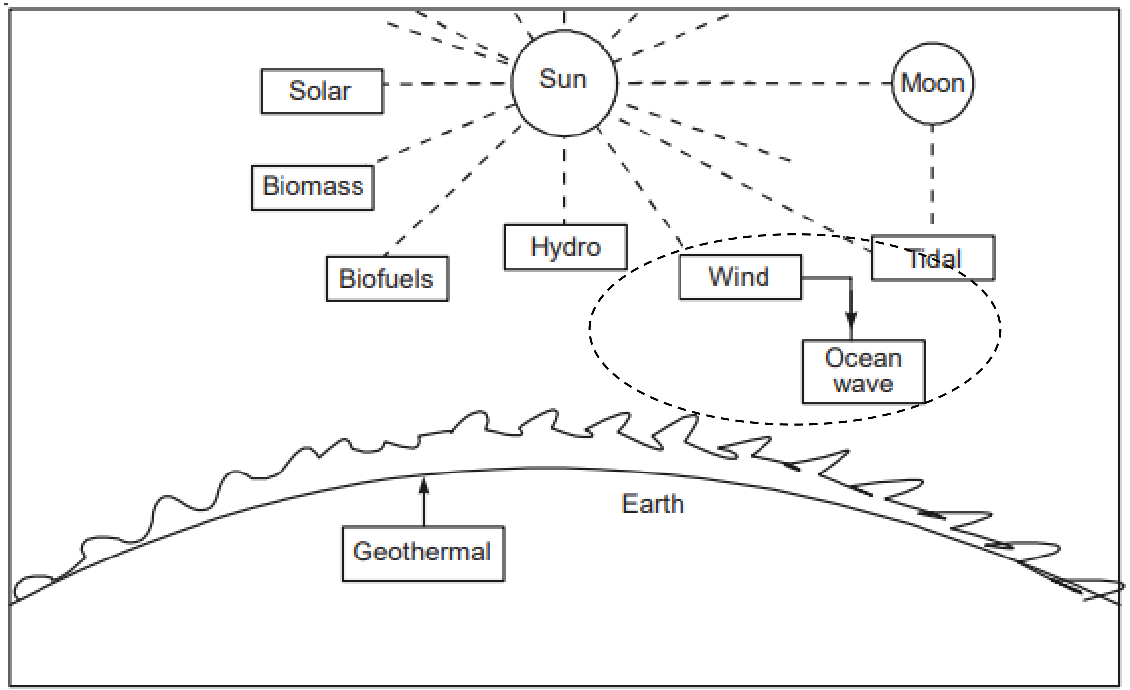
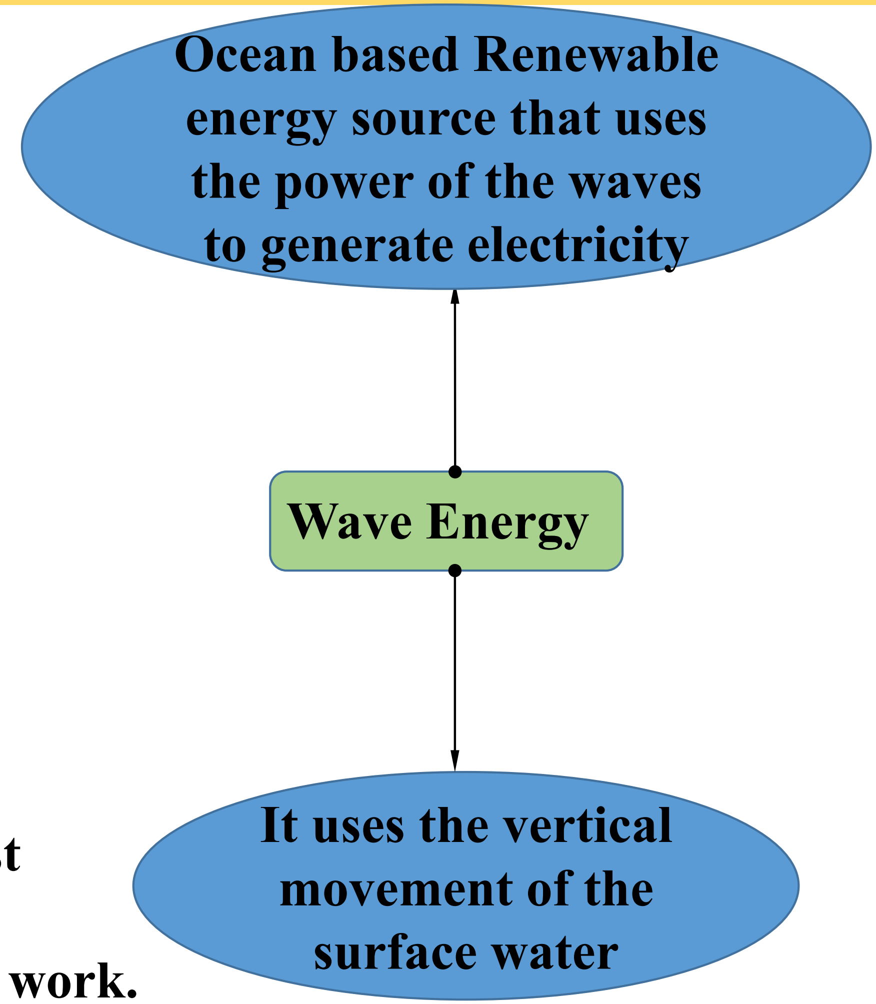
Wave Energy



- **Second form of ocean energy i.e., wave energy.**
- **Wind blows over the surface of sea producing fast moving sea waves.**
- **Energy of these waves used for different kinds of work.**
- **This potential can satisfy world's 40 % need.**



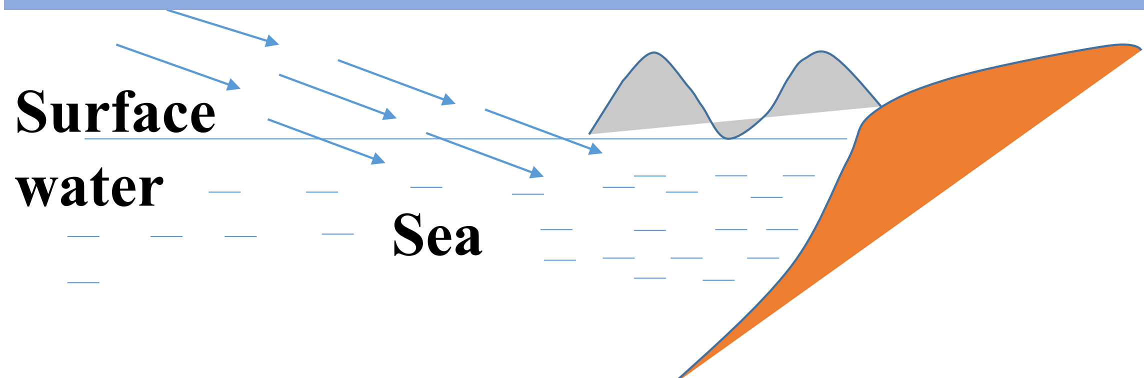
Wave Energy formation

Wave Energy

KE → Wave Propagation

PE → Lifting of water mass w.r.t. mean sea level

Wind Energy transfers its energy to the surface water of the ocean



Formation of wave is a continuous phenomena and keeps on forming in the ocean and destroying on the shore.

Wave Energy

- **Differential warming of the earth causes pressure differences in the atmosphere, which generate winds.**
- **As winds move across the surface of open bodies of water, they transfer some of their energy to the water and create waves.**

✓ **Waves get their energy from the solar energy through the wind.**

✓ **Wave energy will never be depleted as long as the sun shines.**

✓ **Energy intensity may, however, have variation but it is available 24 h a day in the entire year.**

Wave Energy

- **Waves are formed on the surface of water by the <u>frictional action of the winds</u> resulting in the radial depression of energy from the blowing winds in all directions.**

- **Wave energy is available in**

✓ **Coastal areas,**

✓ **Islands and its potential depends upon its geographic location.**

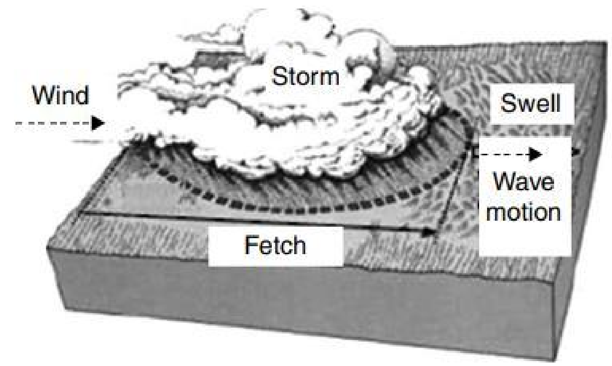


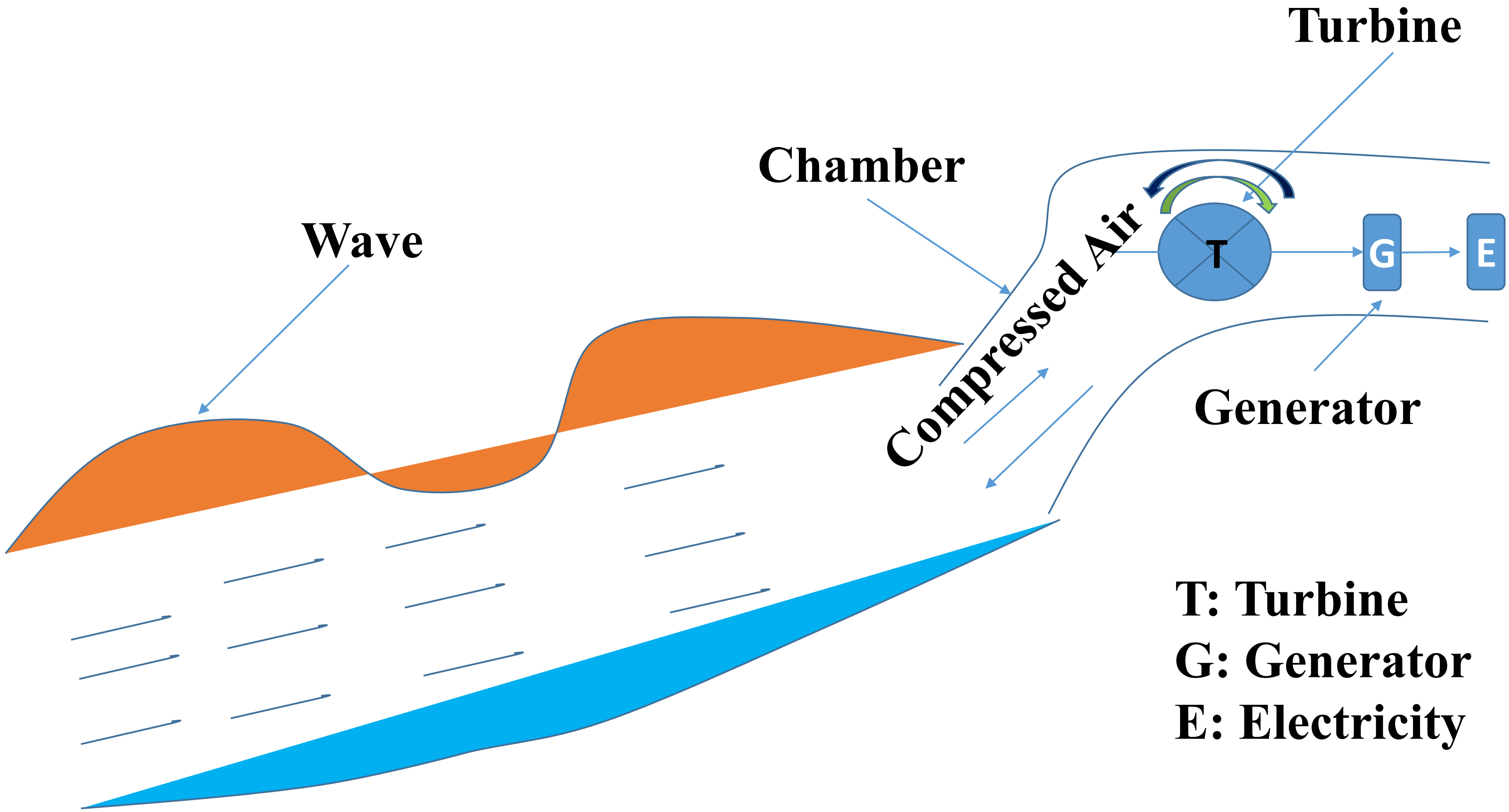
Figure : Sea wave formation by storm

Three major factors which govern the quantum of wave energy

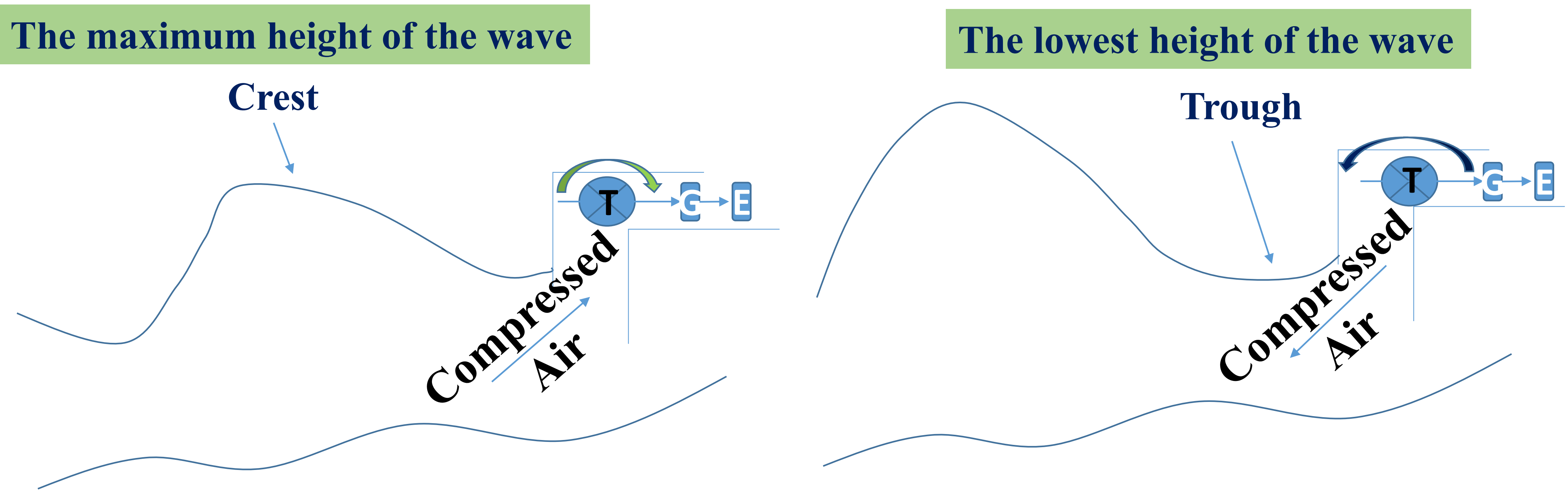
- **Wind speed**
- **Effective fetch value**
- **Depth of the sea water**

Fetch: Ocean waves are generated by wind passing over long stretches of water

Wave Energy


Turbine
Chamber
Wave
Compressed Air
T
G
E
Generator
T: Turbine
G: Generator
E: Electricity

Wave Energy



T: Turbine
G: Generator
E: Electricity

Waves are characterized by the following parameters cont.

1. **Crest: The peak point (the maximum height) on the wave is called the crest.**
2. **Trough: The valley point (the lowest point) on the wave is called the trough.**
3. **Wave height (H): Wave height is a vertical distance between the wave crest and the next trough (m).**
4. **Amplitude (a): It is defined as H/2 (m).**
5. **Wave length (λ): It is the horizontal distance either between the two successive crests or troughs of the ocean waves (m).**

The shape of the typical wave is described as sinusoidal (that is, it has the form of mathematical sine function)

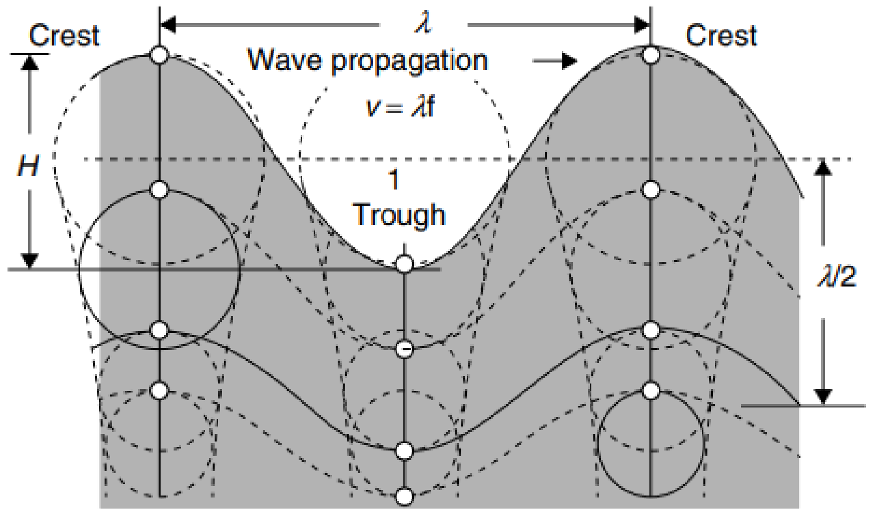


Figure: Sea wave propagation

Waves are characterized by the following parameters

6. Wave propagation velocity (v): The motion of seawater in a direction (m/s).

7. Wave period (T): It measures the size of the wave in time(s). It is the time required for two successive crests or two successive troughs to pass a point in space.

8. Frequency (f): The number of peaks (or troughs) that pass a fixed point per second is defined as the frequency of wave and is given by f = 1/T (cycle/s).

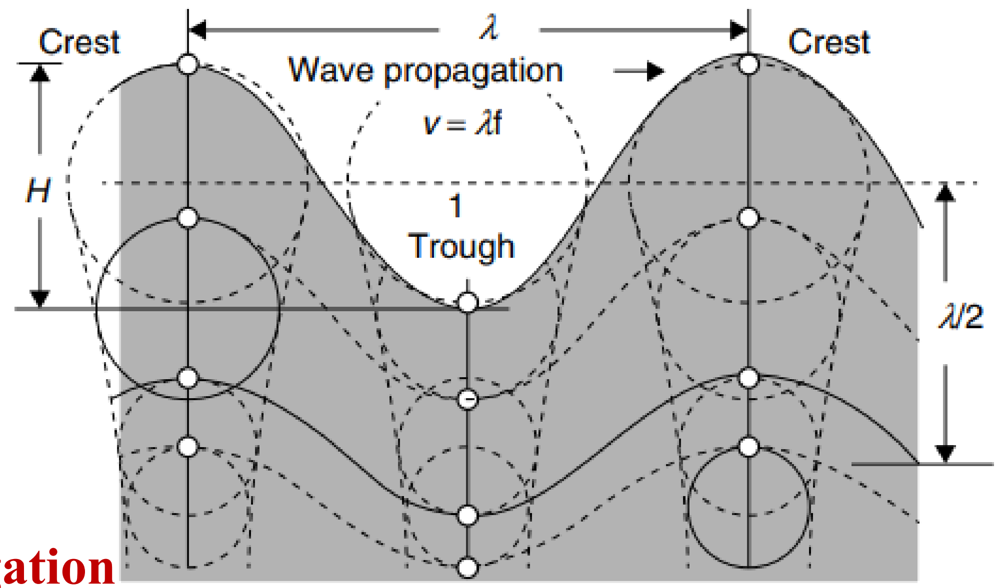
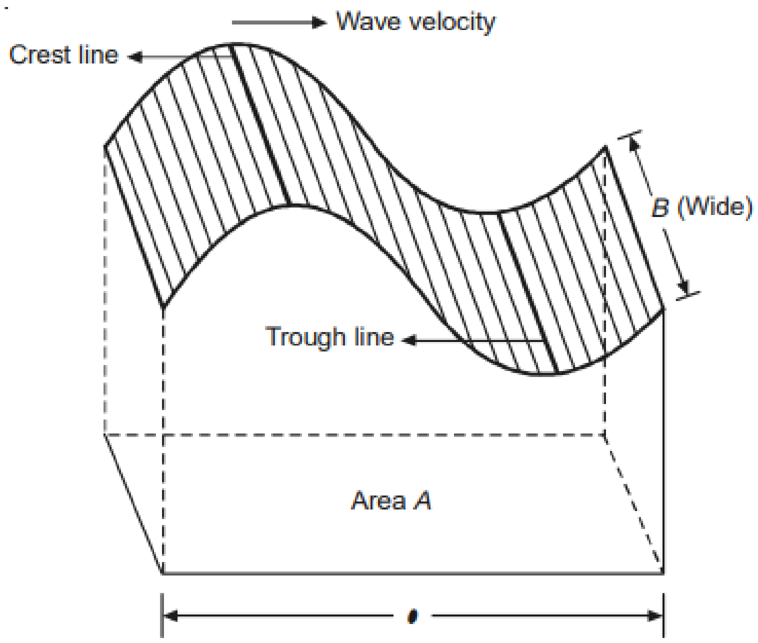


Figure: Sea wave propagation

Numerical Problems

Q.1 A progressive sea wave has a wave width of 100 m with a period of 5 seconds. Calculate the wavelength, the wave velocity and the wave area.

Solution:



$$\text{Wave Length, } \lambda = 1.56T^2$$
$$= 1.56 \times 5^2 = 39 \text{ m}$$

$$\text{Wave velocity, } C = \frac{\lambda}{T} = \frac{39}{5} = 7.8 \text{ m/s}$$

$$\text{Wave area, } A = \text{wave length} \times \text{wave breadth}$$
$$= \lambda \times B$$
$$= 39 \times 100$$
$$= 3900 \text{ m}^2$$

Figure: Water wave width B and length λ (B > λ)

Numerical Problems

Q.2 Ocean waves on an Indian coast had an amplitude of 1 m with a period of 5 s measured at the surface water 100 m deep. Calculate the wavelength, the wave velocity, the energy density and the power density of the wave. Take water density as 1000 kg/m³.

Solution:

$$\text{Wavelength, } \lambda = 1.56T^2 = 1.56 \times 5^2 = 39 \text{ m}$$

$$\text{Wave velocity, } C = \frac{\text{Wavelength } \lambda}{\text{Period } T} = \frac{39}{5} = 7.8 \text{ m/s}$$

$$\text{Wave frequency, } f = \frac{1}{5} \text{ s}^{-1}$$

$$\text{Energy density, } \frac{E}{A} = \frac{1}{2} \times 1000 \times 1^2 \times 9.81 = 4905 \text{ J/m}^2$$

$$\text{Power density, } \frac{P}{A} = \left(\frac{E}{A}\right) f = 4905 \times \frac{1}{5} = 981 \text{ W/m}^2$$

Wave Energy Devices

$$\textbf{Wave Energy} \xrightarrow{\textbf{Wave Energy Devices}} \textbf{Mechanical Energy}$$

- **On the basis of location in sea.**
- **On the basis of actuating motion used in capturing wave energy.**

Wave Energy

Wave Energy Device (WED)

Classified based on the site they are mounted

There are three areas for which wave energy converters are represented

Offshore System

Deals with swell energy not breaking waves

Near shore System

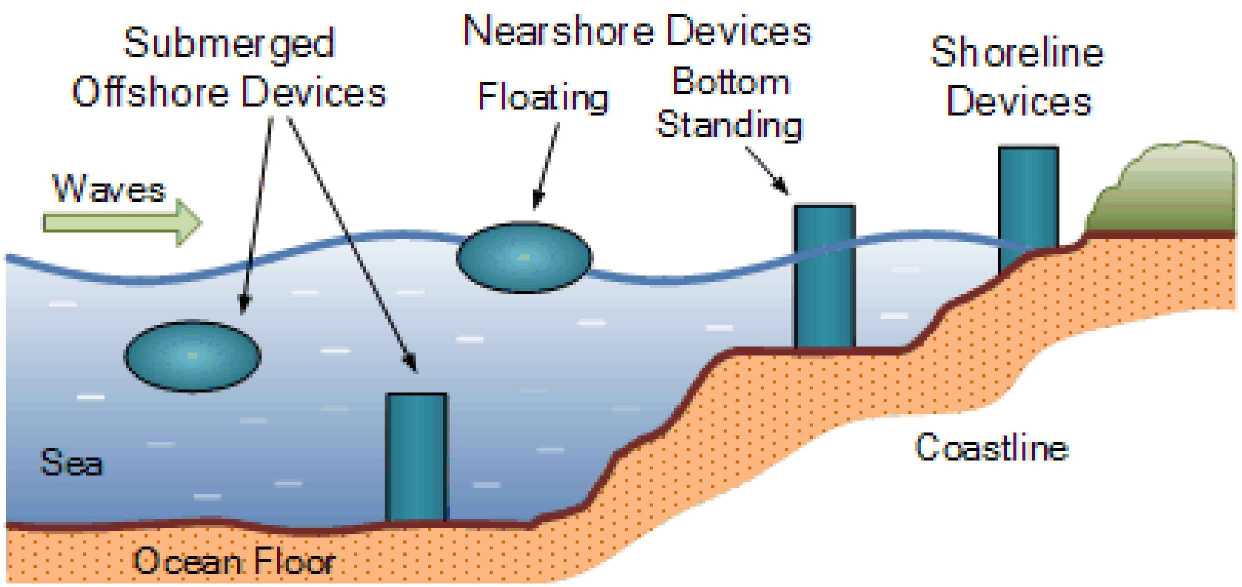
Maximum wave amplitude

Embedded System

Built into shoreline to receive breaking wave-but energy loss is occurring while the wave is breaking

Wave Energy Uses the Power of the Waves

- Ocean wave energy has many advantages over ocean wind energy in that it is more predictable, less variable and offers higher available energy densities.
- Depending on the distance between the energy conversion device and the shoreline, wave energy systems can be **classified** as being either ***Shoreline devices***, ***Nearshore devices or Offshore devices***.



Wave Power Devices

- ✓ ***Shoreline devices*** are wave energy devices which are fixed to or embedded in the shoreline, that is they are both in and out of the water.
- ✓ ***Nearshore devices*** are characterized by being used to extract the wave power directly from the breaker zone and the waters immediately beyond the breaker zone, (i.e. at 20m water depth).
- ✓ ***Offshore devices or deep water devices*** are the farthest out to sea and extend beyond the breaker lines ***utilizing the high-energy densities*** and ***higher power wave profiles*** available in the deep water waves and surges. **Offshore devices are situated in much deeper water, with typical depths of more than 30 meters**.

S. No.	Wave Energy Device	Water Depth	Maximum Wave Height
1	Onshore	10–15 m	reach up to 7.8 m
2	Nearshore	15–25 m	
3	Offshore	Higher than 50 m	reach up to 30 m or even more

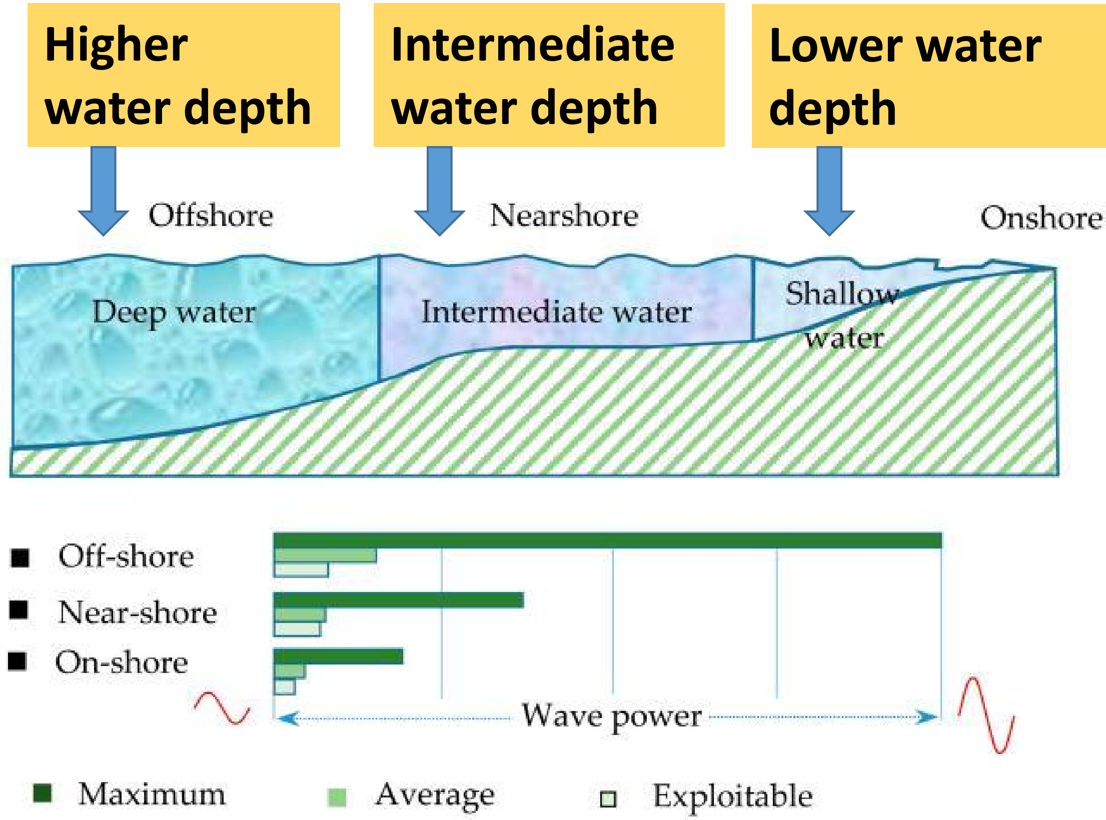


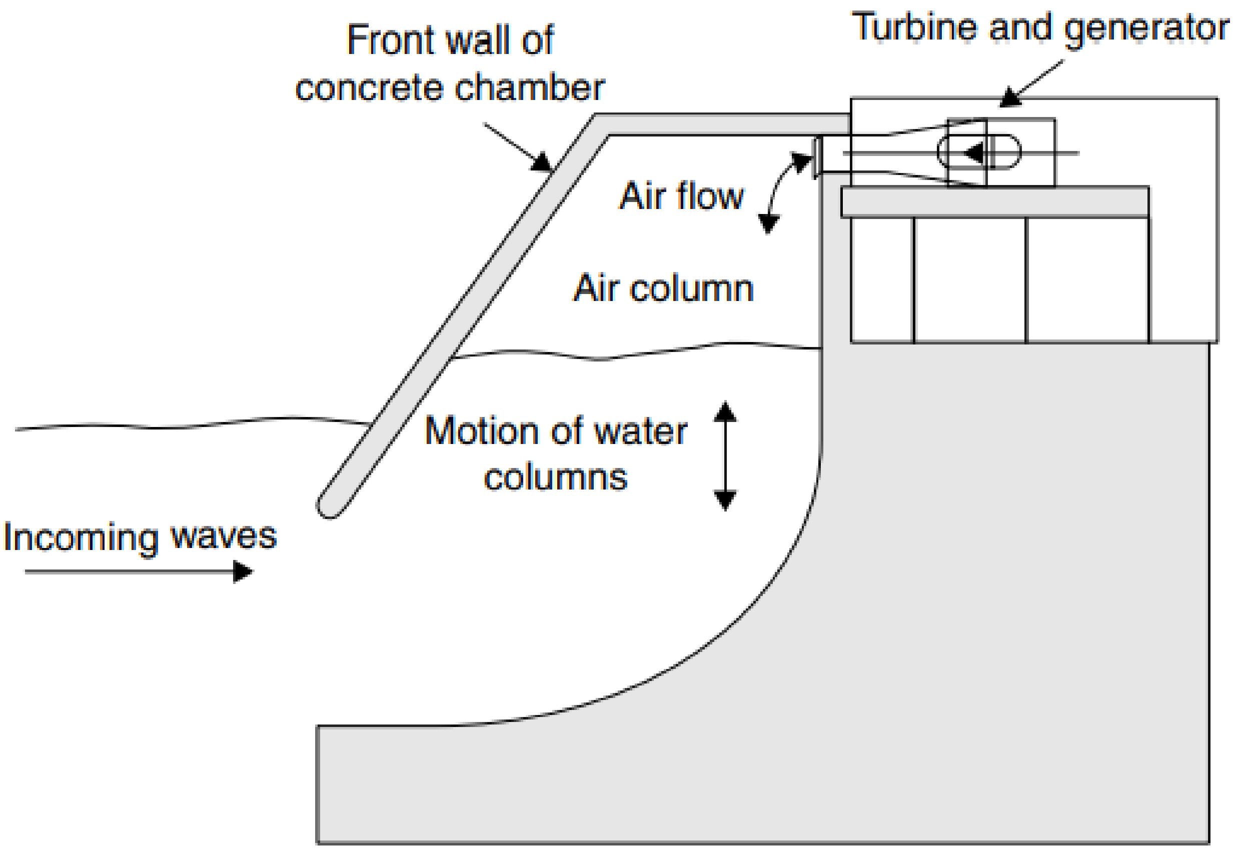
Figure. Position of the wave energy converter system in the sea.

Comments

- ***Onshore device:-*** The waves lose energy as they approach shore due to interaction with the sea floor.
- ***Offshore device:-*** For a wind turbine; to extract all of the kinetic energy from a wave, the wave has to be stopped.

✓ It needs an appropriate mechanism for transporting the generated electricity back to shore.

Oscillating Water Column Devices (OWC) cont.



- An oscillating water column (OWC) converter is an example of terminator device.
- It is a wave energy device oriented perpendicular to the direction of the wave and has one stationary and one moving part.

- The moving part moves up and down like a car piston in response to ocean waves and pressurizes air to drive a turbine.

Oscillating Water Column Devices (OWC)

- These devices generally have power ratings of 500 kW to 2 MW, depending on the wave parameters and the device dimensions.
- It is a shoreline-based oscillating water column.
- Wells’ turbines are used to extract energy from the reversing air flow.
- It has the property of rotating in the same direction regardless of the direction to the airflow.

Advantages of Waves

- ✓ Non-polluting and continuous source of energy.
- ✓ It will remain for a very long period of time.
- ✓ It is free and renewable energy source.
- ✓ Highly suitable to develop power in remote islands, on drilling platforms and on ship where other alternatives are impossible.
- ✓ No storage of power is required.

Disadvantages of Waves

- ✓ Current technology cannot utilize wave energy efficiently.
- ✓ The equipment for utilizing wave energy would be expensive as they have to withstand severe weather conditions.

Disadvantages of Waves

- ✓ It may cause disturbance of marine life.
- ✓ Sea water is corrosive and life of equipment used in conversion devices is limited.
- ✓ Wave energy conversion devices obstruct shipping traffic.
- ✓ Strong waves during storms can damage the wave energy conversion devices.
- ✓ Marine growth such as algae adversely affects the working of wave energy conversion devices.

References

https://www.alternative-energy-tutorials.com/wave-energy/wave-energy.html