WORKSHEETS FOR PUPILS

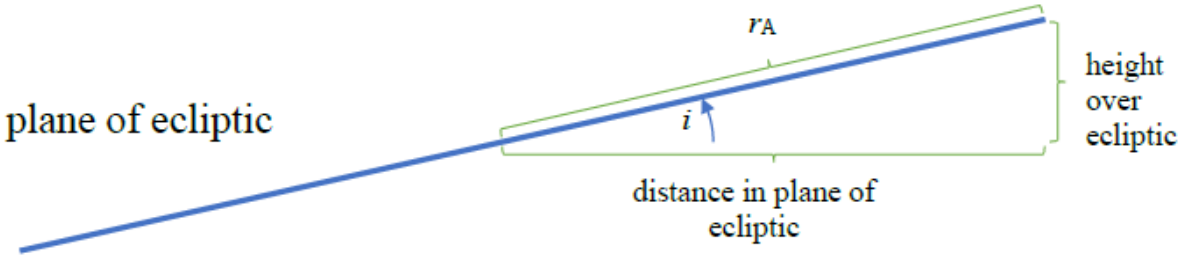
Activity name	Estimated duration	Difficulty of activity	Age of children for which activity is suitable	Aids and material	Objective of activity
Trajectory of dwarf planets	20 – 30 minutes	medium	14 – 15	encyclopedia, atlas or the Internet, calculator, spreadsheet	summary of distances and dimensions of dwarf planets, calculations of various distances
Dwarf planet's set	20 – 30 minutes	medium	14 – 15	encyclopedia, atlas or the Internet, calculator, spreadsheet	work with graph, calculation of equation
Model of trajectory	20 – 30 minutes	medium	14 – 15	paper, computer, calculator	making trajectory model, work with models
What is your weight?	20 – 30 minutes	medium	14 – 15	1 metre long ruler, calculator, spreadsheet, graph paper	average figure, gravitational factor, jump height, order of objects

Worksheet 1: TRAJECTORY OF DWARF PLANET

Dwarf planets and their trajectories

Exercise: Determine the distances of dwarf planets. Order dwarf planets ascending in the distance from the Sun in perihelion and in aphelion. For each object calculate the sum of distances in perihelion and aphelion. Compare the final sum with the double of the semi-major axis.
(Clue: Distance in perihelion is $a(1-e)$, in aphelion $a(1+e)$.)

Exercise: Most objects of the Solar System orbit off the plane of the ecliptic in which Earth orbits the Sun. Orbital plane of an object and the basic plane of the ecliptic form an angle which we call i, from the word inclination (trajectory tilt). We will try to count also the influence of the inclination of the object's orbital plane. For this task we will need the trigonometric functions sine and cosine.



Exercise: Determine the distances of dwarf planets in perihelion and aphelion, if we project them into the plane of the ecliptic and take into consideration also the inclination of their orbital trajectories. How far from the plane of the ecliptic will the dwarf planets get if they are in perihelion and in aphelion?

Exercise: Dwarf planet Ceres has a radius 457 km. A bus running in Bratislava is 25 metres long. How many buses will fit into the diameter of dwarf planet Ceres?

Exercise: In this part, we will try to estimate the orbital speed of a dwarf planet which is located in the main asteroid belt. To make it simple, we will assume that the object moves on a circular orbital trajectory.

a) Ceres, originally considered the biggest minor planet in the main asteroid belt, now classified as a dwarf planet, orbits the Sun once in 4.6 years. Calculate how many seconds it takes dwarf planet Ceres to complete one orbit.

b) Ceres is located at a distance of 2.77 au from the Sun. 1 au is 150 million km. Calculate the distance of dwarf planet Ceres from the Sun in km.

c) Assume that Ceres orbits the Sun on a circular trajectory. Draw a schematic picture which will demonstrate the orbital trajectory of this dwarf planet. In the picture draw and mark the Sun, Ceres and the radius of the circle (orbital trajectory).

d) Use the distance from section b) and calculate how many km Ceres will travel during one orbit. (Clue: the circle circumference is calculated with the help of relation $o = 2\pi r$, where π=3,14)

e) To calculate the average speed, use the relation $v = s / t$ and with the answers from sections a) and b) calculate the orbital speed of Ceres.

Exercise: Orbital speed of dwarf planet Pluto

a) Pluto, originally considered a planet, now classified as a dwarf planet, orbits the Sun once in 248 years. Calculate how many seconds it takes dwarf planet Pluto to complete one orbit.

b) Calculate how many times has Pluto orbited the Sun since its discovery in 1930.

c) Pluto is located in the average distance of 39.5 au from the Sun. 1 au is 150 million km. Calculate the distance of dwarf planet Pluto from the Sun in km.

d) Assume that Pluto orbits the Sun on a circular trajectory. Draw a schematic picture which will demonstrate the orbital trajectory of the dwarf planet. In the picture draw and mark the Sun, Pluto and the radius of the circle (orbital trajectory).

e) Use the distance from section c) and calculate how many km Pluto will travel in one orbit. (Clue: the circle circumference is calculated with the help of relation $o = 2\pi r$, where π=3,14)

f) To calculate the average speed, use the relation $v = s / t$ and with the answers from sections a) and e) calculate the orbital speed of Pluto.