Name of Activity: A spacecraft voyage, part 1: Spacecraft and Earth

Approximate Duration: 45 minutes

Relevant Section of Text: 3.6

Write on Board

- Review previous programs (Motion part 2 & Gravitational Force Calculation).

- Read and Follow Instructions!

- **Do not run the program** until directed to do so in the instructions.

Checking Questions/Things to look for

- Students must make a prediction of what they would expect to see when they run the program before doing so.

- If students produce an incorrect prediction, ask students to justify why their prediction was incorrect, or why the visual output produced the observed behavior of the spacecraft.

- Encourage groups to use earlier programs for reference.

- Emphasize the importance of initial conditions and time steps.

- Make sure they only update the position and axis of the arrow inside the while loop and NOT the whole arrow.

- Ask them the questions from the handout and emphasize the difference between momentum and change in momentum.

  - Why does spacecraft move faster when closer to the Earth?
    Main Points:
    * **NOT** because the force is bigger (this implies the mistaken idea that p is proportional to F rather than Δp is proportional to F).
    * On the way toward the Earth there is a parallel component of the force in the direction of motion, which increases the magnitude of momentum.
    * It goes slower away from the Earth because on the way away from the Earth there is a parallel component of the force opposite to the motion, which decreases the magnitude of momentum.
    * Use example of spring-mass system to make the contrast: the net force is greatest when the speed is zero, and the net force is smallest when the mass has its maximum speed.
  - What is the direction of momentum?
    Main Point: Along the direction of motion
    ($\Delta \vec{p}$ is in the direction of the net force)

- Final program should have an elliptical orbit and an arrow to represent the momentum.

Grading

- Program is running and looks reasonable

- Proper initial conditions

- Correct physics

    - Gravitational force calculated correctly
    - Position update and momentum principle used correctly
    - Arrow points in the correct direction
    - Arrow has correct magnitude (should represent momentum) and changes appropriately

- Reasonable scale factor

- Extra credit for force arrow

General Grading Key for VPython

- 100% of total points for a program that runs correctly and exhibits all the required features.

- 0% for a program that does not run (i.e. produces an error message and quits).

- For partially correct or partially complete programs, give:

    - 90% for a program with no physics errors, but one missing feature
    - 80% for a program with no physics errors, but several missing features
    - 50-70% for a program with some physics errors
    - 40% for a rudimentary program that is not complete