MIKOLA COMPETITION

Miklós Kiss
Berze High School, Gyöngyös, Hungary, mikloskiss2630@gmail.com

ABSTRACT

Back in 1981 it was realized that there is no nation-wide competition in physics for the ninth and tenth grade high school students. To be able to recognize students talented in physics as early as possible, a new competition named after a famous Hungarian physics teacher Mikola was organized for them. The competition consists of three rounds. The first and second rounds mainly focus on theory and problem solving. The final round consists of both theoretical questions and experiments. The usual venues of the finals are the Berze High School in Gyöngyös (ninth grade) and Leőwey High School in Pécs (tenth grade). This year (2015) the 34th Mikola competition was held.

INTRODUCTION

Between 1978 and 1980 a new curriculum was introduced in Hungary. According to this curriculum physics began in the high schools at the ninth grade. In 1981 it was realized that there is no nation-wide competition in physics for the ninth and tenth grade students. To be able to identify students talented in physics as early as possible, it was desirable to organize one. In the following a short history of the competition and, to illustrate the spirit of the competition, an example from the problems of it will be shown.

SHORT HISTORY

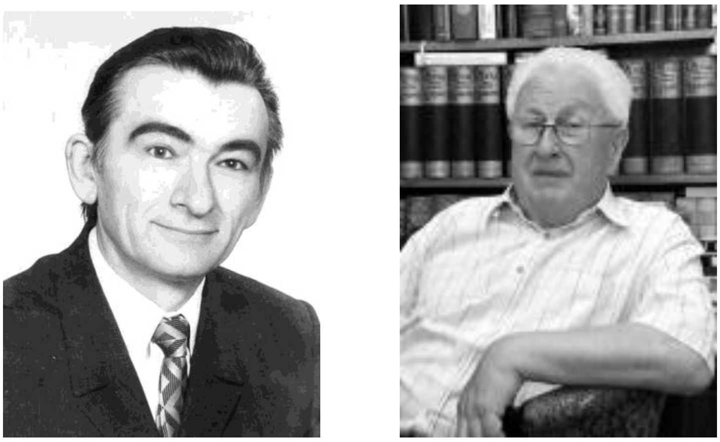

Fig.1. Left panel: Lajos Kiss (1939-1995). Right panel: Márton Nagy [1]

International Physics Olympiad (IPhO) was established in 1967 by Czechoslovakia (Rostislav Kostial), Poland (Czesław Ścisłowski) and Hungary (Rezső Kunfalvy and Géza Tichy). When the Hungarian organizers were looking for new members for the students' Olympic team, they recognized that there is a need for a nation-wide competition in physics for the 9/10th graders. With the help of György Marx a new competition was founded for them. The two organizers of the finals were Lajos Kiss (Berze High School, Gyöngyös) and Márton Nagy (Berzsenyi Dániel Gimnázium, Sopron) Fig.1.

1981/82: The first competition was held with two rounds (regional and national). In the first round only two students per school could participate. The final was held with 40-40 participants. 1982-84: The competition was adopted by the Ministry of Culture as a nationwide physics contest for talent scouting. (Its Hungarian name was: Országos Középiskolai Tehetségkutató Tanulmányi Verseny, OKTTV). In the next academic year (1985/86) the competition had already got three rounds. In its first round the number of participants was not limited, and separate categories were introduced for high school and vocational school students. 1986/87: The competition got its present name after Sándor Mikola, the famous Hungarian physics teacher. The homepage of the competition (edited by Miklós Kiss) started in 1998. From 2001 it was edited by Gergely Kiss. In 2008 the four-day finals were changed to a three-day one.

ROUNDS OF THE COMPETITION

In the first and second rounds of the contest students should solve theoretical problems. Participants reaching a 50% result in the first round can enter into the second round where the best 40 or 50 students are selected for the finals of both grades. Finals are in 2 parts. The theoretical competition consists of some theoretical questions (problems). In the practical exam the competitors complete one or two experimental problems in a laboratory. Initially the number of first-round participants was a few thousand but unfortunately this number is decreasing continuously. The venues of the finals (Figs.2. and 4.) are the Berze High School in Gyöngyös (nine graders) and Leőwey High School in Pécs (ten graders), the latter was held earlier in Sopron.

Fig.2. Left panel: 1999 (Zoltánné Bóna, Dr. László Zsúdel, Béláné Farkas, Miklós Kiss). Right panel: 2000 (Miklós Kiss, Andrea Gyebnárné Nagy, András Mester, Dr. József Kopcsa, János Suhajda, Dr. László Zsúdel, Dr. Péter Czinder)

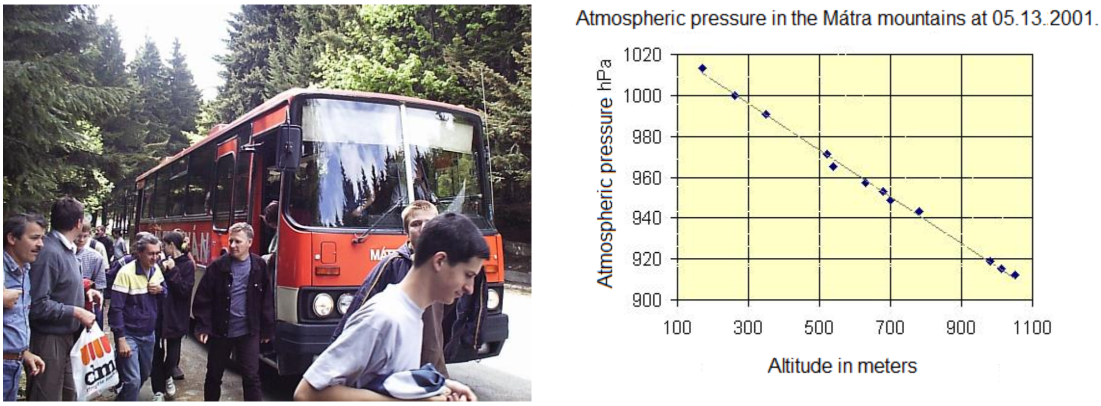

Fig.3. Left panel: 2001 A trip to Kékestető. Right panel: Air pressure in the Mátra Mountains

Fig.4. Left panel: Péter Simon, president of the jury and Ádám Varga, the winner in 2008. Right panel: 2014 Measuring in the BERZELAB

The program of the competition often included a short excursion to the countryside where the participants performed physical experiments, too. Fig.3. shows the result of the atmospheric pressure measurement performed during a trip to the highest mountain of Hungary. The competition is closed with a ceremony of the announcement of the results. The ceremony begins with a scientific presentation which is delivered by a well-known Hungarian physicist. (You can see more pictures at the homepage [2]. A complete report about the 27th final is in [3]. Results, problems, measurements and solutions are in the references [2-10]).

EXAMPLE: THE MEASUREMENT TASK IN THE 33RD FINALS

Investigation of non-central collision of coins

Devices:

-1 pc 50 HUF coin

-1 pc 5 HUF coin

-2 pcs template to mark the centre of the coins

-1 pc short ruler

-1 pc long ruler

-1 pc triangle ruler

-1 pair of compasses

-2 pcs A3 measuring sheets of paper

-Blu-tack (glue)

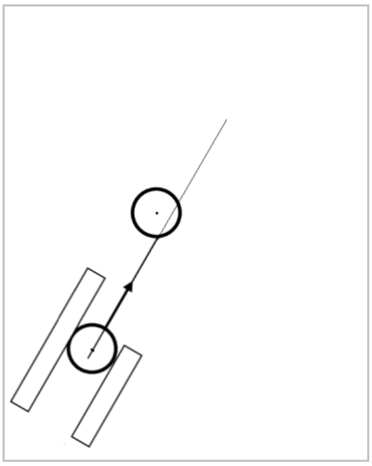

Fig.5. The arrangement of the coins and rulers

The measurement

Investigate the non-head on collisions of coins. The target coin is at rest, while the velocity of the other coin (the projectile coin) can be varied. Let the angle between the velocity vector of the projectile body and the line going through the centres of the coins be 45°. The figure (Fig.5.) and the measuring sheet prepared in advance help to set up. The initial and final position of the coins can be marked on the measuring sheet. It is advisable to fix the rulers with the blue-tech. Templates may help to mark the centre of the coins.

It can be assumed that the coefficient of kinetic friction is the same for every coin.

Make a plan for the evaluation of the measurement!

Tasks:

1. Verify that the velocity of coins is proportional with the square root of the covered distance.

2.

a) Collide the fifty-forint coin with the five-forint coin, which is at rest. Mark the positions of the coins at the moment of the collision and where they stopped.

b) Measure the displacement of the coins. (The direction of the motion of the projectile coin will also be required.)

c) Determine the velocities of the coins after collision. The velocities can be given in convenient arbitrary (freely chosen) unit.

d) Measure the angle of velocities after collision.

e) Construct the velocity of the five-forint coin. Determine the mass ratio of the fifty-forint and five-forint coins.

f) From the measured data determine the collision number (coefficient of restitution) and the energy ratio. (The latter is the ratio of the whole energy of the two coins after collision, divided by the energy of the projectile coin.)

3. How does the measurement verify the assumption concerning the coefficient of kinetic friction?

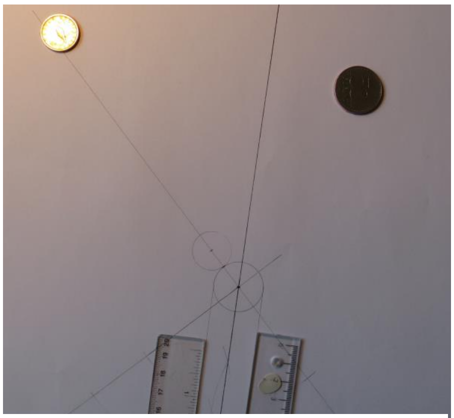

Fig.6. The initial and final position of the coins

The initial positions of the coins should be indicated in advance (Fig.6.). Draw the coins around and mark the centre of the coins with the template. Care should be taken to ensure that the displacement of the coins is determined relative to their own initial position.

Fig.6. shows the result of a collision. After the collision the coins are at rest. The position of the coins at the moment of the collision and the line of the projectile velocity inclining 45° to the line through the centres of the coins are also denoted in the figure. From the magnitudes of the displacements after collision, the velocities can be gained in arbitrary units:

$$v_1 \sim \sqrt{s_1} \text{ and } v_2 \sim \sqrt{s_2} \tag{1}$$

Using the momentum conservation law for the collision we get:

$$M\mathbf{v} = m\mathbf{v}_1 + M\mathbf{v}_2 \tag{2}$$

where M and m are the mass of the fiftyforint and that of the five-forint coin, respectively. In the equation $\mathbf{v}$ and $\mathbf{v}_1$ are the velocities of the fifty-forint coin before and after the collision and $\mathbf{v}_2$ is the velocity of the five-forint coin. The momentum equation can be transformed to a velocity addition rule, where $\frac{m}{M}\mathbf{v}_1$ is called the modified velocity of the projectile coin:

$$\mathbf{v} = \frac{m}{M}\mathbf{v}_1 + \mathbf{v}_2 . \tag{3}$$

This provides a way of construction. Having known $\mathbf{v}_2$ (direction and magnitude), and the direction of $\mathbf{v}$ a parallelogram can be constructed and the value of $\frac{m}{M}\mathbf{v}_1$ can be determined. Comparing this with the magnitude of $\mathbf{v}_1$ the mass ratio can be obtained:

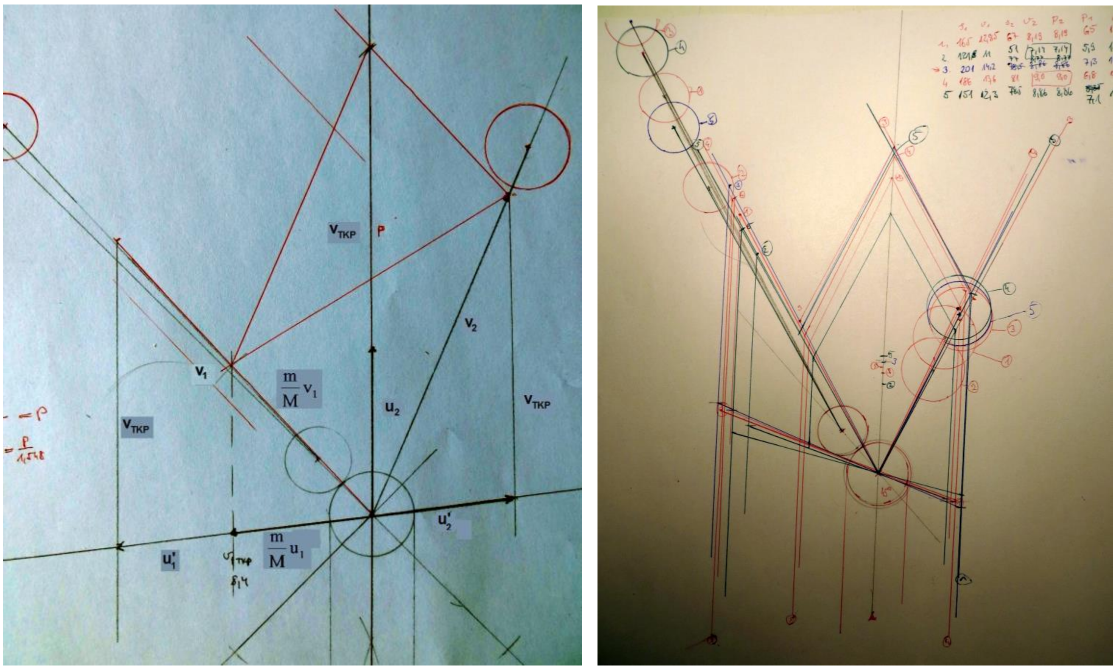

Fig.7. Left panel: Construction of the parallelogram from a measurement, Right panel: Construction of the parallelograms from many measurements

$$\frac{m}{M} = \frac{\frac{m}{M}v_1}{v_1}\,. \tag{4}$$

By the use of the mass ratio the velocity of the centre of mass can be determined.

$$(m+M)\mathbf{v}_{TKP} = m\mathbf{v}_1 + M\mathbf{v}_2 = M\mathbf{v} \tag{5}$$

$$(m+M)\mathbf{v}_{TKP} = M\mathbf{v} \text{ hence } \mathbf{v}_{TKP} = \frac{M\mathbf{v}}{m+M} = \frac{\mathbf{v}}{\frac{m}{M}+1} \tag{6}$$

Subtracting this from the velocities (cf. Fig.7.) we get the velocities in the system of the center of mass: $\mathbf{u}$, $\mathbf{u}_1'$ and $\mathbf{u}_2'$, $\mathbf{u} = \mathbf{u}_2 = \mathbf{v} - \mathbf{v}_{TKP}$. In this system the whole momentum of the colliding bodies both before and after the collision is zero. Therefore $\mathrm{mu}_1 + \mathrm{Mu}_2 = \mathrm{mu}_1' + \mathrm{Mu}_2' = 0$. Hence:

$$\frac{m}{M}u_1 + u = \frac{m}{M}u_1' + u_2' = 0\,. \tag{7}$$

It shows that the vectors which are on the same side of the equation are opposite ones.

Now we can calculate the collision number as well:

$$k = \frac{p_{2TKP}'}{p_{2TKP}} = \frac{u_2'}{u_2} = \frac{u_1'}{u_1} \tag{8}$$

The energy ratio is:

$$\varepsilon = \frac{\frac{1}{2}mv_1^2 + \frac{1}{2}Mv_2^2}{\frac{1}{2}Mv^2} = \frac{\frac{m}{M}v_1^2 + v_2^2}{v^2} = \frac{\frac{m}{M}s_1 + s_2}{s} \tag{9}$$

where *s* is given from the square of the initial arriving velocity.

Table 1. Measurement data

	s1	v1	s2	v2	p2	p1	p	m	v_{TKP}	p_{2TKP}	$p_{2'TKP}$	k	s	ε	α
1.	149	12,21	131	11,45	11,45	6,7	15,3	0,55	9,88	55	46	0,836	234,1	0,91	66
2.	165	12,85	67	8,19	8,19	6,5	13	0,51	8,63	44,5	35,4	0,796	169,0	0,89	54
3.	121	11,00	51	7,14	7,14	5,9	11,5	0,54	7,49	40	32,5	0,813	132,3	0,88	58
4.	201	14,18	78,5	8,86	8,86	7,3	14,4	0,51	9,51	49	39	0,796	207,4	0,88	58
5.	186	13,64	81	9,00	9,00	6,8	13,9	0,50	9,28	42	36,5	0,869	193,2	0,90	56
6.	151	12,29	78,5	8,86	8,86	7,1	14,1	0,58	8,94	51,5	38,5	0,748	198,8	0,83	58
							average:	0,53				0,809		0,88	58,33
							deviation:	0,03				0,041		0,03	4,08

The actual mass ratio is $\frac{m}{M} = 0.555$. The calculated result agrees well with the real mass ratio of the coins.

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