The Research Of Mathematics' Supporting Function For Physics Study In Middle School

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Abstract. Mathematics and physics have always been in the closest relationship. Mathematics is the foundation of many subjects of Science and engineering, while physics enriches mathematics. In the study of physics in junior and senior high school, the basic support of mathematics is very obvious. In this paper, the being thrown small ball is taken as the analysis object in the middle school physics learning. Analyze small ball's force change and the change of velocity, acceleration and displacement by using mathematical principle. At last the mutual relationship and influence rule are discussed between the middle school physics and mathematics.

1. Introduction

"If you learn math, physics and chemistry well, you can go anywhere in the world without fear" is a proverb spread by the older generation. The proverb does not despise Chinese, foreign languages, politics and other subjects of literature and history, but shows the importance of mathematics, physics and chemistry to engineering. Mathematics and physics are like a pair of brothers, mathematical acts as eldest brother and paves in front, providing the basic support for physics. Physics acts as second brother and makes elder brother more rich and colorful. From the beginning of physics learning in high school, basic role of mathematics is clearly presented. Until to the university, the two subjects are fused closer. Because of mathematics, many physical phenomena, laws and concepts can be abstracted and expressed as more accurate and scientific mathematical models and logical forms for logical reasoning and analysis. However, physics provides new research ideas and directions for the study of mathematical problems, which makes the mathematical problems have practical significance. The relationship between the two subjects has been studied by many scholars.

In 2009, Yuan Li[1] of southwest university analyzed the supportive role of mathematics in middle school physics courses in her doctoral thesis. In his master's thesis of 2012, Ding Hua[2] from hunan normal university analyzed the physics and mathematics scores of junior high school students and statistically analyzed the correlation between the two subjects through SPSS software, so as to put forward guiding Suggestions for the teaching of physics and chemistry in junior high school. In 2016, Ziran Zhuoma[3] from Tibet analyzed the important role of mathematics in physics and chemistry in middle school subjects in her paper "exploration of mathematics teaching in junior high school", and proposed strategies to enhance the efficiency of mathematics teaching.

2. Description of the physical example

In physics the test of throwing ball at the initial speed is a classic example, as shown in Fig.1, the ball's initial speed, throwing Angle, as well as the direction of wind speed have the directly impact on ball's flying distance and height. It is the theoretical basis for athlete to choose the right initial Angle to throw the shot put in game. It can be derived that casting Angle of 45 degrees is the optimal choice for reaching the farthest throwing distance. In the test of throwing ball the force of the ball and velocity and acceleration analysis can be analyzed by using mathematical trigonometry, calculus theory.

3. Application of trigonometric function theory

3.1 Description for trigonometric function theory

In right triangle in middle school mathematics, the quantitative relationship between two right angles and hypotenuse is known as trigonometric function theory.

In the right triangle in Fig.2, There exist the following relations among the Angle Θ and the three sides a, b and c,

$$\sin\theta = \frac{a}{c}; \cos\theta = \frac{b}{c}; tg\theta = \frac{a}{b}; ctg\theta = \frac{b}{a} \tag{1}$$

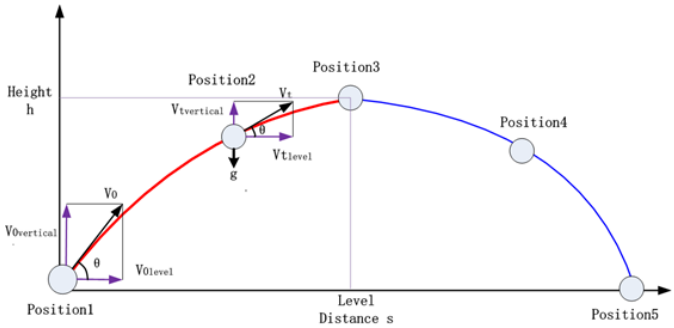

Fig.1. A diagram of the motion for thrown ball

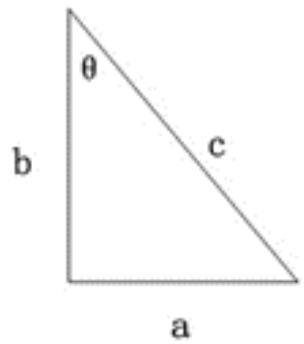

Fig.2. Right triangle

3.2 The ball's velocity decomposition in the initial Position 1

$V_{0vertical}$, V_{0level}, V_0 are three sides of a right triangle, The angle between $V_{0\text{level}}$, V_0 is Θ. Then basing on trigonometric function theory the following formulations can be set up.

$$\sin\theta = \frac{V_{0\text{vertical}}}{V_0}; \cos\theta = \frac{V_{0level}}{V_0}; tg\theta = \frac{V_{0vertical}}{V_{0level}}; ctg\theta = \frac{V_{0level}}{V_{0vertical}} \tag{2}$$

$$V_{0\text{vertical}} = \sin\theta \times V_0, V_{0level} = \cos\theta \times V_0 \tag{3}$$

The small ball at position 2 is taken as the representative for mechanical analysis. In this study, it is considered that in the case of no wind, the flying small ball is only affected by gravity. Let the mass of the small ball be m, then at any time t, the resultant force of the small ball F=ma, and a is the acceleration. That is, the gravity of the small ball is the resultant force, mg=ma, so the gravity of the small ball in the vertical direction is mg, the resultant force in the horizontal direction is 0, according to Newton's law of mechanics, Fjoin=ma=mg, g=9.8m/s, that is, the small ball keeps the downward acceleration -g in the process of flight (upward and the right direction is taken as positive).

The motion of the ball from position 1 to position 3 can be decomposed as,

(1)Moving in a straight line at an initial horizontal constant speed $V_{0\text{level}}$.

(2)The motion is uniformly decelerated with the initial vertical velocity $V_{0\text{vertical}}$, and the acceleration is –g.

The motion of the ball from position 3 to position 5 can be decomposed as,

(1) Moving in a straight line at an initial horizontal constant speed $V_{0\text{level}}$.

(2) The motion is uniformly accelerated with the initial vertical velocity 0, and the acceleration is g.

It can be seen from formula (3) that, $V_{0\text{level}}$ and $V_{0\text{vertical}}$ are determined by the influence of initial velocity V_0 and initial angle θ .

4. Mathematical calculus theory

In the ball flight model, the mathematical differential relation among velocity V, acceleration a, displacement s and time t can be got. From the mathematical calculus theory, the velocity v is the change of displacement Δs in a tiny time Δt , that is,

$$V = \frac{\Delta s}{\Delta t} = \frac{ds}{dt} = S' \tag{4}$$

Similarly, acceleration a is the change Δv in velocity in a small time Δt , that is,

$$a = \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = V' \tag{5}$$

Therefore, there is the following quantitative relationship in the process of small ball flight,

$$V_{t\ \text{vertical}} = V_{0vertical} - g * t;\ H_t = V_{0vertical} * t - \frac{1}{2} g * t^2;$$
$$S_{level} = V_{0level} * t \tag{6}$$

5. Flight process analysis

5.1 Initial Angle for the farthest throwing

Because in the vertical direction the ball keeps uniformly decelerated motion from position 1 to 3, when $V_{t\ \text{vertical}} = 0$ the ball will reach the highest position. The height H and the horizontal distance can be obtained. If we want to make the ball reaches the maximum level distance S as possible, the time t which reach the highest position must be large enough, which means $V_{0\text{vertical}}$ needs to be as large as possible. And there exist such relationship as $V_{0\text{vertical}} = \sin\theta \times V_0; V_{0level} = \cos\theta \times V_0$. When V0 is constant, the maximum level distance S means the requirement for maximum $V_{0\text{verical}}$ and $V_{0\text{level}}$. While $V_{0\text{verical}}$ affects time t, $V_{0\text{level}}$ affects flight speed, so we can take the value of θ which makes $\sin\theta = \cos\theta$, that means $\theta = 45°$ is the optimum angle.

5.2 State analysis of the highest point of the throwing

Position 3 is the highest point. When the ball reach the position, its speed $V_{t\ \text{vertical}} = 0$. From Formula(3)and(6),time t3, height H3 and level distance S3 can be got as $t_3 = \frac{\sin\theta \times V_0}{g}$, $H_3 = \frac{\sin^2\theta \times V_0^2}{2g}$, $S_3 = \frac{\sin\theta\cos\theta \times V_0^2}{g}$.

5.3 State analysis from position 3 to 5

The motion of the ball from position 3 to position 5 can be decomposed as,

(1) Moving in a straight line at an initial horizontal constant speed.

(2) The motion is uniformly accelerated with the initial vertical velocity 0, and the acceleration is g.

Since air resistance is not taken into account, the motion variables of this process and positions 1 to 3 are the same value and opposite directions.

$V_{5\text{vertical}}$=-$V_{0\text{vertical}}$=-$V_0 \sin\theta$, $V_{5\text{level}}$=$V_{0\text{level}}$=$\cos\theta \times V_0$

According to the mathematical trigonometric function and the physical velocity synthesis principle, the value of V_5 is the same as V_0, the direction is pointing down to the right, and remains at an Angle θ to the horizontal. As shown in figure 1, the time taken from position 5 to position 3, the horizontal distance traveled and the height dropped are the same as t3, H3 and S3 in 5.2.

6. Conclusion

Through the analysis of the physical throwing ball‘s movement process, it can be seen that the trigonometric function theory, differential and integral calculus theory of mathematics has made full use in Physics. When considering air resistance and wind speed the movement process will be more complex, the calculus of higher mathematics will get more applications. As the further deepening study for the high school physics and mathematics knowledge all the way to the university’s higher mathematics and college physics, the relations between physics and mathematics will be more closely. Mathematical support will be even more highlighted. Therefore, laying a good foundation of mathematics is very important to the study of physics, and learning physics well will make the study of mathematics more interesting and meaningful.

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