Mathematics in Physics, Physics in Mathematics

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Abstract – In the paper we deal with the movement problems solved in various ways. We try to point to the interconnection of mathematics and physics with real life. We also try to propose the common solution of the same problem in both subjects. Solving of these problems differ in mathematics and physics, though only slightly, and the unification of the solutions would simplify the understanding of the fact that it is the same problem to pupils.

In practice, we often face the situation in which pupils have some knowledge in separate subjects, but they are only seldom able to use them in connection with other subjects.

If the teacher wants to make the educational process efficient, s/he should try to apply inter-subject relations, without which the acquired knowledge is incomplete.

The application problems serve the development of the inter-subject relations of Mathematics with another subject. Application problems are word problems from nonmathematical fields (such as Physics, Biology, Geography, Technology, etc.) solvable in a given field.

In the paper we focus on the word problems of uniform rectilinear motion that are included in the curriculum of Mathematics and Physics for elementary schools. Both subjects deal with solving of such problem, but not completely in the same manner, which can partially confuse pupils. That is the reason why we would like to show the solution of the same problem with the help of more solutions – numerical (mathematical and physical) and the graphic solution of the problem, and to propose some compromise between them.

The subject matter for elementary schools includes only problems of uniform rectilinear motion. In these problems, however, the situation is simplified, it does not describe the real

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situation. Within the problem it is not considered that the moving subject (car, cyclist, train, plain, walker, etc.) changes its speed by the movement. Both subjects deal with the process of solving such problem, but not completely congruently, which can puzzle the pupils.

Example 3. Two cyclists went up from the city. The first started at the speed $30\frac{km}{h}$. 30 minutes later, the second cyclist went up behind him with the speed $40\frac{km}{h}$. At what time after the start of the first cyclist will the second cyclist catch up with the first one? What is their distance from the city at the point where they meet?
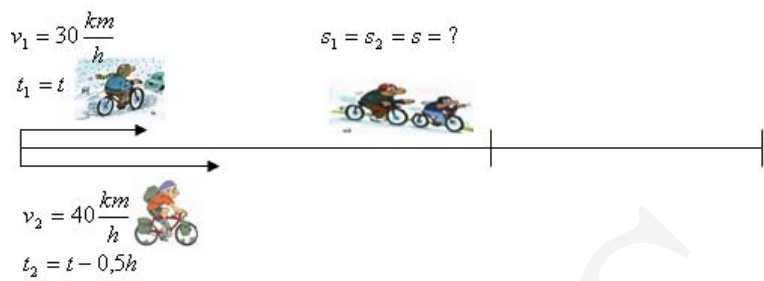
(1) Analysis of the graphic solution:
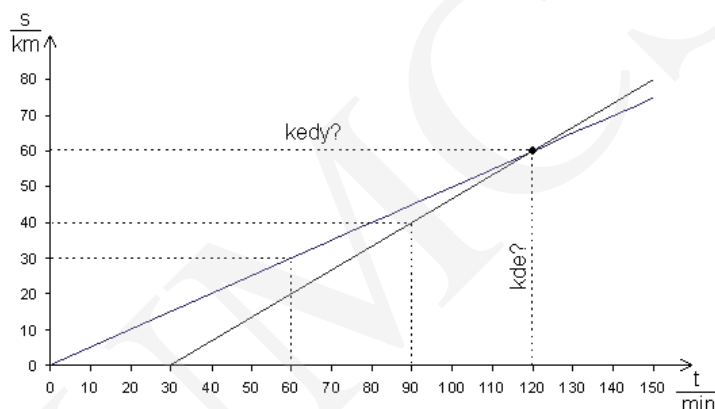
(a) The graph of the trajectory of the uniform motion is the line s=vt. At the horizontal axis we give the time t and at the vertical axis we give the trajectory s.

(b) The city from which they started has coordinates [0,0]. In that point, the graph of the first cyclist begins. We gain the second point from the assignment - the speed of the first cyclist is $30\frac{km}{h}$, thus within 1 hour he covers 30 km, that is 30 km in 60 minutes. The second point is thus [60,30].

(c) The graph of the second cyclist begins in the place 0 km, but it is shifted by the time of 30 minutes. The first point is therefore [30,0]. The second point we obtain, similarly to the case of the first cyclist, from his speed. He goes 40 km in 90 minutes from the start of the first cyclist. The second point is [90,40].

(2) Numerical solutions:
Analysis:
The trial - verification of the solution:

The first cyclist covers for the time of 2 hours the distance 30 x 2 = 60 km. The first cyclist covers for the time of 1.5 hours the distance 40 x 1.5 = 60 km. The distances are the same, the problem is solved correctly.

$v_1 = 30\frac{km}{h}$ $s_1 = s_2 = s = ?$

$t_1 = t$

$v_2 = 40\frac{km}{h}$

$t_2 = t - 0,5h$

Physical solution:	Mathematical solution:
Record:	Record:
$v_1 = 30\frac{km}{h}$	$v_1 = 30\frac{km}{h}$
$v_2 = 40\frac{km}{h}$	$v_2 = 40\frac{km}{h}$
$t_1 = t$	$t_1 = t = x$
$t_2 = t - 30min = t - 0.5h$	$t_2 = t - 30min = t - 0.5h$
$t = ?$	$s_1 = s_2 = y$
$s_1 = s_2 = s = ?$	
Solution:	Solution:
$s_1 = s_2$	$v_1 x = v_2(x - 0.5)$
$v_1 t_1 = v_2 t_2$	$30x = 40(x - 0.5)$
$v_1 t = v_2 t - 0.5v_2$	$30x = 40x - 20$
$v_1 t - v_2 t = 0.5v_2$	$20 = 10x$
$t(v_1 - v_2) = -0.5v_2$	$x = 2h = 120min$
$t = \frac{-0.5 \cdot 40}{30 - 40}$	
$t = 2h$	
The time of the second cyclist spent on the way:	The time of the second cyclist spent on the way:
$t_2 = t - 0.5$	$t_2 = t - 0.5$
$t_2 = 2 - 0.5$	$t_2 = 2 - 0.5$
$t_2 = 1.5h$	$t_2 = 1.5h$
The distance of the city and the point of meeting:	The distance of the city and the point of meeting:
$s = v_1 t$	$y = v_1 x$
$s = 30 \cdot 2$	$y = 30 \cdot 2$
$s = 60km$	$y = 60km$

Answer: The second cyclist overtakes the first cyclist 2 hours after the start of the first cyclist. The cyclists meet 60 km from the city.

Conclusion:

The mathematical solutions of problems aimed at motion are different from the physical solutions in two principal points:

(1) Different marking of unknown quantities

In mathematical solutions, the pupils prefer marking of unknown quantities by letters x, y, ..., that they stereotypically use while solving equations. Consequently, it often happens, that if the marking of unknown quantities in mathematics is changed, it misleads pupils and they are not able to solve the equation.

In Physics, pupils mark the unknown quantities with symbols of adequate physical quantities. Such a choice is more visual because the pupil without the backward consideration automatically gives to the result the unit of the physical quantity.

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(2) Expression of the unknown

During Mathematics lessons pupils try to find the required equation that they will solve.

In Physics, pupils seek first generally to express the unknown quantity and only afterwards they substitute the known values of physical quantities within the formula.