

Kepler's Laws of Planetary Motion

Alabama State Course of Study Objectives:

3.) Explain planetary motion and navigation in space in terms of Kepler's and Newton's laws.

1.) Explain linear, uniform circular, and projectile motions using one- and two-dimensional vectors

A. Go to: http://astro.unl.edu/naap/pos/pos_background1.html

Johannes Kepler published _____ laws of _____, the first _____ in 1609 and the _____ in _____. The laws were made possible by planetary data of unprecedented _____ collected by _____. The laws were both a radical departure from the astronomical prejudices of the time and profound tools for predicting _____ with great accuracy. Kepler, however, was not able to describe in a significant way _____.

1st Law: Law of Ellipses

The orbit of a planet is an _____ where one _____ of the _____ is the _____.

An ellipse is defined by two _____ and all points for which the sum of the distances are the same. The **semimajor axis** (a) is the long distance from the _____. If r_1 and r_2 are the distances from the foci to any point on the ellipse then $r_1 + r_2 = 2a$. The short axis is called the _____ axis.

How "elliptical" an orbit is can be described by the _____ (e). The eccentricity is equal to the distance between a focus and the center (c) of the ellipses divided by _____ (a).

That is, $e = c/a$. Go to the NAAP Eccentricity

Demonstrator <http://astro.unl.edu/naap/pos/animations/ellipsedemo.swf> which shows ellipses for different values of a and c . Note c is always _____ than a by definition. Describe what this simulation demonstrates when you change the variables: _____

2nd Law: Law of Equal Areas

A line from the planet to the sun sweeps out equal _____ in equal _____.

With elliptical orbits a planet is sometimes closer to the sun than it is at other times. The point at which it is closest is called _____. The point at which a planet is farthest is called _____. Kepler's second law basically says that the planets speed is not constant – moving slowest at _____ and fastest at _____. The law allows an astronomer to calculate the _____ of a planet at any point. In the space below, DRAW an ellipse, and use shading to demonstrate how a planet sweeps out equal areas in equal times.

3rd Law: Law of Harmonies

The period of a planet's orbit squared is proportional to its average distance from the _____.

The average distance of a planet from the sun is equal to its semimajor axis (a). If the period (P) is measured in years and the semimajor axis (a) is given in astronomical units (the earth sun distance is _____) then Kepler's 3rd can be written as the formula:

However, this equation is only good for our solar system. Isaac Newton was able to derive a more general form of the equation using his Law of Gravitation. Read more about Newton and Planetary Motion. The formula for Newton's Universal Gravitation is:

What does this law mean? _____

What does G mean? (include the number) _____

B. Go to <http://astro.unl.edu/naap/pos/animations/kepler.swf> and run the Planetary Orbit Simulator. Under Orbit Settings try different planets. Which orbit is the most elliptical? _____

Describe Earth's orbit: _____

Be sure to try running the simulation with ALL different options. You can see all planets moving around the sun at the same time. Also run the simulation with each tab for Kepler's Laws, as they each show different things.

C. Try the following PhET Physics Motion Sims. **For each one, explain at least TWO scenarios with different things you CHANGED in the simulation, and the RESULTS.** Put in the table below.

<u>SIMULATION</u>	<u>Describe Variable Changed</u>	<u>Describe Results</u>
1) <u>Gravity and Orbits</u> Scenario a)		
Scenario b)		
2) <u>Gravity Force Lab</u> a)		
b)		

<u>SIMULATION</u>	<u>Describe Variable Changed</u>	<u>Describe Results</u>
3) <u>My Solar System</u> a)		
b)		
4) <u>Ladybug Motion 2D</u> a)		
b)		
5) <u>Ladybug Revolution</u> a)		
b)		
6) <u>Torque</u> a)		
b)		
7) <u>Pendulum Lab</u> a)		
b)		
8) <u>Lunar Lander</u> a)		
b)		

D. Use the Internet to answer these questions:

- 1) a) What is the formula for torque? _____ b) What is the UNIT for torque? _____
- 2) a) Define/explain torque, and b) Give an example of torque.
- 3) What is meant by the ecliptic?
- 4) Explain what is meant by "zodiac" constellations?