

“Water, water, everywhere,
nor any drop to drink!”

Waves, marine energy, and strange ocean phenomena.

Chloe Leung



About me :)

1. she/they pronouns
2. 2nd year Mechanical Engineer
 - a. Possible Ocean Engineering master's or PhD
3. Chicago Public Schools and FIRST Robotics graduate
4. Sandia National Laboratories Water Power Intern
5. Research interests in marine energy, rogue waves, biomimetics
6. Favorite marine animal = handfish





(Both Endangered) Spotted Handfish and Red Handfish - [link to playlist](#)



Goals for Today:

1. What are waves and how do they form?
2. Learn about rogue waves and tsunamis
3. What else is out there?
4. What is ocean engineering? Use waves knowledge to understand marine energy.
5. Conduct wave tank mini experiment



What are waves?

1. Waves are the propagation of ENERGY.
 - a. In this case, through water.
2. Anything with mass can be a medium for mechanical waves: water, land, air, string, etc
3. Most water waves are surface waves.
 - a. A type of wave that propagates along the boundary between two media (such as the boundary between water and air)
4. Surface waves do NOT transmit mass.

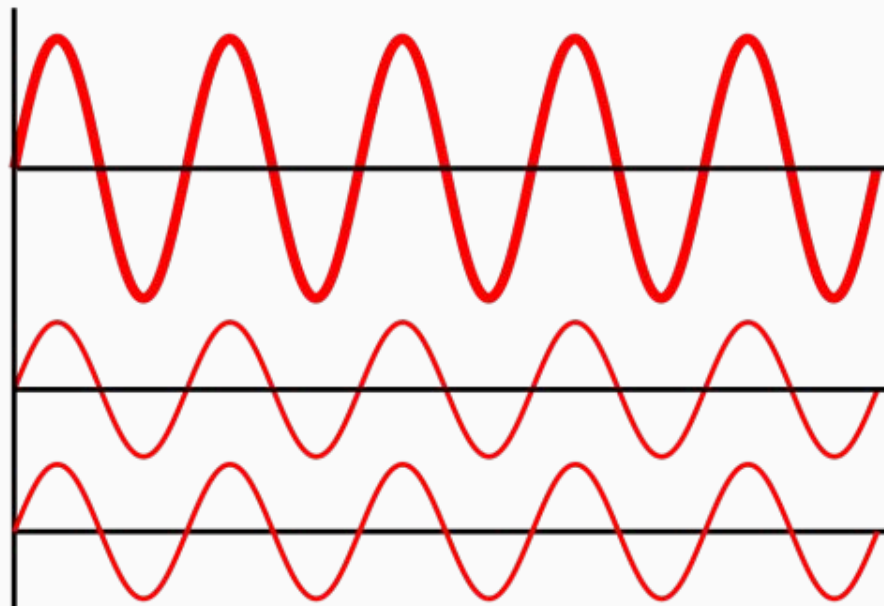
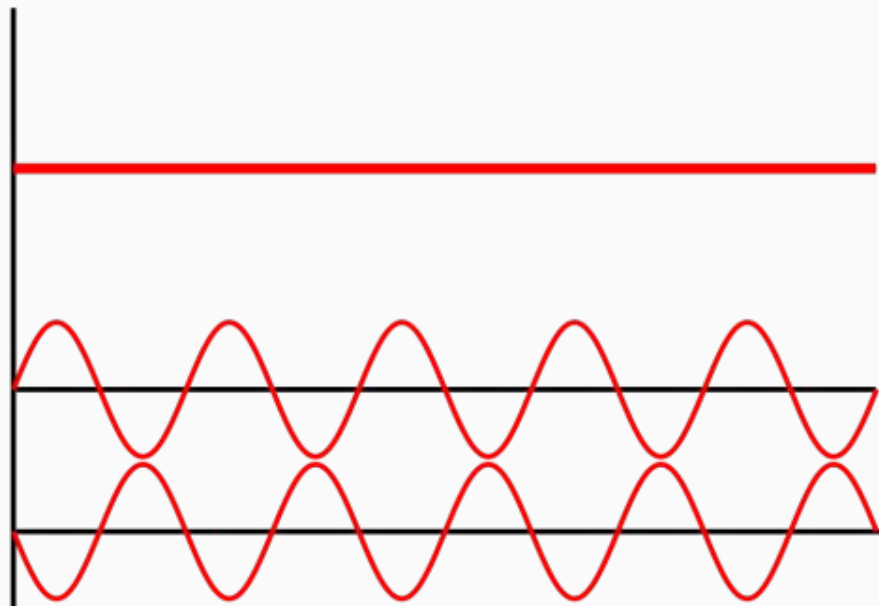


How do waves get BIG?

- Waves form when wind blows across the surface of water.
- Waves also gain energy over large distances (fetch).
 - Fetch is the distance waves can travel without disruption.
 - Wind velocity increase = wavelength increase = exponential energy increase [2]
- Interference causes waves to get bigger and smaller.
 - Constructive interference causes them to get bigger.
 - Destructive interference causes them to get smaller.



Destructive (left), Constructive (right)



The Great Wave off Kanagawa.



MASSIVE Waves!!

What the heck is the difference between these two types of giant waves?
Both can be 100+ feet and are very dangerous if encountered.

Tsunami (link)	Rogue Wave (link)
Forms near the shore	Forms in the middle of the ocean
Caused by energy from earthquakes and underwater volcanic eruptions	Caused by constructive interference from smaller waves
Limited prediction ability based on earthquakes	Currently impossible to predict



What else is out there?

Megatsunamis



Whirlpools



Waterspouts



Rip Currents

(often mislabeled rip tides)



Tidal Bores



Bonus: The Great Pacific Garbage Patch

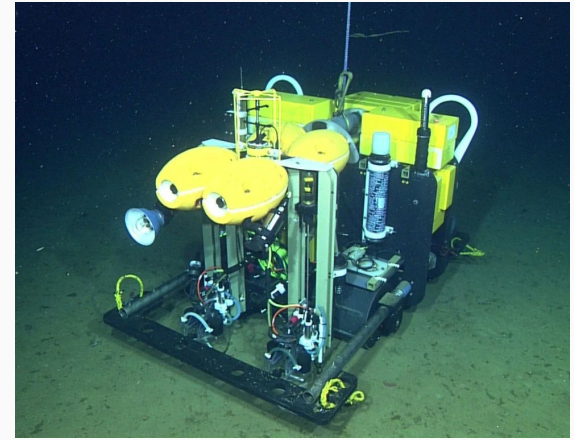


What is Ocean Engineering?

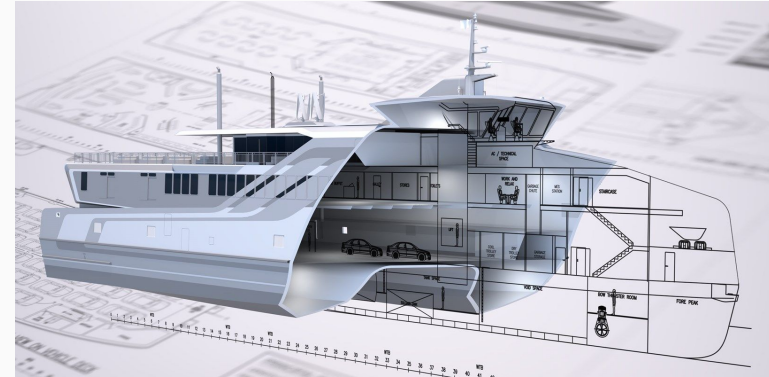
Designing structures for marine systems.



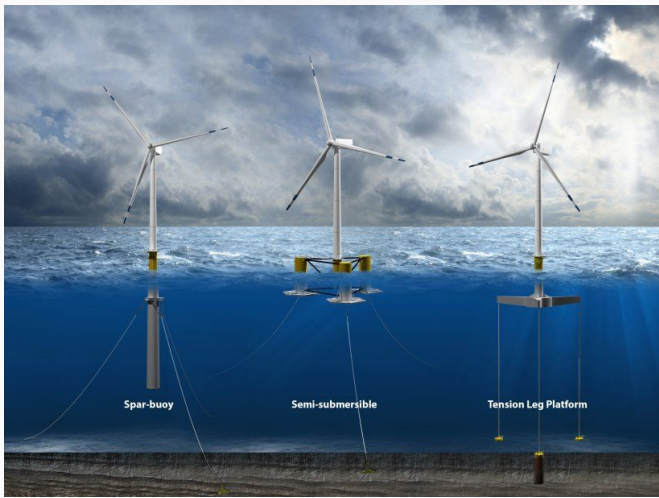
Ocean Plastic Collection System
(The Ocean Cleanup)



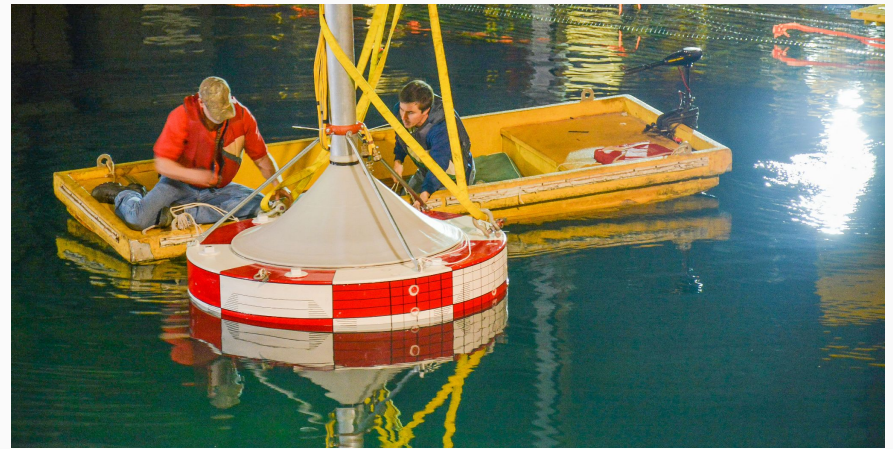
Seafloor Exploration Robot (MBARI)



Ship Design/Naval Architecture



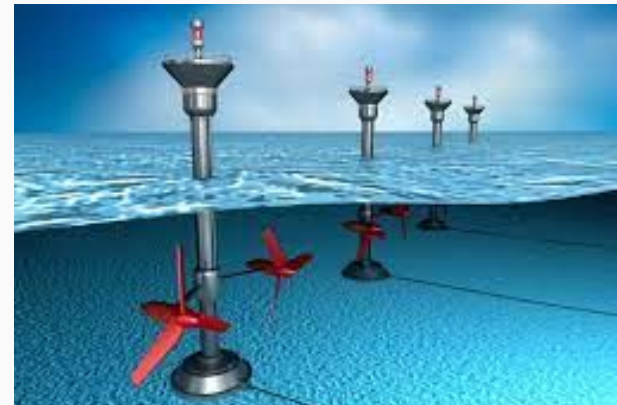
Offshore Wind Turbine



Wave Energy Converter (Sandia Labs)



Wave Energy Converter (WEC)



Tidal Energy Converter

Marine Energy!

Waves along the US coast are estimated to contain 2.64 TRILLION kWh,
64% of US utility electricity generation in 2021! [3]

Most of them rely on vertical motion and float on the sea surface.



Wave Tank Uses

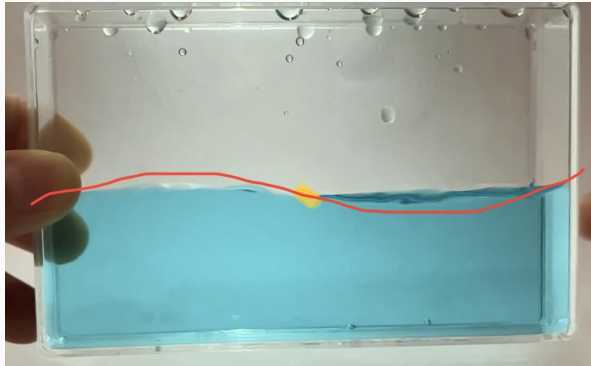
- Simulate real wave dynamics
 - Sometimes includes sediment, like sand or pebbles or plastic blocks to simulate a seawall.
- Big wave tanks can also be used to test prototypes.



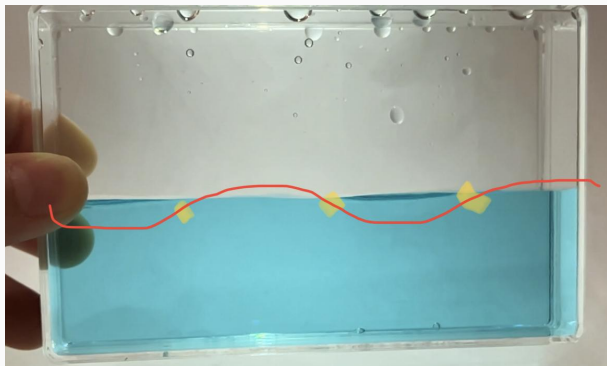
Coastal Studies Institute (UNC System)



Mini Wave Tank Experiment



2nd Harmonic



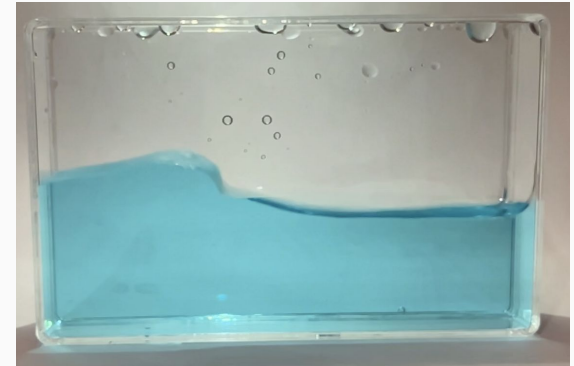
4th Harmonic

What else can you create?

Shake it, tap it, turn it sideways, use your imagination! Just don't drop it from a distance.

Can you create destructive interference?

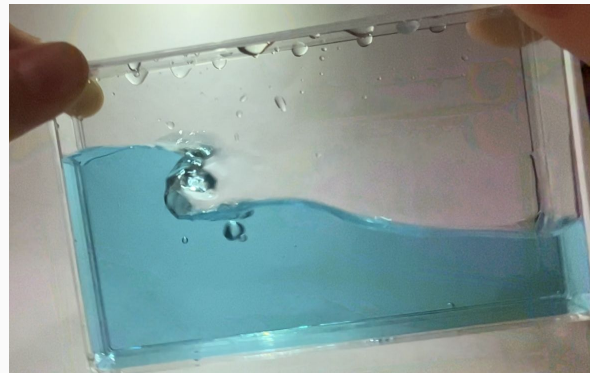
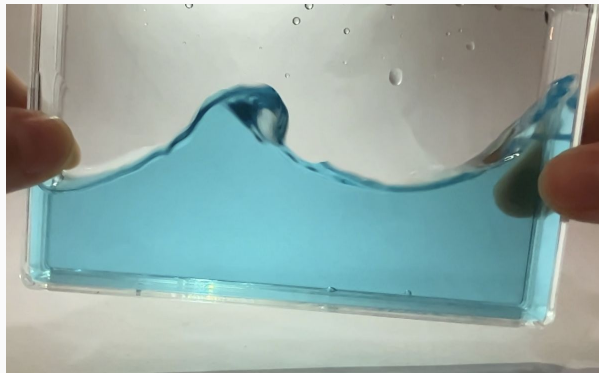
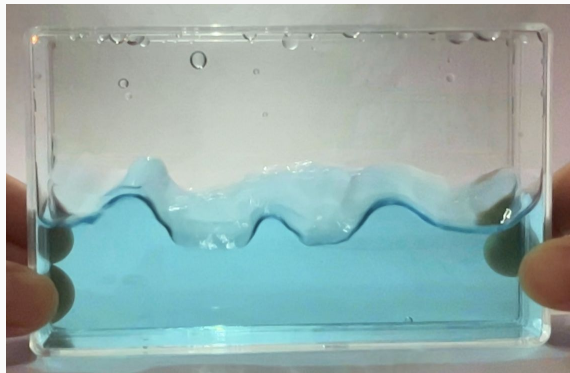
What about 5th or 6th harmonics?



Tsunami-like displacement



Rogue wave



Rogue Wave
Recreation
(right)





Thank you!

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Slide decks + link to construction info coming in email!



Terms

Mechanical Waves

Surface Waves

Fetch

Constructive/Destructive Interference

Rogue Waves

Tsunamis

Ocean Engineering

Wave Tank



Sources

[1]

<https://onlinelibrary.wiley.com/doi/full/10.1002/9781118476406.emoe077#:~:text=From%20the%20smallest%20to%20the,%2Dperiod%2C%20and%20tidal%20waves.>

[2]

<https://www.nature.com/scitable/knowledge/library/coastal-processes-and-beaches-26276621/>

[3]

<https://www.eia.gov/energyexplained/hydropower/wave-power.php#:~:text=Waves%20have%20a%20lot%20of%20energy&text=Ocean%20waves%20contain%20tremendous%20energy,scale%20electricity%20generation%20in%202021.>

