METHODOLOGY FOR SOLVING OLYMPIAD TASKS IN KINEMATICS

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Abstract. *The article analyzes the specifics of the Olympiad tasks in physics, the mathematical knowledge necessary to prepare for the Olympiad, as well as the methodology for solving some Olympiad tasks in the field of kinematics.*

Key words: *physics, kinematics, Olympiad tasks, problem solving, associative thinking.*

МЕТОДИКА РЕШЕНИЯ ОЛИМПИАДНЫХ ЗАДАЧ ПО КИНЕМАТИКЕ

Аннотация. *В статье анализируются специфика олимпиадных задач по физике, математические знания, необходимые для подготовки к олимпиаде, а также методология решения некоторых олимпиадных задач в области кинематики .*

Ключевые слова: *физика, кинематика, олимпиадные задания, решение задач, ассоциативное мышление.*

INTRODUCTION

Solving difficult or Olympiad tasks in physics is considered as the first step for pupils to the scientific world. Each task is a small scientific problem that needs to be solved. Olympiad tasks are a kind of scientific problems that scientists face in their research activities. [3].

The modern development of science and technology requires the training of more highly qualified specialists in the natural and technical fields. To this end, increasing the effectiveness of teaching physics, identifying talented young people and developing their creative abilities is one of the urgent tasks of our time. If sections are organized in an educational institution, competitions in physics are held among students, correspondence olympiads are organized in subjects, the interest of students will grow, their abilities will be formed and self-confidence will increase.

MATERIALS AND METHODS

Tasks for different stages of the Olympiad differ significantly in terms of the level of difficulty. At the final stage of the Olympiad, students will be asked to solve complex problems that require creative skills in applying the laws of physics, physical phenomena, and developed associative thinking. Only well prepared students can complete the tasks of the final stage. Olympiad tasks are compiled on the basis of knowledge and skills that do not go beyond the framework of the secondary school curriculum. The solution of the task usually does not require complex and inconvenient calculations, the main attention is paid to the physical content of the problems.

Olympiad tasks - the most attractive collection of elementary tasks in physics. Olympiad tasks teach the pupil to think deeply, work on himself, improve his talents and skills, have a rich imagination, be a purposeful person and be able to make decisions. It is known that Olympiad tasks encourage pupils to think logically and justify their conclusions. In the course of solving problems, pupils repeat theoretical knowledge and acquire the ability to apply it in practice.

RESULTS

Olympiad tasks differ from ordinary tasks of general physics in that they simultaneously cover several physical processes and physical laws. That is, if a pupil can solve a simple task with knowledge of a given topic, this will not be enough to solve the task of the Olympiad, and it is necessary to know other physical laws. It is also necessary to fully represent the process mentioned in the condition of the task and reflect it in the drawing, and this happens on the basis of strong logical thinking. In addition, when solving Olympiad tasks, it is necessary to have a high level of mathematical knowledge, in particular, in addition to simple arithmetic calculations, it is necessary to fully master derivatives, differentials, integrals and, of course, geometry.

When preparing pupils for Olympiads in a subject, the teacher should first of all pay attention to the level of both physical and mathematical knowledge and the ability to think logically. If to choose a gifted pupil and teach him to solve tasks from simple to complex in accordance with his age, his level of knowledge will increase, and he will definitely show high results at the Olympiad in the subject.

There are no clear instructions on the criteria for selecting questions for the Olympiad on the subject, and the responsibility lies with the organizers of the Olympiad. The level of complexity of the questions is selected depending on the stage of the Olympiad in the subject and the age of the participants. One of the main differences between republican and international olympiad tasks from lower-level olympiad tasks is that the condition of the problem consists of several stages and a large number of required values.

DISCUSSION

Below we will consider peculiar methods for solving several Olympiad problems related to the Kinematics section of Physics.

1. The hunter released the fox and the rabbit from the cage at the same time (Fig. 1). The fox ran towards the forest along the shortest path 15 m long at a speed of 3 m/s, and the rabbit began to run around the lake. If the rabbit saw the fox reach the edge of the forest, bypassing the lake, determine the rabbit's running speed. Assume that the radius of the lake is 15 m and that while running the rabbit can only see objects in front of him.

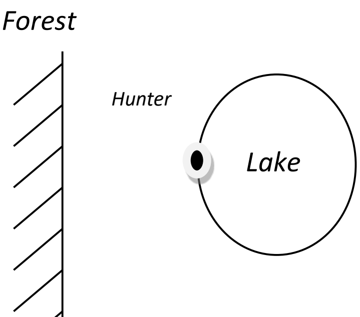

Figure 1

Solution: Draw a tangent from point A, where the fox ran. So, at the time the fox came running, the rabbit had to be at point B to see it. (Fig. 2). The arrival time of the fox is $t_1 = L/v_1$ According to the condition of the problem, $L = R$, so $t_1 = R/v_1$. At this time, the rabbit crossed the CB arc. Geometrically, it can be easily found from the drawing that the angle BOC is 60^0. In this case, the length of the path traveled by the rabbit is equal to the following:

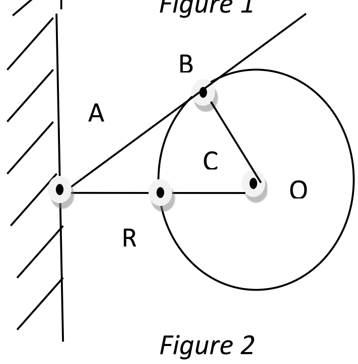

Figure 2

$$S_2 = R\left(2\pi - \frac{\pi}{3}\right) = \frac{5\pi R}{3}$$

Find the running time of the rabbit and equalize the time:

$t_2 = \frac{5\pi R}{3v_2}$ $\quad t_1 = t_2 \quad$ $\frac{R}{v_1} = \frac{5\pi R}{3v_2}$

From the last equation we find the speed of the rabbit:

$$v_2 = \frac{5\pi}{3} v_1 \approx 15.7 \frac{m}{s}$$

Answer: $v_2 \approx 15.7\, m/s$

2. The level of water in a cone-shaped vessel rises at a constant rate v_0. How is the rate at which water exits a hole with surface s related to time? Assume that the angle at the vertex of the cone is 2α and the vessel is initially empty

Solution: For a small value of time dt, the volume of water dv leaving the pipe is equal to the following:

$$dV = v(t)sdt$$

This volume of water increases the water level in the vessel by dz.

$$dV = S(z)dz$$

Geometrically, one can easily find the dependence of the cross-sectional surface of the vessel on the height of the vessel:

$$S(z) = \pi R(z)^2 = \pi z^2 tg\alpha^2$$

So

$$dV = \pi z^2 tg\alpha^2 dz$$

Equate the first and last equality

$$v(t)sdt = \pi z^2 tg\alpha^2 dz$$

We divide both parts of the equation by sdt, and the expression $\frac{dz}{dt}$ is equal to the height of the rise of water, and it is known by the condition of the problem

$$v(t) = \frac{\pi z^2 tg\alpha^2 v_0}{s}$$

Finally, if we take into account that $z = v_0 t$, then the answer is:

$$v(t) = \frac{\pi v_0^3 tg\alpha^2}{s} t^2$$

Answer: $v(t) = \frac{\pi v_0^3 tg\alpha^2}{s} t^2$

3. What is the smallest angle at which a basketball must be thrown in order for it to fall into the basket? Ball radius r, ring radius R=2r, located at a height of 3 m from the floor. A basketball player throws a ball from a height of 2 m to a distance of 5 m from the ring.

Solution: According to the minimum angle condition, we see a situation where the ball hits the front and back walls of the ring (Fig. 3).

So $\sin\beta = r/R$. If the mooing speed is v_0 and the flight time is t

$$l = v_0 t \cos\alpha$$

$$H - h = v_0 t \sin\alpha - \frac{gt^2}{2}$$

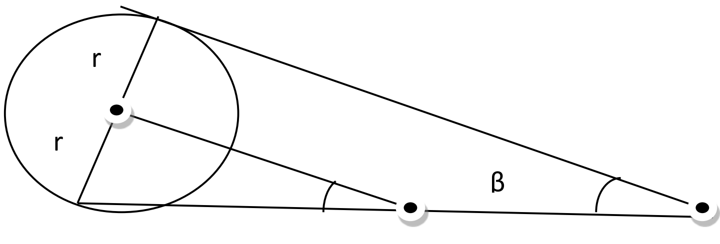

Figure 3

The horizontal component of the velocity at the moment the ball hits the front wall is $v_x = v_0 cos\alpha$ and the vertical component is$v_y = v_0 sin\alpha - g$. So $g\beta = -v_y/v_x$. Solving the above system of equations, we obtain the following result:

$$a = arctg\left[2\frac{H-h}{l} + \frac{r}{(R^2-r^2)^{1/2}}\right] \qquad \alpha = 45°$$

Answer : $\alpha = 45°$

CONCLUSIONS

Summing up, we can say that if pupils are given these types of Olympiad tasks, then they will increase their interest in the subject and their level of knowledge. After all, the task and goal of each teacher is to identify and reveal the talents, abilities and capabilities of the younger generation and create an opportunity for their development.

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