An Introduction to Tsunami

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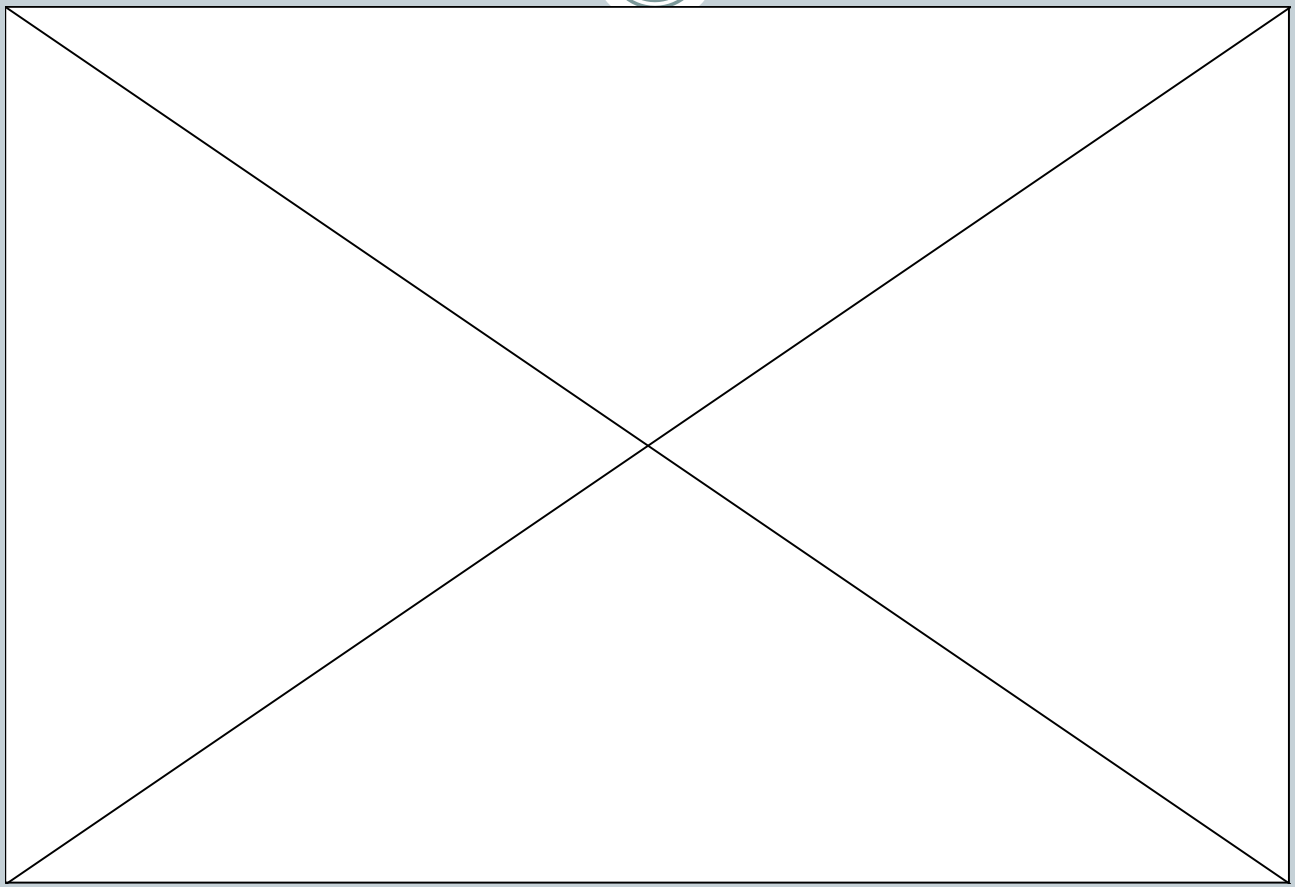
1. Review time:

- What are amplitude, frequency, period, wavelength, etc? What exactly is a wave?
- Wikipedia answers:
  - A wave is a disturbance that propagates through space and time, usually with transference of **energy** without transporting **mass**. A mechanical wave is a wave that propagates or travels through a **medium** due to the **restoring forces** it produces upon deformation.
- Energy? Mass? Medium? Restoring forces? Let's put them into a simpler manner:

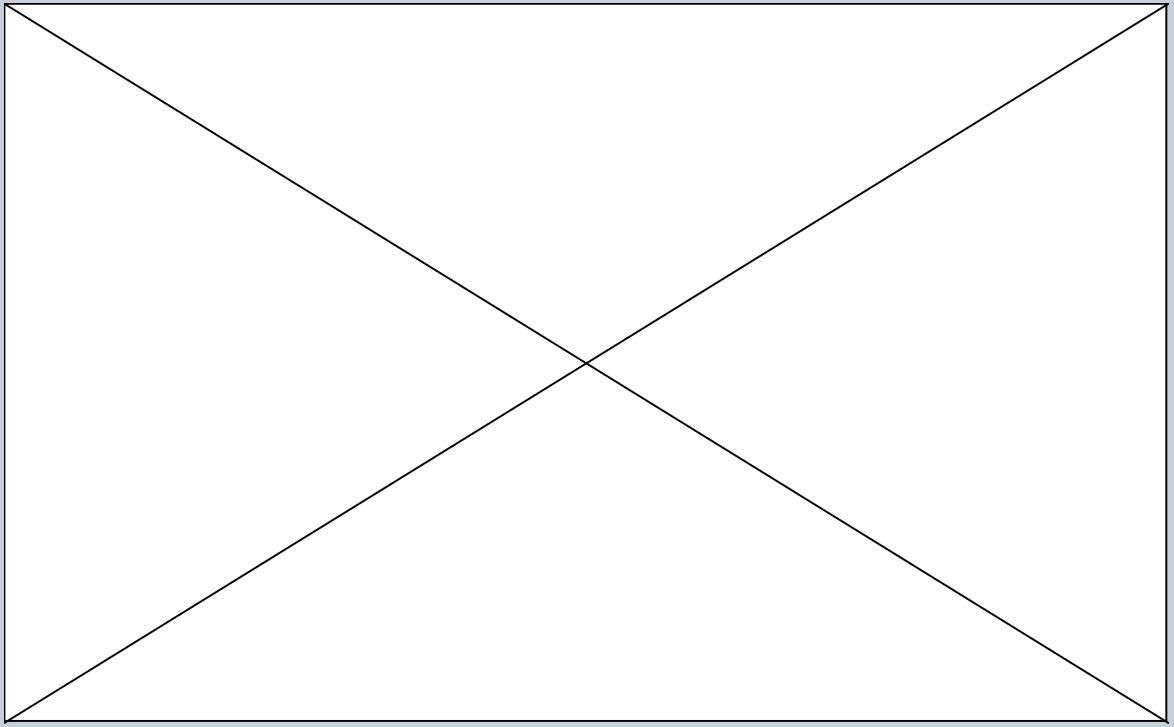
This is a wave!



- Medium? Propagation direction? Restoring force?

Review

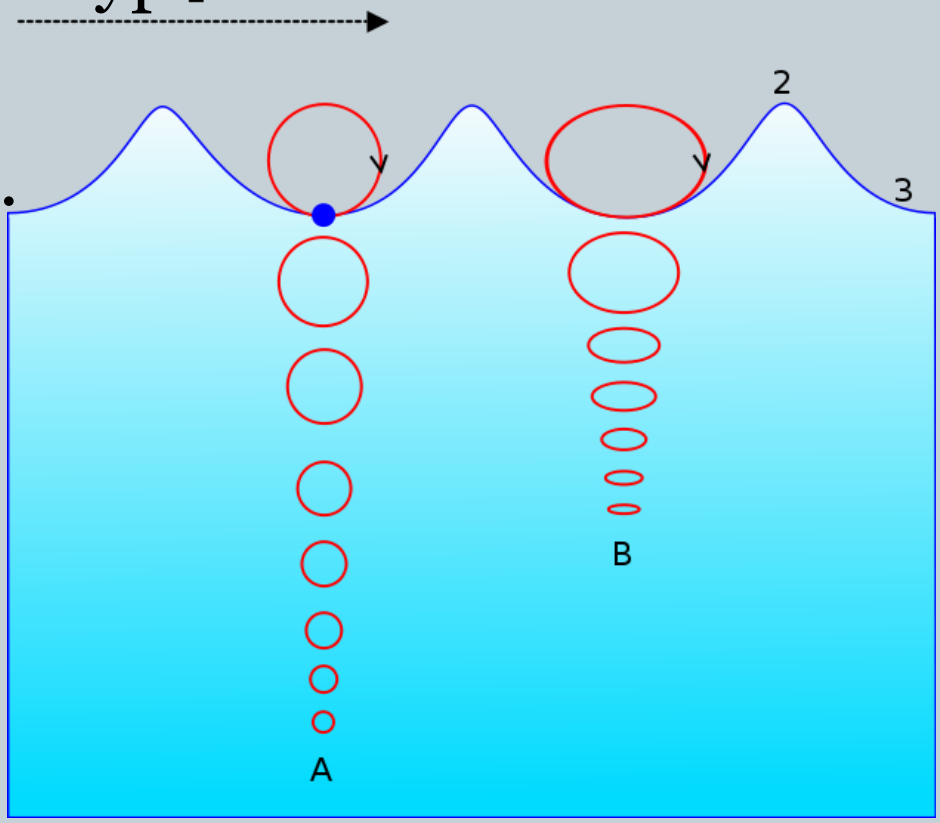
- Now here is another wave.



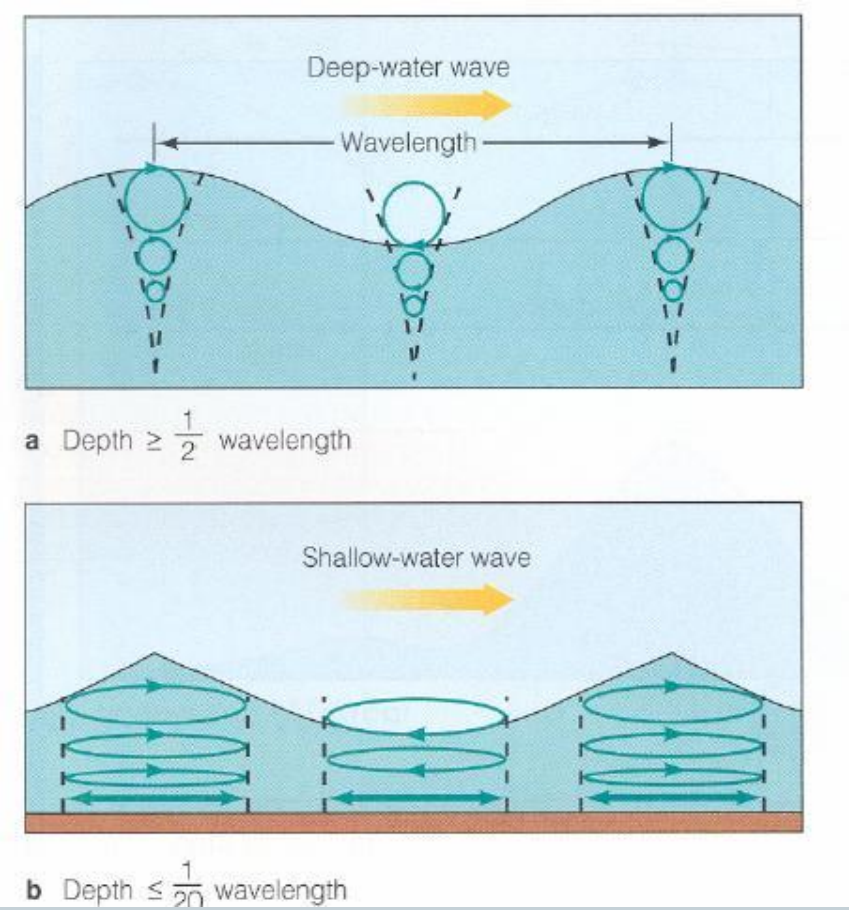
- What is the main difference between the two waves? Similarities?

Transverse+Longitudinal=?

- What about waves of both properties?
- Waves in ocean are of both types.
- A particle will move in a cyclical or elliptical motion.
- Such type of wave can be further divided into two groups:



Two types of water waves



- **Deep-water wave**: when the depth of the ocean is larger than ½ of the wavelength.
- **Shallow-water wave**: when the depth is smaller than 1/20 of the wavelength.
- Tsunami is a shallow-water wave.
- How deep is the ocean?
- How long is a tsunami

Is this not dangerous?

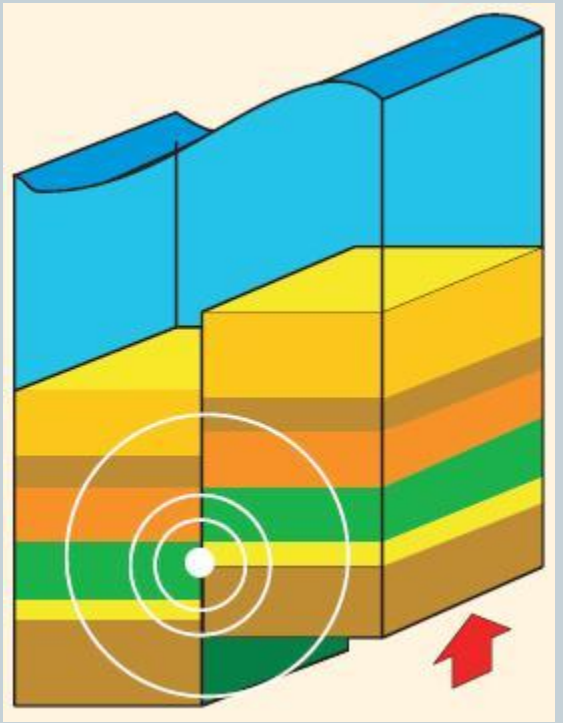
- Waves such as this one can sometimes reach as high as 10m.
- Yet it is not dangerous. Why?
- Such waves are generated mostly by wind, and only carries a small volume of water in comparison to a tsunami.

Let's compare with normal waves

- Let's assume a **2m high** wave surging onto the shore for a **distance of 5m** with **wavelength of 3m**. An approximate volume of water is **30 m^3**
- Now let's repeat the same calculation for a **2m high** tsunami wave using the wavelength obtained before. It also surges up **5m onto the shore**. How many times more of mass of water are we getting?
- Answer: **800000 m^3 !!**

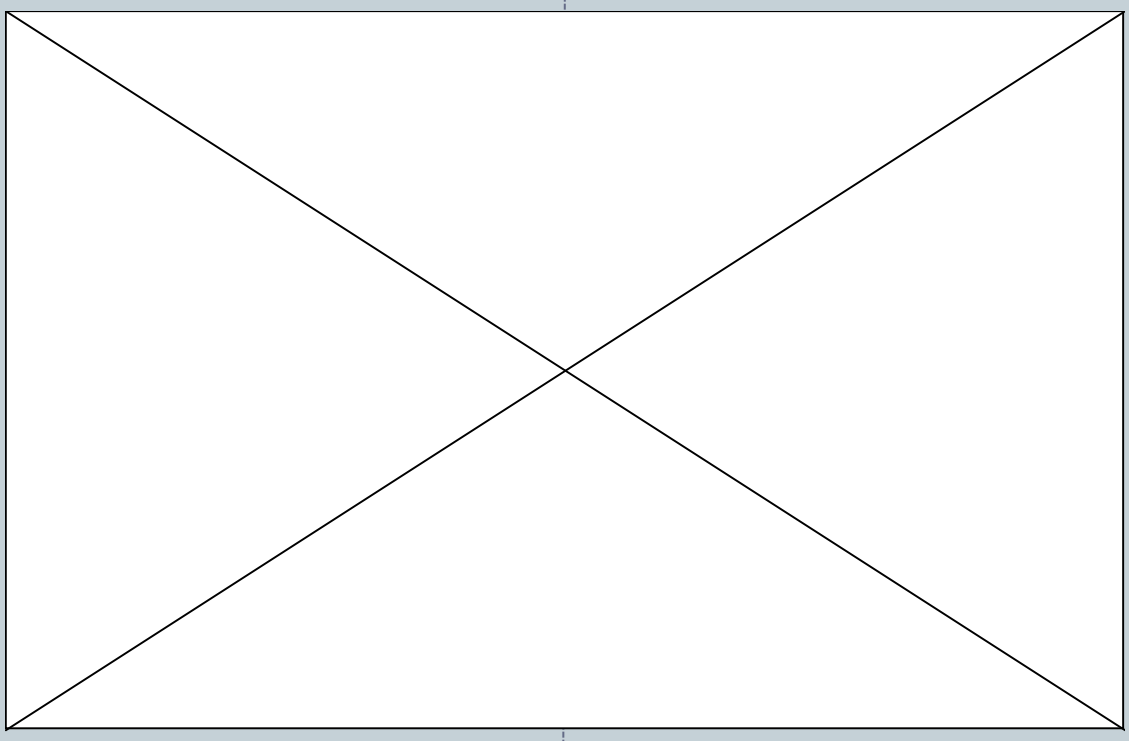
Tsunami-Background

- Mostly caused by earthquakes, landslides or volcanic eruption underwater.
- Travels **far and fast** reaching many corners of the world.
- While in **deep** ocean, hardly detected by ships above due to **small amplitude** and large wavelength.



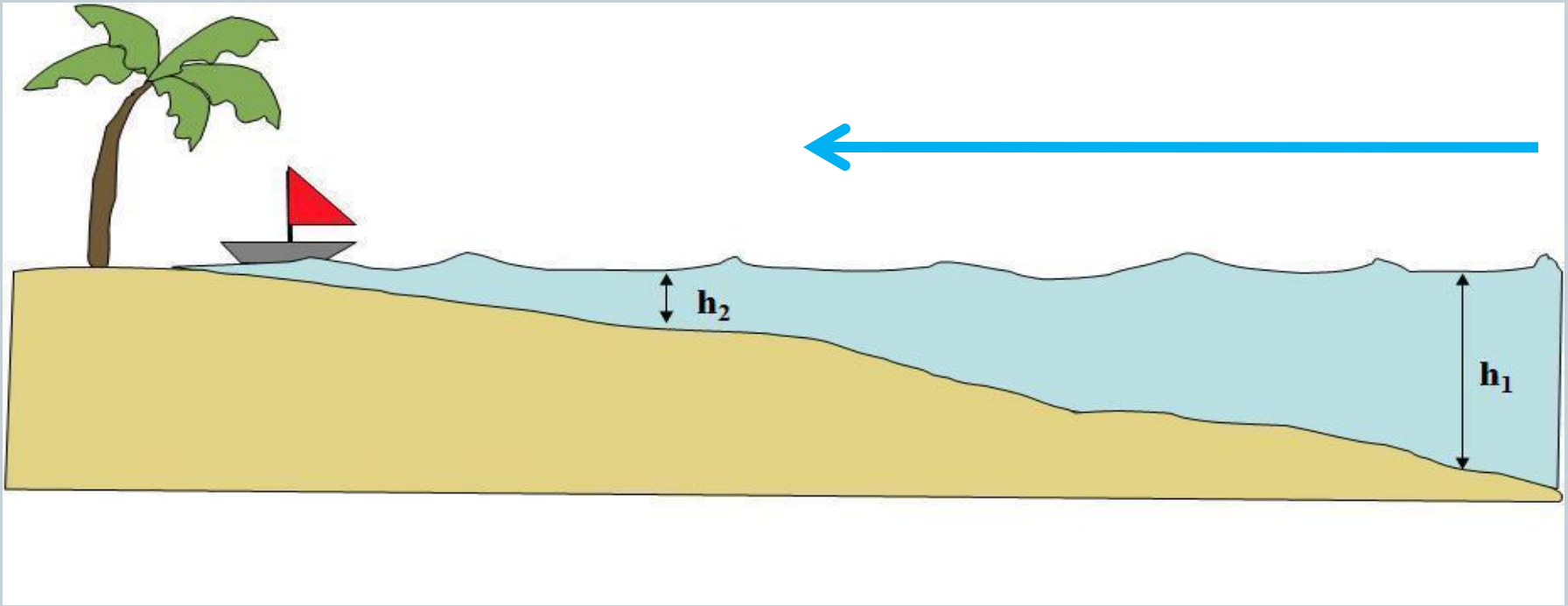
Animation

- Cause of a tsunami by an earthquake.

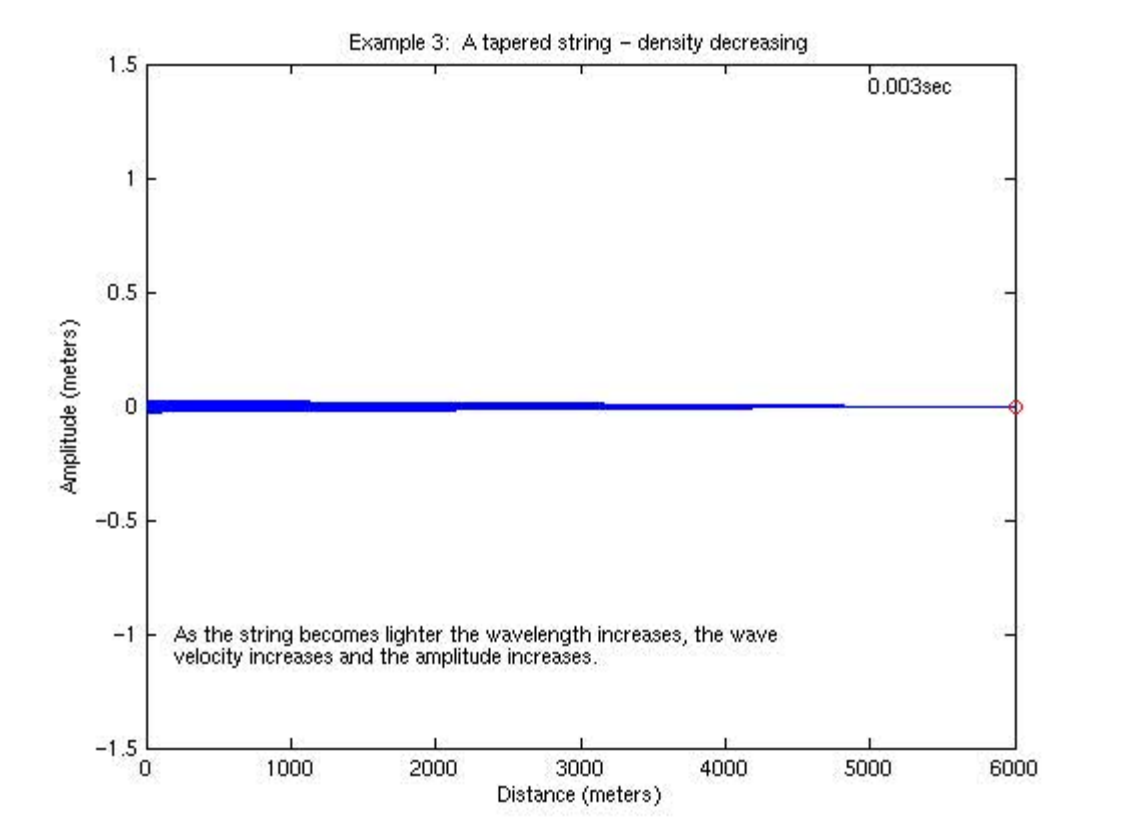


The Why and How behind a tsunami

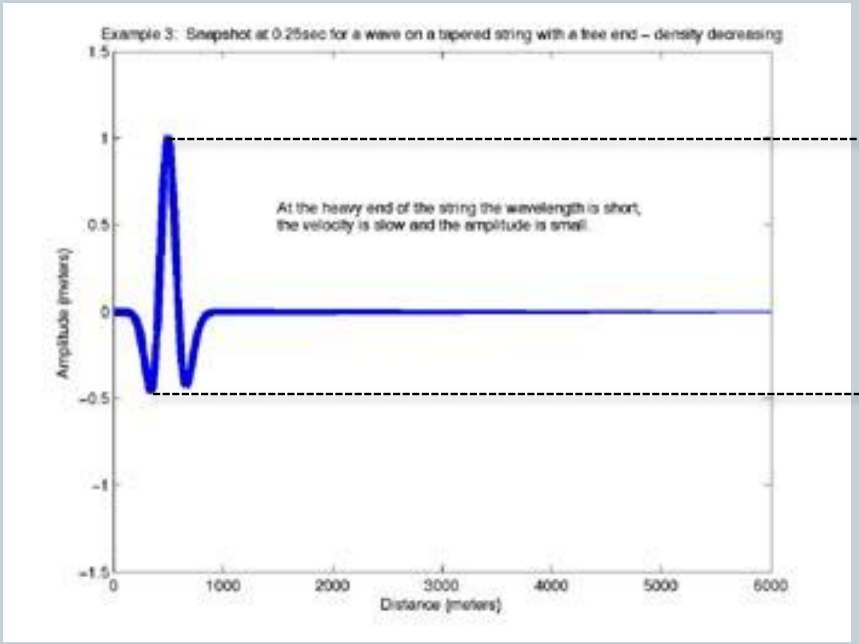
- What would happen to the wave with less than 1 meter of amplitude in deep ocean when it hits the shore?

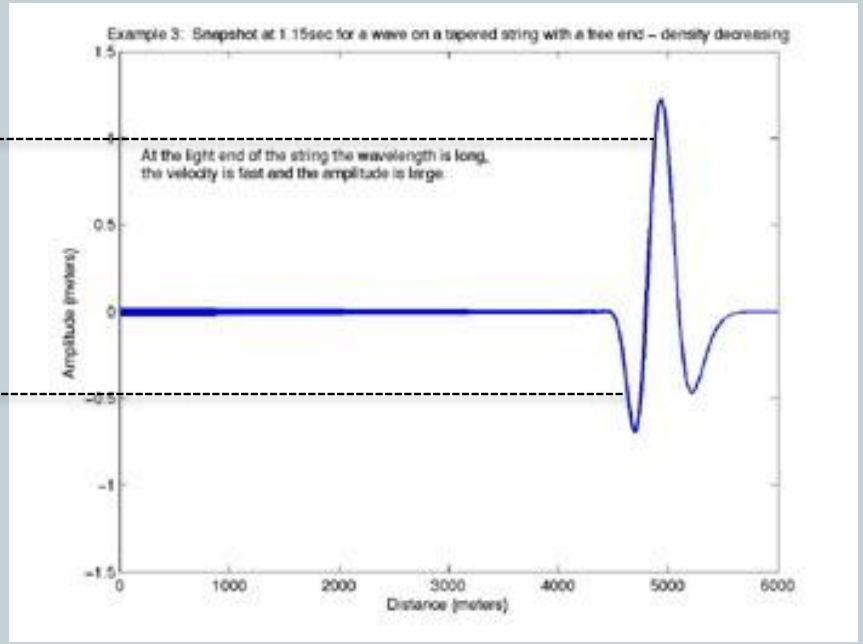


Here is a string



Comparison

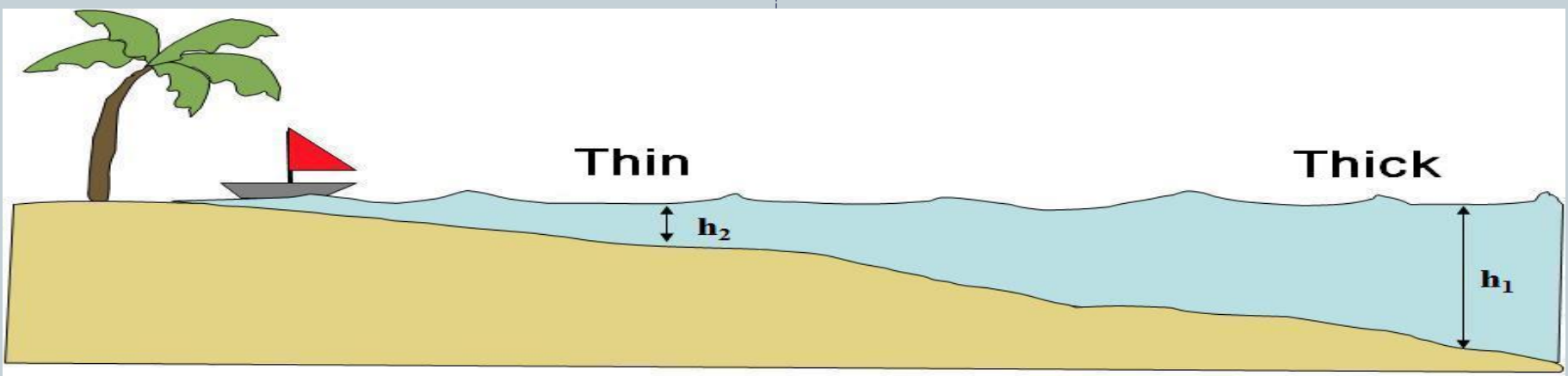




- Snapshots at two ends of the string.

Why?

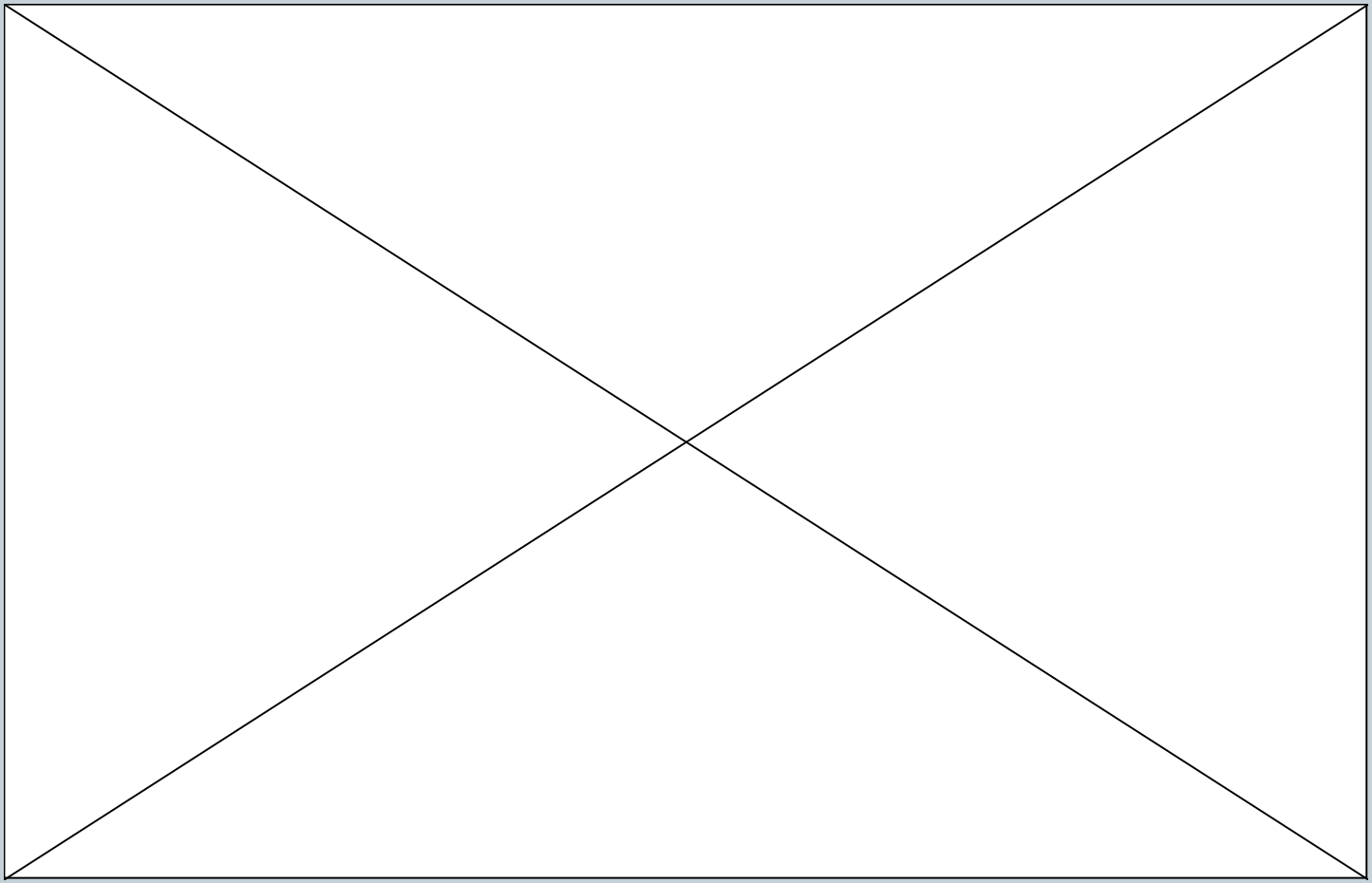
- Who can explain why the string behaved the way it did?
- Hint 1: conservation of energy
- Hint 2: mass of the string is changing from end to end
- Hint 3: refer to hint 1 and 2.
- Same reasoning can be applied to a tsunami approaching shore. Think of the ocean as a big string!



Another approach:

- Velocity of a shallow-water wave is
  - V= √(g*depth);
  - How fast does a tsunami travel in the middle of an ocean?
  - How fast is this?
- We also know the relationship governing frequency, velocity and wavelength.
  - If period of a tsunami is about 40 minutes, what is the wavelength of a tsunami in the middle of an ocean?
  - How long is this?
- Now repeat the calculation for when the tsunami is near shore.

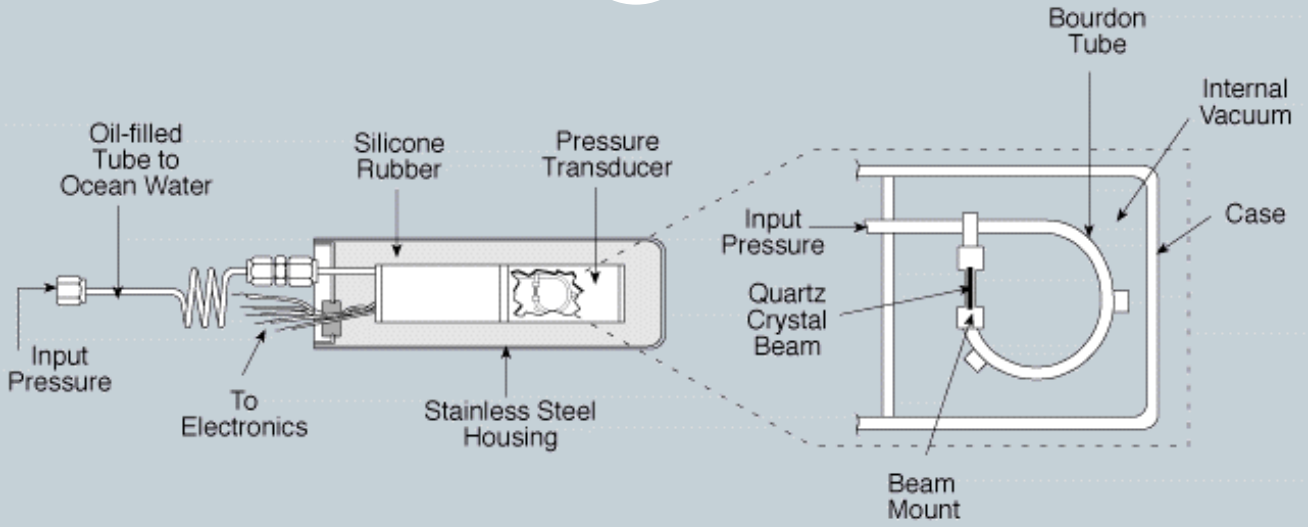
Little Clip



Drawback Effect

- What happens on shore if the trough of a tsunami arrives before the crest?
- A phenomenon called “drawback” will happen where water will recede hundreds of meters, exposing large area of sea floor.
- Do **NOT** walk toward a receding ocean!

Prevention? Prediction!



- There is no prevention. But there are many tsunami warning systems across the world.
- Above is a bottom pressure sensor. Detecting pressure change in the column of water above. Sensitivity to the millimeter changes of wave height.

Conclusion

- Today we learned about a special type of shallow water wave, tsunami.
- It is unique due to its large wavelength and high velocity in deep ocean, which transforms into high rising wall of water once reaching the shore.
- Tsunami cannot be prevented but only predicted. When an earthquake happens, pay attention to radio and TV broadcasting possible tsunami warnings.