Destination L1: A Thematic Unit

Studying Orbits About Bodies in Space

TEACHER GUIDE SUPPLEMENT

PROCESS FRAME

The process frame strategy is a good tool to use when students are completing a task using a method. The process frame can be used for any task. It has been adapted here for finding the orbital period of a satellite above a planet. In this example, it has four boxes. In the first box, students list the assumptions for the process; in the second box, the definitions of the variables; in the third box, the equation used to find the period of a satellite in orbit above a planet; and the fourth box, a place for students to describe how a problem can be solved.

Based on the student activity sheet, describe the process of finding the orbital period of a satellite.

Part 1: List the assumptions:

- This process is used with a body in space with a satellite orbiting it.
- The body is a perfect sphere.
- The body is completely smooth with no atmosphere.

Part 2: List definitions to the following variables.

“a” is the altitude of the satellite above the bodies surface.

“F” is the center of the body.

“R” is the radius of the body.

“A” is a plus R or the altitude of satellite plus radius of the body.

“P” is the period of the satellite. (The time it takes for the satellite to go around the body exactly one time.)

Part 3: Write the equation to solve for P^2

$P_S^2 = (P_R^2 \quad A_S^3) / A_R^3$

Part 4: Describe the process for finding the period of a satellite in orbit about a planet using the above equation.

The first step of the process: Put the values for the variables into the equation. P_R is from the table. A_S is R from the table plus the altitude of the satellite. A_R is the radius of the body.

The second step of the process: Square or cube all of the values as indicated in the equation.

The third step of the process: Compute the value of P_S^2 by multiplying and dividing the values.

The fourth step of the process: Find the period (P_S) by taking the square root of the P_S^2.

The fifth step of the process: Plug the numbers into the Excel spreadsheet macros to check work.

QUESTIONS

1. Based on the data you put into the *Kepler's Third Excel Calculation Using Macro*, from the student activity, what is the period of a satellite at an altitude of 150-miles above the Earth?

89.55 minutes

2. Using this same spreadsheet, what is the period of a satellite at an altitude of 9950 miles above the Earth?

557.01 minutes or 9.28 hours or0.39 days

3. Using this same spreadsheet, determine the period of satellites at the 150-mile altitude above each of the planets. Remember to change the body radius, reference period, and Starting (A+B) which equals body radius plus150. Once you have completed the spreadsheet, fill in the table below.

Planet	Period of satellite with an altitude of 150 miles above the surface (minutes)
Mercury	97.88
Venus	93.10
Earth	89.55
Mars	111.81
Jupiter	174.88
Saturn	254.92
Uranus	158.62
Neptune	158.19
Pluto	277.31

a) At an altitude of 150 miles above the planet, which planet's satellite would have the greatest velocity?

The satellite around Pluto (277.31 minutes)

b) At an altitude of 150 miles above the planet, which planet's satellite would have the slowest velocity?

The satellite around Earth (89.55 minutes)

c) According to the table, which planet would have a satellites would have the most similar orbital velocity?

The satellite around Uranus and Neptune

4. Compare the orbital periods of the moons of Earth and Mars. Make sure to change the information in the spreadsheet to kilometers as you enter the numbers. The spreadsheet will give you orbital period in minutes. Fill in the table below.

Moon (Planet)	Altitude (Kilometers)	Orbital Period (Minutes)
Moon (Earth)	384,000	39,568.85
Phobos (Mars)	9,370	747.53
Deimos (Mars)	23,520	2,296.51

A) Based on the data in the data table, which moon has the fastest orbital period?
Phobos

B) Write a statement that describes the relationship between the altitude of a satellite and its orbital period.
The closer the satellite is to the planet, the shorter the orbital period.