of causation is wind energy, which can be from local or distant winds. They are also known as stokesian waves or short waves.

Shallow Water Waves

These waves have their origin where the depth of the water is much lesser. They typically travel in waters which have depths lesser than 1/20th of the wavelength of the wave. But unlike deep water waves, the speed of the wave has nothing to do with the wavelength of the wave, and the speed is a function of the depth of water. This means that waves in shallow waters traverse faster than waves in deeper waters. More specifically, the speed is equal to the square root of the product of the depth of water and the acceleration due to gravity.

Speed = $\sqrt{(g \cdot depth)}$ (g = gravitational constant, 9.8m/s2; D = depth in metres)

They are also known as lagrangian waves or long waves.

These waves may have a variety of causation factors behind them. There are two types of shallow water waves that we generally encounter –

• Tidal waves – They are caused due to astronomical forces like the gravitational pull of the sun and the moon on the ocean water. You can think of the high and low tides as the traversing of a wave with a time period of 12 hours.

• Tsunamis – Tsunami is a Japanese word, as Japan is possibly the country most frequently affected by tsunamis. The word ‘tsunami’ finds it’s the origin in two different words; ‘tsu’ which means harbor, and ‘nami’ which means wave. So it roughly translates to ‘harbour waves’. Most of the tsunamis (about 80%) result from large scale underwater earthquakes. The rest 20% are generated by underwater landslides, volcanic eruptions and even meteorite impacts. They travel at very high velocities, so are highly dangerous and devastating.

They are considered shallow water waves, because a typical tsunami wavelength is several hundred miles long, as an example let’s say 400 miles, while the deepest part of the ocean is 7 miles deep. So the depth is obviously less than 1/20th of wavelength, as discussed earlier.

Inshore Waves

The length of these waves is less than the depth of the water they enter, which decreases the velocity of the waves. This results in the decrease of the wavelength and increase in the height, eventually breaking the wave. These waves drain the beach as a backwash.

Internal Waves

They are one of the largest waves in the ocean but are barely noticeable on the surface due to their formation in the internal layers of the water. Ocean water is composed of different layers because the more saline and colder water has a tendency to sink beneath the less salty warmer water. When the interface between these distinct layers is disturbed due to external forces like tidal movements, internal waves are generated.

Although similar to surface waves in shape and structure, they traverse long distances and attain towering heights when they hit a landmass. According to scientists, the largest known internal waves are generated in the Luzon Strait in the South China Sea (about 550 feet tall)

Kelvin Waves

Kelvin waves are large scale waves, which are caused by a lack of wind flow in the Pacific Ocean. They were discovered by Sir William Thompson (who was later known as Lord Kelvin). Kelvin waves are a special type of gravity waves that are influenced by the Earth's rotation and get trapped at the Equator or along lateral vertical boundaries such as coastlines or mountain ranges. There are two kinds of Kelvin waves – coastal and equatorial waves. Both these waves are gravity driven as well as non-dispersive in nature.

Progressive Waves

For a progressive wave, the amplitude is equal to overall points and has net energy flow. In other words, it's a form of a wave in which the ratio of an instantaneous value at one point to that at any other point is constant. There are three types of progressive waves such as longitudinal, transverse, and orbital waves.

Capillary Waves

Capillary waves closely resemble ripples in their structure. The restoring force involved is capillarity, which is the binding force that holds together the water molecules on the surface of the ocean. Their particularly wavy structure is caused due to light breezes and calm winds that blow at small speeds of about 3-4 metres per second, at a reference level height of 10 metres from the surface of the water. Typical wavelengths are less than 1.5 cm and time periods less than 0.1 seconds.

As stated by the famous Physical Oceanography professor Blair Kinsman in his book 'Wind Waves'(1965), "The shortest-period waves, and the first to be noticed on the ocean surface when wind starts blowing, are the capillary waves, which resemble a cat's paws ripping the otherwise smooth surface of the water"

Refracted Waves

Refracted Waves travel in shallow water when they approach the shore and the shallowness decreases the power of the wave and causes a curve. These are usually seen near headlands and bays.

Seiche Waves

Seiche waves, or simple a seiche (pronounced 'saysh') are standing waves that form in a confined or partially confined body of water. Standing waves, in general, can form in any type of semi-enclosed or enclosed body of water. In general terms, when water sloshes back and forth in a swimming pool, a water tub or even a glass

of water, it is a seiche on a much smaller scale. On a larger scale, they are formed in bay areas and large lakes.

Seiches are generated when either rapid changes in the atmospheric pressure or strong winds force the water and push it to pile up in one part of the water body. When the external force finally stops, the piled up water, possessing potential energy, rebounds back to the opposite side of the enclosed water body. This periodic oscillation of water, without anything to offer resistance, continues for long intervals of time, typically many hours or even many days at end. They can also be caused by storm fronts, tsunamis or earthquakes in ocean harbours or sea shelves.

Many a times, Seiches may be mistaken for tides. This is because the time period of the wave (the difference between the high(crest) and low(trough)) may be upto 7-8 hours, which is comparable to the time period of most tides. Although the causal factors may be the same for seiche waves and tsunamis, seiches are fundamentally different from tsunamis. Seiches are basically standing waves with long time periods of oscillations and occur in confined bodies of water, while tsunamis are progressive waves which generally occur in free bodies of water.