**Physics: Lab 13.1**

**Newton's Mountain Cannon**

Name ______________________

Hour ______

## Purpose:

Investigate the effects of tangential velocity and orbital radius on a satellite in orbit.

## Equipment:

Computer with Internet access

## Preparation: Newton's Mountain Cannon

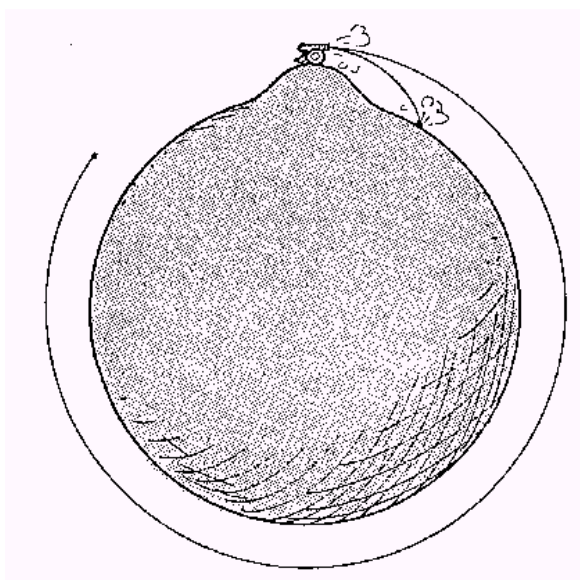
1. The Newton's Mountain Cannon program is based on one of Isaac Newton's original drawings, showing that an object launched from the surface of the Earth could become an orbiting satellite when moving at a high velocity. Open the program, located at http://galileoandeinstein.physics.virginia.edu/more_stuff/flashlets/NewtMtn/NewtMtn.html

2. Click the "*Fire*" button to fire the cannon and the "*Stop*" button to stop the cannon ball in mid-flight. The cannon ball will stop automatically when it reaches the cannon again after circling the Earth.

3. The velocity of the cannon can be adjusted by moving the bar at the bottom of the screen or typing the velocity in the "*Initial Velocity*" field and pressing "*Enter*."

## Procedures: Newton's Mountain Cannon

1. Fire a cannon ball at a velocity of less than 6000 m/s. Describe the path of the cannon ball below. Then sketch and label the path of the cannon ball on the drawing at right.



2. Fire a cannon ball at a velocity of more than 11,000 m/s. Describe the path of the cannon ball below. Then sketch and label the path of the cannon ball on the drawing at right.

3. Find the velocity that causes the cannon ball to move in the most circular path around the Earth. Record it below in both miles per hour and meters per second. (*HINT: 1 m/s = 2.2 mph*)

Velocity = ____________ *(mi/hr)*　　　Velocity = ____________ *(m/s)*

## Preparation: Satellite Motion

1. The Satellite Motion program models the path of a satellite placed in orbit above the surface of the Earth. Open the program, located at http://phet.colorado.edu/sims/my-solar-system/my-solar-system_en.html

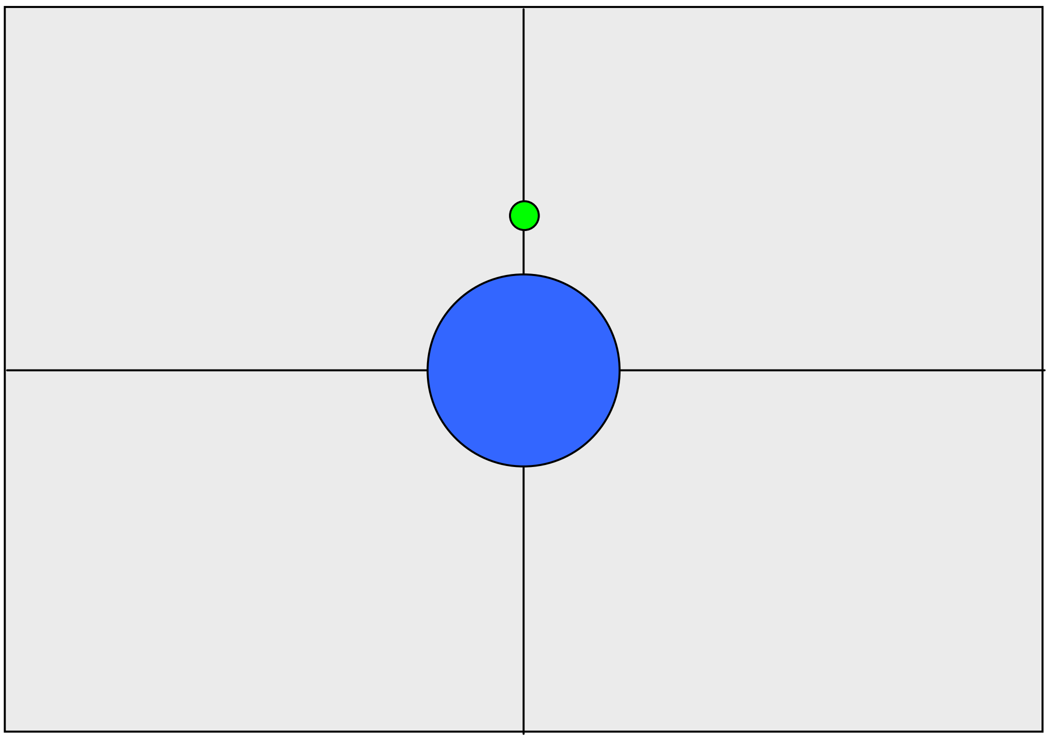
2. The yellow planet in the center of the screen represents Earth. All distances are given in kilometers.

3. The satellite's distance from the center of the Earth can be found by checking the purple x value under "position."

4. To choose a velocity for the satellite, change the purple y value under "velocity." You will never change any of the yellow values.

5. To set the satellite in motion, click on the "*Start*" button at the top of the screen. The motion of the satellite can be paused at any time by clicking on the "*STOP*" button at the right of the screen. To reset the satellite with a new distance or velocity, stop the satellite and click on the "*Reset*" button at the right of the screen.

6. To view the velocity of the satellite at the current point, press "stop" and move your cursor over the satellite. Information will appear in the bottom right corner.



## Procedures: Satellite Motion

1. Place a satellite at a distance of 100 by changing purple x position value. Find two different velocities that cause the satellite to crash into the Earth. Remember to only change the purple y value under "velocity," when changing speeds. Record these velocities below. Then sketch and label the paths of the satellite on the diagram above.

Velocity #1 = ______________ Velocity #2 = ______________

2. Reset the satellite at a distance of 100. Find a velocity that causes the satellite to orbit the Earth in the most circular path possible. Record this velocity below. Then sketch and label the path of the satellite on the diagram above.

Velocity #3 = ______________

## Procedures: Satellite Motion *(cont)*

3. Reset satellite at a distance of 100. Find two different velocities that cause the satellite to orbit the Earth in an elliptical orbit. Record these velocities below. Then sketch and label the paths of the satellite on the diagram on the previous page.

Velocity #4 = _____________ Velocity #5 = _____________

4. Reset satellite above the Earth at a distance of 100. Find a velocity that causes the satellite to escape the Earth's gravity and fly off into space. Record this velocity below. Then sketch and label the path of the satellite on the diagram on the previous page.

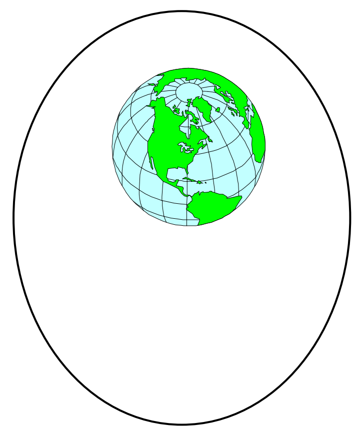
Velocity #6 = _____________

5. Place the satellite at a distance of 200. Find the velocity that causes the satellite to orbit the Earth in the most circular path possible. Record this velocity below.

Velocity #7 = _____________

6. Place a satellite above the Earth at a distance of 100. Launch the satellite at an initial velocity of 110.

a) A satellite in an elliptical orbit does not travel at the same tangential velocity throughout the entire orbit. At which point in orbit is the satellite traveling with the fastest tangential velocity? Mark this point on the diagram at right with the symbol "*F*". Why do you think this point is the fastest point?



b) At which point in orbit is the satellite traveling with the slowest tangential velocity? Mark this point on the diagram at right with the symbol "*S*". Why do you think this point is the slowest point?

c) At which point in orbit does the satellite possess the most kinetic energy? Why?

## Summary:

1. Compare the velocities needed to create a circular orbit for the satellite at the distance of 100 and 200. *(See Velocity #3 and Velocity #7)* Are they the same? If not, which satellite has the higher velocity? What might account for any differences in velocities?

2. Do satellites in circular orbits and satellites in elliptical orbits have the same initial velocity? What might account for any differences in velocities?

3. Satellites in orbit never hit the ground. Does this mean that the Earth's gravity is not acting on a satellite? Why or why not?

4. Suppose that on the planet Zokar, a mountain cannon fired at an initial velocity of 5,550 meters/second produces a perfectly circular orbit. Refer to your answers for #'s 2 and 3 to help you.

a) Give a possible velocity that would produce an elliptical orbit. Explain your answer.

b) Give a possible velocity that would cause the cannon ball to fall to the ground. Explain your answer.

c) Does the planet Zokar have more or less gravity than Earth? Explain how you arrived at your answer. *(HINT: Use your answers from Newton's Mountain Cannon to help you decide.)*