Problems for the 3rd International Young Physicists' Tournament

Moscow, Soviet Union, 1990

Translated from Russian in November 2007 [1]

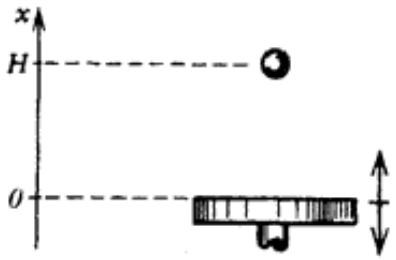
The victories do not invite him.
His growth is that, when deeply defeated,
He always continues growing.
R.M. Rilke [2]

1. Invent yourself – a physical photo contest

Submit to a contest the photographs of a rapidly occurring physical phenomenon. Explain in your commentaries the physical value of these photographs.

2-4. Ball and piston

A horizontal piston oscillates up and down. The coordinate of the piston's surface is defined with the expression $x=x_0\cos\omega t$. At an arbitrary moment, a small ball is dropped without initial speed onto the piston from a height H (Fig. 1).



2. At what altitude the ball will bounce after the first collision with the piston? For this case, consider the collision absolutely elastic and $H > x_0$.

3. The system "forgets" initial conditions after a big number of collisions. Estimate at what maximum altitude a ball may bounce after many collisions. What is the average bounce altitude? Consider that the surfaces of the ball and the piston are not damaged at collisions.

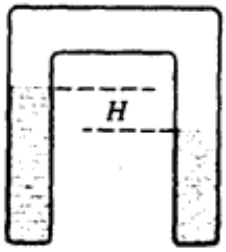
4. Let a ceiling be at a height H above the piston. In this case stationary solutions are possible. Find some of them and research their stability. Consider H = 1 m, $H >> x_0$, g = 10 m/s^2 for numerical estimations. Consider the restoration coefficient of ball collisions with piston and with ceiling, as k = 0.8.

5. Planet

What is the maximum possible size of a cube-shaped planet?

6. Evaporation-condensation

A П-shaped soldered glass tube contains some water (Fig. 2)

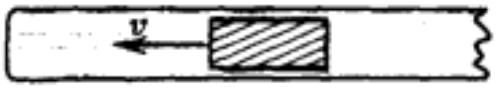


If there is an initial difference of water levels *H,* then after some time water levels will become equal. Estimate the rate of this equalization for a given *H* and *T*=const

a. if there is no air in the tube
b. if there is some air in the tube, at normal atmospheric pressure.

7. Cylinder in a tube

A cylinder is moving in a long tube filled with water towards the closed end (Fig. 3).



Inner diameter of the tube is *D*, diameter of cylinder is *d*, cylinder length is *L*, $D - d = h$, $L > D$, $h << D$. How does the resistance force depend on the speed of cylinder? Compare the theoretical estimations with experimental results.

8. Segner's wheel

A Segner's wheel rotates due to the reactive force of streams flowing out of the nozzles when the wheel is placed into the water. Will it rotate backwards in a reverse regime, if the water is sucked into the nozzles not flowing out of them? It is recommended to look through the book 'Surely You're Joking, Mr. Feynman!' (a partial Russian translation can be found in the "Nauka i Zhizn" magazine, 1986, №12)

9. Franklin's wheel

Rotation of a little metal bar with pointed spearheads in a well-known "Franklin's wheel experiment" is explained by the existence of "electric wind". Explain why the wheel rotates if one places it between the plates of a plain capacitor and charges the capacitor with an electrostatic generator. If the Franklin's wheel is replaced with a dielectric disk, will such a disk rotate between the plates of a plain capacitor charged with an electrostatic generator?

10. Electret

150 years ago, M. Faraday predicted electrets as electrostatic analogues to permanent magnets. Manufacture an electret and research its properties.

11. Color of a cloud

Clouds in the skies above, heavenly wanderers,
Long strings of snowy pearls stretched over azure plains!
Exiles like I, you rush father and father on…
M.Yu. Lermontov. [3]

Explain the observed colors of white clouds and rain bearing clouds.

12. Border of a cloud

An observed border of a cloud is often sharp. It is especially evident on a board of a plane. Evaluate the “diffuseness” of the cloud’s border.

13. Cosmonauts cloud (a fantasy with physical sense)

A great number of cosmonauts form a “cosmonauts cloud” in the open space. Initially each of them has a football (soccer) ball with him. Starting from a certain moment, cosmonauts begin throwing these balls one to another (without losing them). Describe the evolution of a “cosmonauts cloud”. In order not to limit your imagination you are allowed to choose on your own the initial conditions, throwing rules and other parameters of the “cloud”. The only important aspect is that the choice of model should be logically validated; the conclusions should be supported with quantitative estimations; the number of described evolutions should not exceed two.

14. Fractal?

Grandmother is collecting woolen thread in a spherical ball. How does the mass of the ball depend on its diameter?

15. Light in a tube

Look through a glass tube at a light (tube diameter is approx. 5 mm, length is approx. 25 cm). Explain the origin of observed circles.

16. Interference

Take two photo plates (9x12 cm), well-washed from emulsion. If they are tightly pressed (lapped) one to another, the interference bands can be observed in the reflected light. If the plates are laid on the table and the upper one is pressed in the middle part with finger, the interference pattern looks like concentric circles. When the finger is removed, the circles “run away” from the centre. Carry out such an experiment and explain the observed phenomena. Evaluate theoretically how fast the circles “run away”, as the loading is removed.

17. Scientific Organization of Labor – SOL

You have to hammer 1989 similar nails (l = 50 mm, d = 2.5 mm) into a wooden bar. What hammer would you choose to perform this job quicker and better? (A more formalized question: what is the mass of a hammer and the length of its handle?)

a. for a pine bar
b. for an oak bar.

Notes

[1] Source of the Russian version: Е.Н. Юносов. XII Турнир юных физиков. Квант, 8, 1989. - стр. 76-78.* The Slovak IYPT Archive** releases the Slovak translation of this Kvant publication. The list of the problems for 1990 was not released on the Evgeny Yunosov's Faraday Tournament Web-site***.

As it was explicitly stated in the Kvant publication, the problems of the all-Soviet rounds and International rounds in 1990 were expected to be identical to the problems of the Correspondence round, presented in this document.

[2] Translated from German. Original version: “Die Siege laden ihn nicht ein. Sein Wachstum ist: der Tiefbesiegte von immer Größerem zu sein” (Aus: “Der Schauende” von Rainer Maria Rilke //Buch der Bilder). Other known English translations: “This is how we grow: by being defeated, decisively”; “The purpose of life is to be defeated by greater and greater things”. The Russian text quotes the translation by Boris Pasternak.

[3] Translated from Russian by Irina Zheleznova

References

* Е.Н. Юносов. XII Турнир юных физиков. Квант, 8, 1989. - стр. 76-78. http://kvant.mccme.ru/1989/08/XII_turnir_yunyh_fizikov.htm.

** The Slovak IYPT Archive. http://www.tmfsr.sk/index.php?vyber=archiv&kategoria=archiv-1996&lang=svk

*** Evgeny Yunosov's Faraday Tournament official Web-site (www.farad.ru, in Russian, now unavailable).

POISK Centre (Russia), 2007.