Spring 2025 Astronomy 98 Final Project: Simulating Tidal Waves with Gravitational Physics

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Overview

This project aimed to model the tidal waves on the Earth by using python to simulate the gravitational physics of the Earth-Sun-Moon system.

Modeling

We took into account body masses, distances, times, etc. We modeled the Moon's elliptical orbits around the Earth, and the Earth's around the sun.

$$D_{EmX} = D_a cos(\frac{2\pi t}{P_E * T_m})$$

$$D_{EmY} = D_p sin(\frac{2\pi t}{P_E * T_m})$$

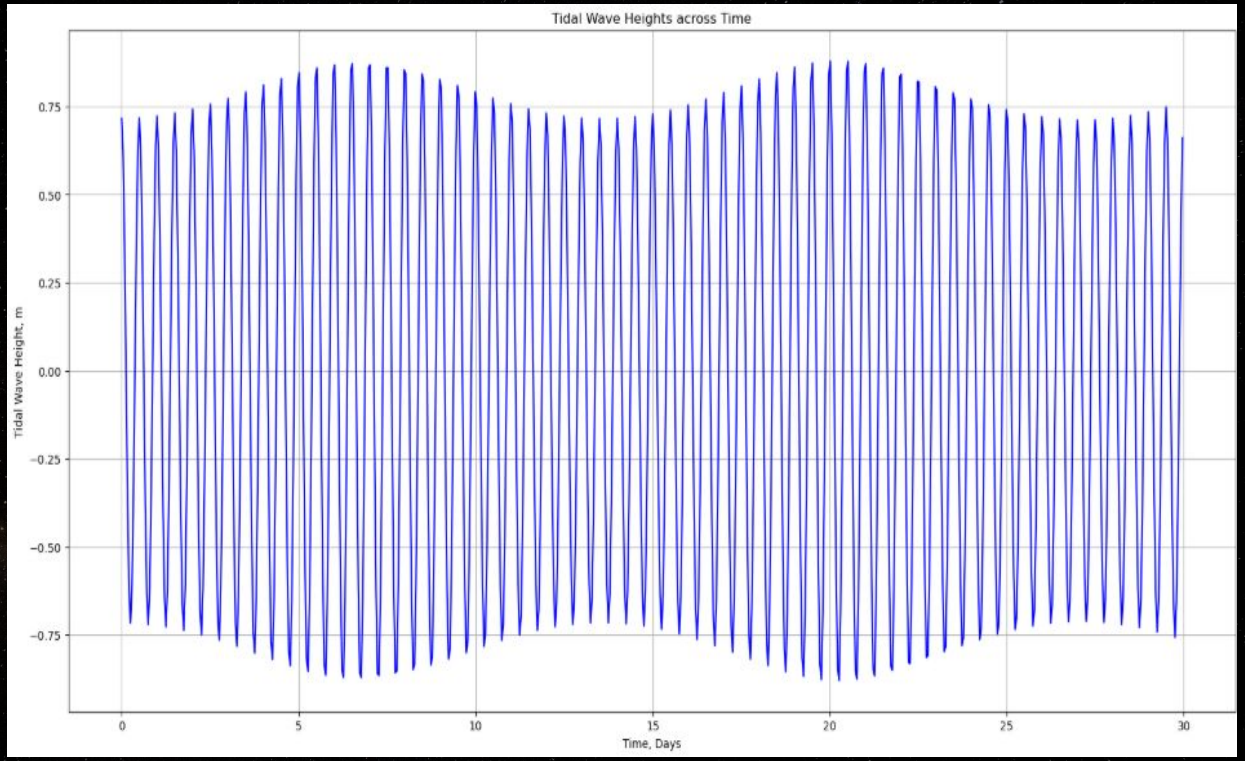
$$D_{Em} = \sqrt{(D_{EmX})^2 + (D_{EmY})^2}$$

$$h_{wave} = \frac{3GM_m R_E^2}{2g_E D_{Em}^2}$$

$$L_{SE} = (A_S)cos(\frac{2\pi t}{P_E * T_E}) + (L_a - A_S)$$

Graph ~ Unanimated

- Accounts for tidal forces from Sun and Moon
- These forces cancel out completely in some areas and are summed in others



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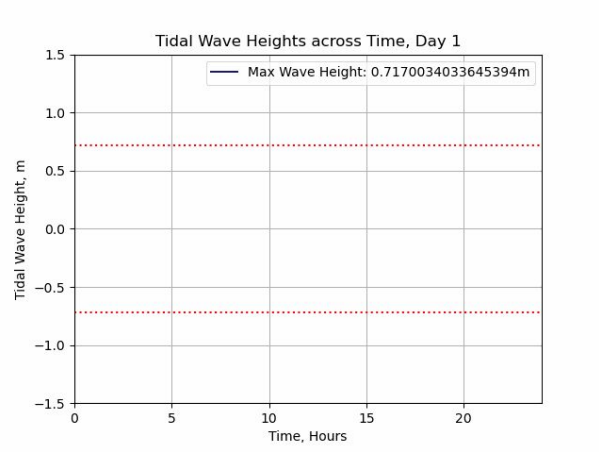
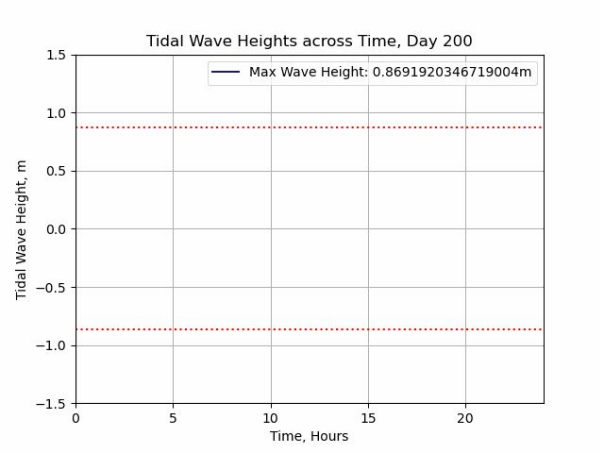
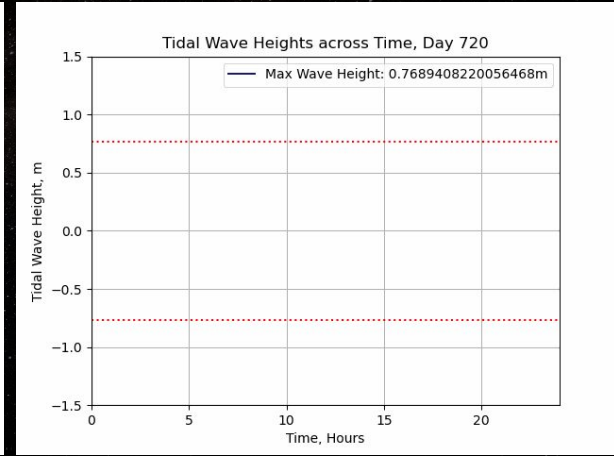
Results

Lastly, we animated the tidal wave height graph as shown below to track the wave heights across time, using matplotlib.animation.



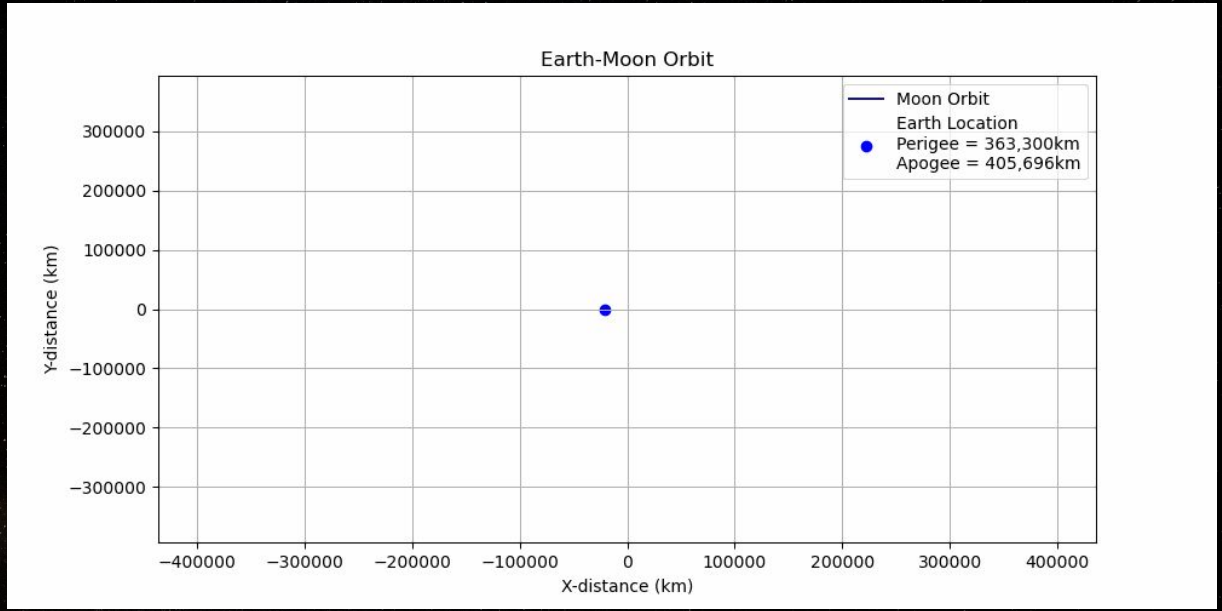




We selected three examples of the wave heights as a function of hours on days 1, 200, and 720. The dotted red lines indicate the maximum height of the waves throughout the day.

Extra: Earth-Moon Orbit!

- The first actual thing we animated :)



Works Cited

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- Jim Branson. 2012. The Tides. https://hepweb.ucsd.edu/ph110b/110b_notes/node13.html
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