ROZHLEDY

matematicko-fyzikální

$$\left(\frac{5-6}{1992}\right)$$

Problems for the VI International Young Physicists' Tournament

1. Think up a problem yourself

Invent a problem in which an object is moving in some way and then changes its state of motion abruptly as a result of some influence. In this process interesting phenomena may arise which you must explain by, for example, making experiments and performing the necessary calculations.

2–5. Gravitation

Imagine that the gravitational constant G decreases slowly from April 1, 1993 until May 1, 1993 by 10 % and keeps this value afterwards. How would this process (i) in the given time interval and (ii) up to the date of the VI International YPT opening affect the Universe as a whole and, in particular,

2. the Sun;
3. the Earth;
4. aviation and astronautics;
5. things important for you personally.

6. Gagarin's record

In April 1961 Yury Gagarin set a world record for the fastest round-the-world orbit space flight. Suggest the cheapest way of beating this record. Note that not every record may be officially recognized.

7. Pressure and temperature

Explain why the pressure inside a house and outdoors are practically the same or become equal quickly, while the temperature may be substantially different. What is the characteristic equalizing time for pressure and temperature in- and outdoors? What is the answer to this question in the case of spacecraft?

8. Dominoes

Dominoes are placed vertically at a small distance from each other in a long row on a table surface. Make the first domino fall on the second one and "the wave of falls" will proceed along the row. Calculate and measure experimentally the maximum speed of this wave.

9–10. Gun

The picture shows an electromagnetic gun circuit. It can launch metal rings.
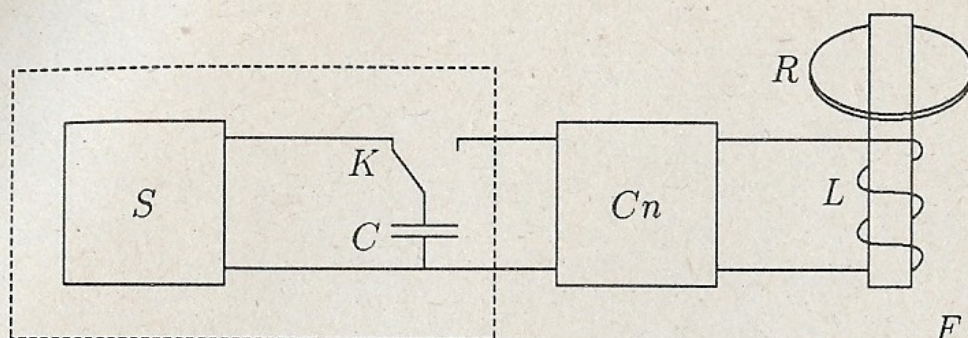
(S, C, K)—power supply consisting of
    S—the source of constant voltage in the range 10–300 V,
    C—capacitor with $C = 1000\,\mu\text{F}$,
    K—switch;
L—induction coil;
F—ferromagnetic core;
Cn—converter (some device that converts the energy passing from the capacitor to inductance L in a way you need). This element does not contain energy sources. It may be completely absent from your gun.

You are to construct, make and demonstrate the electromagnetic gun. It is worth mentioning that the demonstration of your gun will take place with the power supply (elements S, C and K) presented by the Organizing Committee of YPT.

    9. Long-range gun

is to be constructed to achieve the maximum height of the ring. The control parameter is the quantity $H = kh/U^2$, where $k = 10\,000\,\text{V}^2$, h is the height of the projectile, U is the voltage to which the capacitor is charged.

    10. Gun-lift

is to be constructed to achieve the maximum work of lifting a weight (ring). Control parameter is $W = mgh$, where m is the mass of the ring, $g = 10\,\text{m/s}^2$.

11. Recharge

You are given a capacitor $C = 1000\,\mu\text{F}$ charged to 10 V and an uncharged capacitor $C_{\text{x}} = 1\,\mu\text{F}$. Using a self-constructed device containing no energy sources charge capacitor C_{x} to the maximal voltage.

12. Transmission of energy

You are given a capacitor $C = 1000\,\mu\text{F}$ charged to 300 V. Transmit without wires to a distance of 5 meters the largest possible proportion

of energy stored in the charged capacitor and measure it. Your device should be without energy sources.

13. Microwave oven

Why it is not recommended to cook eggs with unbroken shells in a microwave oven?

14. Boiling

A metal ball at room temperature is plunged into a thermos filled with liquid nitrogen. Describe the observed process of intense vaporization of nitrogen and find the time dependence of vaporization intensity $q(t)$ [g/s]. We ask you to use balls from 2 to 4 cm in diameter.

15. Fence

A picture of a moving bicycle wheel is strongly distorted by being observed through a fence. How and why?

16. Grand Unification

According to modern views Grand Unification is possible at energy of about 10^{24} eV. Estimate the parameters of an accelerator capable of producing particles of such energy.

17. Karate

Karate is power, speed, force and beauty!

Develop objective quantitative criteria making it possible to confer a "black belt" to karate fighter. Maybe you'll become the inventor of a BB (black belt) device badly needed by referees or you'll create a KM (karate meter) complex which is even more necessary for karate fighters for improving their skill.

These problems were suggested by S. Varlamov, H. Kissinger, T. Korneeva, E. Pikersgill, E. Surkov, E. Yunosov and A. Yarov.

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B. Henry