The Laboratory

The Great Mass Attraction Lab
Teacher's Guide

Topic:

    Circular Motion and Satellite Motion

The following information is provided to the student:

> **Question:**
> What is the effect of varying separation distance, object mass and planet mass upon the gravitational force of attraction between an object and a planet?
>
> **Purpose:**
> To determine the effect of separation distance, object mass and planet mass upon the gravitational force of attraction between an object and a planet.
>
> A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include the provided diagram, data table and accompanying questions. The Conclusion/Discussion should include a thorough discussion of the answer to the question posed in the Purpose of the lab; the discussion should include both qualitative and quantitative information about the relationships.
>
>   URL: http://www.physicsclassroom.com/shwave/gravitn.cfm

Materials Required:

    A page from The Shockwave Physics Studios:
      http://www.physicsclassroom.com/shwave/gravitn.cfm

Description of Procedure:

    Students log on to the above page and manipulate the variables of the animation in an effort to explore the answers to the given *question* (purpose).

Alternative Materials and Procedure:

    A more thorough approach to this lab is provided at The Shockwave Physics Studios:

      http://www.physicsclassroom.com/shwave/gravdirns.cfm

    The alternative exercise is a guided exercise with an extensive procedure.

Safety Concern:

    There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

Suggestions, Precautions, Notes:

The Laboratory

1. Based on the background grid provided with the animation, the radius of the Earth is the length of a square along one of its edge. As such, a distance of $4 \cdot R_E$ is equivalent to four squares (along the edge) from the center of the Earth.
2. The controlled environment of this animation makes this activity a great means of assessing student understanding of variable control and manipulation. Students have an opportunity to experiment with changing variables and observing the outcome on a target variable without the added complication of manipulating and reading instruments.

Auxiliary Materials:

The following page is provided to the student for completion and inclusion in the Data section of their lab notebook.

Draw a force vector (arrow with arrowhead) to depict the direction and magnitude of the force acting between the earth and the object. **Note**: the size of the arrow is indicative of the strength of the force.
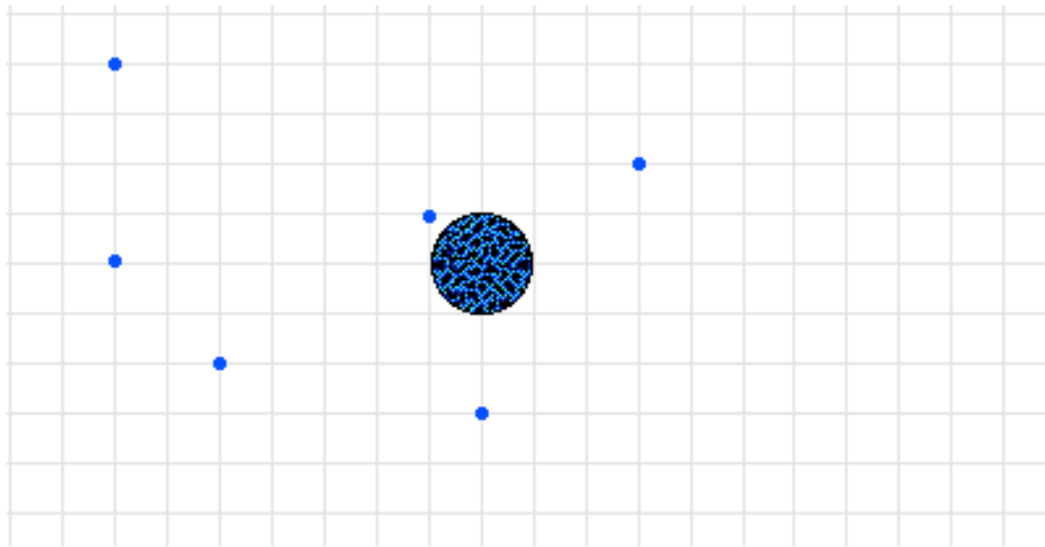
The Laboratory

Consider the earth's surface to be a distance of one Earth-radius (1 R_{Earth}). Use the table at the right to record data for whole-number multiples of R_{Earth}.

Then use the data and the simulation program to answer the questions at the right.

Distance	F_{grav} (N)
1•R_E	_____
2•R_E	_____
3•R_E	_____
4•R_E	_____
5•R_E	_____
6•R_E	_____
7•R_E	_____
8•R_E	_____
9•R_E	_____

Use the simulation program to answer the following questions:

As the **separation distance** between the object and the Earth is increased by a factor of …

… 2, the F_{grav} is _____ by a factor of ____.

… 3, the F_{grav} is _____ by a factor of ____.

… 4, then F_{grav} is _____ by a factor of ____.

As the **mass of the object** is increased by a factor of …

… 2, then the F_{grav} is _____ by a factor of ___.

… 3, then the F_{grav} is _____ by a factor of ___.

… 4, then the F_{grav} is _____ by a factor of ___.

As the **mass of the Earth** is increased by a factor of …

… 2, the F_{grav} is _____ by a factor of ____.

… 3, the F_{grav} is _____ by a factor of ____.

… 4, the F_{grav} is _____ by a factor of ____.

Scoring Rubric:

CG4.	The Great Mass Attraction Simulation	Score
___	Included, labeled and organized all parts of the lab report.	
___	Data section includes the provided sheet with all questions answered. Vector arrows reflect relative magnitude and direction; data are reasonably accurate; answers to questions are correct.	___/___
___	Conclusion/Discussion accurately and thoroughly describes the three variables which effect the gravitational force, including both qualitative and quantitative information.	

Connections to The Physics Classroom Tutorial:

The following readings are a suitable accompaniment to this lab:

http://www.physicsclassroom.com/Class/circles/u6l3b.cfm

http://www.physicsclassroom.com/Class/circles/u6l3c.cfm

Connections to Minds on Physics Internet Modules:

Sublevel 6 of the Circular and Satellite Motion module is a suitable accompaniment to this lab:

http://www.physicsclassroom.com/mop/module.cfm