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THE CONQUEST OF OUTER SPACE – OPTIONAL CURRICULUM MODEL

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Abstract: This paper proposes an optional syllabus for the students in the XIIth grade. The proposed theme analyzes the concept of "variable mass" both in terms of classical mechanics and relativistic mechanics. In terms of classical mechanics we refer to the slow motion of a body, whose mass ranges in ascending way (by annealing a mass particle *dm* of the external environment to the mass body *m*, within an elementary time interval *dt*,) or in descending way (by detaching a mass particle *dm* from the mass body *m* within a time interval *dt*). If the theory of relativity, the body mass varies with speed and the body neither captures nor loses substance. Particular attention was paid to the analysis and synthesis of the physical phenomena involved and to their concrete applications.

Key words: optional syllabus, classical mechanics, relativistic mechanics, variable mass

1. Introduction

One of the most exciting pages of human knowledge is the history of the outer space conquest. There are many theories and scientific observations on Earth and the Solar System which date back to the Antiquity. All this ancient knowledge was systematized by Aristotle, who paid special attention to the following physical concepts: causality, motion, space and time. It was also Aristotle who first ascertained that the Earth is round.

Throughout the Middle Ages the evolution of scientific ideas was promoted by scientists and thinkers such as Nicolaus Copernicus, who stated that Earth is not the center of the universe, but that it revolves around the Sun. The same idea was then supported by Galileo Galilei who, forced by the Inquisition to deny his beliefs, exclaimed the famous phrase "Eppur si muove!"

The idea of man`s trials to explore the outer space is very old; it is so beautifully described in the famous ancient legend of Icarus, the mythical character. He could fly at such a height that lost his wings stuck with wax due to the heat of the sun, eventually finding his ending in the sea waters.

The very beginning of the XXth century witnessed important steps in the conquest of space. There are the Romanian pioneers Traian Vuia, Ion Stroescu, Aurel Vlaicu, Henri Coanda, Anastasius Dragomir and so on [1-4] who stand among the prominent international figures in the field of aviation and astronautics as well.

The first patterns of multistage rockets were designed in the early XVIth century (in 1529) by Conrad Haas from Sibiu, and the father of modern spatial navigation is Hermann Oberth from Medias, an active participant in NASA space missions programming. Moreover, Nicolae Vasilescu-Karpen, a former student of the National College "Carol I", Craiova, is one of the international pioneers who invented the combustion piles used to propel spacecrafts. And it is also Dumitru Prunariu, the only Romanian astronaut who was aboard "Soyuz-40" in a space mission, for 7 days, 20 hours and 42 minutes, within 14th and 22nd May, 1981.

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2. Optional Syllabus

To write this optional syllabus - "The Conquest of Outer Space" - we have considered both the curricula approved by the Ministry of National Education [5-8] to avoid possible overlapping content, and the evaluation criteria and indicators of the optional curricula [9], namely:

A. Compliance with the standard structure of the curriculum: rationale, general skills, specific skills, learning activities (at least one for each specific competence), content, methods of evaluation.

B. Bibliography.

C. Quality items: respect for the students' age peculiarities, compliance with the school ethos, with the students' interests and the needs of the community; the rationale of this optional syllabus reflects its necessity and realism in relation to the educational resources, the correlation between the specific skills and the learning activities, the correlation between the specific skills and the content units, accurate evaluation in the teaching approach proposed.

2.1 Presentation

This optional curriculum "The Conquest of Outer Space" belongs to the broad curriculum "Mathematics and Natural Sciences", which offers the students in the 12^{th} grade - mathematics-computer science specialization and natural sciences specialization - the possibility to choose their own school curriculum and also the possibility to study a particular "area" from the broad field of interdisciplinary physics.

To devise this optional syllabus we considered all the curricular recommendations [9], international trends and the views of certain teachers with extensive teaching experience [4, 10-13]. The curriculum has been designed to ensure concrete and coherent links between physics and other sciences that have common themes with physics.

The structure of this curriculum gives the teacher the possibility to choose and organize his teaching activities necessary to achieve optimal general and specific skills. The number of hours proposed for the optional curriculum "The Conquest of Outer Space" is one hour per week.

The bibliography of the optional "The Conquest of Outer Space" is presented at the end of this paper.

2.2 General skills and specific skills

The general skills proposed by the optional curriculum "The Conquest of Outer Space" were formulated taking into account the enforced educational regulations [9], avoiding duplication with other school curricula in teaching physics [5-8]. The general skills we propose are as follows:

G.S.1. Acquiring specific notions of physics, science and technology.

G.S.2. Developing the students` capability of investigating and experimenting realia and environment by tools and procedures specific to physics, science and technology.

G.S.3. Developing the students` ability to analyze and solve problems using cognitive skills acquired through the study of physics, science and technology.

G.S.4. Developing the students` communication skills using specific terminology of physics, science and technology.

G.S.5. Creating certain values and attitudes regarding the impact of physics, science and technology on our everyday life.

For G.S.1, "Acquiring specific notions of physics, science and technology", the specific skills proposed are:

S.S.1.1. Observation and description of specific systems encountered in physics, science and technology.

S.S.1.2. Recognition and description of the motion of bodies of variable mass.

For G.S.2, "Developing the students` capability of investigating and experimenting realia and environment by tools and procedures specific to physics, science and technology", the specific skills proposed are:

S.S.2.1. Individual or team-work designing and running simple experiments to highlight the motion of bodies of variable mass.

S.S.2.2. Identification of applications of the studied phenomena.

G.S.3. "Developing the students` ability to analyze and solve problems using cognitive skills acquired through the study of physics, science and technology covers the following specific skills:

S.S.3.1. Analysis of the causal relationships between the studied phenomena.

S.S.3.2. Solutions to certain problems of the studied phenomena using mathematical patterns.

S.S.3.3. Knowledge transfer from other fields and their application on the studied phenomena.

For G.S.4, "Developing the students` communication skills using the specific terminology of physics, science and technology", we proposed the following specific skills:

S.S.4.1. Accurate observations and scientific findings of the laboratory experiments and of everyday phenomena.

S.S.4.2. Assumptions of different roles in group activities.

S.S.4.3. Knowledge transfer to explain other phenomena specific to related disciplines.

G.S.5, "Creating certain values and attitudes regarding the impact of physics, science and technology on our everyday life" has the following specific skills:

S.S.5.1. Commenting the positive and negative consequences of the impact of the studied phenomena on our everyday reality.

S.S.5.2. Arguments for the different aspects of science and technology development in nature and society.

2.3 Content

The notions we are proposing are not included in the actual school curricula [5-8] and are illustrated in the following chapters:

C.1. The conquest of outer space - a brief history.

C.2. Classical mechanics of the bodies of variable mass.

C.3. Relativistic mechanics of the bodies of variable mass.

In the first chapter, "C.1. The conquest of outer space – a brief history", the topics covered are:

C.1.1. Prolegomena - from Antiquity to the Renaissance.

C.1.2. From Galileo to Newton.

C.1.3. Classical physics: before and after Maxwell.

C.1.4. Revolutionary discoveries in physics and science.

C.1.5. Modern physics - Paradigm shift.

The second chapter, "C.2. Classical mechanics of the bodies of variable mass", covers not only knowledge of physics but also more complex knowledge of mathematics studied only in the XIIth grade:

C.2.1. Bernoulli's problem: the translational movement of a hydro reactive ship.

C.2.2. Dynamics of variable mass particles.

C.2.3. Fundamental differential equation of the motion of particles of variable mass.

C.2.4. Simultaneous mass capture and emission.

C.2.5. Inverse problem of the dynamics of particles of variable mass.

C.2.6. Concrete applications in science and technology.

The last chapter, "C.3. Relativistic mechanics of the bodies of variable mass", is based on the principal concepts of the theory of restricted relativity. This chapter involves complex knowledge of mathematics to approach the following contents:

C.3.1. Bodies of variable mass in the theory of restricted relativity.

C.3.2. The motion of the body of variable rest mass - covariant equations.

C.3.3. Relativistic rocket.

C.3.4. Photon rocket.

2.4 Evaluation Guide

In the evaluation guide we presented one example for individual evaluation for each type of items, namely the evaluated field, evaluation objective and evaluation task:

A. Objective items

A.1. Dual choice items

A.1.1. True/False items and the replacement of a key word

Evaluated field: The conquest of outer space - a brief history

Evaluation objective: Students will be able to use expressions of certain fundamental concepts, physics concepts, laws, principles.

Task:

> Read the following sentence carefully. If you consider the sentence a true one, circle the letter T, if you consider it false, circle the letter F and replace the underlined word to make the statement true. The replaced word will be written after the letter F.
>
> *The closest celestial body to Earth is the Sun.* **T** **F** (_____)

A.1.2. True/False items without any replacement

Evaluated field: The conquest of outer space - a brief history.

Evaluation objective: Students will be able to use expressions of certain fundamental concepts, physics concepts, laws, principles.

Task:

> Read the following sentence carefully. Circle the letter T if you consider the sentence a true one and circle the letter F if you consider it false.
>
> *If a supersonic missile moves in a resisting environment, the drag resistant force varies proportionally with the speed of the missile.* T F

A.1.3. Cause – Effect items

Evaluated field: Relativistic mechanics of the bodies of variable mass.

Evaluation objective: The students will be able to explain the laws, the interactions, the links between the physical phenomena studied.

Task:

Read carefully the following phrase made up of two sentences linked by the word BECAUSE. Circle the letter **Y** if the latter sentence expresses the cause of the phenomenon described by the former sentence, and the letter **N** if there is no causal link between the two sentences.

According to the theory of restricted relativity the speed of a rocket can not be greater than the speed of light in vacuum BECAUSE the rocket speed is influenced by the fuel emission. **Y** **N**

A.1.4. Right – Wrong items

Evaluated field: Classical mechanics of the bodies of variable mass.

Evaluation objective: Students will be able to use expressions of certain fundamental concepts, physics concepts, laws, principles.

Task:

Read carefully the following statement. Circle the letter **R** if you consider the statement correct and the letter **W** if you consider it wrong.

The fundamental equation of the motion of a point of variable mass, determined by I.V. Mescerski, shows that the multiplication product of the mass of a free particle mass and its acceleration is the sum of the resultant of the external forces, the reaction force $\vec{R}$ *and the reactive force which is acting on the particle. When a meteorite falls to Earth's surface, the absolute speed of the meteorite is zero and the fundamental equation of motion of the variable mass point can be written as*: $\mathrm{d}(m\cdot\vec{v})/\mathrm{d}t = \vec{R}$. **R** **W**

A.2. Pair Items

Evaluated field: The conquest of outer space - a brief history.

Evaluation objective: The students will be able to correlate certain name of scientists with their inventions or discoveries.

Task:

Match the names of the scientists in the table with their discoveries:

K.E. Ţiolkovski	*He introduced the concept of space colony.* *He devised the first project of a manned rocket.*
H. Oberth	*He introduced the concept of a step- rockets.* *He designed the first rocket launcher.*
C. Haas	*He first described a multi-stage rocket.* *He introduced the concept of orbital station.*

A.3. Multiple choice items

Evaluated field: The conquest of outer space - a brief history.

Evaluation objective: The students will be able to apply the laws, principles, methods of physics to solve specific problems.

Task:

Choose one of the following variants to state that the information is complete and correct.

We assume that a rocket with $\vec{G}$ *weight is kept at rest above the Earth when the gases are discharged vertically, downward, at* $\vec{v}$ *speed. The power of the rocket engine is equal to:*

a. $G\cdot v/4$ **b.** $G\cdot v/2$ **c.** $G\cdot v$ **d.** $2G\cdot v$ **e.** $4G\cdot v$

B. Semi-objective items

B.1. Items with short answers or items which needs completion

Evaluated field: The conquest of outer space - a brief history.

Evaluation objective: Students will be able to use expressions of certain fundamental concepts, physics concepts, laws, principles.

Task:

Answer the following questions completing the answer in the gaps.

Who was the first Romanian astronaut? (…….....……)

B.2. Structured items

B.2.1. Structured questions with one premise

Evaluated field: The conquest of outer space - a brief history.

Evaluation objective: The students will be able to analyse the consequences of the laws, interactions, links between certain physical phenomena

Task:

How can you explain the motion of the planets around the Sun from the point of view of classical mechanics?

B.2.2. Structured questions with cascade tasks

Evaluated field: Classical mechanics of the bodies of variable mass.

Evaluation objective: The students will be able to analyze the consequences of the laws, interactions, links between certain physical phenomena

Task:

You are visiting a plant specialized in building airplanes. To benefit from one-hour travel by a jet you must correctly solve the following problems.

a) A plane of M mass can take off vertically, like a helicopter of $m = M/10$ *mass that has the length of the propeller L. You have to determine the power of the aircraft engine required to maintain the plane in the air if the air spinning under it moves downward in a homogeneous flow.*

b) Explain why the power of jet aircrafts decreases with increasing temperature and altitude.

c) A jet aircraft has its air velocity on entry $\vec{v}_1$*, exit gas velocity* $\vec{v}_2$ *and mass flow of flue gas ejection* q*. You have to determine the reactive force of the jet aircraft.*

C. Items with open answer

C.1. Solutions to problems

Evaluated field: Classical mechanics of the bodies of variable mass.

Evaluation objective: The students will be able to apply the laws, principles, methods of physics to solve specific problems.

Task:

To change the direction of a missile of m_0 *mass, travelling at a constant speed* $\vec{v}$*, there shall be operated its engine which eliminates a gas jet at a speed* $\vec{v}$*, in a normal direction to the trajectory, relative to the rocket. If the final mass of the rocket is M, you have to calculate the rotation angle of the rocket.*

C.2. Essay items

C.2.1. Short-answered essay (mini-essay)

Evaluated field: Classical mechanics of the bodies of variable mass

Evaluation objective: The students will be able to apply certain investigation methods to analyze specific situations and phenomena.

Task:

Give a short answer to the following question. Allow maximum 6 lines to answer the question.

How does a jet vessel work?

C.2.2. Long essay

Evaluated field: Relativistic mechanics of the bodies of variable mass

Evaluation objective: The students will be able to apply certain investigation methods to analyse specific situations and phenomena.

Task:

You have 20 minutes to complete the following task:

Write an essay on "From the classical rocket to ultra-relativistic rocket".

C.2.3. Structured or semi-structured essay

Evaluated field: Classical mechanics of the bodies of variable mass

Evaluation objective: The students will be able to apply certain investigation methods to analyze specific situations and phenomena.

Task:

Write an essay on "The conquest of outer space".

You have to use the following planning:

a) short history;

b) the role and importance of space flight;

c) Romanian involvement in astronautics;

d) new dimensions of space flight;

e) personal observations, conclusions, comments.

C.2.4. Free essay

Evaluated field: Classical mechanics of the bodies of variable mass.

Evaluation objective: The students will be able to apply certain investigation methods to analyze specific situations and phenomena.

Task:

Make a functional project aiming at the classic case of the motion of a body of variable mass. Justify the importance of your project to promote science.

3. Conclusion

The presentation of the optional curriculum "The Conquest of Outer Space" expresses the topics that can be integrated in the educational process, so this option can be a useful choice for the secondary school students.

We strongly believe that the students in the XIIth grade who choose this optional syllabus will develop their critical thinking and will be able to actively participate at the educational process.

Moreover, they will be familiar with the many applications of the mechanics of bodies of variable mass, with the classical problems of particle dynamics (for instance: the mathematical pendulum of variable mass, the motion of a particle of variable mass in a central frame) and with certain functional,

practical issues (for instance: the motion of an air-jet engine aircraft – whose propelled gas jet is the pre-compressed air, the motion of a jet vessel, the motion of a rocket).

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