Instructions: The competition lasts for two hours, please try to solve as many problems as you can. All questions carry equal weight. You do not have to solve all problems to win the competition! Good luck!

Problem 1.
A wolf running with velocity $v$ is chasing a rabbit running with velocity $u < v$ toward its burrow. At the initial moment the rabbit and the wolf are separated by a distance $L$ and their velocities are orthogonal ($v \perp u$). Find the maximal distance between the rabbit and the burrow that allows the rabbit to escape.

Problem 2.
A carpet of thickness $t$ and $\rho \text{ kg/m}$ is in a roll of height $h$. If the carpet begins to unroll with zero initial velocity, what will the speed of the end of the carpet be just as it finishes unrolling?

Problem 3.
A homogeneous spherical cloud consists of particles with mass $m$ interacting gravitationally. At $t = 0$ all particles have velocities obeying the “Hubble law”: $v = Hr$, where $r$ has its origin at the center of the cloud. Find the maximal initial density of the cloud that results in an indefinite expansion.

Problem 4.
In this problem please give the order of magnitude estimates.
(a) How many tennis courts are needed to blanket the surface area of the star Betelgeuse (which has 18 times the mass of the Sun)?
(b) What is the probability of a human tunneling through a closed door?
(c) A weather balloon is one meter in diameter and filled with helium. What is its diameter when taken to the bottom of the Atlantic Ocean?
(d) If the water of the oceans was to evaporate, what mass of minerals would remain behind?

Problem 5.
An object slows uniformly from speed $s$ to zero while moving around a circle of radius $r$. What is the magnitude of its acceleration as a function of time? What is the average acceleration?
**Problem 6.**
Charge $q$ is placed in the axis of a fixed dipole with moment $d$. Initially the charge, which has velocity $v_0$ towards the dipole, is repelled by it. Find the time when the charge stops.

**Problem 7.**
Find the maximal possible power that can be extracted by a windmill of radius $r$ placed in a region where the windspeed is $s$.

**Problem 8.**
(a) Find the energy associated with electrostatic interaction between protons in a nucleus with atomic number $A$ and charge $Z$. The radius of a nucleus is $R = A^{1/3} \times 1.25 \cdot 10^{-15}$ m.

(b) Estimate the energy necessary to remove the Moon from its orbit and send it to interstellar Space. How many years will it take the humanity to generate the required amount of energy at the current rate of production?

**Problem 9.**
Consider two large buckets, $B_1$ and $B_2$, containing one liter of water each at temperatures $T_1$ and $T_2 < T_1$. An experimentalist performs a two–step procedure:

(i) Some amount of water is moved from $B_2$ to $B_1$.

(ii) After a thermal equilibrium is reached in $B_1$, some amount of water is removed to bring the volume to one liter.

These two steps are repeated until $B_2$ becomes empty. Find the minimal possible temperature that can be reached in the bucket $B_1$ and specify the corresponding algorithm.

**Problem 10.**
Why when people see animals and faces in clouds, they are almost always in profile.