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MEST Final Project Proposal

Simulating a Gravity Assist Maneuver

This final project aims to create a 2D Python-based simulation of a gravity assist maneuver. Gravity assists are sometimes used to give spacecraft extra kinetic energy to reach their destination as in the case of the Voyager probes (which used partial slingshots to reach the outer Solar System). In the movie *The Martian*, a gravity assist maneuver is depicted as being used to conserve fuel for the extra lap around Earth to Mars and back (albeit with a few caveats).

The simulation will be carried out without the use of formulas such as the standard gravity assist formula ($\Delta v = 2|v_{planet}|\cos(\theta)$), and will instead rely on a second-by-second calculation of change in velocity due to acceleration from gravitational force. In other words, relying on the basic equations of motion and gravity covered in this course.

The final deliverable (aside from the write-up and usage instructions) will be a Jupyter Notebook, potentially with accompanying helper scripts, to calculate the spaceship's final velocity, change in heading, and time associated with the maneuver. Time permitting the notebook will include a graph or two depicting the path of the spaceship in relation to the planet.

Lastly, as the problem of accurately simulating a gravity assist maneuver gets quite complicated and also computationally expensive, I am using the following assumptions which will make the challenge more doable, however still well within the difficulty of a final project. One last note on the assumptions, any "arbitrary" values will be modifiable as a "constant" value in the notebook. The assumptions are as follows:

Spaceship

- The spaceship starts off at (0, 0) on a cartesian coordinate grid
- The spaceship's initial x-velocity is an arbitrary number
    - Most likely will be kept at 0 m/s
- The spaceship's initial y-velocity is an arbitrary number
    - Most likely set around 11176 m/s (Voyager exit velocity) or 5.36e3 m/s (estimated speed of Hermes ship from the movie *The Martian*)
- Spaceship will have an acceleration of 0 m/s^2
- Initial heading of spaceship is parallel to the y-axis (i.e. straight up)
- Calculations are done from the "perspective" of the spaceship

Planet

- The planet's mass and radius will be arbitrary (most likely defaulted around that of Mars)
- The planet starts off offset by an arbitrary x-value which will be a multiple of its radius
- The planet's y-coordinate will be determined by the distance from the spaceship where the gravitational force exerted on the spaceship is equal to an arbitrary threshold
- Planet is stationary and there is no interference from atmosphere even if spaceship flies close enough

Apologies for the slightly longer proposal. Looking forward to the project!