Picture: https://i.redd.it/hzahguuq04cy.jpg

GRAVITATIONAL IMPACT OF THE DEATH STAR ON ENDOR AND EARTH-LIKE PLANETS

A Scientific Exploration Using Newtonian Mechanics

BY: SIMON TEBECK, PRANAV GUPTA

TEAM NAME: THE SKYWALKERS

PI: PROF. OLIVER BECKSTEIN

HTTPS://GITHUB.COM/PY4PHY/FINAL-2024-THE-SKYWALKERS

Background

- Problem Statement: Investigate the gravitational impact of the Death Star on nearby celestial bodies like Earth and Endor.

- Equations Used:
  Newton's Law of Universal Gravitation: F= GMm/r^2
  Equations of Motion for Circular Orbits: F = ma
  Velocity Verlet

- Motivation: Understanding these effects is crucial for predicting potential real-world outcomes in similar massive body interactions within a planetary system.

Methods

- Algorithms: Velocity Verlet Integration for accurate motion simulation.

- Main Libraries Used:
  NumPy for numerical operations
  Matplotlib for plotting and animations
  Moviepy for creating videos

- Objectives:
  1. Collection of data
  2. Calculation of orbits
  3. Surface impacts
  4. Implication of sudden disappearance or crash

Results - Task 1: Data Collection

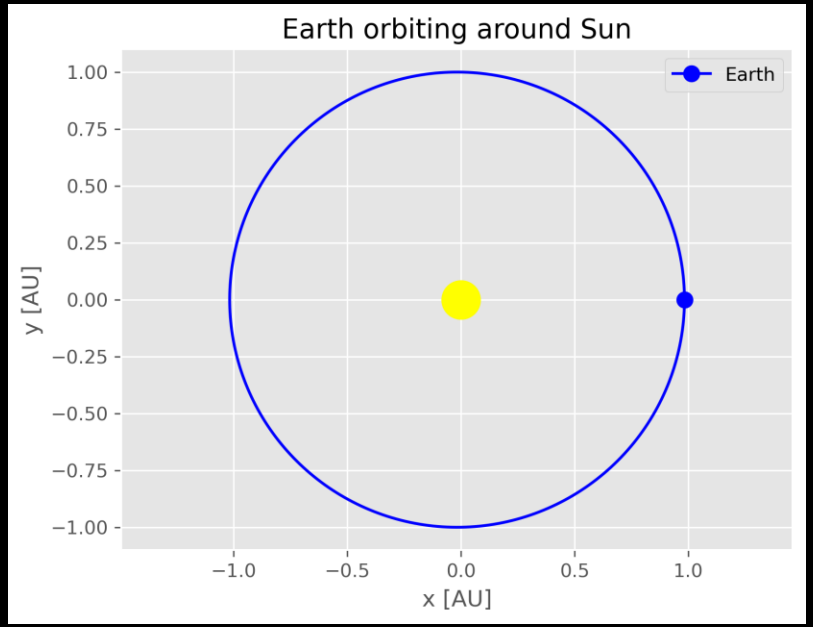
- Collected the required information form fan pages, reddit and publicly available data for Masses, distances,

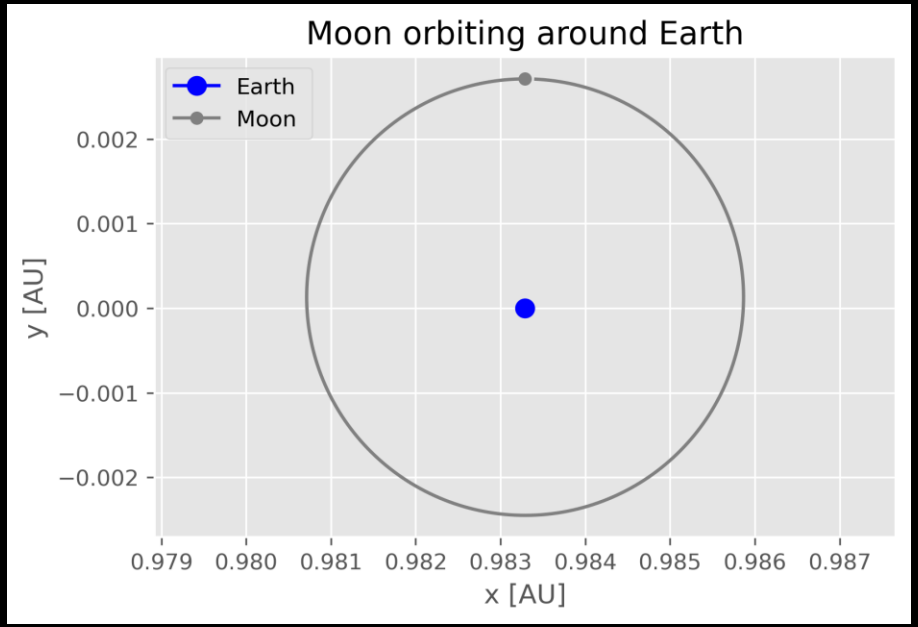
Distances		
Earth	Sun	1.49E+08
Earth	Moon	3.84E+05
Endor	Death Star	2.50E+04
Endor	Big Brother	1.25E+07

	Mass(kg)	Radius (km)	Rotation period (hours)	Orbital period (days)	Population	Surface Gravity	Extra	Refernce links
Endor	7.52E+23	2450	18	402	3.00E+07	8.35		https://starwars.f
Earth	5.97E+24	6357	24	365	8.10E+09	9.81		https://en.wikipe
Moon	7.35E+22	1737	655.7	27.3	0	1.62		Moon (nasa.gov)
Star Killer Base	1.60E+22	330					the der	https://fictionomi
Star Killer Base-2	1.37E+24	415						https://www.redd
Big Brother	2.01E+27	74000						https://starwars.f
Death Star 1	2.80E+23	60					6.2e32	https://www.tdgu
Death Star 1-2		80						
Death Star 2		100			2.47E+06		Made u	https://starwars.f
Sun	1.99E+30	696000	28	0	0	275		

Results – Task 2: Orbits

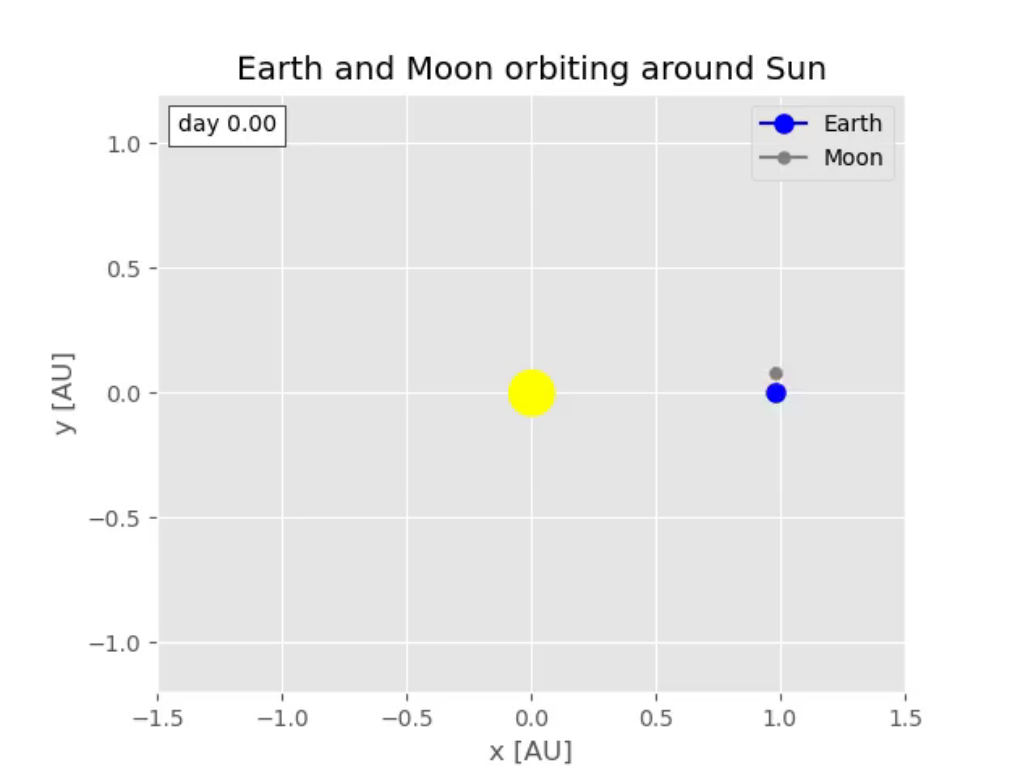
Control Orbits

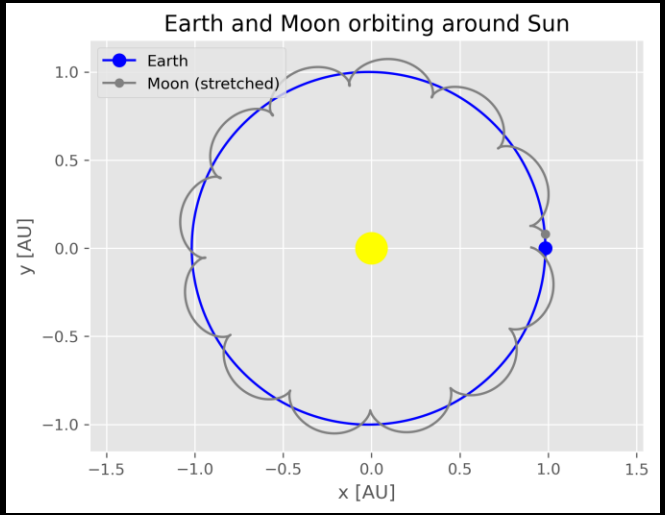




Results – Task 2: Orbits

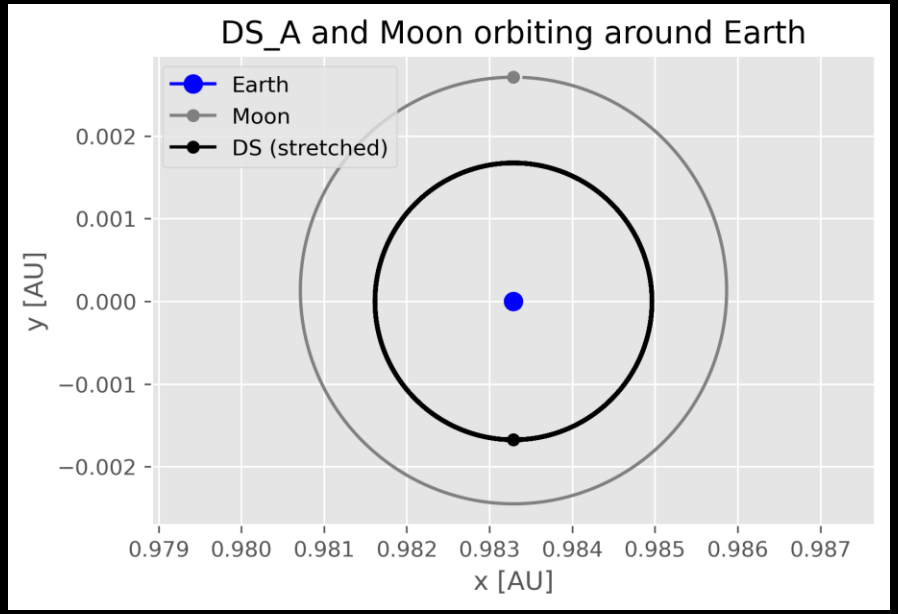
Control Orbits

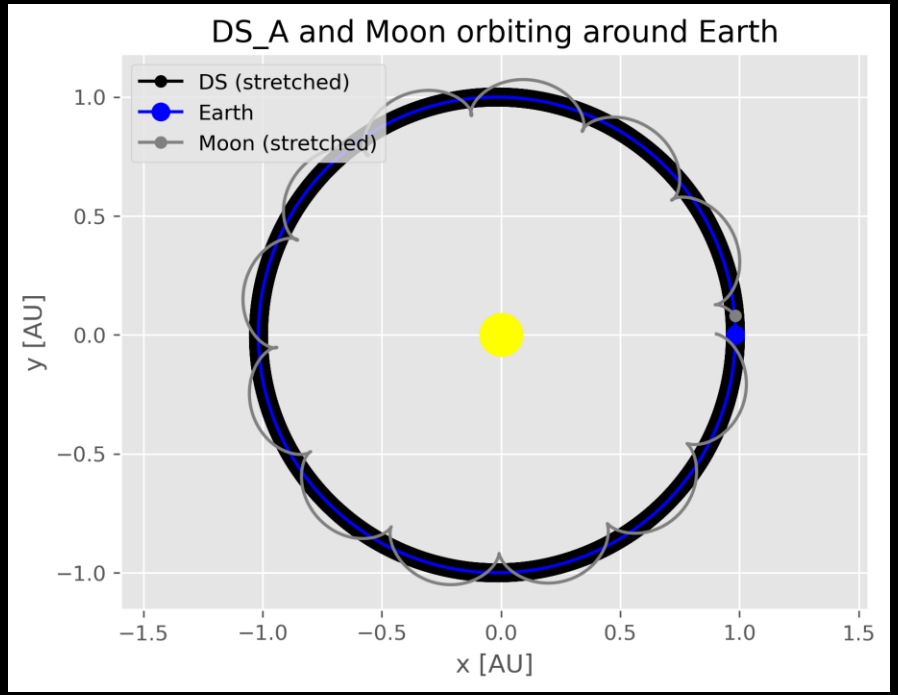




Results – Task 2: Orbits

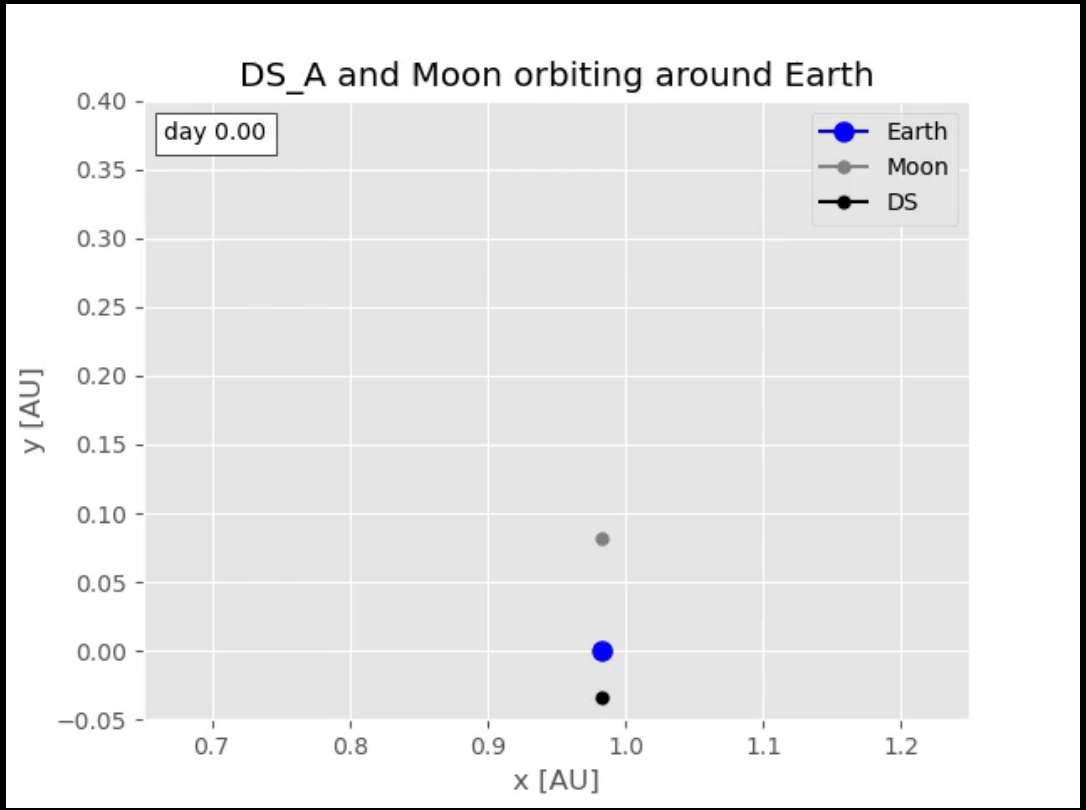
Orbits with the light Death Star

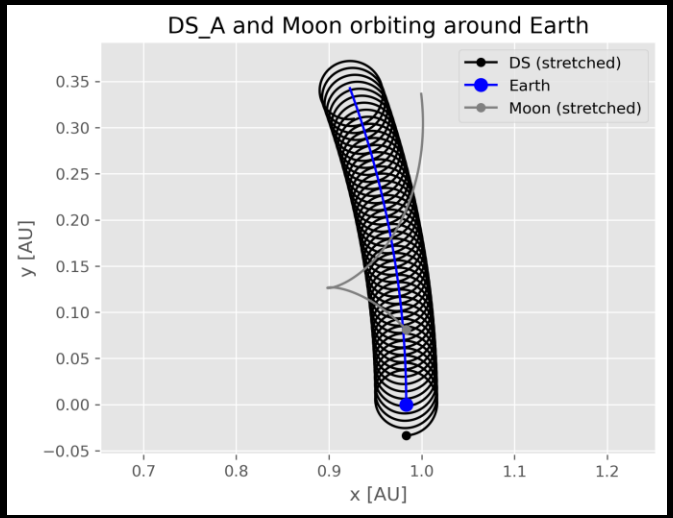




Results – Task 2: Orbits

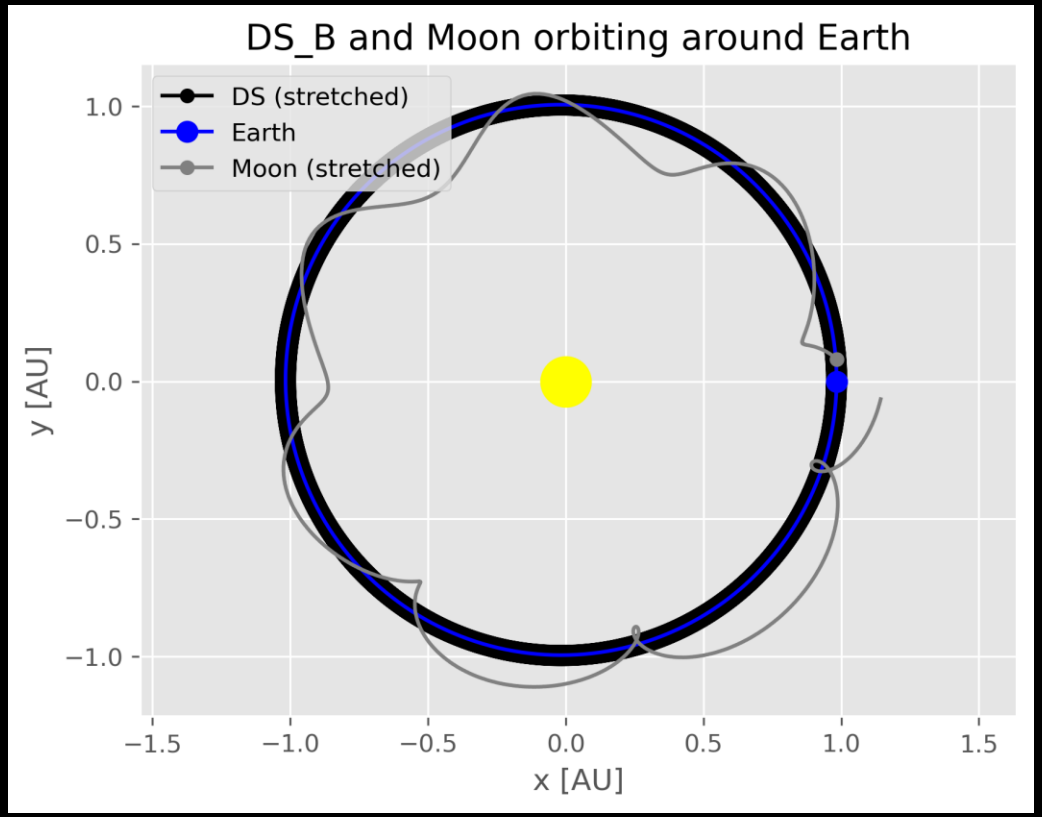
Orbits with the light Death Star

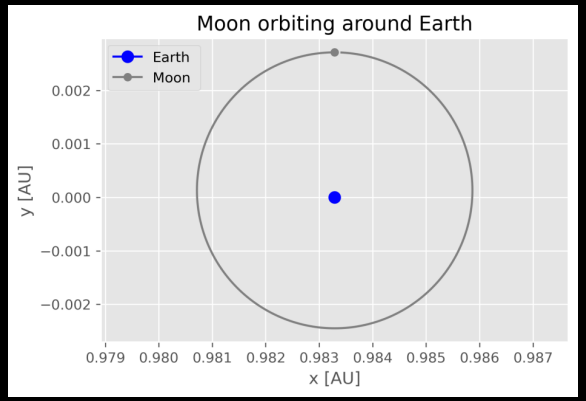


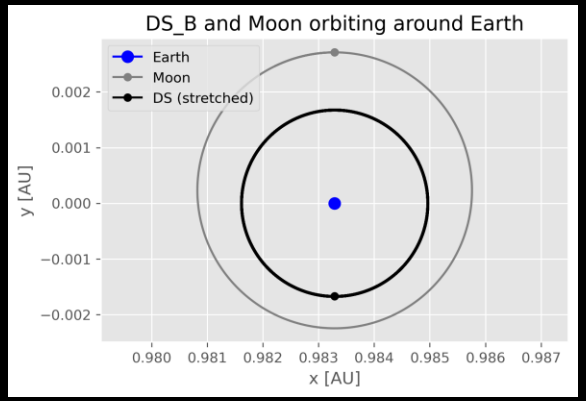


Results – Task 2: Orbits

Orbits with the heavy Death Star

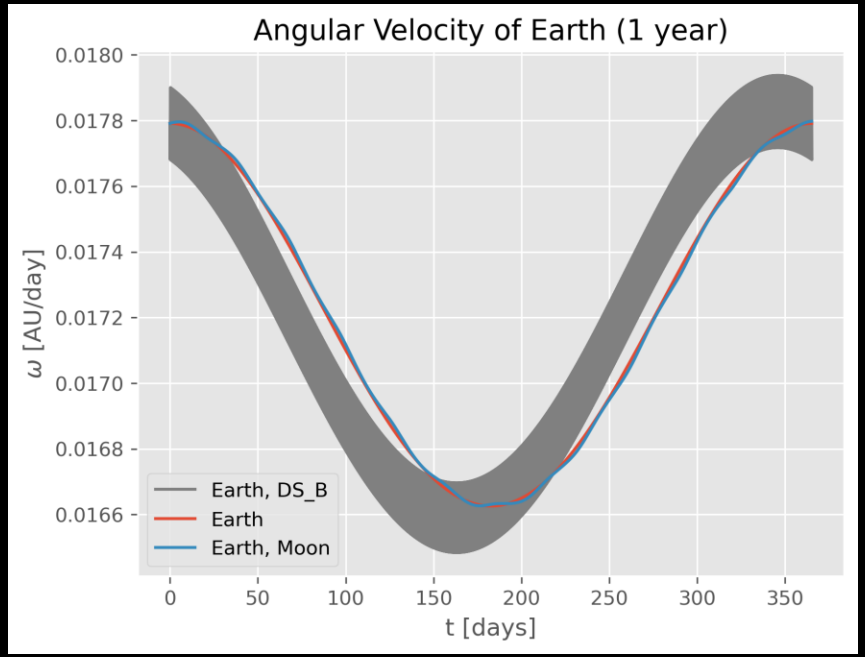


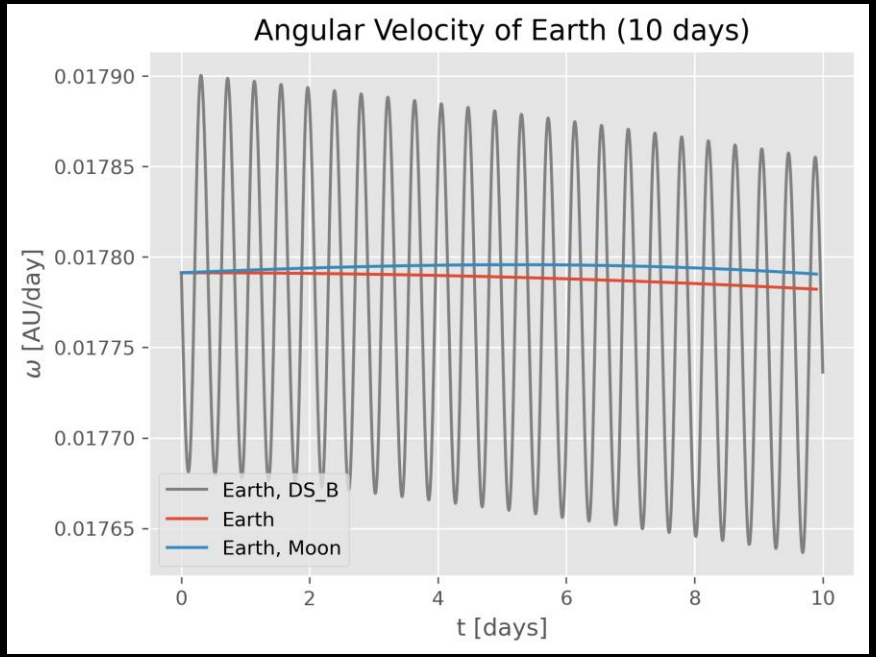




Results – Task 2: Orbits

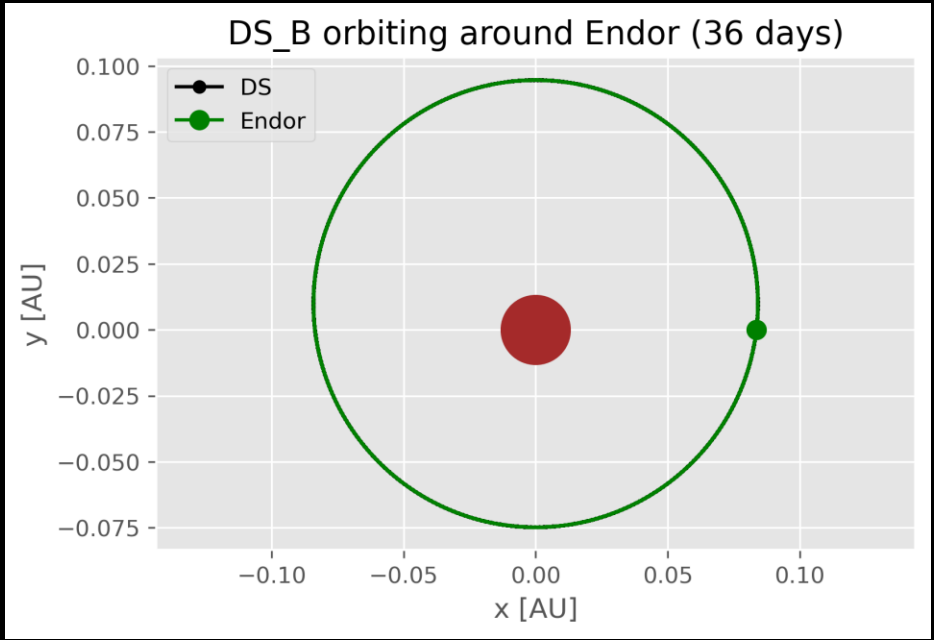
Angular Velocity Impacts

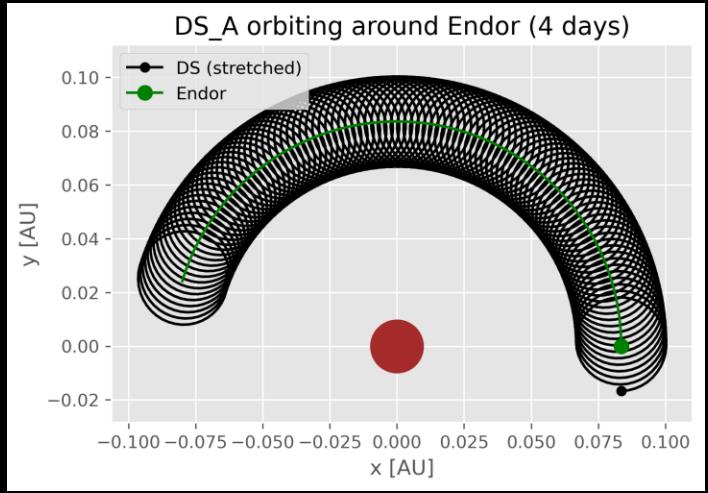


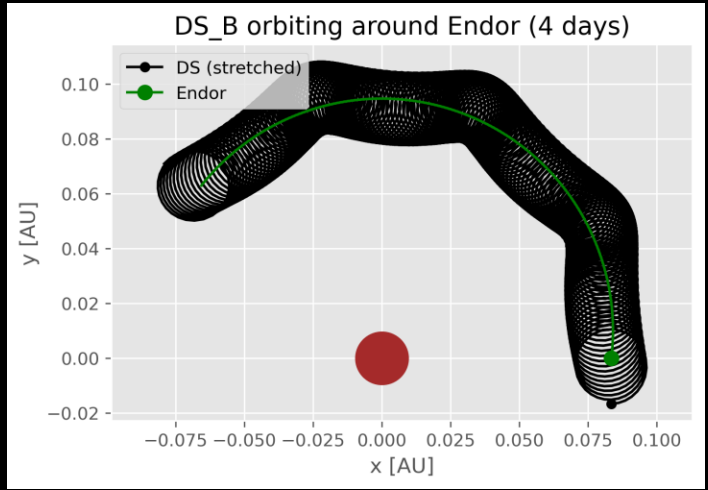


Results – Task 2: Orbits

Orbits for Endor

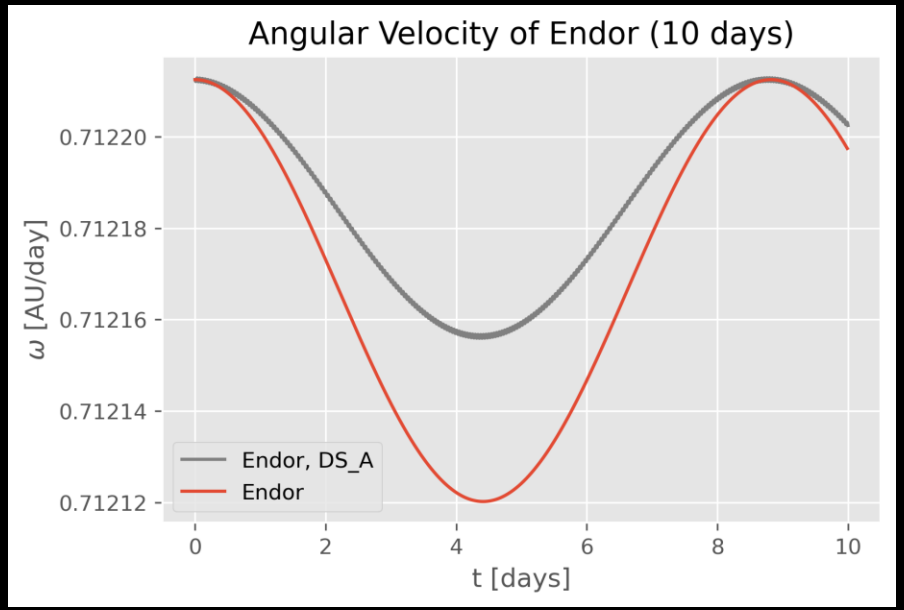


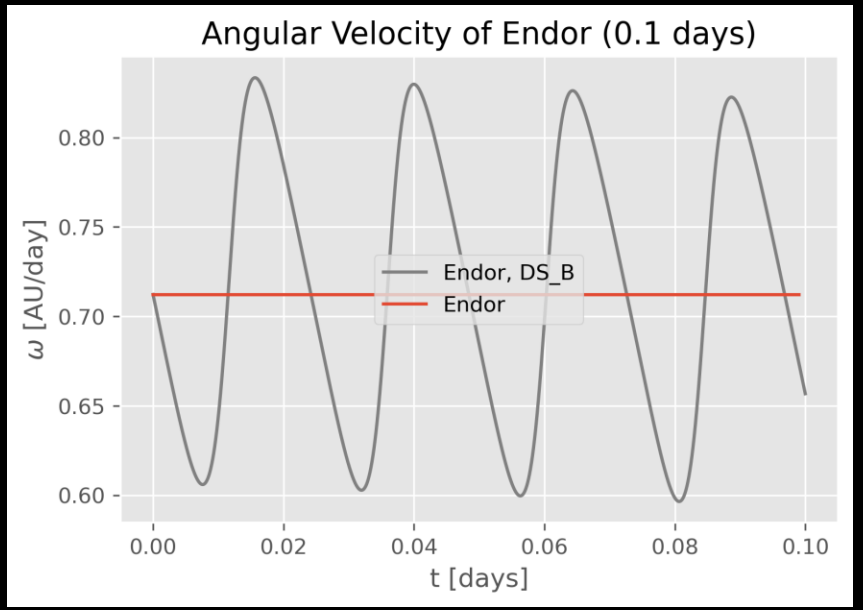




Results – Task 2: Orbits

Angular Velocities for Endor





Results – Task 2: Orbits

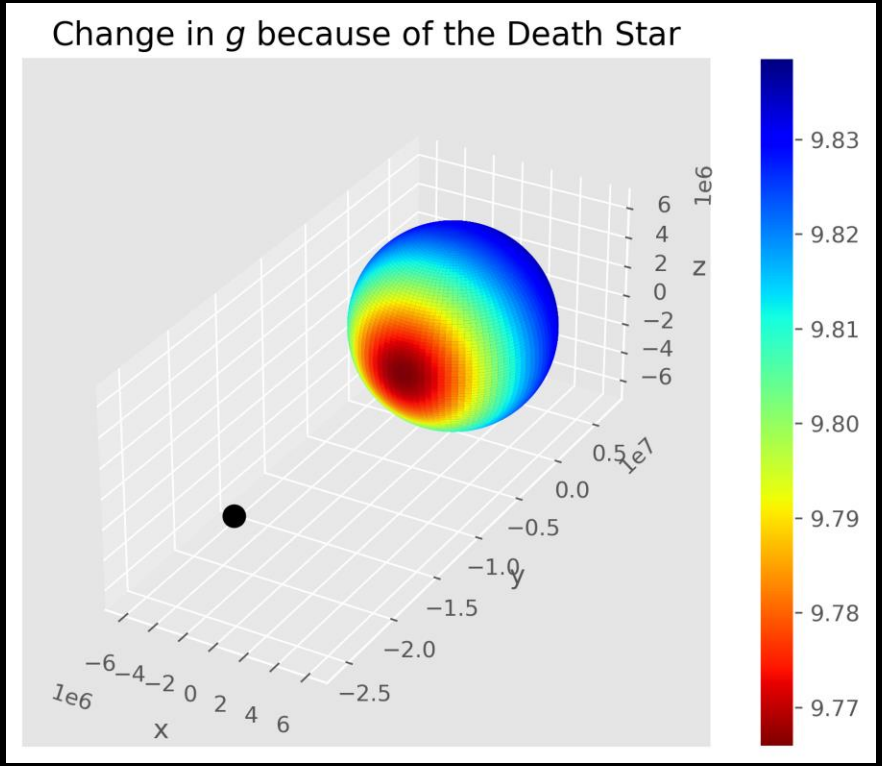
Period Deviations

	Earth	Moon	Endor
Period [days] Normal conditions	365.37	27.44	8.82
Period [days] DS_A impact	365.37	27.44	8.82
Period [days] DS_B impact	365.34	25.24	9.00
Deviation of DS_B impact to normal	0.009%	8.00%	2.04%

Results – Task 3: Surface Impacts

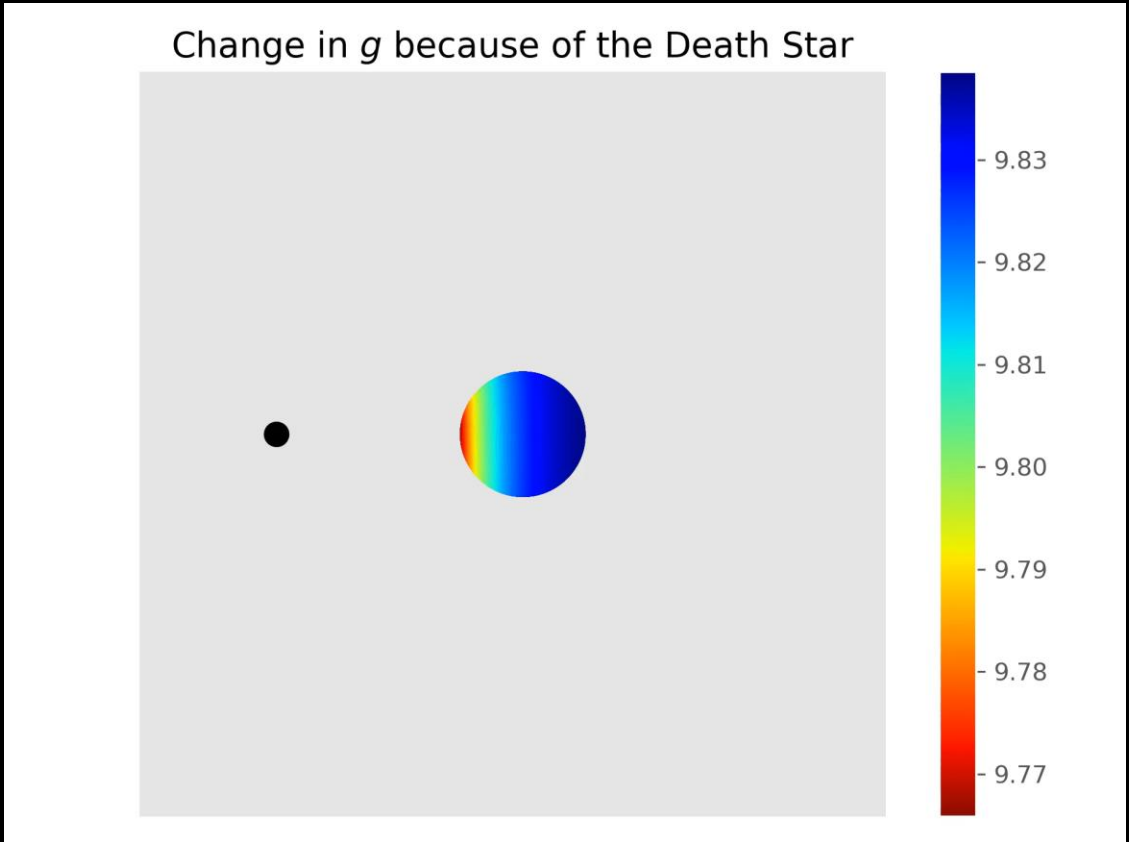
Reduction of local gravitational acceleration

- The gravitational pull of Death Star (B) reduces the local gravitational acceleration on Earth
- Value can go as low as 9.756 m/s²
- Pull is three orders of magnitude stronger than Moon's



Results – Task 3: Surface Impacts

Reduction of local gravitational acceleration

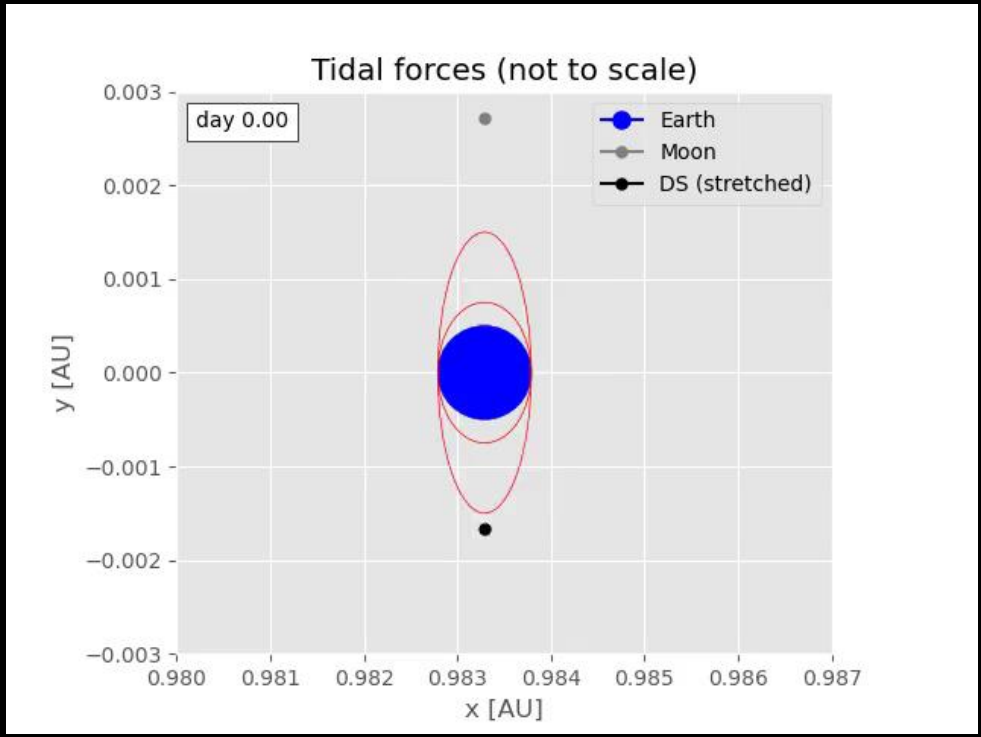


Results – Task 3: Surface Impacts

Tidal effects

- Estimation of tidal effects based on the gravitational differential
- The mass and proximity of the Death Star create huge tidal forces which are four orders of magnitude bigger than Moon's (for DS_B)
- We have to expect waves on the ocean with heights of around 3.7 km, even higher ones on the coast

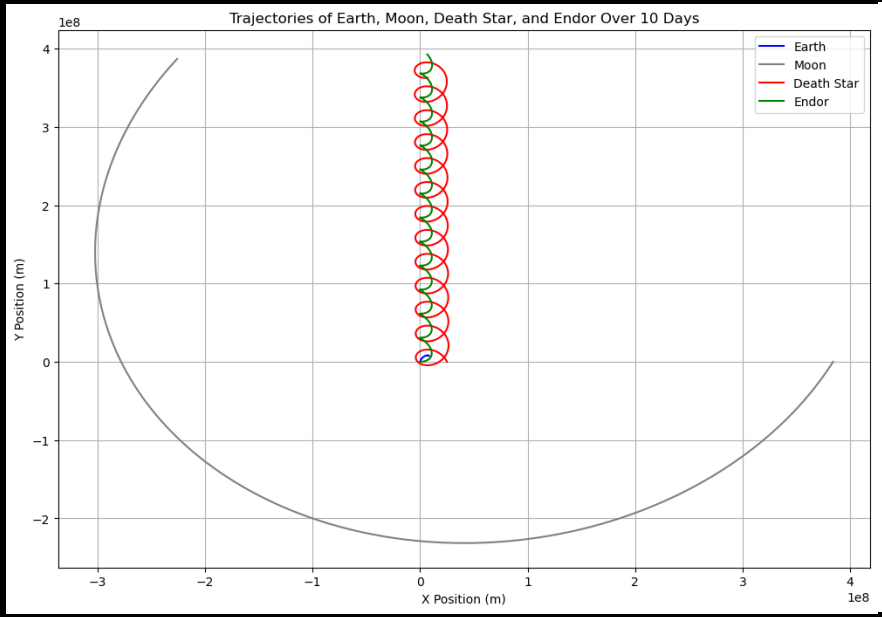
	Tidal effect [m/s²]
Moon	1.873e-06
Sun	1.063e-6
DS_A	1.245e-7
DS_B	3.486e-2

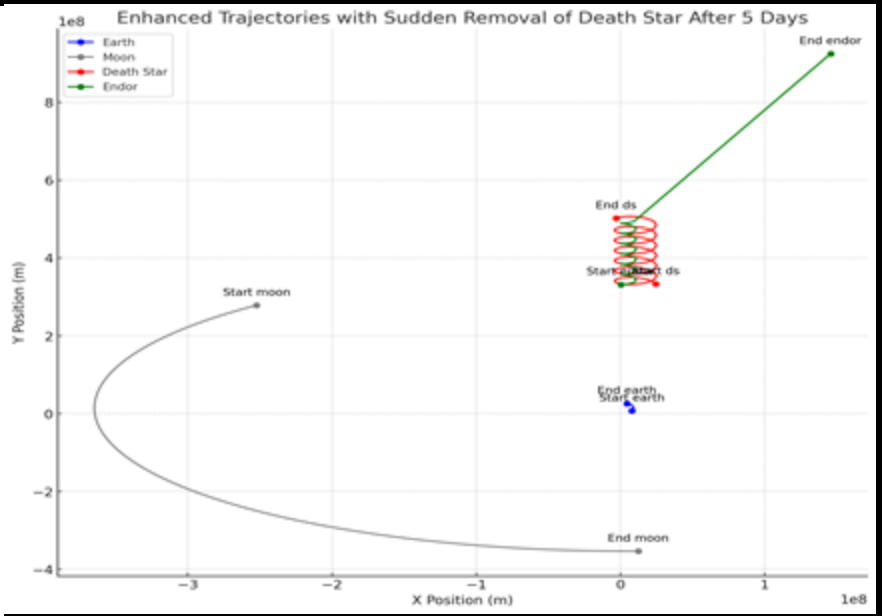


Results - Task 4 (Sudden Disappearance)

Implications of Death Star's Sudden Disappearance

- The sudden removal of the Death Star leads to a destabilization of Endor's and Earth's orbit, demonstrating the significant gravitational influence exerted by the Death Star.

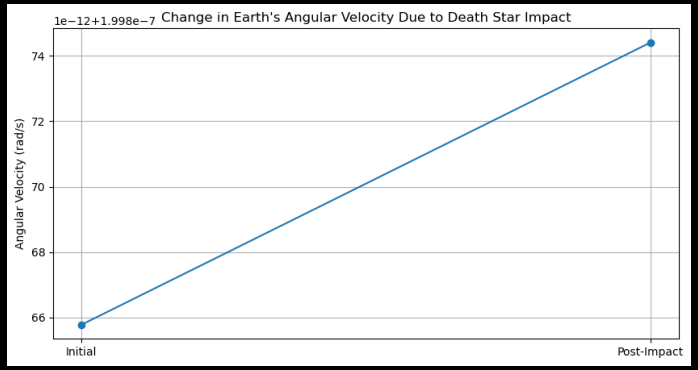


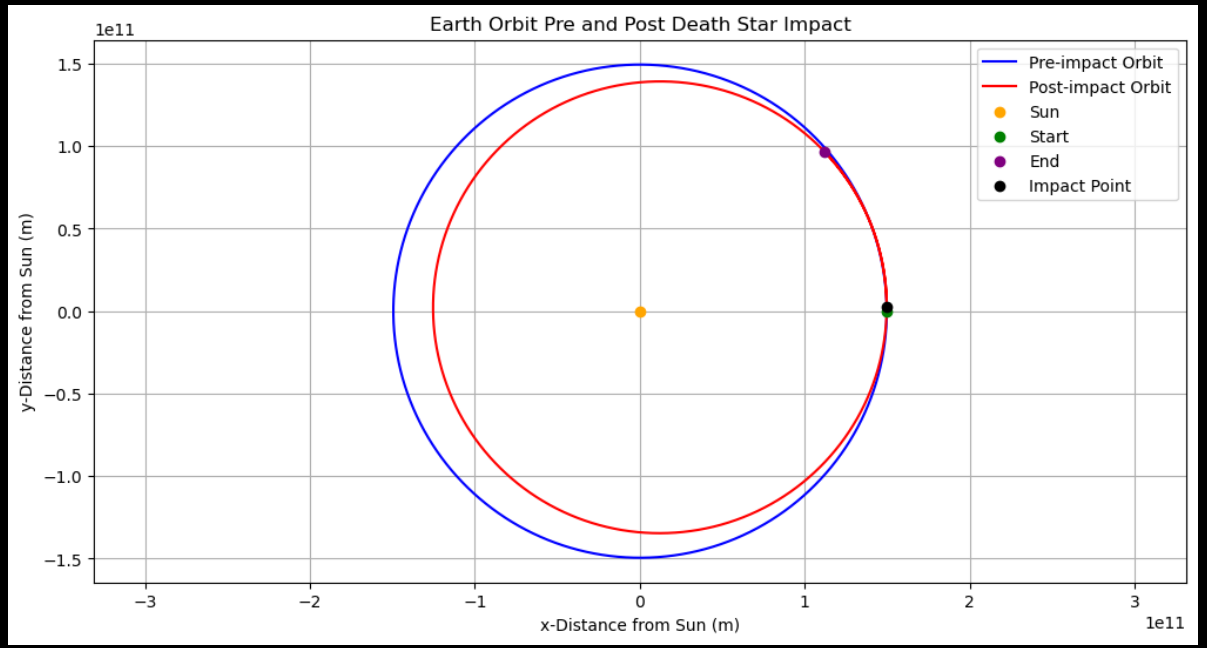


Simulation of Death Star Impact on Earth

Results - Task 4 (Sudden Crash)

- The sudden crash of the Death Star leads to a significant reduction in Earth's distance from the Sun with higher angular and orbital velocity.





Conclusions

- The simulation showed significant gravitational effects of the Death Star, especially the heavy estimation, on nearby planets, altering their trajectories and potentially causing orbital destabilization.
- Period times change because of the Death Star, slightly for big objects like Earth, but significantly for smaller objects like the Moon or Endor
- On Earth, the heavy Death Star would create monstrous tides and kilometer-high waves on the ocean
- Demonstrated how the sudden removal of a massive body affects planetary systems.
- The simulation confirmed that the Death Star’s crash would lead to substantial modifications in Earth's orbital and kinetic energy.

Future Work

- Could include more bodies or consider non-circular orbits for further complexity and realism.
- Make more sophisticated tides calculation

Acknowledgement

1. For animation code and template for the report:
   Department of SC/Physics. “L01 PHYS 2030”. PHYS2030 3.0 Computational Methods for Physicists and Engineers Course Lecture slides Winter 2023. York University 2023.

References

1. Values for mass, distances extracted from https://starwars.fandom.com/wiki/Endor
2. https://en.wikipedia.org/wiki/Orbit_of_the_Moon
3. https://en.wikipedia.org/wiki/Earth%27s_orbit
4. https://phys.org/news/2014-11-earth-orbit-sun.html
5. https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html
6. https://science.nasa.gov/moon/tides/
7. https://www.physicsforums.com/threads/solar-vs-lunar-tides-explaining-the-difference.535403/

References

1. https://nssdc.gsfc.nasa.gov/planetary/factsheet/moonfact.html
2. https://moviepy.readthedocs.io/en/latest/getting_started/working_with_matplotlib.html
3. https://austides.com/wp-content/uploads/2014/06/Kowalik_Luick_2011.pdf
4. https://www.youtube.com/watch?v=pwChk4S99i4&t=423s
5. https://matplotlib.org/stable/gallery/mplot3d/surface3d_2.html#sphx-glr-gallery-mplot3d-surface3d-2-py
6. https://en.wikipedia.org/wiki/Tidal_range#/media/File:M2_tidal_constituent.jpg

MAY THE

$$F = \frac{dp}{dt}$$

BE WITH YOU

From: SJSU PHYSICS AND ASTRONOMY CLUB