Physical application: Cannon case

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Abstract. The study of physical phenomena by means of guided experimentation and experimental thinking, allow students to infer and understand the reason for the different variations that evidence. Parabolic motion of a projectile powered by a cannon under the spring mechanism, generates discussion regarding the choice of the proper angle, according to a certain distance, a known average initial velocity, and a given height. Give the blank is a great encouragement, however, being able to explain which conditions of the environment influenced the failed launches, generates a space of dialogue and a durable concrete learning.

1. Introduction
The study of the different phenomena that occur in nature has been one of the important activities that are addressed from the Academy. In the halls or classrooms is a theoretical and practical work of some thematic components developed in different university courses. Physics and mathematics are two areas that are closely related, physics as natural science and mathematics as the language to give explanation to the studied phenomena. The rigor that has been given to the teaching of physics, left out its ancestral commitment to unveil the mysteries of the universe and came to be considered only as a new area, at best, that did not correspond to their same expectations and sometimes, with the untiring eagerness to fulfil with the proposed curriculum the enthusiasm of teaching was lost [1]. The importance of generating a lasting knowledge is evidenced when a new information is related to some aspect of what already exists in the cognitive structure of the individual, and thus a process that leads to significant learning is produced [2]. Understand the different variables that affect a case study, allows to create spaces for analysis, discussion, and interpretation that are conducive to a real and meaningful concrete knowledge for those who deal with it. Although equations have traditionally been used as recipes for problem-solving, they provide deeper insight when used as guides to thinking [3].

One of the phenomena of great interest in the study of University Physics is the parabolic motion, for example using cannons. It is important that at the moment of directing this exercise towards meaningful learning, we take into account the pertinent moment, the presentation of the phenomenon, the relationship of the variables, the prediction of the behavior and the environment [4]. The use of compressed air cannons in an undergraduate laboratory provides a way to illustrate the connection between diverse physics concepts, such as conservation of momentum, the work-kinetic energy theorem, gas expansion, air drag, and elementary Newtonian mechanics [5]. Cannons with different specifications, the bullet from the barrel are used in different scenarios, it is possible to use a swab of cotton, in this type of experiment is discussed friction and resistance of the airspeed swab [6]; others focus on the use of compressed air cannon to investigate the impulse, the conservation of the moment and kinematics, also used electronic force plates to measure the recoil of the barrel when fires [7].
other experiments, meteorological parameters such as wind vector, air pressure, temperature, density and sound velocity are used. [8-11]. There are other types of studies a bit more advanced as the magnetic cannon that converts magnetic energy into kinetic energy. When a steel with low initial speedball hits a string, which consists of a magnet, followed by additional steel balls, the last ball of the chain is expelled to one much larger speed [12]. All these studies enable you to check as seen in class which is out of it. The movement which describes a projectile launched by a cannon, whose mechanism is based on stretching and compression of a spring, can be described with trigonometric equations. However, there are functions, such as the Green function, that are based on the sensitivity models of the projectile trajectory. The best way to analyze the characteristics of the projectiles trajectories under nonstandard conditions is the build of any of the explicit sensitivity models of projectile trajectory [13-16].

Trigonometry as a branch of mathematics is based on the theoretical analysis and practical problems involving triangles basically. For three courses of geometry and trigonometry at the Bolivarian Pontifical University during the two semesters of the academic year 2016, set out as a final project of class, the comparative study of experimental data and data obtained with the trigonometric equations, with which it is possible to calculate the maximum horizontal range of a cell phone shot by a gun, depending on the angle and the initial velocity. The focus is on shooting a small glass, using a cannon powered by spring with some basic specs and General ball, ball glass that should be given a blank ready for a glass of carton with given measures. The distance to which the vessel is left and placed cannons was approximately 2 meters. In order for all the groups that carried out the experiment to be evaluated in the same way, it was necessary to describe the objectives, the competences to be evaluated, the construction parameters, among other data, through a methodological guide and to socialize it from the beginning of the semester

2. Methodological guide of trigonometry project

For the simulation stage of the activity, it is important to stipulate the criterion under well-defined parameters so that the objectives are achieved. The context

2.1. Location
This project will be developed with students from the Universidad Pontificia Bolivariana found studying geometry and trigonometry class. For the development of the same, looking for transversally in each subject of the basic cycle, the student must submit basic knowledge functions, relations, equations.

2.2. Objective
Analyse and argue about the usefulness of the different laws and theorems of trigonometry to represent a model based on a phenomenon of projectile launch.

2.2.1. Specific objectives of the project. (a) Contextualize the concepts learned in geometry and trigonometry class. (b) Design and build a model of canon (projectile based release) with the basic specs. (c) Analyze the launch and (horizontal and vertical) maximum range of a projectile through a canyon constructed, using equations, functions, and trigonometric laws as a tool.

2.3. Justification
Students, using trigonometric ratios, the law of Sines, law of cosines and the trigonometric functions, will analyse various models of phenomena in the environment which can be represented with equations or functions that they involve trigonometric ratios.

2.4. Skills
In the need to assess the members of the groups from their integral formation, it is necessary to stipulate performance indicators for each of the capacities that can be evidenced.
2.4.1. Cognitive skills. (a) Understand parameters analysis and argumentation of trigonometry in response to representations of the context. (b) Analyze the functions and trigonometric reasons as tools that facilitate the solution of various questions in a model that represents a phenomenon of projectile launch.

2.4.2. Communicative competence. (a) Communicate your project smoothly and consistently. (b) Analyze the functions and trigonometric reasons as tools that facilitate the solution of various questions in a model that represents a phenomenon of projectile launch.

2.4.3. Procedural skills. (a) Investigate seriously and gives results according to the provisions. (b) Analyze what are the most suitable design conditions for the optimization of the model. (c) Understand the behavior of the phenomenon according to variability of the environment.

2.4.4. Attitudinal competencies. (a) Values the views of other members of the team. (b) It promotes teamwork. (c) It is consistent with the principles and Bolivarian values of the Universidad Pontificia Bolivariana.

2.5. Design parameters
- Object or mobile: a Mara (small glass marble).
- The use of any type of glue is permitted.
- Must have a base on which rest the object built (30 cm × 30 cm). About the height is free but should be less than 50 cm.
- The maximum Cannon launch tube 30 cm, the material is free.
- Canon must be fixed to the base and must present an angle for the release meter.
- The force employed for the launch can be generated through a spring or elastic band.
- Canon material, in general, is free.

2.6. The target parameters
- Glass of carton.
- Height 7.6 cm.
- Height inclined 7.7 cm.
- Diameter base lower 5 cm, diameter base top approximately 7.5 cm.

Groups known distance to which this vessel at the precise moment of the experiment. With this data, they perform the calculations required to find the angle of launch and proceed to realize three direct releases. Crystal ball releases are marked on a sheet of paper that has with carbon paper. Three is the number of maximum possible launches.

At the end of the experimental activity is the delivery of a written paper type, in which the groups write the corresponding analysis of the observed. At this stage, groups should consider conditions low which the projectile was able or not hit the target. This activity requires an appropriation of the phenomenon in terms of the variables that this involves. In this space the use of experimental thought is evident to understand variables and how these they influenced the observed phenomenon, also this kind of thinking in physics teaching helps students to use their imaginations, to form hypotheses and draw conclusions, all of which are objectives that should be pursued in the modern teaching of Science [17]. Students who attempt to "interpret" mentally an experiment, express their points of view on phenomena that occur in the system under study, allowing teachers to be aware of the ideas of his pupils [17-19].

3. Mathematical method
In a course of University basic physics, the study of the phenomenon of the parabolic motion is made in conjunction with appropriate laboratory. This practice of laboratory and theoretical classes usually are makes it clear that free fall acceleration is constant in the range of movement and is directed downward
and in addition, that the effect of the air resistance is negligible. Under these assumptions is that the trajectory of a projectile always describes a parabola. Vector shape describes the function position of the projectile by:

\[ \vec{r}_f = \vec{r}_i + \vec{v}_i t + \left[ \frac{1}{2} \right] \vec{g} t^2 \]  \hspace{1cm} (1)

Where \( \vec{r}_f \) represents the final position, \( \vec{r}_i \) initial position, \( \vec{v}_i \) the initial speed, \( t \) the time and \( \vec{g} \) the acceleration of gravity.

The components of the initial velocity of the projectile in the flat are determined by:

\[ v_{xi} = v_i \cos(\theta_i) \] \hspace{1cm} \( v_{yi} = v_i \sin(\theta_i) \) \hspace{1cm} (2)

Equations (1) and (2) is that the model that describes the phenomenon of parabolic motion, whit respect to its horizontal and vertical scope depends on \( v_i, \theta_i \), as seen in Figure 1, and the value of \( g \).

\[ R = \frac{v_0^2 \cos(\theta)}{g} \left[ \sin(\theta) + \sqrt{\sin^2(\theta) + \frac{2gh}{v_0^2}} \right] \] \hspace{1cm} (3)

For which \( R \) represents the scope. It is possible to show that if \( \theta \) satisfies.

\[ \cos(2\theta) = \frac{gh}{v_0^2 + gh} \] \hspace{1cm} (4)

Then the maximum horizontal range can be determined by:

\[ R_{max} = \frac{v_0 \sqrt{v_0^2 + 2gh}}{g} \] \hspace{1cm} (5)
4. Results and discussion

The analysis of parabolic motion using canon, with Spring-based mechanism, by the groups was emphasized in assert that there were other variables such as air friction, the spring elasticity coefficient and wear of the material, which influenced the practical and theoretical calculations in the experiment. Of the 12 groups presented, only 25% (3 groups) they managed to hit the target in three possible attempts, i.e., in one of three attempts, the crystal ball was inside the vessel placed 2 meters from the base of the Canyon, as seen in Figure 2(a). For 36 releases, 3 for each group, the 88% (32 releases) of them hit to 50\(cm\) of the target approximately, implying that 12% of them hit less than 50\(cm\) of the target, and the other 8% of the total hit the target, this relation between the releases is observed in Figure 2(b).

![Figure 2](image.png)

Figure 2. (a) Percentage of hits by groups (b) Percentage of hits by throws.

Average of the horizontal scope with an initial speed varied between 3.15\(m/s\) and 3.57\(m/s\), is shown in Table 1, which shows the relationship between angle and distance.

| Angle | Distance (cm) |
|-------|---------------|
| 10°   | 113.000       |
| 20°   | 139.000       |
| 30°   | 169.330       |
| 40°   | 208.160       |
| 45°   | 225.875       |
| 50°   | 183.500       |

By observing physical phenomena, such as compound movement or projectile movement, the student can identify the variables that affect the phenomenon, since his proposal under the equations presented approaches the evidence in the simulation, which allows him to create a structure of thought under which it adopts analytical positions towards experience and this, in turn, drives it to infer conclusions regarding the same phenomenon [1].
5. Conclusion
With the use of experimental thought, generated a space in which student can mentally interpret an experiment, arguing characteristics which presents a phenomenon in study. The value of the angle for each canon was the same, and in some groups, the difference was considerable respect to the distance reached, because one could conclude that the coefficient of elasticity plays an important role in the calculation of the maximum horizontal distance. Using a strategy to explain two-dimensional movements is a powerful tool for student learning, who find access to knowledge at their fingertips. From the experimental part it can be concluded that the maximum horizontal reach was achieved with the 45° angle and as shown in Table 1 and Figure 2, there are more variables that affect this phenomenon which were not contemplated in the use of the equations proposed, which shows that the failure has a direct relationship with external variables. It was concluded that the equations are models that can represent a phenomenon, but their validity will also depend on the most representative variables that influence the environment.

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