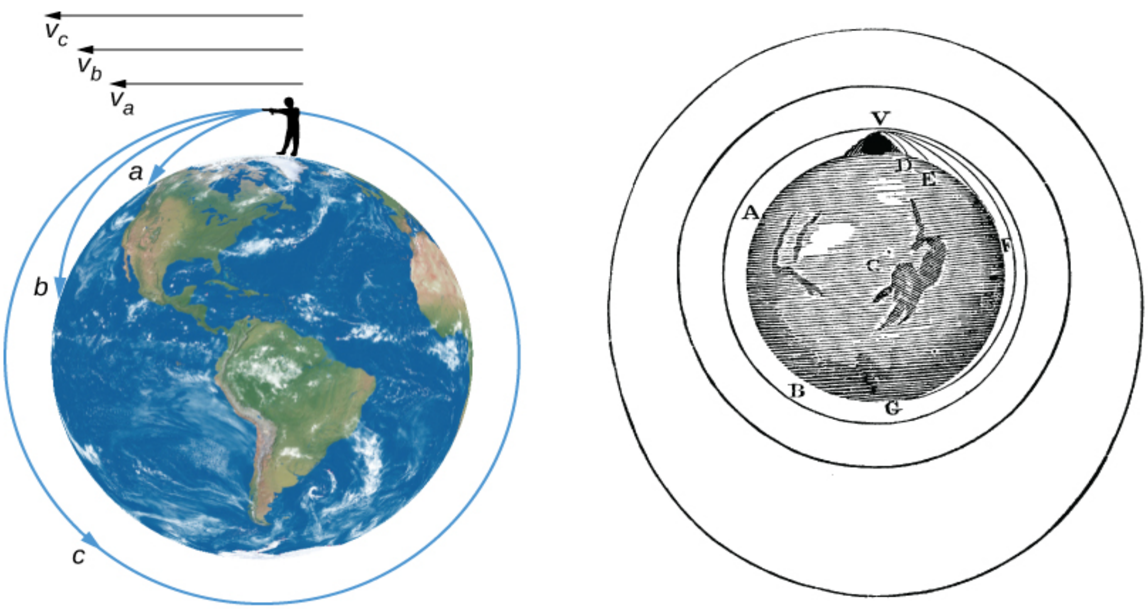
Newton’s Law of Gravity and Orbital Motion

Lab originally written by Jatila van der Veen, with modifications by Erin O’Connor

This interactive simulation gives you a feel for launching something into orbit.

The illustration below shows the path for different projectiles, all assumed to have identical mass, launched parallel to the local ground, with different initial velocities. The diagrams below were taken from the OpenStax Astronomy Text, Chapter 3.5 (https://openstax.org/books/astronomy/pages/3-5-motions-of-satellites-and-spacecraft).

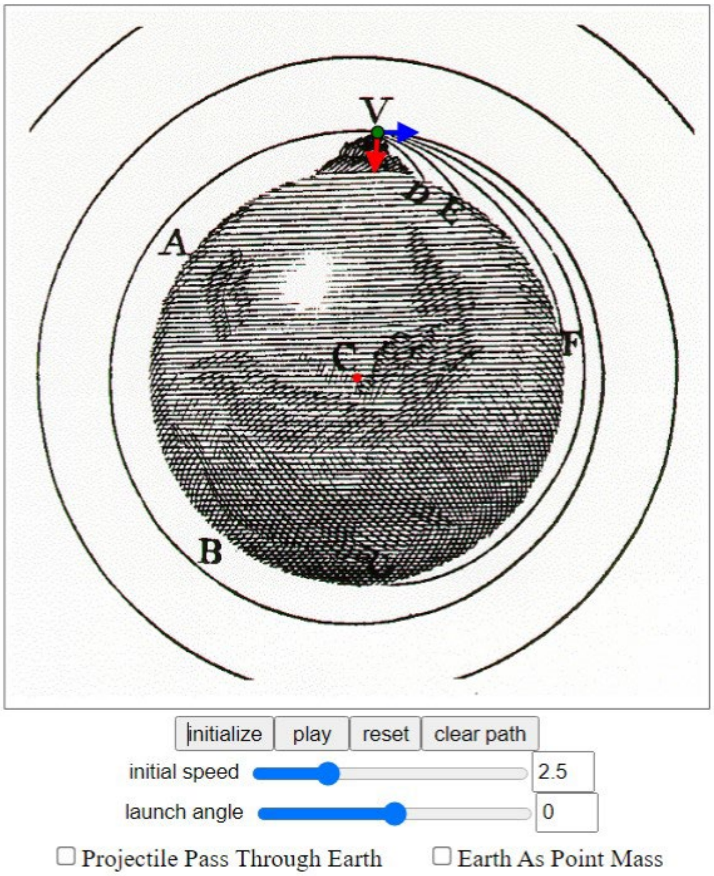


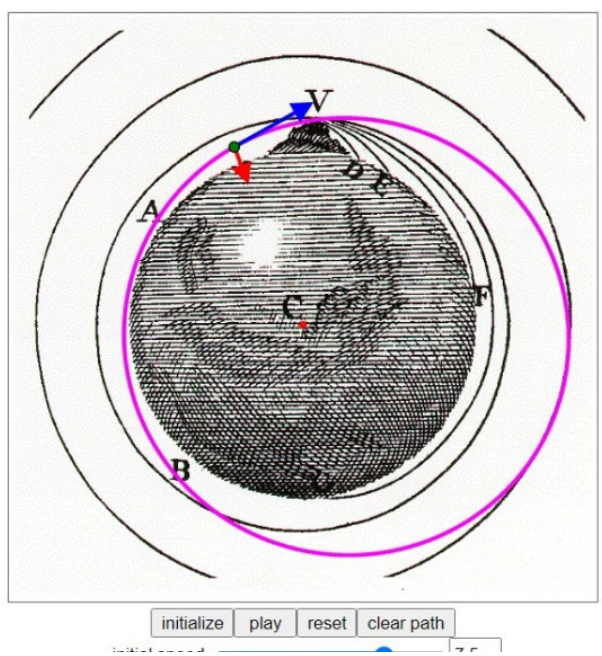
(a) (b)

The image on the right (b) is from Newton’s book *De Mundi Systemate* which he published in 1731. The diagram on the left (a) is an illustration of a hypothetical giant throwing projectiles with different initial velocities. The one with the greatest initial velocity goes into orbit. Newton was the first to realize that if one could throw a projectile with sufficient force to get it going fast enough, it would go into orbit. With a greater initial velocity it could escape Earth’s gravity. This speed is called the ESCAPE velocity.

Go to this website: https://www.compadre.org/osp/EJSS/3648/20.htm

Newton's Mountain Simulation. There you will find a simulation in which you can vary the launch angle and initial velocity of a projectile shot from the top of a giant mountain.





You can change the initial speed and launch angle of your projectile with the sliders. Click on "initialize" and then click "play" to launch your projectile.

Keep trying different combinations of initial speed and launch angle until you get your projectile to go into orbit. Here's an example of what you will see when you have gotten your projectile into orbit:

Lab Questions:

For full credit, copy and paste the question, with your answer following below, and always put a space between answering the different questions.

1) What combination of initial speed and launch angle did you use to get your projectile into orbit?

2) Read the General Description. What was Newton's conclusion about projectiles?

3) Once you have gotten a projectile into orbit, let it keep orbiting while you observe the following:

a) What is the shape of the orbit? Refer back to Kepler's Laws.
b) Notice the two arrows: The red arrow that always points towards the center of the Earth shows the relative strength of the force of gravity on the projectile. The blue arrow that always points in the direction of motion, shows the instantaneous velocity of the projectile. Notice that the lengths of the arrows change!

b1. Where in the orbit is the force of gravity strongest (red arrow longest)?
b2. Where in the orbit is the force of gravity weakest (red arrow shortest)?
b3. Where in the orbit is the instantaneous velocity greatest (blue arrow longest)?
b4. Where in the orbit is the instantaneous velocity least (blue arrow shortest)?

4. What happens to the projectile if it does not have sufficient launch velocity to go into orbit?

5. What happens to the projectile if is launched too fast to go into orbit?