

## Satellite Motion Simulation

### Teacher's Guide

**Topic:**

Circular Motion and Satellite Motion

**The following information is provided to the student:**

**Question:**

How do the magnitude and direction of the velocity and net force vector for a perfectly circular orbit of a satellite compare to that for an elliptical orbit of a satellite?

**Purpose:**

To compare and contrast the magnitude and direction of the velocity and the net force for a perfectly circular orbit of a satellite to the elliptical orbit of a satellite.

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 sheet. The Conclusion/Discussion should include a comparison of the two types of orbital motion - circular and elliptical. Attention should be given to how the magnitude of the  $\mathbf{v}$  and  $\mathbf{F}_{\text{net}}$  vectors change (or don't change) during the orbit and their direction relative to each other.

URL: <http://www.physicsclassroom.com/shwave/orbits.cfm>

**Materials Required:**

A page from The Shockwave Physics Studios:

<http://www.physicsclassroom.com/shwave/orbits.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* (i.e., the Purpose).

**Alternative Materials and Procedure:**

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

<http://www.physicsclassroom.com/shwave/orbitdirns.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:**

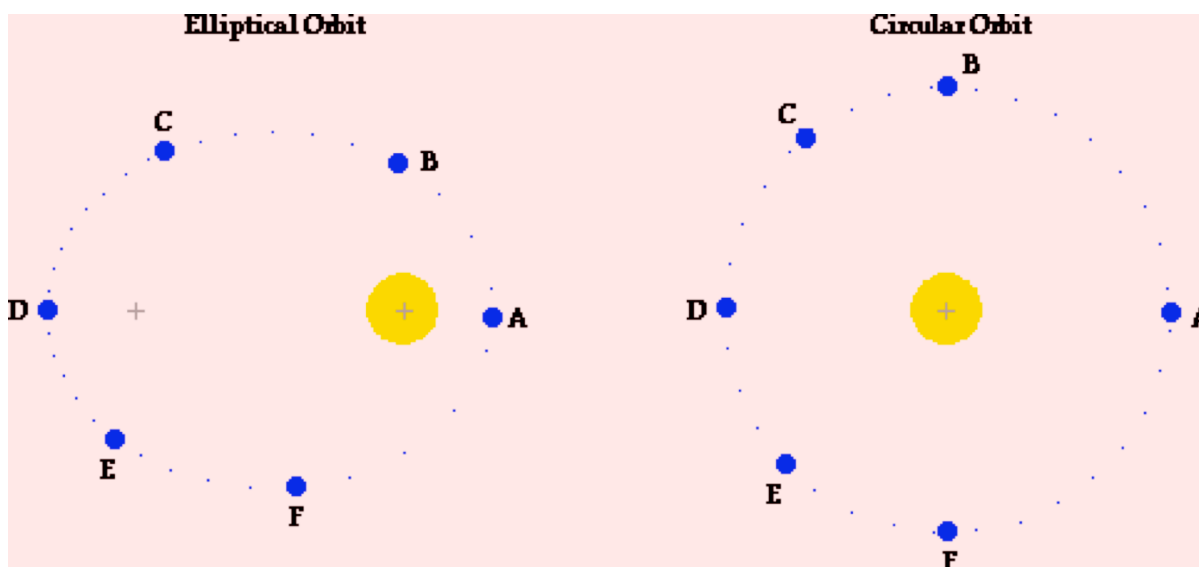
## The Laboratory

1. The online controls allow the eccentricity of the orbit to be altered; an eccentricity of 1.0 corresponds to a circle. Velocity and force vectors for the satellite can be displayed in order for students to explore the answer to the questions raised in the purpose.
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.

1. A circular orbit and a highly elliptical orbit are shown in the diagram below. Draw and label the net force ( $\mathbf{F}$ ) and velocity ( $\mathbf{v}$ ) vectors for each of the six marked positions for a counter-clockwise orbit. Draw the vectors in the appropriate direction and of the proper magnitude (relatively speaking).



2. Complete the following sentences by filling in the blanks:  
For elliptical orbits: the direction of the velocity of the satellite is \_\_\_\_\_ (always, seldom, never) perpendicular to the net force acting upon the satellite.  
For circular orbits: the direction of the velocity of the satellite is \_\_\_\_\_ (always, seldom, never) perpendicular to the net force acting upon the satellite.
3. Fill in the blanks in the following paragraph:  
If a satellite is orbiting the Earth in elliptical motion, then it will move \_\_\_\_\_ (slowest, fastest) when it is closest to the Earth. While moving towards the Earth (along the path from C to D) there is a component of force in the \_\_\_\_\_ (same, opposite) direction as the motion; this causes the satellite to \_\_\_\_\_ (slow down, speed up). While moving away from the Earth (along the path from D to A) there is a component of force in the \_\_\_\_\_ (same, opposite) direction as the motion; this causes the satellite to \_\_\_\_\_ (slow down, speed up).

## The Laboratory

### Scoring Rubric:

<b>CG6. Satellite Motion Simulation</b>	<b>Score</b>
— Included, labeled and organized all parts of the lab report. — Data section includes provided diagram and questions; answers are complete and accurate; vector arrows are labeled. — Conclusion/Discussion thoroughly and accurately describes how the magnitude of the $v$ and the $F_{\text{net}}$ change (or don't change) during the course of an orbital path. The direction of these two vectors relative to each other is also discussed. Discussion reveals an intelligent understanding.	—/—

### Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/circles/u6l4b.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevel 8 of the Circular and Satellite Motion module is a suitable accompaniment to this lab:

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