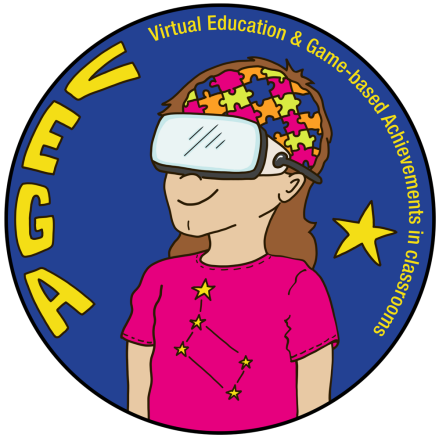
Erasmus+



Physics: Newton's Law of Universal Gravitation

– VEGA Teaching Scenario

Topic: Learning about Newton's Law of Universal Gravitation through observations on characteristics of the planets of our solar system, the Sun and Earth's Moon.

Subject(s): Physics, Astronomy

Age / Grade: 16-17 years old (2nd class of high school)

Short description of the VR game:

1) Star Chart VR

Star Chart VR is a Virtual Reality experience that lets you explore the solar system and night sky in a real-time simulation.

Star Chart currently includes:

- An accurate real-time simulation of the visible stars and planets as you see them from Earth
- A 3D solar system to explore, including the Sun, the planets, major moons and more
- A Sky View mode that recreates your view of the night sky from your own GPS coordinates
- All 88 constellations based on the beautiful artwork of 17th century astronomer Johannes Hevelius
- IAU Named rocky planet surface details.

(Images retrieved from https://store.steampowered.com/app/460580/Star_Chart/)

Introduction to the scenario:

In this scenario the students will learn the theory about Newton's Law of Universal Gravitation through empirical observations on characteristics of the planets of our solar system with the use of Star Chart.

Learning outcomes:

The students are able to:

- formulate and apply Newton's law on Universal Gravitation, as well as explain the law's importance for the movement of celestial bodies in our solar system;
- extract from the law of universal gravitation the relation on gravitational acceleration and explain why all bodies fall freely with the same acceleration regardless of their mass;
- make observations and work with others to draw some conclusions.

A selection of learning outcomes from the Cypriot Curriculum:

- Familiarity of the students with the laws of Physics and well as their encouragement in pursuing a relationship between cause and result, in understanding the importance of conducting correct calculations and the value of expressing justified statements;
- Development of skills and competences relevant to the formulation of investigable questions which can be answered by Science;
- Cultivation of skills and competences to develop and use models;
- The design and conduction of research with the aim of answering such questions;
- Reaching conclusions based on research data and evaluating the conclusions of others;
- Investigation and study of concepts and phenomena.

Formative assessment

Number of students: 15-20 (3 students per group)

Duration: 2 lessons of 40-45 min each

Prerequisites:

1. VR glasses with the VR application ”Star Chart”.
2. Check that the internet is working.
3. Gather information to introduce the students to the topic and accompanying materials (videos, pictures, etc.):
   - Newton’s Law of Universal Gravitation
   - the solar system
   - information on the planets of our solar system and the Earth’s moon (Name, mass of each planet, distance of each planet from the Sun, the time period of orbit of each planet around the Sun, radius of the Earth, mass of the moon, distance of the Moon from the Earth and time period of orbit around the Earth).
4. Exercise sheet on Newton’s Law of Universal Gravitation.

Before the program begins (preparatory work for teacher):

- Ensure that the VR glasses and remote controls are fully charged;
- Familiarize yourself with the “Star Chart VR” experience and complete the game’s tutorial for the Orrery mode.
  Watch the trailer: https://www.youtube.com/watch?v=hGr1TKoWSR0
- Print out a sufficient number of copies of the exercise sheet on Newton’s Law of Universal Gravitation to hand out to the students;
- Divide the students into working groups (with equipment; up to 3).

The main part of the scenario:

2 lessons of 40-45 minutes:

Lessons 1-2:

Preparations:

- Bring the VR glasses and check that they are charged.
- In case there are not enough devices for all groups, the educator could cast the VR Glasses to a computer and the projector.
- Familiarize yourself with the “Star Chart VR” simulator and complete the game’s tutorial for the Orrery mode.
  Watch the trailer: https://www.youtube.com/watch?v=hGr1TKoWSR0
- Create the exercise sheet on Newton’s Law of Universal Gravitation and print enough copies for all the students.
- Divide the students into working groups (with equipment; up to 3).

Learning sessions:

- The educator presents to the students the game and asks them to start playing it in Orrery mode after having watched the relevant tutorial.
- The students “visit” the planets in turns and complete the exercise sheet with information displayed in the game. One person plays the simulation and the other two complete the sheet.

  The students will be looking for (exercises 1 and 3):

  1. The motion of the planets
  2. Information on the planets (Name, mass of each planet, distance from the Sun and time period of orbit of each planet around the Sun).
  3. Radius of the Earth
  4. Information of the moon of Earth (Mass of the moon, distance from the Earth and time period of orbit around the Earth)
- Then, the educator asks the students what they observe about the time period of orbit of each planet around the Sun in comparison to the distance of each planet from the Sun (exercise 2).

  The conclusion is that **the time period of orbit is proportional to the distance from the Sun (**$T \propto R$**)**.
- Following this and based on the observations made on Earth’s moon during the VR experience, the students will complete exercise 4 and 5 and make conclusions on the relation between Moon’s and Earth’s acceleration and the radius of the Earth and the distance of the Moon from the Earth. The conclusion made is that **the fraction of the two accelerations is proportional to the squared fraction of the radius and the distance (** $\frac{g(R_E)}{g(r_{EM})} \cong \left(\frac{R_E}{r_{EM}}\right)^2$ **), so the acceleration of the moon is proportional to the distance from the Earth at the power of minus two. (** $g\left(r_{EM}\right) \propto \frac{1}{r_{EM}^2}$**.)**

- Then, the educator discusses with the students the mass dependance of the force acting on a body due to another body (see figure after exercise 5) and draw the conclusion that the force must be dependent on the masses of both bodies. Based on this, the students complete exercise 6 and the outcomes are discussed in class.
- After these empirical observations are made, the educator provides the theory on **Newton's Law of Universal Gravitation** (1678):

  "Every particle in the Universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them."
- The lesson concludes with the debriefing questions.

Debriefing:

- How is the assignment and cooperation going?
- Does everyone understand the assignment and know what to do?
- How did you feel when experiencing the universe and the solar system?
- What comes to mind now when you think about universal gravitation?
- Did all students have the opportunity to experience the Star Chart experience and take part in the activities?
- Was the VR app easy to navigate or did you face any problems?
- How do you find learning through VR and immersive experiences?
- Is there something that you would change from these sessions?