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New Types of Physics Competitions

Zsuzsa Rajkovits
Department of General Physics, Eötvös Loránd University, H-1117 Budapest, Pázmány sétány 1A, Hungary, phone: +36 1372 28 22, E-mail:RAJZSU@ludens.elte.hu

Abstract

International physics competitions play an important role in the education of highly talented secondary school students opening new possibilities to extend their knowledge in physics and other sciences. There are many ways of educating gifted students in and outside the school. International competitions prove the individual abilities of students and their capability to work in a team. The results are in connection with the educational and scientific level of the participating countries. There are many types of competitions, here we present only two of them. The **International Conference of Young Scientistst** (ICYS) and the **International Young Physicists' Tournament** (IYPT) are new forms of competitions. In this paper some of the problems of the IYPT will be presented together with the short description of the training method the Hungarian students for the competition.

Introduction

It is well-known, that there are many ways of educating gifted students in and outside the school, too. Competitions play an important role in this work opening new possibilities to extend the student's knowledge and to prove their abilities in problem solving. Nowadays, during the permanently decreasing popularity of sciences talent-spotting has a special significance.
International competitions have especially great importance in this work, the results are in connection with the educational and scientific level of the participating countries. There are many kinds of international physics competitions. The most well-known one is the International Physics Olympiad, which is an individual competition, at which students have to solve 3 theoretical and 2 experimental problems in their native language.
In the frame of talent-spotting there can be shown two new types of international competitions, the ***International Conference of Young Scientists***, (ICYS) and the ***International Young Physicists' Tournament*** (IYPT). The first, the ICYS was organized three times in Hungary, in Visegrád, and in the IYPT Hungarian secondary school students have been participating for twelve years.

The characteristic features of these competitions

1. International Conference of Young Scientists

The representatives of Eötvös Loránd University, Budapest and the State University, Minsk in 1993 decided to organize together a conference for 14-18 year-old secondary school students.

The aim of the organizers with organizing such a ***new type of a competition*** was to get the secondary school students' acquainted with the methods of scientific research. This includes different phases of research work from the very beginning the pointing out the topic to the last step, summing up the results of the research in a foreign language-lecture. The conference gives the challanging opportunity to the young scientists to get some feedback of the work with which they are just trying to deal, and to measure their strength in an international field.
The International Conference of Young Scientists is a special type of competition in ***physics, mathematics***, ***computer science*** and ***ecology*** for 14-18 year-old secondary school students. Every participant has to prepare a ***research report*** on a subject chosen by herself/himself from any part of the above mentioned sciences. The language of these ten-minute reports is English and an international jury evaluates and rewards the presentations.
During the 7 years students from the following countries have partcipated in the Conference: Belarus, Greece, Romania, Yugoslavia, Macedonia, The Netherlands, Russia, Ukraine, Georgia, Singarore, Hungary. The conference in Hungary (Visegrad, 1994, 1996, 1998) and Belarus (Baranavichi, 1995, 1997, 1999) was organized respectively, and in 2000 will be held in The Netherlands in Nijmegen.
Every year generally 60-70 lectures are delivered in 4 section on the Conference.
This kind of competition has importance in teaching the students:
to do research work,
to present and discuss their own results, and
to formulate research reports, especially in foreign languages.
Perhaps most of the participating students will later become students at various universities and will be researchers reporting at scientific conferences, this first appearance may be a decisive factor in their future scientific career.

2. International Young Physicists' Tournament

The competition will be analysed through the following points:
a.) the essential features of the competition
b.) the preparation-work in Hungary
c.) the importance of the competition.
The IYPT is a new form of team competitions, a competition among teams of secondary school students in their ability ***to solve*** complicated scientific problems, ***to present*** solutions of these problems in a convincing form and ***to defend*** them in scientific discussions so-called " Physics Fights".
The IYPT was founded at the Physics Faculty of Moscow State University in 1979. For almost 10 years the YPT was only a competition for secondary school students of Moscow and its environs. The competition became international in 1988. The first six YPTs were organized in Moscow (Olimpietz, Protvino). From 1994 the following countries were organizers:
The Netherlands (Groningen, 1994), Poland, (Spala, 1995), Georgia, (Kutaisi, 1996), Czech Republic, (Cheb, 1997), Germany (Donaueschingen, 1998), Austria, (Vienna,

1999) and Hungary (Budapest) will be in 2000.
The problems are chosen by the International Organizing Committee from those sent previously in by participating countries to the organizers. The Organizing Committee of the host country sends the 17 chosen problems until December to the national committees who want to participate in the tournament. Representatives of a new country at first participate as an observer. The team of that country can participate only the next year.The IYPT is usually organized next year in June or July.
Every participating team consists of five secondary school students (the participation of university students is not allowed). The composition of teams can not change during the tournament. The team is headed by the captain, who is the official representative of the team during the competition. The teams participate in scientific discussions in 3 selective fights, in the semi-final, and in the final. Every fight is carried out in three stages. In each stage every team plays each of the following three roles: the Reporter, the Opponent and the Reviewer. The official languages of the IYPT are English and Russian. The reporters make their presentations only in English. The discussion of the students may be carried out in English and Russian too. Countries can take charge for the organization of the competitions voluntarily.
An international jury formed by the local organizing committee consists of independent members of the host country and the representatives of the participating countries, it grades, qualifies the work of the students.

Preparing work in Hungary

In our country the problems are published in Hungarian language in the Mathematical and Physical Journal for Secondary Schools already before December. Every student who wants to participate in the competition has to send three or four solved problems to the organizers until April. The National Organizing Committee selects the students who will be the members of the Hungarian team. Knowledge of English is a very important factor of the selection.
The methodology of the preparation of the students varies in different countries (Kluiber, 1995). In Hungary there is an intensive training for the team at the Eötvös Loránd University in Budapest for three weeks immediately before the tournament. Then university professors, specialists of the corresponding branches of physics are invited to give lectures. A very important part of the preparation is the experimenting through which the students learn teamwork and acquire important skills. Every member of the Hungarian team is responsible for three or four problems. That means, after the preparing work they have to formulate the reports in English and to present it at the tournament. To be successful each team must have students interested in theoretical analysis and experimental work and computer science too.

About the problems

The problems of the tournament usually are taken from life and Nature. These are so-called "Kapitza's school's problems", which allow the students to choose their own

approach and method during their investigation. Every year there are problems from various fields of physics and from the boundary areas of physics with other sciences. The obtained results and the solutions of the problems generally can not be classified as right or wrong. Every solution can be one of the possible ways of trying to solve the problem.
To illustrate the wide variety of topics here are a set of problems, problems of the 13^{th} IYPT, Budapest, 2000.

1. Invent for yourself

Suggest a contact-free method for the measurement of the surface tension coefficient of water. Make an estimate of the accuracy of the method.

2. Tuning fork

A tuning fork with resonant frequency of about 100 Hz is struck and held horizontally, so that its prongs oscillate up and down. A drop of water is placed on the surface of the upper prong. During the oscillation of the tuning fork standing waves appear on the surface of the drop and change with time. Explain the observed phenomena.

3. Plasma

Investigate the electrical conductivity of the flame of a candle. Examine the influence of relevant parameters, in particular, the shape and polarity of the electrodes. The experiments should be carried out with a voltage not exceeding 150V.

4. Splash of water

Measure the height reached by splashes of water when a spherical body is dropped into water. Find a relationship between the height of the splashes, the height from which the body is dropped, and other relevant parameters.

5. Sparkling water

Bubbles in a glass of sparkling water adhere to the walls of the glass at different heights. Find a relationship between the average size of the bubbles and their height on the side of the glass.

6. Transmission of signals

Using a bulb, construct the optimum transmitter of signals without any modulation of the light beam between transmitter and receiver. Investigate the parameters of your device. The quality of the device is defined by the product of the information rate (bits/sec) and the distance between transmitter and receiver.

7. Merry-go-round

A small, light, ball is kept at the bottom of a glass filled with an aqueous solution and then set free. Select the properties of the solution, so that a moving up time of several seconds is achieved. How will this time change if you put your glass on the surface of a rotating disk?

8. Freezing drop

Drops of melted lead or tin fall from some height into a deep vessel filled with water. Describe and explain the shape of the frozen drops as a function of height of fall.

9. Radioactivity

Use efficient methods to collect as much radioactive material as you can in a room. Measure the half-life of the material you have collected.

10. Liquid fingers

When a layer of hot salt solution lies above a layer of cold water, the interface between the two layers becomes unstable and a structure resembling fingers develops in the fluid. Investigate and explain this phenomenon.

11. Throwing stone

A student wants to throw a stone so that it reaches the greatest distance possible. Find the optimum mass of the stone that should be used.

12. Tearing paper

Tear a sheet of paper and investigate the path along which the paper tears.

13. Rolling can

A can partially filled with water rolls down an inclined plane. Investigate its motion.

14. Illumination

Two bulbs, 100 and 40 watts, respectively, illuminate a table tennis ball placed between them. Find the position of the ball, when both sides of the ball appear to be equally lit. Explain the result.

15. Cooling water

Two identical open glasses, filled with hot and warm water, respectively, begin to cool under normal room conditions. Is it possible that the glass filled with hot water will ever reach a lower temperature than the glass filled with warm water? Make an experiment to investigate this and explain the result.

16. Coloured sand

Allow a mixture of differently coloured, granular materials to trickle into a transparent, narrow container. The materials build up in distinct bands. Investigate and explain this phenomenon.

17. A strange sound

Pour hot water into a cup containing some cappuccino or chocolate powder. Stir slightly. If you then knock the bottom of the cup with a teaspoon you will hear a sound of low pitch. Study how the pitch changes when you continue knocking. Explain the phenomenon.

The way of preparing our students will be shown throughout the solving of a problem. This is only one of the possible ways as it was mentioned above.

The problem is the following:

Bottle *(1995)*
A plastic bottle of a capacity between 1 and 2 litres completely filled with water is "accidentally" dropped on the floor from the height H=1m. What maximum height can the spray reach and why? Determine the minimal height from which the bottle should be dropped to burst!

The stages of the investigation

1. Dropping experiments were done. Various kinds of bottles in size, in shape and in material were dropped.
2. The material of the chosen bottle was investigated.
3. The collision was observed and a simple model was created for describing the formulation of the waterspray.
4. A theoretical approximation was given for the height of the spray reached after the collision with the floor taking into account the cumulation of the water at the neck of the bottle.
5. A consideration was given about the place of burst of bottle.

We could illustrate how many difficulties the students met during the work.

(At the first stage)
The height of the waterspray was so high that it was not easy to measure. They had to find a special method for measuring it. Many different kinds of bottles were tested, the most characteristic one had to be chosen according to the formulation of the problem (The maximum height of the spray was the point of view of the choice.).

(At the second stage)
They had to notice that the elasticity of the material of the bottle was an important factor. They had to measure the Young-moduli of the material. From the numerous methods they had to choose one. Two stripes were cut from the bottle, one horizontally the other vertically, and a tensile testing was done by an MTS - machine.

(At the third stage)
What happens at the moment of the collision?

A shock wave forms in the water and propagates to the neck of the bottle. During the preparing lectures they had learned about the shock waves, about the development, the propagation and the velocity of the shock wave.

(At the fourth stage)
The cumulation of the water at the neck of the bottle is a very interesting phenomenon.
How can this phenomenon be taken into account?
A very simple experiment demonstrates the cumulation of the water at the neck. When immersing a funnel upside down into relatively deep water with its pipe closed and then suddenly opened, a similar cumulative effect can be observed.
The quantitative description of this cumulation is not too easy, but it can be performed by solving a series of relatively simple problems. But the students can calculate the height of the spray without any knowledge of cumulation. They can determine it by considering how the kinetic energy of the water changes from the bottom to the top of the neck.

And finally about the burst of the bottle (At the fifth stage)
A closer look at the damaged bottles provided a very precious piece of information. It was observed, that the bursting caused by the collision always occurred at the bottom - no matter what kind of bottle the experiment was done with. It means, that in the course of determination of the critical height from which the bottle should be dropped to burst, they had to take into consideration the shape and rigidity of the bottom of the bottle and not the parameters of the wall.
In possession of the above mentioned information the students solved the problem together.

The educational value of the competitions

This type of competition is very important from the point of view of education of young talents. The working method of the students is similar to the methods of the research work in science. Everybody works on the basis of his own plan at the beginning, and the final solution of the problem is developed during the discussion. The preparation of the students for the competition requires a relatively long time, during which they need our help ***in finding appropriate literature, in learning things which are not in the plan of physics education in the secondary schools, in the composition of the report, in writing the article, in making some experiments by devices which they do not have in their schools....etc.***
Although the problems seem often very simple, the solution is very difficult. The students like the teamwork very much, and are very interested in the presentation too. It is not rare, that the younger members of the team want to participate in the next tournament, and therefore they work hard next year too.
The IYPT have had teams during its history from the following countries:
Bulgaria, Czech Republic, Slovakia, Germany, Great Britain, The Netherlands,

Hungary, France, Italy, Poland, Sweden, Georgia, Belarus, Ukraine, Russia, Uzbegistan, Kazahstan, Armenia and from 1997 Austria, Australia, Mexico and USA.

The winners of the IYPT

1988: Poland and Soviet Union
1989: Bulgaria and Germany
1990: Moscow (team of Secondary School of the University)
1991: Hungary
1992: Belarus and Czech Republic
1993: Georgia
1994: Czech Republic and Moscow (team of Secondary School of the University)
1995: Germany
1996: Czech Republic
1997: Hungary
1998: Czech Republic
1999: Germany

Summary

The aim of this paper was to increase the popularity of these competitions. During the history of IYPT many countries are trying to participate permanently, but except of The Netherlands only the Eastern-Middle European countries managed to do so practically continuously. The IYPT become more and more popular all over the world. Newer and newer countries have continuously joined to the tournament from the wide world since 1995.
As it could be seen above, during the solving of a special problem, receiving of new information requires fundamental knowledge of physics, which can be reached only by a professional physics education. We would like to emphasize, that both of the mentioned competitions are for highly-gifted secondary school students, and for educating young talents. This level, of course, is not the average secondary school's level, and to reach it is impossible without a good background in physics.We have been following the walk of life of our students who had participated in the IYPT and the ICYS, and now study at our university. They are able to join the research-work at the university and successfully participate in conferences, competitions for university students earlier then the others. There can be found among them a student, who has 28 publications in famous international journals already before finishing his studies at the university. Former competitors usually help us with pleasure in the preparing work, their scientific career serves as a good example for the younger university students.
During the competitions students make friends with competitors from other countries, this friendship can mean the beginning of a later scientific cooperation.
Nowadays, when the majority of the secondary school students does not have enough perspective in studying sciences, our work has greater importance. If we find

only a few students for this job, it has already been worth of trying.

Reference

Kluiber, Z.:1995, „Development of Talents in Physics”, The Union of Czech Mathematicians and Physicists, Prague 1995