

## Lesson 9

# Astronomy and the Scientific Method II - Kepler's Laws

## Worksheet

School: ..... Class: ..... Date: .....

### Activity 1: Story telling (7 minutes)

Please watch the video with the storytelling.

### Activity 2: The phenomena (1 minute)

Please watch the images and the simulation so that you may ask your questions.

### Activity 3: Questions of the students (2 minutes)

Please formulate your questions, based on the storytelling, the images and the simulation you watched:

1.	
2.	
3.	

### Activity 4: Questions of the lesson-of the teacher (3 minutes)

1. Which is the structure and which the form of a scientific law?
2. Does a scientific discovery always entail experimentation in the laboratory?
3. Which are the laws of Kepler?
4. How can I construct an ellipse with simple materials?
5. How could Kepler certify the equality of the areas?
6. How can I apply the laws of Kepler?

### Activity 5: Answers/hypotheses of the students (5 minutes)

Please write down your answers/hypotheses to the questions above.

1.	
2.	
3.	
4.	
5.	
6.	
7.	

### Activity 6.1: Why do scientists formulate scientific laws?

Based on slide (4) please answer the question above.

.....

.....

### Activity 6.2: Which is the form of a scientific law?

Based on slide (4) please answer the question above.

.....

.....

## The laws of Kepler

### Activity 7: Questions of the students. The discovery of the laws of Kepler (5 minutes)

Please watch the simulation and pose your own questions:

1.	
2.	
3.	

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4.	
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**Activity 8: Questions of the lesson. The discovery of the laws of Kepler (2 minutes).**

- Which is the form of planetary orbits?
- Which is the relation between the time interval of the orbiting planet and the area swept out by the line segment joining the planet and the Sun?
- Which is the relation between the orbital period of a planet and the large semi-axis of the ellipse of its orbit around the Sun?

**Activity 9: Hypotheses. The discovery of the laws of Kepler (3 minutes)**

Please formulate your own answers/hypotheses to the above questions.

1.	
2.	
3.	

**Activity 10.1: The discovery/formulation of the laws of Kepler (20 minutes)**

Based on the simulation, discover the laws of Kepler.

1 <sup>st</sup> Law	Which is the form of planetary orbits? .....
2 <sup>nd</sup> Law	What is the relation between the time interval and the corresponding area swept out by the line segment joining the planet and the Sun? .....
3 <sup>rd</sup> Law	Which is the relation between the orbital period of a planet and the large semi-axis of the ellipse of its orbit around the Sun? .....

## Activity 10.2: The formulation of the laws (1 minute), based on this lesson

### How were the laws formulated? (Underline)

- A. Verbally.
- B. Mathematically.

### The discovery of a law includes: (Underline)

Question

Hypotheses

Observations

Measurements

Experiment

## Activity 11: Construction of an ellipse with simple materials (10 minutes)

Please follow the instructions bellow in order to construct an ellipse with simple materials.

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### Construction materials:

- Thick cardboard<sup>1</sup> 35x50 cm.
- Push pins.
- Scissors or cutter.
- String.
- Pencil
- Marker.
- Ruler of at least 50 cm long, or tape measure.
- Gnomon

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<sup>1</sup> We propose the use of white mass model cardboard.

The steps of the construction:

- Step 1: Please draw with a pencil, the gnomon and the ruler the perpendicular bisector of the linear segment between the two small sides of the orthogonal cardboard.
- Step 2: Place the first of the push pins at a distance between 5 to 6 cm from one of the ends of the perpendicular bisector, and the second push pin in a distance of about 35 cm from the first, on the perpendicular bisector.
- Step 3: Cut with the scissors a piece of the rope-not an elastic rope- of about 1 m, and tie with a knot its two ends. Place the string as shown in Image 1, in order to cover both the foci of the ellipse ( $E_1$  and  $E_2$ ), as given by the two push pins.

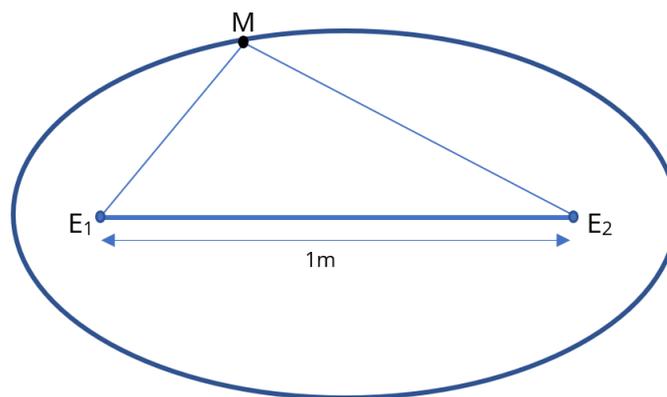


Image 1: Drawing the ellipse.

- Step 4: Draw with the marker the ellipse by using the rope, taking into consideration that the string is always stretched, and always forming a triangle with its vertices given by the two push pins ( $E_1$  and  $E_2$ ) and the end of the marker ( $M$ ). As we move the marker, the ellipse is drawn. We pay attention, so that the tip of the marker stays always perpendicular to the cardboard.

## Activity 12: How could Kepler deduce the equality of the areas? (10 minutes)

Please follow the instructions below:

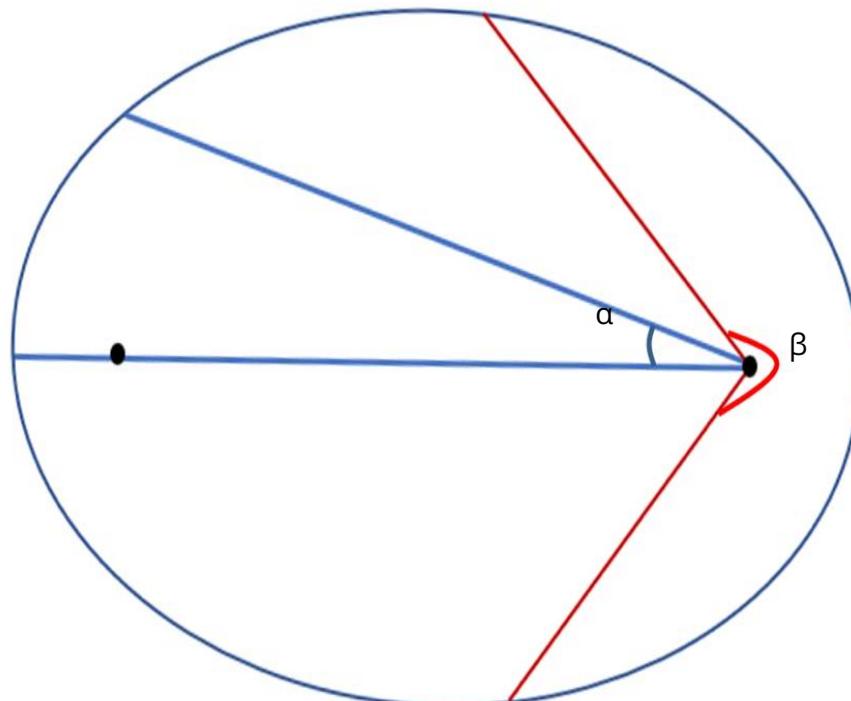
### Materials:

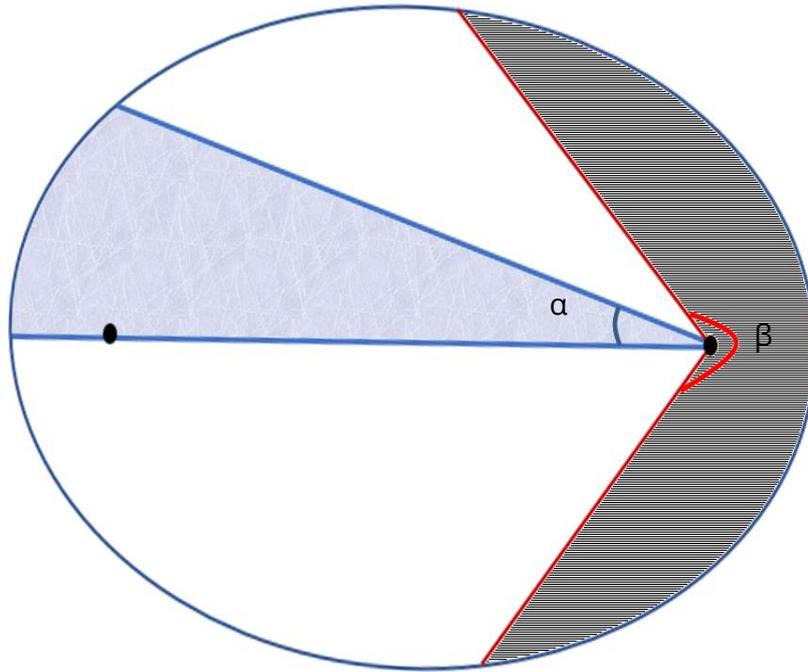
- The ellipse drawn in activity 11.
- Two wooden sticks of about half a meter long.
- Protractor.
- About 90 marbles of a diameter of 1.5 cm.

### The steps for the construction:

1<sup>st</sup> step: Please draw the two areas A and B on the ellipse you have constructed in the previous activity, as shown in Image 2. The acute angle measures  $18^\circ$  and the obtuse angle measures  $265^\circ$ .

2<sup>nd</sup> step: Examine which area is larger by using the marbles.





**Activity 13: Conclusions (5 minutes)**

•One of the main pursuits of scientists is the discovery..... and .....

•1<sup>st</sup> Law of Kepler: .....

•2<sup>nd</sup> Law of Kepler: .....

•3<sup>rd</sup> Law of Kepler: .....

The formulation of a scientific law is accomplished by .....

**Activity 14: Comparison between the conclusions and the answers of the students (2 minutes)**

Please compare your initial answers to the questions with your derived conclusions.


### Activity 15: Application of the conclusions (5 minutes)

Please answer to the following questions:

1. At which point does the planet Jupiter move faster? (based on slide 25)
  - a. On the left
  - b. On the right
  - c. The same at both points
  
2. Which is the formulation of a scientific law? (based on this lesson, encircle the correct answer)
  - a. In words
  - b. Mathematically
  - c. By using a graph
  
3. The discovery of a scientific law includes: (based on this lesson, encircle the correct answer)
  - a. Hypotheses
  - b. Observations
  - c. Measurements
  - d. Question of the scientist
  - e. Formulation
  - f. Application
  - g. Experiment

### Activity 16: Connection of the lesson with vocational guidance (10 minutes)

An astronomer, except the study of the stars and the planets, can also be employed in other professional areas, such as: Present your results to the classroom.

Professional areas
1.
2.
3.
4.
5.



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