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METHODOLOGY FOR ORGANIZING LABORATORY WORK "MOVEMENT OF A BODY SHOT AT AN ANGLE TO THE HORIZON" IN THE DEVELOPMENT OF PROFESSIONAL COMPETENCE OF STUDENTS

Abstract: This article describes the content, methodological aspects and educational significance of laboratory work on the study of the motion of an object when thrown at an angle to the horizontal. During the study, physical quantities such as the trajectory of the object, flight height, maximum distance and time were determined, and their theoretical and experimental values were compared and analyzed. develops.

Keywords: physics, angled shot, trajectory, parabolic motion, laboratory work, kinematics, experiment, physical laws, competent approach

Аннотация: В статье рассматриваются содержание, методические аспекты и образовательная значимость лабораторной работы по изучению движения тела, брошенного под углом к горизонту. В ходе исследования были определены такие физические величины, как траектория движения объекта, высота полета, максимальная дальность и время, а также проведено сравнение и анализ их теоретических и экспериментальных значений. развивается.

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Ключевые слова: физика, стрельба под углом, траектория, параболическое движение, лабораторная работа, кинематика, эксперимент, физические законы, компетентный подход

Annotatsiya: Mazkur maqolada gorizontalga nisbatan burchak ostida otish holatida jismning harakatini o‘rganish bo‘yicha laboratoriya ishining mazmuni, metodik jihatlari hamda ta’limiy ahamiyati yoritib berilgan. Tadqiqot davomida jismning trayektoriyasi, uchish balandligi, maksimal masofa va vaqt kabi fizik kattaliklar aniqlanib, ularning nazariy va eksperimental qiymatlari taqqoslab tahlil qilingan. rivojlantiradi.

Kalit so‘zlar: fizika, burchak ostida otish, trayektoriya, parabolik harakat, laboratoriya ishi, kinematika, tajriba, fizik qonuniyatlar, kompetent yondashuv

Introduction

In the Presidential Decree of the Republic of Uzbekistan No. PF–5847 dated October 8, 2019, “On the Approval of the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030,” the need to modernize the higher education system, ensure the integrated development of science, education, and industry, as well as widely introduce innovative pedagogical technologies into the teaching process, is emphasized. Likewise, the national “Uzbekistan–2030” Strategy, adopted by Presidential Decree No. PF–158 on September 11, 2023, identifies the development of digital education, the training of practice-oriented specialists, and the formation of scientific and creative thinking among students as priority tasks.

One of the main goals of modern physics education is to develop in students the skills to explain real-life phenomena on a scientific basis, to observe them and analyze them through experience. Kinematics, one of the important branches of mechanics, in particular, the study of the motion of a body thrown at an angle to

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the horizon, is of not only theoretical but also practical importance. The laws of this type of action are widely used in many technical, sports, military and engineering fields. In particular, determining the trajectory, flight distance and height of a thrown body plays an important role in solving many problems.

STUDYING THE MOVEMENT OF AN OBJECT THROWN AT AN ANGLE TO THE HORIZON

The purpose of the work:

1. To study how the trajectory of the object depends on the angle at which it starts to move at the initial moment of its movement relative to the horizon.

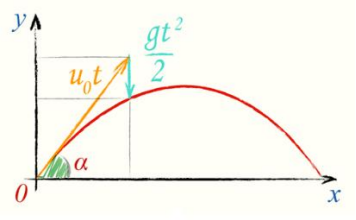
2. Learning curvilinear movements based on the principle of independence of movements.

Required equipment and devices: Ballistic pistol, measuring tape, laboratory tripod and other equipment.[1]

THEORETICAL PART

Objects can be thrown horizontally, vertically and at a certain angle. During such movements, the forces acting on the object and the direction of their equal components can be different. Considering the motion of an object thrown at an angle as complex, it can be divided into a straight motion moving along the line AC with a speed of υ_0 and a straight accelerated motion moving along the line BC. Therefore, from our above considerations, we can conclude the following[2]

$$h=BC=\frac{gt^2}{2}.$$



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$AB = \upsilon_0 t = \sqrt{2s}$, because the angle $\alpha = 45°$

In that case $\upsilon_0 = \frac{\sqrt{2s}}{t}$ and $t = \frac{\sqrt{2s}}{g}$. So, $\upsilon_0 = \sqrt{\frac{2s^2 g}{2s}} = \sqrt{s \cdot g}$

Thus, in the case under study, the initial speed of the object is found from the above expression. As can be seen from the above, when an object is thrown at different angles, its height and path of travel may also be different. We will examine these in the experiment.[3]

The structure and operation of the device

A schematic view of the experimental device is shown in Figure 1. The ballistic cartridge shown in the figure is the basis of the device. The pistol consists of a spiral spring a, through which a rod b, which acts as a trigger, passes. A board indicating the angle of the projectile is attached to the head of the pistol body. A metal core with a clear channel, designed to adjust the angle of the projectile, is also attached to the pistol through a clamp.



Ballistic pistol and its mounting clip

The projectile is lowered into the barrel of the gun and the spring is compressed by means of a hook that acts as a trigger. The hook is turned to the angle of 90º and lowered into the cut. A cut trigger is mounted on the gun, which can freely rotate at an angle of 45º on its axis. When the trigger is turned to the left, it pushes the hook located in its notch and pulls it out of the gun notch. Then the free end of the spring. Due to the force of elasticity, it moves sharply forward and pulls the ball with a blow. The ball is fired due to this force. A sheet of white paper

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is placed on the table surface on which the ball will fall, and its surface is covered with copy paper. This allows the ball to leave a mark on the paper where it falls. The gun is fixed to the clamp in such a way that the center of the ball does not move even when it is installed at different angles. Thus, the calculation for measuring the flight distance does not change at all times[4]

A measuring tape 150 cm long, divided into centimeters on both sides, is used to measure the height and distance of the balloon. The ballistic pistol clamp is fixed to the edge of the table with a screw and the pistol rod is fixed with the barrel directed towards the table. The pistol is set at an angle of 45º using a protractor. A balloon is lowered into its channel and the spring is compressed. A test is carried out to check the device. The place where the balloon fell is marked and white paper is poured into this place and covered with carbon paper.



An image of the device to perform the work

After shooting the ball several times, the copy paper is taken and the white paper marks the places where the ball landed. When the equipment is set up correctly, the places where the balloon landed will not be very scattered. Therefore, it is necessary to perform the experiment with great precision.

Note: 1. When conducting the experiment, the gun must be used with extreme caution. 2. It is strictly forbidden to look into the gun when the ball is in it!

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PROCEDURE FOR PERFORMING THE WORK

Task 1. To study the relationship between the distance a balloon flies and the angle of its launch.

1. Set the gun at different angles and try shooting three or four times in each position.

2. Mark the points on the ball with a pencil and determine the average point of impact. Measure the distances of the ball with a measuring tape and enter the results in a table.

Angle in degrees	20	25	30	35	40	45	50	55	60	65	70
Distance in cm											

3. Draw conclusions based on the results found in the experiment.

Task 2. Determine the initial speed.

1. Use the results of the above experiment to determine the initial speed of the balloon.[6]

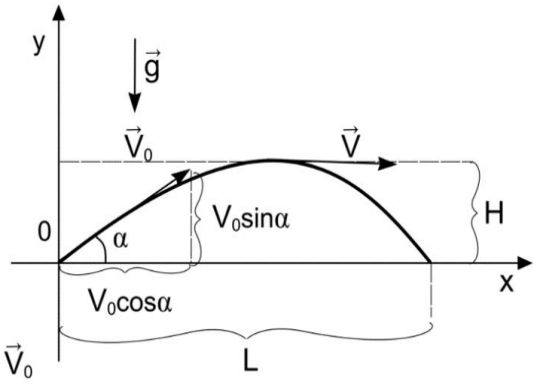
2. Set the gun at an angle of 45^0 to the horizon and shoot it three times and determine the average distance traveled.

3. Calculate the initial speed of the balloon based on the determined results.

Task 3. Study the dependence of the height of the balloon on the angle of launch.

The initial speed υ_0 of a balloon placed at an angle of 45^0 to the horizon is a complex speed, which can be decomposed into components consisting of the horizontal uniform speed υ_1 and the vertical uniform decelerating initial speed υ_2.

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As you can see from the picture, the triangle is equilateral, so $\upsilon_1=\upsilon^2$ and according to the Pythagorean theorem $\upsilon_0^2=\upsilon_1^2+\upsilon_2^2$. The height of the balloon is determined by the following formula $h=\frac{\upsilon_2{}^2}{2g}=\frac{\upsilon_0}{4g}$[7]

The vertical speed we are checking is equal to the horizontal speed. Accordingly, in equal time intervals, the height of the vertical rise should be less than half of the distance traveled by the ball in the horizontal direction. That is, $h=\frac{s}{4}$.

APPLICATION OF PEDAGOGICAL TECHNOLOGY METHODS TO TRAINING

Setting up a laboratory based on the Gamification method has several advantages. Students are divided into teams, each of whom plays the role of a “rocket launcher.” They complete various missions and earn points.[5]

Step 1: "Rocket ready for flight" (Start the experiment)

• Teams choose a shooting device.

• They set the angle to 30°, 45°, 60°.

• The rocket (object) is launched and the flight time, altitude, and distance are measured.

Mission accomplished: If the team measures all the results correctly, they will earn 5 points.

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Step 2: “Longest Flight” (Repeat Experiment)

• Teams change the angle to find the best conditions for the rocket to fly the farthest distance.

• The longest distance out of three attempts is recorded.

Mission accomplished: The team that correctly calculates the longest distance gets 10 points.

Stage 3: “Scientific Research” (Calculation and Analysis)

• Comparison with Theory: Teams compare their results using the following formulas:

• If the error between the measured and calculated values is less than 5%, the team gets an additional 5 points.

Mission accomplished: The team that correctly calculated the results will receive the highest score.

Stage 4: “Space Team” (Results Presentation)

• Teams present their results and analysis.

• Additional points will be awarded for the most accurate result and the best presentation.

• The winning team will receive the title of “Best Rocket Engineers”!

Conclusion and Assessment

Team	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Total**
A	5	10	5	5	25
B	5	7	5	4	21
C	4	8	4	5	21

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Why is this method interesting? The element of competition and play increases motivation.;Students actively participate and interest increases.; Practical measurement and theoretical calculation are combined; Teamwork a Performing laboratory work and calculation[6]

Performing laboratory work and calculation

Work related formulas

$$S=\frac{v_0^2 sin2\alpha}{g}$$

$\alpha=45^0$

$$v_0=\sqrt{\frac{Sg}{sin2\alpha}}$$

$$H=\frac{v_0^2 sin^2\alpha}{2g};\ t=\frac{2v_0 sin\alpha}{g}$$

$$S_1=1{,}44\ m;\ v_1=\sqrt{\frac{Sg}{sin2\alpha}}=\sqrt{\frac{1{,}44\cdot 10}{\sin 60^0}}=4{,}08\ \frac{m}{s}$$

$$H_1=\frac{v_0^2 sin^2\alpha}{2g}=\frac{(4{,}08)^2 sin^2 30^0}{2\cdot 10}=0{,}208\ m$$

$$t_1=\frac{2v_0 sin\alpha}{g}=\frac{2\cdot 4{,}08\cdot sin30^0}{10}=0{,}408\ s$$

$$S_2=1{,}45\ m;\ v_2=\sqrt{\frac{Sg}{sin2\alpha}}=\sqrt{\frac{1{,}44\cdot 10}{\sin 60^0}}=4{,}08\ \frac{m}{s}$$

$$H_2=\frac{v_0^2 sin^2\alpha}{2g}=\frac{(4{,}08)^2 sin^2 30^0}{2\cdot 10}=0{,}208\ m$$

$$t_2=\frac{2v_0 sin\alpha}{g}=\frac{2\cdot 4{,}08\cdot sin30^0}{10}=0{,}408\ s$$

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$S_2=1{,}45\ m;$

$$v_3=\sqrt{\frac{Sg}{sin2\alpha}}=\sqrt{\frac{1{,}44\cdot 10}{\sin 60^0}}=4{,}08\ \frac{m}{s}$$

$$H_3=\frac{v_0^2 sin^2\alpha}{2g}=\frac{(4{,}08)^2 sin^2 30^0}{2\cdot 10}=0{,}208\ m$$

$$t_3=\frac{2v_0 sin\alpha}{g}=\frac{2\cdot 4{,}08\cdot sin30^0}{10}=0{,}408\ s$$

$$H_{o'rt}=\frac{H_1+H_2+H_3}{3}=\frac{0{,}208+0{,}209+0{,}212}{3}=0{,}209$$

$$\Delta H_1=\left|H_{o'rt}-H_1\right|=|0{,}209-0{,}208|=0{,}001\ m$$

$$\Delta H_2=\left|H_{o'rt}-H_2\right|=|0{,}209-0{,}209|=0\ m$$

$$\Delta H_3=\left|H_{o'rt}-H_3\right|=|0{,}209-0{,}212|=0{,}003\ m$$

$$\overline{H_{o`rt}}=\frac{\Delta H_1+\Delta H_2+\Delta H_3}{3}=\frac{0{,}001+0+0{,}003}{3}=0{,}0013\ m$$

$$\varepsilon=\frac{\Delta H_{o`rt}}{H_{o`rt}}\cdot 100\%=\frac{0{,}0013}{0{,}209}\cdot 100\%=0{,}62\%$$

$$t_{o`rt}=\frac{t_1+t_2+t_3}{3}=\frac{0{,}408+0{,}409+0{,}412}{3}=0{,}409$$

$$\Delta t_1=|\Delta t_{o`rt}-t_1|=|0{,}409-0{,}408|=0{,}001\ s$$

$$\Delta t_2=|\Delta t_{o`rt}-t_2|=|0{,}409-0{,}409|=0\ s$$

$$\Delta t_3=|\Delta t_{o`rt}-t_3|=|0{,}409-0{,}412|=0{,}003\ s$$

$$\Delta t_{o`rt}=\frac{\Delta t_1+\Delta t_2+\Delta t_3}{3}=\frac{0{,}001+0+0{,}003}{3}=0{,}0013\ s$$

$$\varepsilon=\frac{\Delta t_{o`rt}}{t_{o`rt}}\cdot 100\%=\frac{0{,}0013}{0{,}409}\cdot 100\%=0{,}31\%$$

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№	$S(m)$	$v(\frac{m}{s})$	$H(m)$	$\Delta H_{o`rt}$ (m)	$\Delta H(m)$	$\overline{H_{o`rt}}$	ε,%	(t,s)	$t_{o`rt}(s)$	Δt	$\Delta t_{o`rt}$	ε
1	1,67	4,08	0,416	0,419	0,003	0,003	0,72	0,575	0,577	0,002	0,002	0,34
2	1,68	4,09	0,418		0,001			0,576		0,001		
3	1,7	4,12	0,424		0,005			0,58		0,003		

Conclusion

The laboratory work studied the motion of an object thrown at an angle to the horizon. During the experiment, the trajectory of the object, its maximum height, flight time, and horizontal distance were determined and compared with theoretical calculations.[7] The results showed that the motion of the object was in accordance with physical laws. Also, ideal parabolic motion was observed during the work, without taking air resistance into account. The results obtained helped to understand how the initial velocity and angle of the object affect the characteristics of the motion. Through this laboratory work, students strengthened important concepts of mechanics and developed experimental work skills.

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