



Non-typical Physical Problems

Vladimir Shelest

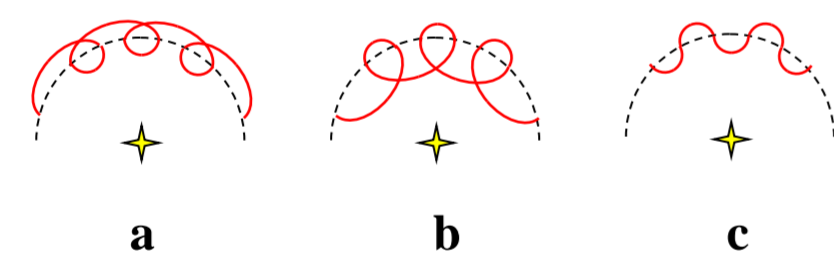
It is well known that students' motivation to study science at school decrease all over the world. How to change this situation? Our approach is based on the fact that most of the students, independently of their age and initial training, usually prefer making their own research to listening to lectures. How to formulate a problem which will be interesting for the class' "tail", not boring for the class' "head" and promotional for class research activity?

Our workshop is devoted to Physics teaching by means of non-typical problems. These problems have a lot of answers on different levels of complexity, which leads to a deeper understanding of the problem and makes it interesting to everyone.

Let us consider an example of the non-standard problem:

What is the form of the Moon trajectory relatively to the Sun?

This problem seems to be an easy question. I often gave it to students and teachers. It is well known that Moon moves around the Earth, Earth moves around the Sun and year consists of 12 months. It does not take long to create such pictures:



Which picture is correct? In my practice the picture **b** was quickly rejected because the directions of rotation of the Earth around the Sun and the Moon around the Earth are the same. After some discussion somebody usually suggested to compare the gravitational forces between the Moon and the Earth (F_{ME}) and between the Moon and the Sun (F_{MS}). It is well known that

$$F_{ME} \sim m_M m_E / R_{ME}^2 \text{ and } F_{MS} \sim m_M m_S / R_{MS}^2,$$

where m_M , m_E and m_S are the Moon, Earth and Sun masses, R_{ME} and R_{MS} are the Moon-Earth and Moon-Sun distances.

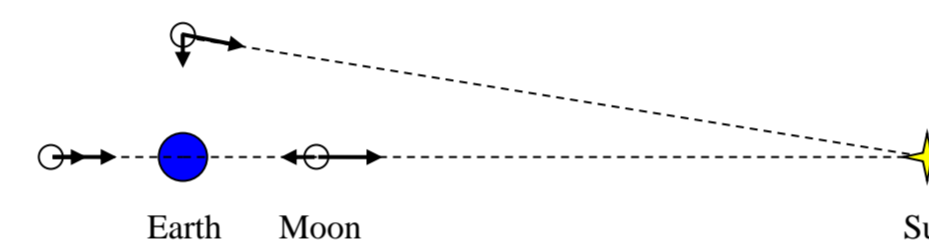
It is evident that

$$F_{ME}/F_{MS} = (m_E/m_S) \cdot (R_{MS}/R_{ME})^2.$$

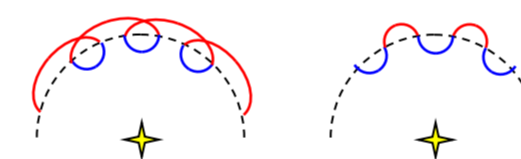
Since $m_E \approx 6 \cdot 10^{24}$ kg, $m_S \approx 2 \cdot 10^{30}$ kg, $R_{ME} \approx 400 \cdot 10^3$ km, $R_{MS} \approx 150 \cdot 10^6$ km, we get that

$$F_{ME}/F_{MS} \approx 1/2.$$

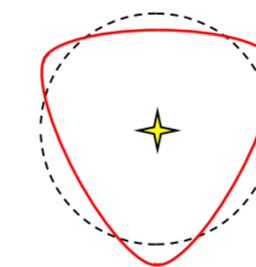
Look at it, $F_{MS} > F_{ME}$! It means that the resultant force, which affects the Moon, is always directed to the Sun.



Therefore, the centripetal acceleration is always directed to the Sun. It means that the previous pictures include incorrect curve pieces, where the centripetal acceleration has the opposite to the Sun direction (marked by blue):



The correct form must curve around the Sun in every point. It can be done only in convex 12-gon, which is inscribed-circumscribed in the Earth orbit circle. As example you can draw the convex 3-gon (triangle):



We got the answer to the initial question. But this answer gave rise to new problems:

- Is the Moon a planet in the solar system or is it an Earth satellite?
- What is about moons of other planets?
- What is about artificial satellites?

And so on...

These problems are not simple school questions. The question "what can be called a planet" is still under discussion. For example, in 2006 the International Astronomical Union (IAU) declared that the solar system consists of only 8 planets, because Pluto does not satisfy all planet criteria.

Interestingly, we began from "training educational" question and came to real scientific problems.

A good formulated non-standard problem can seem extraordinarily complex, or stupidly simple. Such problems can be suggested in a kindergarten and in the Cavendish Laboratory, for example:

- Asteroid hit a spaceship and made a finger-thick hole in it. How much time do the astronauts have to escape?
- Do we have tides in a glass of water?
- A man stands at some distance from a long wall. He illuminates the wall by a projector, which is rotated from left to right. How does the velocity of the light spot depend on time?
- It is the photo-finish of British Cycling in June 2004 at the photo. How to explain the visible form of bike spokes?



During the workshop we shall train in creating and practical usage of such problems. We shall consider how to organize students' research projects. Also we shall discuss a difficult themes of school Physics, selected by the workshop participants.

Vladimir Shelest (*Hans Knöll Institute, Jena*) is a theoretical physicist, the member of Executive Committee of United Physical Society of Russian Federation, a teacher with more than 20-year experience, the head of "Students' Scientific Laboratory" (Novosibirsk Center for gifted children), the author of books "Non-typical physical problems" and "Physics in questions and answers".

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Programm & Kurzbeschreibung: <http://www.pbh.de/>

Anmeldung: Eine formlose Email mit Ihren vollständigen Koordinaten an gomer@pbh.de

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