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:
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.
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.

<table>
<thead>
<tr>
<th>Distance</th>
<th>$F_{grav}$ (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1$R_{E}$</td>
<td></td>
</tr>
<tr>
<td>2$R_{E}$</td>
<td></td>
</tr>
<tr>
<td>3$R_{E}$</td>
<td></td>
</tr>
<tr>
<td>4$R_{E}$</td>
<td></td>
</tr>
<tr>
<td>5$R_{E}$</td>
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<tr>
<td>6$R_{E}$</td>
<td></td>
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<tr>
<td>7$R_{E}$</td>
<td></td>
</tr>
<tr>
<td>8$R_{E}$</td>
<td></td>
</tr>
<tr>
<td>9$R_{E}$</td>
<td></td>
</tr>
</tbody>
</table>

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, then $F_{grav}$ is _________ by a factor of ____.

**Scoring Rubric:**

<table>
<thead>
<tr>
<th>CG4. The Great Mass Attraction Simulation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>____ Included, labeled and organized all parts of the lab report.</td>
<td><strong><strong>/</strong></strong></td>
</tr>
<tr>
<td>____ 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.</td>
<td></td>
</tr>
<tr>
<td>____ Conclusion/Discussion accurately and thoroughly describes the three variables which effect the gravitational force, including both qualitative and quantitative information.</td>
<td></td>
</tr>
</tbody>
</table>

**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