DISCOVERING A LAW OF SPACE PHYSICS

Performance Standard 12F/11A/13B. J

Students will apply processes of scientific inquiries to explore the nature of forces accordingly:
- *Knowledge:* Understand the basis of the law relating the variables of time for a planet to orbit the sun and the average radius of its orbit around the sun.
- *Application:* Manipulate the force variables of radius and period in various ways to determine which manipulation shows a direct proportion when graphing them for all the planets.
- *Communication:* Interpret the data manipulations graphically to support Kepler's laws and describe the significance the law had upon the scientific community.

Procedures

1. ***In order to know and apply concepts that explain the composition and structure of the universe and the Earth's place in it (12F), the concepts, principles and processes of scientific inquiry (11A), and the concepts that describe the interaction between science, technology and society (13B)*** students should experience sufficient learning opportunities to develop the following:
   - Review scientific research associated with planetary radii and periods.
   - Test historical data to replicate the assertions of a law.
   - Use appropriate technologies.
   - Test applicable simulation models.
   - Interpret and represent analysis of results to produce findings.
   - Analyze observations and data to provide evidence that supports or refutes original hypothesis.
   - Evaluate data sets and trends.
   - Substantiate basis of inferences, deductions and perceptions.
   - Report, display and defend the findings of an inquiry investigation.
   - Reflect on comparable class inquiry findings.
   - Describe the impact of this law through history.
   Note to teacher: This activity relates to knowledge associated with standard 12F, while addressing the performance descriptors for stage J within standard 11A. The historical setting and interactions which continue to have impact over time are described in standard 13B. This activity can follow a discussion of the gravitational interactions as described by Newton and prior to a discussion of satellite motion. Do not disclose Kepler Laws of satellite motion before this experiment, since the students should discover his third law.
   Discuss:
2. Have students review and discuss the assessment task and how the rubric will be use to evaluate their work.
3. Give the students the instruction/task description for "Discovering a Law of Space Science". Discuss how to use a computer software package such as *Excel* to manipulate the data.
4. Evaluate each student's work using the Science Rubric as follows:
   - *Knowledge:* The identity of the astronomer (Kepler) was correctly determined and the correct statement of his law was given. The significance of the discovery was described accurately.
   - *Application:* Data was manipulated mathematically and plotted correctly on a graph showing a direct proportion.
   - *Communication:* Graph is displayed with correct labels, units and with data points filling the space adequately. Summary is written clearly, coherently, and including enough background material to describe the impact the discovery had on the scientific community.

Examples of Student Work not available

Resources
- Student instruction/task sheet
- Computer access with data manipulation software
- Science Rubric

Time Requirements
2-3 class periods

Discovering a Law of Space Physics
Student Instruction/Task Description

Problem:

Using the data collected by an important astronomer of the past, determine the relationship between the time it takes a planet to orbit the sun and the average radius of the planet's orbit around the sun. Find the relationship between the two variables that will produce a direct proportion when you graph those variables for all the planets. You must use the same method of trial and error that was used by the astronomer who originally discovered the direct proportion; however, you may use technology that was not available to him at that time, the computer. (Without a computer, it took the astronomer ten years to discover the relationship.) Make as many plots of the data as needed in order to determine which produces a direct proportion. Examples of plots between the variables: T vs. R, T vs. R^2, T^2 vs. R^2, and so on. Attach the graphs of all your trials, indicating the selection of the correct plot, along with your summary.

Data:

Table 1: The Periods and Average Radii for the Nine Planets

PLANET	PERIOD (years)	AVERAGE RADIUS (AU)
Mercury	0.241	0.39
Venus	0.615	0.72
Earth	1.00	1.00
Mars	1.88	1.52
Jupiter	11.8	5.20
Saturn	29.5	9.54
Uranus	84.0	19.18
Neptune	165.	30.06
Pluto	248	39.44

Concluding Summary:
State the problem and a short description of how you solved it. State the solution as a law of planetary motion, in your own words. Research this topic, determine the identity of the astronomer, state the law in his words, and describe the impact this astronomer's work had on the scientific community.

Evaluation:

The Science Rubric will be used to evaluate the following:

- *Knowledge:* The identity of the astronomer was correctly determined and the correct statement of his law was given. The significance of the discovery was described accurately.
- *Application:* Data was manipulated mathematically and plotted correctly on a graph showing the appropriate proportions.
- *Communication:* Graph is displayed with correct labels and units and with data points filling the space adequately. Summary is written clearly, coherently, and including enough background material to describe the impact the discovery had on the scientific community.