GRAVITATIONAL FACTORS

Performance Standard 12D/11B/13A.H

Students will apply the processes of technological design to investigate mathematical models of gravitational force accordingly:

- *Knowledge*: Describe the gravitational factors that affect the weight of an object.
- *Application*: Devise multiple mathematical models which can demonstrate gravitational attraction between objects.
- *Communication*: Explain the relationship between the weight and mass of an object from mathematical models.
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Procedures

1. ***In order to know and apply concepts that describe force and motion and the principles that explain them (12D) and apply the concepts, principles and processes of technological design (11A),*** students should experience sufficient learning opportunities to develop the following:
   - Generate strategies which can test and/or model the scientific and mathematical relationship of mass and gravitational forces.
   - Formulate proposals for designs that investigate mathematical models for the relationships of mass and gravitational forces.
   - Access resources which provide planetary or stellar gravitation data references.
   - Predict mathematical relationships graphically, incorporating technology capabilities (as applicable).
   - Predict additional variations of relationships for possible testing/graphing.
   - Record data accurately in appropriate format.
   - Graph data appropriately according to appropriate variables.
   - Compare data sets according to prescribed criteria.
   - Apply scientific habits of mind during investigation:
     - evaluating evidence,
     - inferring statements from data,
     - explaining necessity of manipulating one variable at a time, and
     - retrieving mathematical data accurately for scientific analysis.
   - Represent results of analysis to produce findings.
   - Propose explanations for sources of error with regards to model limitations.
   - Select graphs and charts that effectively report the mathematical relationships.
   - Present findings for peer review, and consolidation or refinement of data interpretations.
   - Generate additional mathematical model modifications for further study.

   Note to teacher: This activity relates to knowledge associated with standards 12D, while addressing the performance descriptors for stage H within standard 11B. The scientific habits of mind of 13A are foundational in this exercise.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Introduce the concepts associated with gravitation with initial brainstorming by students about the factors that influence gravitational forces. Provide foundation about the appropriate metric units for gravitational attraction. Provide each student a copy of the "Gravitational Factors" task sheet as an introductory activity. You may decide to offer fewer instructions for the initial graphic display so that students can begin to create differing displays of the same data. Students should be encouraged to generate other variations for graphic display of this information.
4. Access scientific resources of additional planetary or stellar gravitational force data. Students should be assigned to develop additional models (graphic, visual, physical, etc.) which can be used to test or explain the relationships of gravitational factors. They should present their mathematical models and explanations for whole group consideration. Facilitate a classroom discussion about the findings so that generalizations can be made about the relationships of gravitational forces from multiple sources of data sets. Allow students time to generate additional model modifications for further study.

5. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - *Knowledge*: The factors that affect the gravitational forces affecting an object were described correctly and completely.
   - *Application*: Mathematical models were well-executed and accurate.
   - *Communication:* The explanations and comparisons were well-reasoned, thorough, and accurate.

Examples of Student Work not available

Time Requirements

- 30 minutes for initial graphing activity; 1-2 days for mathematical model research; 1 day for group presentations and concept consolidation.
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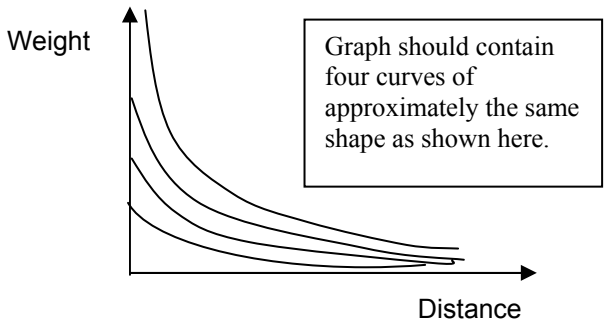
Resources

- Copies of the "Gravitational Factors" task sheet
- Sheets of graph paper
- Access to established scientific sources for planetary and stellar gravitational data
- Science Rubric



NAME _____ DATE _____

GRAVITATIONAL FACTORS

These two tables contain information about the gravitational attraction between two small objects and two planets. Each table shows the weight of a 1 kilogram and a 3 kilogram object at various distances away from the center of the planets.

Planet A

Distance from the Center of Planet A	Weight of 1 kg Object	Weight of 3 kg Object
16,000 Kilometers	1.6 Newtons	4.8 Newtons
8,000 Kilometers	6.3 Newtons	18.9 Newtons
4,000 Kilometers	25 Newtons	75 Newtons
2,000 Kilometers	100 Newtons	300 Newtons

Planet B

Distance from the Center of Planet B	Weight of 1 kg Object	Weight of 3 kg Object
16,000 Kilometers	0.8 Newtons	2.4 Newtons
8,000 Kilometers	3.2 Newtons	9.6 Newtons
4,000 Kilometers	12.5 Newtons	37.5 Newtons
2,000 Kilometers	50 Newtons	150 Newtons

1. Using graph paper, graph the information in the two tables on the same set of axes. Graph the distance from the center of the planets along the x – axis and the weights of the different objects along the Y – axis. Label each of the four curves, for example: A (1 kg), B (3 kg).

2. According to your graphed data, list the factors that affect the weight of an object?

3. What does your graphed data suggest about the relationship between the weight and mass of an object?

4. What does your graphed data suggest about the weight of an object and the distance between the object and the center of a planet?

5. What can you predict about the relationship of masses between Planet A and Planet B?