



Kepler's Laws of Planetary Motion

AS-level Physics

Classroom Activity

Material List:

- Internet Access
- Pen/pencil

Outline

Revise Kepler's laws of planetary motion and Newtonian features using an online simulator to create visual representatives.

Procedure:

1

State Kepler's 3 Laws of Planetary Motion:

2

Launch the Planetary Orbit Simulator from <http://astro.unl.edu/naap/pos/animations/kepler.html> (you may have to enable flash by going to the 'general overview' page and scrolling down).

3

Open Kepler's First Law tab and enable all 5 check boxes.

4

Practise using the simulator, the white dot is the "simulated planet". You can click on it and drag it around. Change the size of the orbit with the semimajor axis slider. Note how the background grid indicates change in scale while the displayed orbit size remains the same. Change the eccentricity and note how it affects the shape of the orbit.

Online Observatory: onlineobservatory.eu

The online observatory collaboration consists of the following partners:

Baldone Observatory, Brorfelde Observatory, Cardiff University, Harestua Solar Observatory, Helsinki Observatory

**5**

Use the simulator to help you answer the following questions:

Create an orbit with $a = 20$ AU and $e = 0$. Drag the planet first to the far left of the ellipse and then to the far right. What are the values of r_1 and r_2 at these locations?

Create an orbit with $a = 20$ AU and $e = 0.5$. Drag the planet first to the far left of the ellipse and then to the far right. What are the values of r_1 and r_2 at these locations?

For the ellipse with $a = 20$ AU and $e = 0.5$, can you find a point in the orbit where r_1 and r_2 are equal? Sketch the ellipse, the location of this point, and r_1 and r_2 in the space below.



6

Use the 'clear optional features' button and open the Kepler's Second Law tab.

7

Practise using the 2nd law simulator. Press the "start sweeping" button. Adjust the semimajor axis and animation rate so that the planet moves at a reasonable speed. Adjust the size of the sweep using the "adjust size" slider. Click and drag the sweep segment around. Note how the shape of the sweep segment changes, but the area does not. Add more sweeps. Erase all sweeps with the "erase sweeps" button. The "sweep continuously" check box will cause sweeps to be created continuously when sweeping. Test this option.

8

Use the simulator to answer the following questions:

Erase all sweeps and create an ellipse with $a = 1$ AU and $e = 0$. Set the fractional sweep size to one-twelfth of the period. Drag the sweep segment around. Does its size or shape change?

Leave the semi-major axis at $a = 1$ AU and change the eccentricity to $e = 0.5$. Drag the sweep segment around and note that its size and shape change. Where is the sweep segment the "skinniest"? Where is it the "fattest"? Where is the planet when it is sweeping out each of these segments? (What names do astronomers use for these positions?)

What eccentricity in the simulator gives the greatest variation of sweep segment shape?

**9**

Once again clear the optional features and then open the Kepler's Third Law tab.

10

Use the simulator to complete the table below:

Object	P (years)	a (AU)	e	P ²	a ³
Earth		1.00			
Mars		1.52			
Ceres		2.77	0.08		

11

Use the simulator to answer the following questions:

Start with the Earth's orbit and change the eccentricity to 0.6. Does changing the eccentricity change the period of the planet?

As the size of a planet's orbit increases, what happens to its period?



12

Use the “clear optional features” button to remove other features and open the Newtonian features tab.

13

Click both show vector boxes to show both the velocity and the acceleration of the planet. Observe the direction and length of the arrows. The length is proportional to the values of the vector in the plot.

14

Use the simulator to help you answer the following questions:

Where do the maximum and minimum values of velocity occur in the orbit?

The acceleration vector is always pointing towards what object in the simulator?