VI. Problems for the IYPT from the 1st IYPT to the 20th IYPT

Problems for the 1st IYPT, Russia, Moscow, 1988

1. Invent Yourself
Propose an original project for technical and scientific using of the superconductivity at high temperatures.

2. Receiver /eternal/
Make construction of a portable radio receiver which works without a supply source. Required parameters: x=P/Lm, where P is sound pressure at distance 1m from the receiver, L is maximum linear size of the receiver, m is the mass of the receiver.

3. Dark Camera
Take a group picture of your team with the help of a dark camera. Give reasons for physics principles, which allow the creation of qualitative picture with the help of such device.

4. Electrical circuit
Several junctions /n $_j$ 10 / are connected each other with a battery with known electromotive force/ emf/ and electrical resistance r. Create computer programme for determination of the difference of the potentials/ the voltages/ between the first and the last junctions. As a criterion for the quality of the programme assume the time of the beginning of the reading of the input information in the computer / the tables with the value of emf and r/ to the moment of the outcome of the correct result.

5. Metrology
Determine the maximum accuracy of the measurement of the length with a steel ruler.

6. Seller of Vacuum
An inventive astronaut decided to transfer vacuum from the cosmic space to world physics laboratories. What is the chance for a success of such initiative?

7. Setting Sun
The Sun disk at the setting Sun seems flattened. Measure experimentally and describe this deformation / deviation/.Calculate theoretically the correlation between the horizontal and vertical radius of the Sun disk at the moment of contiguity of the Sun with the horizon line.

8. Color Television
Construct a four-color television receiver. Which colors you would choose as basic ones? Is it needed in this case the scanning apparatuses?

9. Ninth Wave
“In front of me there are the waves. There are a lot. It is impossible they to be counted.”, V. Pasternak. Does “ninth wave’ exist? Clarify this question. As a starting point can use the thought, which is elucidated in the article “Trey, seven, ace….”, journal “Znanije-Sila”, 1987, issue1, p.97-104.

10. Self-Ignition

"And when by the winter the branches of a tree set swinging, strongly seesawing, impacting upon themselves, mutually stems and brunches rub each other, their vigorous friction evokes fire and sometimes during inflammation suddenly flashes and flies up a hot flame".

Titus Lukrecius Carus

This Roman philosopher explained the origin of forest fires. Estimate the reliability of such inflammation and its place in the variety of reasons evoking the rise of fires in the nature, this means these reasons which are not consequent of the activities of the human being.

11. Electrical Bulb

It is argued that two electrical bulbs with electrical power 60 W produce more light than three electrical bulbs with power 40W. Is it right? Investigate how the light power and the life of electrical bulb changes under rather small change of the voltage.

12. The Spring in the City

The spring in the city comes earlier than in the countryside. Describe the basic factors promote for this and carry out numerical assessment. By the way what will happen if all snow of Moscow will be transported in the country?

13. Heat Conduction

Examine heat conducting in vertical water column in two cases: $T_1 < T_2$ and $T_2 < T_1$ where T_1 is the temperature of the lower plane of the layer and T_2 is the temperature of the upper part of the layer. For the experiment use a heat isolated vessel.

14. Electron-microscopy

One of the effects of the electron- microscopy consists in that the resistance of a two dimensional metal samples can be significantly altered at low temperatures, if the position only of one atom from the lattice is changed. Visual imagine for this effect can be obtained by the observation of the following model: in the lattice points of a two dimensional lattice is put a small mirror with the index of reflection is equal to one. The position of the mirror is chaotically changed and that`s why the laser beam which strikes the lattice point with equal probability can be reflected to one or other side at 90^0 degree. Estimate how the intensity of the light will be changed at the outlet of the system if to one lattice point instead a mirror is put an element which entirely absorbs the light.

15. Copper Penny

A coin with a size of a copeck "drops out" a cosmic rocket and becomes an artificial "planet" of the Solar System. Estimate the time of the existence of the coin as a "planet" with a view of the impact of the solar light.

16. Electrons in a trap

Several electrons / 2< a <30 / can freely relocate inside a ring with a radius R. What mutual position of electrons is stable?

17. Resistor

For the school tester is a resistor even a man. By the help of the school tester investigate the laws of the parallel and series connection of such resistors. /The problem №17 possesses traditionally a funny character. /.

Problems for the 2nd IYPT,
Russia, Moscow, 1989

1. Invent yourself
Invent a device for demonstration of the wave properties and the propagation of the sound trough the air.

2. Midday
Can we name "midday" the moment exactly in the middle of the time interval between the sunrise and sunset of the Sun? By the help of the calendar you can easily convince yourselves that this moment fluctuates during the year. Clear up the reasons for this phenomenon.

3. High and Low Tide
Estimate the height of the high tide in the Black Sea on the 12th of December, 1988.

4. Rolling Resistance Force
Determine the dependence between the rolling resistance force and speed of the motion. In particular consider the rolling of the wood disk along wood board.

5. Clock
You had visited a planet and get back after 10 thousand years or even 1 million years. What kind of a clock you have to leave on the planet for precisely measuring of the time during your absence from the planet?

6. Rainbow
Can it be three or more rainbows to be in the sky in same instant?

7. Sparks
In the course of grinding of knives upon the rotating grindstone can been seen many sparks. The single spark usually disintegrates in the end of its trajectory to a lot of / subsequent / sparks. Clarify this phenomenon.

8. Metro
Determine the speed of the train between two metro stations.

9. Astronauts
What is the maximum distance to which an astronaut can fly off during his travelling in the cosmos:
1. On the present level of the technology?
2. In the distant future, when almost all difficulties will be solved?

10. Water Planet
What quantity water can form a planet with a constant mass at distance 1 astronomical unit from the Sun?
1. Far remote from the Sun.
2. 1 astronomical unit distant from the Sun?

11. Mosquito
Up to what maximum height can fly the mosquito?

12. Sand in a Tube
A glass tube is fixed vertically. Its low part is locked by a valve. The tube is filled with sand. The valve opens up. For what time T the sand will pour? Find the dependence between T and the following parameters: d-diameter of the grains of the sand, L-the length of the tube, B-the diameter of the tube. The “degree of the compression” of the sand is constant / you can initiate and corroborate this parameter by yourself/. In order the results to be comparable, don`t take great “degrees of the compression”. L could be from 1cim to 1m.

13. Electrolytic Tank
Prepare saturated solution of salt /NaCl / in the tank with sizes: depth 3cm, width 10cm and length 15cm. In the middle of the tank put two carbon electrodes/ carbon sticks from out R20, manganese-zinc element/ at a distance 4cm. Their metal parts to be not sunk in the solution. Define:
1. The dependence of the electrical current on the voltage in this electrolytic tank to electrical current 10μA-50 μA
2. How changes this dependence if the solution is diluted?

14. Fence
A fence consists of vertical bars with gaps between them closes before you an outlying object. The object is visible better, if you don`t stand still, but move along the fence by car. Clarify this phenomenon. What speed of the movement will be enough, if the parameters are the following:
-the width of the rods a, the distance between gaps is b, the distance between you and the fence is L /L>>a, b/, the angle size of the remote object is ((a+b)/L)?

15. Electron
Electron having a speed $v=3x\ 10^5$ m/s moves closely to metal ball with an impact parameter d. The radius of the metal ball is several cm. The charge of the ball changes according to $q(t)=q.\cos \omega t$,
Where q=10 C, $\omega= 10^8 s^{-1}$. Describe the dependence of the angle of the scattering of the electron on the parameter d.

16. Information
How many bits information have you obtained by reading of this question? How many bits you obtain with view of a plane geographical map?

17. Karlson
How much jam has to eat up Karlson from the tale of A. Lindgren, in order to not loose weight during his flight. / We hope that you understand the solution of this problem by humor point of view. /

Problems for the 3rd IYPT,
Russia, Moscow, 1990

1. Invent Yourself

Invent yourself a physics photographic competition. At the competition offer photographs of the fast running physics processes. By the comment to the photographs explain the values of the physics quantities of these processes.

2 - 4. Pellet and Piston

A horizontal piston vibrates up and down /fig.1/. The coordinates of the position of the piston are determined by the dependence $x=x.\cos\omega t$. At random instant on the piston is dropped a little pellet from a height H without an initial vertical velocity.

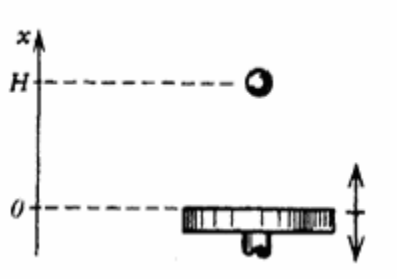


Fig. 1

2. Up what height the pellet will bounce after the first collision with the piston. In this case assume that the collision is absolute elastic and $H > x_0$?

3. After many collisions the system "forgets" the initial conditions. Estimate to up what a maximum height can bounce the pellet after many collisions, what will be an average height of the bound. Presume that during the collisions the surfaces of the pellet and the piston are not damaged.

4. Let now at a given height H above the piston there is a ceiling. In this case are possible stationary solutions. Find out some of them and investigate their stability. For a qualitative estimation, assume that H= 1m, $H >> x_0$, $g=10 m/s^2$ and that in the course of the collisions of the pellet with the ceiling the coefficient of reduction is K=0.8.

5. Planet

How much have to be the maximum sizes of a planet with the form of a cube?

6. Vaporization and Condensation

In a glass sealed tube with the form of the Russian letter Π there is water/fig.2/. If at the beginning in the vertical ends of the tube we create a certain difference in the levels of the surface H, after that in the course of time these levels of the surface equalize. Estimate the speed of the equalization at a given H and a temperature T, if:

1. In the tube there is not air.
2. In the tube there is air at normal pressure

If at the beginning we create a certain difference in the levels of the surface H in the vertical ends of the tube after that in the course of time these levels of the surface equalize.

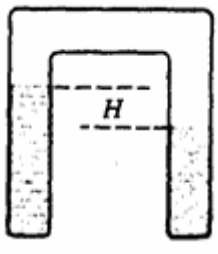


Fig.2

7. Cylinder in a Tube
In a long tube, filled with water, a cylinder moves to its closed end at a constant speed. Inner diameter of the tube is D, the diameter of the cylinder is d, the length of the cylinder is L, D-d=h, L > D, h << D.

Fig.3

How does the resistance force of the motion of the cylinder, depends on the speed of the cylinder? Compare the theoretical evaluations with the experimental results.

8. Segner Wheel
The Segner`s wheel put in water rotates in consequence of the reactive force of the stream, flowing out the nozzles. Will such wheel rotate in a reverse regime, i.e. the water doesn`t flow out but runs into /sucks in/ the nozzles?
We recommend you to refer to the book “Surely You're Joking, Mr. Feynman!” /partial translation in the Journal “Nauka i Jizn”, 1986, № 12/.

9. Franklin`s Wheel
The rotation of the metal vane with sharp tips in the famous experiment “Franklin`s Wheel” is explained by the existence of “electrical wind”. Explain why this vane rotates if it is put between the plate of the plane capacitor, which is charged by an electrostatic generator. Consider as well if a dielectric disk put instead Franklin`s Wheel between the plates of a plain capacitor charged by an electrostatic generator will move.

10. “Electret”
150 years ago Faraday predicted the existence of electrets as electrostatic analogues of the constant magnet. Make an electret and investigate its properties.

11. Colors of the Clouds
Clouds heavenly, eternal wanderers!
Circuit silent in steppes azure,
Maybe you are not such me poor exiles from
dear North to the southern lands
M. J .Lermontov
Explain the observed colors of the clouds and storm clouds .

12. Cloud Boundary
Observed boundary of the cloud often is sharply outlined. Especially well it can be seen by the board of the plane. Estimate the “fuzziness” of the boundaries of the clouds.

13.” Cloud of Astronaut” /imagination with physics sense/
The big number of cosmonauts form in a free space “a cloud of cosmonauts”. Originally each of them has at itself a football. From a certain instant the cosmonauts start to throw each other these balls / thus any ball doesn`t lose/. Describe the evolution of “a cloud of cosmonauts”. Because we don`t want to limit your imagination, we give to you a choice of initial conditions, rules of transferring of the balls and other parameters of the cloud. Important only the following: the choice of model should be logical proved, conclusions should be supported by quantitative estimations, the quantity of described by you variants should not be more than two.

14. “Fractal?”
The grandmother takes up a woolen string in a spherical ball. How the weight of a ball depends on its diameter?

15. Light in a pipe
Look at the light through a glass tube / the diameter of the tube is approximately 5mm, the length is approximately 25cm/. Explain an origin of observable rings.

16.”Interference”
Take two well washed from emulsion glass photographic plates /9 X 12 cm/. If you press them densely to each other /to grind in/ in the reflected light can be seen interferential strips. If you put the plate on a table and press with a finger on the middle of the top plate, the strips get a kind of concentric rings. If the finger is picked up, rings will start “to run up”. Do this experiment and explain the observable phenomena. Estimate theoretically the speed of “the running up" of the rings after the removal of the loading.

17. The scientific organization of work /SOW/
You should hammer 1989 identical nails/ l= 50mm, Ø= 2,5mm/ into a wooden bar. What hammer you will choose for the prompt and qualitative performance of this work? / More definitely-what is the weight of a hammer and length of its handle/.
a/ the bar is pine
b/ the bar is oak.

Problems for the 4th IYPT,
Russia, Moscow, 1991

Motto:
Is it blackcurrant?
No, it is redcurrant.
But then why it is white?
Because it is green one.

1. Invent yourself
Prepare a cycle of demonstrations and experiments by which you to explain physics essence of the sound waves and their properties.

2. Fortune-teller
If we drop liquid paraffin from a candle in the bowl with water, we will obtain various hard - set forms by the sort of a lens, a skiff, an ink-spot. Investigate the forms of the drops with dependence of the height if their falling.

3. Geyser
A strong ceramic resistor with form of a slightly slanting cylinder is dipped in water so that the axis of the cylinder is vertical and upper end of resistor is a little above or under the surface of the water.
When through the resistor electrical current flows, the resistor as a geyser throws out periodically upward portions of hot water. Calculate and follow up the dependence of the period of the water release on the power of current.

4. Feedback
At the concerts of the beginning rock bands sometimes arises strong noise when the microphone is not far from the loud speaker. How the frequency and amplitude of the arising sound vibrations depend on the distance and mutual orientation of the microphone and loudspeaker?

5. Cosmic Sculptural Composition
A certain extraterrestrial civilization wants to build a sculptural composition from three planets, one of which has to move on a trajectory near to an equilateral triangle. What correlation between mass and speed you recommend them? Decide the problem as well for a square.

6. Radiometer
Make a device for measuring of the level of radiation. With its help measure the basic places of radiation in a flat.

7. Runner
Estimate the maximum speed of a race of a man. What be the world record of a race at 100m in 2000?

8. Photography on a Screen
When we photograph a TV screen we can investigate the motion and speed of the shutter of the photographic camera. Measure as well the exact values of the time of the exposure and the speed of the motion of the shutter.

9. Passive Vane
An apple released from the balcony of many-storeyed house will be easily fall down in the hands of a friend, if with the help of a match you attach to the apple a passive vane made from thick paper. Explain the principle of such parachutism and investigate the dependence of the resistive force on the velocity of the flying and the size of the sheet of the vane.

10. Blow-pipe
From a blow-pipe is shot away a rather small dart with two circle bits of paralon drown on it. Find out optimum sizes of the pipe for shooting with such shells. What is maximum speed which you succeeded to obtain?

11. Gold Cube
Around the Sun revolves a cubic planet of pure gold, which constantly face the Sun with one and same side. Estimate the difference in the temperatures of the sides of the cube.

12. Boat
On the surface of liquid electrolyte floats a boat. When trough the electrolyte electrical current starts flowing, the boat starts moving. Estimate the velocity of the boat.

13. Wood Die
The die is cut of one piece of wood. The length of the edge of the die is much smaller then the diameter of the wood by which the die has been cut. Indicate method for determination of the direction of the fibers of the die /positive direction of the fibers- from the root to the top of the tree.

14. Glider
Make a water glider operated by a piece of soap. Your glider has to be a winner in two events- fast travelling in time at a distance 50cm and floating to a distance for a definite period / for every competition you can do a different glider/. The sizes of the glider have to be no more then 6,28cm. In the second competition the glider has not carry more then 0,5g soap.

15. Moon
Experimentally determine the correlation of the brightness of the Sun and lighted and unlighted part of the Moon during different phases. Compare with your estimation.

16. Sunset
At sunset the Sun appears red. What will be the color of the Moon, Venus and a clear star when they will be low above the horizon?

17. "Motto"
We think that the motto to the problems of the tournament can be a basis of reliable observations, as well good-natured jokes.

Problems for the 5th IYPT
Russia, Protvino, 1992

1. Invent yourself
"The magnetic suspension" is used in high-speed trains of the future. Design and make a model of such magnetic suspension.

2. Monocycle
The Circus artists often perform travelling by "monocycles". The size of the wheel can be different. What is the maximum possible diameter of the wheel?

3. Barrier
In Russia it is said - "the money flow as water trough sand". But sand barriers detain water. How long has to be the barrier in order to retain the water with height 10m above the surface?

4. Swing
For the training of pilots a special swing is used, which can revolve around its axis. What is the minimum time needed for deviation of such swing from equilibrium state to an angle equal to 180 degrees?

5. Jumper
In Russia it is said- "nobody can jump higher then his head", but many jumpers easily prove it. Estimate the maximum height beyond which the sportsmen will get in 2000 with the aid of a long pole or without it.

6. Flame
By what the height of flame depends on?

7. Steel Bar
A steel bar with a diameter 8mm is bent to 90^0. Specify the place and the temperature of the maximum warming.

8. Boiling
A high cylindrical vessel, not entirely full to the brim, is put in a wide-neck vessel also full of water. If we heat the water to the boiling point and after that cool it, the height of the level of the cylinder will change. Find out the dependence of the height of the water column from the temperature of the repeated warming and cooling. Clarify the observed phenomenon.

9. Fountain
Design construction of a fountain, which at the constant capacity gives a maximum height of the water jet. What will be the reached height to the power 1kW?

10. Fuse
A fine copper filament can be used as a fuse. Find out the dependence between the critical current and the diameter of the filament.

11. Hopfield Model
Work out an algorithm of putting of images in the memory of the computer and their recognition.

12. Butterflies
The butterflies mutually find each other with the help of the sense of smell. Estimate the power of the transmitter and the sensitivity of the receiver of the butterflies.

13. Inverted World
In some medical publications it is said that the 2 monthly babies see the world around them as heels over head. Adduce arguments pro and con.

14. Laser
The laser beam is directed perpendicularly to the transparent vessel with water. If the beam passes above or under the surface of water, we can see a point on the screen behind the vessel. If the beam passes along the surface we observe a vertical line. Clarify the origin of the line and define its parameters.

15. Electrical bulb
Estimate the amplitude of the change of the temperature of the filament of the electrical bulb.

16. Depth of Sharpness
Find out the dependence of the depth of sharpness from a diameter of the diaphragm.

17. Figures
Some people assert that if on the surface of a puddle there are figures, the rain will be prolonged, but other think that it is a sign for the end of the rain. Why is right?

Problems for the 6th IYPT,
Russia, Protvino, 1993

1. Invent yourself'
Invent a problem for an object which moves in some way and after that quickly changes its way of motion under an outside influence. In such case interesting phenomena can occur, which you can explain for example by calculations after the carrying out of the experiment.

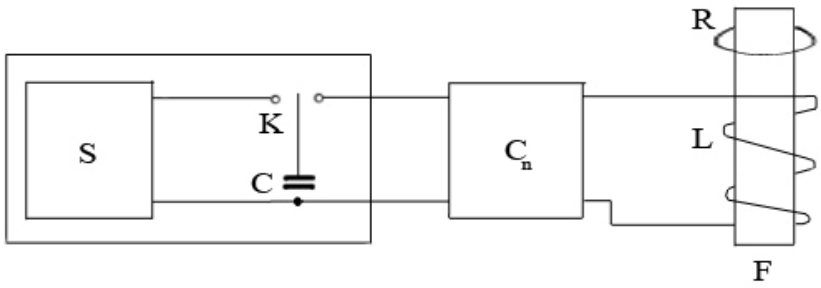
2.-5. Gravitation
Imagine that the gravitational constant G from the 1st of April to the 1st of May decreases its value with 10% and after that keeps to it. How this process a/ in the given time interval and b/ to the time of the carrying out the VI IYPT will influence over the Universe as whole and especially:
2. The Sun
3. The Earth
4. Aviation and aeronautics
5. Especially important for us things.

6. Record of Gagarin
In April, 1961 Jury Gagarin got a world record for the fastest orbital rounding of the Earth. Suggest a cheapest way to do better than this record. Don`t forget that no any record is registered.

7. Pressure and Temperature
Explain why the pressure outside and inside home is practically equal or quickly equalizes while the temperature can be significantly different. What is the characteristic of the speed of equalization of the pressure and this one of the temperature outside and inside home? What will be the answer to this question in the case of universal ship?

8. Dominos
The tiles of domino are put vertically at a small distance between them in a long row on the table. When we knock the first tile the subsequent tiles start falling down and by this way the "domino wave" arises. Calculate and measure the maximum speed of these waves.

9-10.Gun
The figure shows an electric circuit of electrical gun, which throws metal rings. Design and construct electromagnetic gun, the voltage source / S, C and K/ will be supply by the Organizing Committee of the IYPT.



S, C, K- a voltage source group consists of:
S - a voltage source ,10-300V

C – a capacitor with capacitance 1000μF
L – a coil
F - a ferromagnetic core
R – a metal ring with a mass 1-100g
C_n – an alternator / a device which change the energy from the capacitor to the coil in way expedient for you/. This element doesn`t contain an energy source and it is not obligatory you to have it in the device.

9. Range Gun
It has to built it so that you to reach a maximum height of the throwing out of the ring. A control parameter is the value H=k.h /U, where k=10 $000V^2$, h-the height of the ring and U is the voltage, to which the capacitor has to be charged.

10. Gun-Lift
You have to reach a maximum height for the lifting of the ring. A control parameter is W= mgh. Where m is the mass of the ring, g=10m/s^2.

11. Charging
You have a capacitor with a capacitance 1000 μF, charged up to 10V, and an uncharged capacitor with a capacitance C= 1 μF. By using of a constructed device, which doesn`t contain an energy source, charge the capacitor C to a maximum possible voltage.

12. Transfer of Energy
You have a capacitor with a capacitance C=100 μF charged up to 300V. Transfer wirelessly a maximum amount of energy of the capacitor to a distance 5m and measure it. Your device has not to contain an energy source.

13. Microwave Stove
Why the boiling of an egg in a microwave stove is not recommended?

14. Boiling
A metal vessel at a room temperature is sunk in a thermos with liquid nitrogen. Describe the observed phenomenon of the intensively evaporation of the nitrogen and find out the time dependence of the intensity of the evaporation q(t) [g/s]. Use vessels with diameters 2-4 cm.

15. Fence
An image of a moving wheel of a bicycle is strongly disturbed at observation through a fence. Why and how?

16. Great Unification
According to the modern conceptions a great unification is possible by energy 10 eV. Estimate the parameters of an accelerator which can reach such energy.

17. Karate
The karate is a power, speed, force and beauty. Pronounce objective and subjective criteria, which will make easy the conferment of a black belt. It is possible you to be an inventor of the BB /black belt/, a device needed for the judges or you will invent a KM /karatemeter/ which will be more needed for the karatemen for the improvement of their abilities.

Problems for the 7th IYPT, Netherlands, 1994

Think up a problem yourself
/problems 1, 2, 3/ Invent yourself and solve a problem on the given theme.

1. Optics
Think up and solve a problem connected with employing a thin lens of a large focal length.

2. Compass
"In sledge trips we use liquid compasses, the most exact of the small ones. But you understand of course that due to proximity to the magnetic pole the arrow usually points downwards. To make it horizontal, its opposite end is balanced with a weight". /From the letter of Cherry - Garrad, member of the last expedition of R. Scott/. Use the context of this quotation to formulate a problem.

3. Magnetization
A cylindrical permanent magnet falling inside a copper tube is found to move at an almost constant velocity, the slower the thicker and the walls of the tube. Use this fact to formulate a problem / see also 14/.

Gravitation machine
/problems 4, 5, 6/. A horizontal plate / a vibrator/ oscillates harmonically up and down. A steel ball put on the surface of the plate starts jumping higher or lower. For the experimental device one may successfully use a ferrite core in a coil connected to an alternating current generator / a sound generator/.The butt-end of the ferrite core will play the part of the vibrating horizontal plane. Steel balls of diameter 1 or 2 mm are suitable for the experiment. The glass tube approximately 1m long can also be very helpful.

4. Upper boundary
Measure experimentally the maximum height to which the ball rises to and explain the result.

5. Distribution function
Determine experimentally what part of a sufficiency large time interval the ball is in the range of heights H, H+ dH and explain the result.

6. Acceleration
The mechanical energy of the ball changes after every impact. The mean mechanical energy / averaged overall successive impacts/ increases at the beginning of the process and then tends to a constant value. Try to obtain experimentally the time dependence of the mean mechanical energy of the ball.

7. Aspen leaf
Even in windless weather aspen leaves tremble slightly. Why does an aspen leaf tremble?

8. Superball
A highly elastic ball / a superball/ falls on a horizontal surface from a small height / 4cm or less/ and recoils several times. What is the number of impacts of the superball against a table?

9. Meteorite
A meteorite of mass 1000 tons files directly to the Sun. Can modern instruments register the fact of its fall on the Sun?

10. Water dome
A vertical water jet falls on the butt-end of a cylindrical bar and creates a bell-like water dome. Explain this phenomenon and evaluate the parameters of the dome.

11. Siphon
A rubber tube is used as a siphon to flow water from one vessel into another. The vessels are separated by a high partition and the levels of water in them are different. If one withdraws the tube from one vessel, lets the pole of air enter it and then puts the tube into the water again, the action of the siphon may be resumed or not. Investigate this phenomenon.

12. Boiling
Put a metallic ball heated to the temperature 150^0 C - 200 ^{0}C into hot water at the temperature close to 100^0 C and observe the process of intensive evaporation of the water. Explain the observed phenomenon.

13. Spirits
A closed vessel / a bottle/ contains spirits- pure or substantially diluted by water. Suggest a method of estimation of the concentration of spirits without opening the vessel.

14. Magnetic friction
To investigate the phenomenon described in the problem 3 we suggest to create the device containing the following elements:
a / a copper plate / or a set of plates/ 0. 3 to 15 mm thick. The length and the width of the plate may be chosen according to one`s convenience, but they should be large enough to avoid the effect of the boundaries;
b/ a cylindrical electromagnet with a flat butt-end;
c/ a device providing free motion of the flat butt-end of the electric magnet over the horizontal surface of the copper plate. It is very important that the gap between the magnet and the plate is small as possible and constant everywhere;
d/ the push providing the uniform motion of the magnet at a given velocity over the plate surface.
Introduce the following notation: T- the push / and the force of magnetic friction/, v- the velocity of the magnet, h- the thickness of the plate. Investigate and determine experimentally the dependence of T on h at v= constant for several values of v.

15. Transmission of energy
Transmit without wires to a distance of 3 meters the largest possible part of the energy stored in a capacitor having capacity of C= 10μF charged to voltage U= 100 V. Measure this energy. Your device should not contain energy sources. Naturally the capacitor itself must not be transported.

16. The Moon and the Sun
" If you are asked what is more important, The Sun or the Moon, you should answer the Moon. For the Sun shines in daytime when there is enough light without it", says a joke. When is it possible to see the Sun and the Moon at the same time? Calculate the schedule of the events for the European countries during 1994.

17. Straw
The Russian proverb says "Had I known the place where I fell, I would have laid some straw there". How much straw should be laid to guarantee a safe fall?

Problems of the 8th IYPT, Spala, Poland, 1995

1. Think up a problem yourself /paradox/
Try to puzzle your rivals by a paradoxical physical experiment.

2. Boiling water
Some people say it is important to put a lid on the pot when you want to boil water for tea to save energy and time. Investigate this phenomenon and determine the energy and time saving.

3. Drop
A drop of salted water drying on a smooth surface creates a system of rings. Investigate and explain this phenomenon.

4. Gravitational spacecraft
A spacecraft (having a shape of a dumb-bell of variable length) can shift from the Earth orbit (300 km above the Earth surface) to the Moon orbit without the use of jets. Calculate the time taken by such a manoeuver.

5. Sound
Transfer the electric energy stored in a capacitor of 0.1 mF charged to the voltage of 30 V into the energy of the sound, with the highest efficiency possible. No external energy sources are allowed. Determine the fraction of energy converted into sound in the discharge.

6. Curtain
A light curtain (light scatters on dust particles) is used in some theatres. Suggest the design of a light curtain, which allows its effective action with the minimum power supplied for one meter of stage width?

7. Three discs
Investigate collisions of three homogeneous, rigid discs which can move in a plane. At first two discs are at rest. The third disc:

a. collides at exactly the same time with two other discs,
b. collides at first with one of the discs.

8. Carpet
When a carpet is rolled into a cylinder it sometimes unrolls by itself or with the help of a gentle push. Determine the factors on which the speed of the rolling carpet depends.

9. Ice cream
Obtain super-cooled water in an experimental setup. By how many degrees below 0 C did you manage to super-cool it? What can be the record in this experiment? Determine the freezing point of water.

10. Cathode –ray tube
While a well-known physicist A. First watched a football match by TV, another well-known physicist B.Second made a hole of diameter 0.001 mm in the cathode-ray tube. Did A. First manage to see the football match up to the end?

11. Moon light

It is possible to set paper on fire using a lens and solar radiation. Could it be possible using lunar instead of solar light? If yes - invent an optimal optical system for such a purpose. If not - what should the Moon be like, for being this possible?

12. Tinder box

When someone strikes two pieces of flint rock, sparks are created. Investigate and explain this phenomenon.

13. Air lens

Lenses are usually made of solids and sometimes made of liquids. Construct an optical lens made of air in such a way that light can travel through the lens without crossing any material but air. Determine on which factors the focal length of an air lens depends.

14. Frozen lake

The water surface of a lake is in winter exposed to cold air at a fixed temperature below zero. There is no wind. Determine the thickness of the ice layer as a function of time.

15. Bottle

A plastic bottle of a capacity between 1 and 2 litres completely filled with water is "accidentally" dropped on the floor from the height H = 1 m. What maximum height can the spray reach and why? Determine the minimal height from which the bottle should be dropped to burst?

16. Oscillation of plates

Water has been poured on a horizontal glass plate and a second glass plate placed on it. If the lower plate is oscillating in a horizontal plane, at certain amplitudes and frequencies, the upper plate begins to oscillate in vertical direction. Investigate and describe this phenomenon. Is there any difference when you use another liquid ?

17. Epic Hero

An epic Russian hero Ilya Muromets had once thrown his mace weighing forty poods (1 pood = 16 kg) and in forty days this mace fell at the same place. Estimate the parameters of the throw of the hero.

Problems for the 9th IYPT
Kutaissi, Georgia, 1996

1. Invent yourself.
Invent and solve yourself a problem concerning the ozone holes.

2. Paper clot.
Crumple arbitrarily a sheet of paper A4 in your hand. This clot can be approximated by a sphere. Making many of this clots and measuring their average diameters a histogram of distribution of diameters can be plotted. Try to explain the result obtained. Make more comprehensive investigation of the dependence of the average diameter of a clot on the parameters which you consider important.

3. **Cycle racing**
According to the forecast of specialists two very strong and "absolutely identical" sportsmen had to show equal time in a highway race for 100 km. But, alas, one sportsman lagged behind. Later it was found out that some malefactor adjusted a nut of mass 5 g to the rim of the rear wheel of his bicycle. For what time is the victim?

4. Self-formation of a pile.
A horizontal rigid plate vibrates vertically at a frequency of the order of 100 Hz. A cone-shaped pile of fine dispersed powder (e.g. Licopodium or talc) which is heaped up on the plate remains stable at small amplitudes of the vibration. If the amplitude is increased the cone decays. Further increase of the amplitude yields a distribution confined by a sharp border and at still higher amplitudes a pile appears again .Investigate and explain this phenomenon.

5. Auto oscillations.
Produce and investigate auto oscillating system containing thermistor as a single non-linear element.

6. Water generator.
If some volume of water is frozen from one side, a potential difference appears across the ice-water frontier. Measure this potential difference and explain the phenomenon.

7. Sun.
In the centre of the Sun suddenly an extra quantity of energy is produced which is equal to the energy emitted by the Sun per year. How will the parameters of the Sun observed on the Earth change during one year?

8. Surface information.
Develop a method for transferring information by the waves on the surface of water. Investigate the angular characteristics of the emitter and the receiver (the antennas) which you constructed.

9. Floor-polisher.
A device stands on two identical disks lying flat on a horizontal surface. The disks can rotate in opposite directions at a given velocity. Investigate how the value of a force providing a uniform motion this device along a horizontal plane depends on the velocity of this motion and the velocity of rotation of these disks.

10. Soap bubbles.
Dip the ring of a children's toy for blowing out soap bubbles into a soap solution and blow on the film formed in the ring. At what velocity of the air flux blown into the ring will the bubbles form ? How must the velocity of the air flux be adjusted to produce the bubble of maximum size ?

11. Candle
Some candles twinkle before dying out. Investigate and explain this phenomenon.

12. Motor car.
A car driven at constant power moves onto a wet section of a straight road. How will its speed change when the thickness of the water layer increases slightly and linearly with the distance ?

13. Grey light.
Construct a source of light which would seem to be grey.

14. Coherer.
It is known that a glass tube with two electrodes and metallic filings between them (coherer) has different resistance in d.c. and a.c. circuits. Investigate the frequency dependence of the coherer's resistance.

15. Salt water oscillator.
A cup with a small hole in its bottom containing salt water is partially immersed in a big vessel with fresh water and fixed. Explain the mechanism of the observed periodical process and investigate the dependence of its period on different parameters. To visualize the process, the water in the cup should be coloured.

16. **Hail**
Explain the mechanism of hail formation and propose your own method to prevent the hailing.

17. Gloves
.Some people refuse to wear gloves in winter because they suppose to feel colder than without gloves. Others prefer to wear mittens instead. What is your opinion?

Problems for the 10th IYPT
Cheb, Czech, 1997

1. Invent yourself
Construct and demonstrate a device which moves in a definite direction under chaotic influence.

2. Coin
From what height must a coin with heads up be dropped, so that the probability of landing with heads or tails up is equal?

3. Paper
How does the tensile strength of paper depend on its humidity?

4. Electron Beam
An electron beam is cast upon a planparallell plate of known homogenous material. Some of the electrons get through it, some do not. Try to simulate processes taking place, e.g. using Monte Carlo method and compare your results with the ones described in literature.

5. Blue Blood
Human blood is known to be red, but the veins seem to be blue. Explain this phenomenon and illustrate it by a model.

6. Magic Tube
A compressor blows air into Ranque-Hilsch T-shaped tube at a pressure of 0,5 Mpa or higher so that the air begins to circulate. In such a case hot air is coming out from one end of the tube and cold air from the opposite one. Find out which end of the tube is the "hot" one and explain the difference of the temperatures obtained. Investigate the parameters this difference depends on.

7. Water Jet
A water jet streaming vertically downwards from a tube is divided into drops at some distance from the tube. Choose the conditions under which the length of the unseparated jet is largest. What maximum length did you obtain?

8. Floatation
A piece of chocolate, which is dropped into a glass of soda water, periodically sinks and goes back to the surface. Investigate the dependence of the period of these oscillations on various parameters.

9. Jet-spread
A water jet falling onto a horizontal plane spreads out radially. At some distance from the center the thickness of the layer increases dramatically. Explain the phenomenon.

10. Cooling the Earth
How would the temperature of the Earth change with time, if the Sun suddenly stopped radiating?

11. Candle Generator
Construct a device for charging an electric capacitor (1000 □ F/100 V) using the energy of a candle burning for a period of one minute.

12. Static Friction
A force of motion friction is known to independent on the rubbing surface area of a body. How does the static friction depend on the rubbing surface area?

13. Tea Cup
If one fills a cup with hot tea (60□ – 80□ C), a thin layer of steam emerges above the surface. One can see that some parts of the steam layer disappear suddenly and reappear after a few seconds. Investigate and explain this phenomenon

14. Rain
On a long-time exposure photograph of night rain taken in the light of a projector, the tracks of drops appear interrupted. Explain this phenomenon.

15. Cell and Accumulator
How does the voltage-current characteristics of a cell and of an accumulator change during discharging?

16. Roghe Spiral
The Roghe Spiral is a device where a source of current is connected to a vertically suspended spring, the lower end of which dipped mercury. Mercury is a highly dangerous chemical substance and thus the experiments with it are not permitted. Substitute the mercury with a less dangerous substance and investigate the functioning of this device.

17. Leap
To make a leap it is necessary to squat. How does the height of a leap depend on the depth of the s

Problems for the 11th IYPT
Donaueschingen, Germany, 1998

1. Invent yourself

Construct an aeroplane from a sheet of paper (A4, 80 g/mI). Make it fly as far and/or as long as possible. Explain why it was impossible to reach a greater distance or a longer time.

2. Popping body

A body is submerged in water. After release it will pop out of the water. How does the height of the pop above the water surface depend on the initial conditions (depth and other parameters)?

3. Spinning disc

Investigate and explain the phenomenon of a spinning annular disc as they progress down a straight, cylindrical rod. If the rod is moved upwards at a defined velocity, the disc spins at constant height. Investigate the mechanism.

4. Water streams

A can with three holes in the side-wall at the same height slightly above the bottom is filled with water. The water will escape in three separate streams. By gently touching the streams with a finger they may unite. Investigate the conditions for this to happen.

5. Water jet

If a vertical water jet falls down onto a horizontal plate, standing waves will develop on the surface of the jet. Investigate the dependence of this phenomenon on different parameters.

6. Mount Everest

Can you see Mount Everest from Darjeeling?

7. Air bubble

An air bubble rises in a water-filled, vertical tube with inner diameter 3 to 5 mm. How does the velocity of the rising bubble depend on its shape and size?

8. Trick

It is known that a glass filled with water and covered with a sheet of paper may be turned upside down without any loss of water. Find the minimum amount of water to perform the trick successfully.

9. Woven textiles

Look at a point-like light source through different woven textiles. Describe what you see. What is the explanation of the phenomenon?

10. Repeated freezing

While a vessel filled with an aqueous solution of a volatile fluid, e.g., ammonia, ethanol or acetone, is being cooled, repeated freezing and melting may be observed near the surface. Describe and explain the phenomenon.

11. Current system

In a Petri dish (shallow bowl), small metal balls, e.g., 2 mm in diameter, are immersed in a layer of castor oil. The inner rim of the dish contains an earthed metal ring. Above the centre of the dish there is a metal needle which does not touch the oil surface. Investigate what happens when the voltage between needle and earth is about 20 kV.

Warning: The high voltage should be obtained by means of a safe generator, e.g., an electrostatic generator!

12. Powder conductivity

Measure and explain the conductivity of a mixture of metallic and dielectric powders wit various proportions of the two components.

13. Rope

How is it possible that a very long and strong rope can be produced from short fibers? Prepare a rope from fibers and investigate its tensile strength.

14. Water rise

Immerse the end of a textile strip in water. How fast does the water rise in the strip and what height does it reach? In which way do these results depend on the properties of the textile?

15. Luminescent sugar

Investigate and explain the light produced when sugar crystals are pulverized. Are there other substances with the same property?

16. Strange motion

Make a mixture of ammonium nitrate and water, proportion 5 to 1. When the mixture is heated to about 100 °C it melts. When it cools,it crystallizes and you may observe a strange motion below the surface. Investigate and explain the phenomenon.

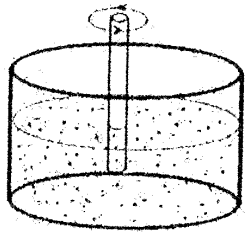
Safety rules: Do not heat the ammonium nitrate without water, preferably use a water bath! Use protection glasses during the experiment!

17. Icicles

Investigate and explain the formation of icicles.

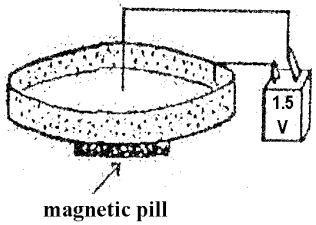
Problems for the 12th IYPT
Vienna, Austria, 1999

1. Rotation



A long rod, partially and vertically immersed in a liquid, rotates about its axis. For some liquids this will cause an upward motion of the liquid on the rod and for other liquids a downward motion

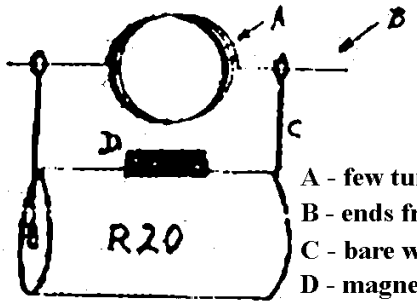
2.Ionic Motor



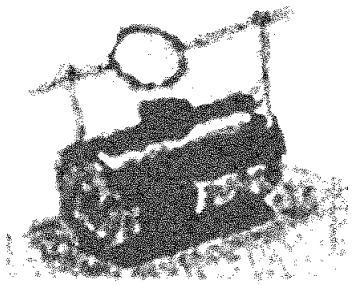
An electrolyte (an aqueous solution of $CuSO_4$, NaCl, ...) in a shallow tray is made to rotate in the field of a permanent magnet (a small "pill" placed under the tray). The electric field is applied from a 1.5 V battery in such a way that one electrode is in the form of a conducting ring immersed in the electrolyte --- the other is a tip of wire placed vertically in the centre of the ring. Study the phenomenon and find possible relations between the variables.

3. Magic Motor

Construct a DC motor without a commutator, using a battery, permanent magnet and a coil. Explain how it functions



A - few turns of insulated wire
B - ends free of insulation (here)
C - bare wire
D - magnetic pill



4. Soap Film

Explain the appearance and development of colours in a soap film, arranged in different geometries.

5. Dropped Paper

If a rectangular piece of paper is dropped from a height of a couple of meters, it will rotate around its long axis whilst sliding down at a certain angle. How does this angle depend on various parameters**?**

6. Singing Glass

When rubbing the rim of a glass containing a liquid a tone can be heard. The same happens if the glass is immersed in a liquid. How does the pitch of the tone depend on different parameters**?**

7. Heated Needle

A needle hangs on a thin wire. When approached by a magnet the needle will be attracted. When the heated needle will return to its original position? After a while the needle will be attracted again. Investigate this phenomenon, describe the characteristics and determine relevant parameters.

8. Energy Converter

A body of mass 1 kg falls from a height of 1 m. Convert as much as possible of the released potential energy into electric energy and use that to charge a capacitor of 100 mF.

9. Air Dryer

During 4 minutes collect as much water as possible from the air in the room. The mass of the equipment must not exceed 1 kg. The water should be collected in a glass test tube, provided by the jury.

10. Charged Balloon

An air-filled balloon rubbed with wool or dry paper may stick to the ceiling and stay there. Investigate this phenomenon and measure the charge distribution on the surface of the balloon.

11. Billiard

Before a snooker game starts, 15 balls form an equilateral triangle on the table. Under what conditions will the impact of the white ball (16th ball) produce the largest disorder of the balls?

12. Flour Craters

If you drop a small object in flour, the impact will produce a surface structure which looks like moon crater. What information about the object can be deduced from the crater?

13. Gas Flow

Measure the speed distribution of the gas flow in and around the flame of a candle. What conclusions can be drawn from the measurements?

14. Wheat Waves

The wind blowing through a wheat field creates waves. Describe the mechanism of wave formation and discuss the parameters which determine the wavelength.

15. Bright Spots

Bright spots can be seen on dew drops if you look at them from different angles. Discuss this phenomenon in terms of the number of spots, their location and angle of observation**.**

16. Liquid Diode

Make an electrochemical diode and investigate its properties, in particular the frequency dependence**.**

17. Sound from Water

When you heat water in a kettle you hear a sound from the kettle before the water starts to boil. Investigate and explain this phenomenon**.**

Problems for the 13th IYPT
Budapest, Hungary, 2000

1. Invent for yourself
Suggest a contact-free method for the measurement of the surface tension coefficient of water. Make an estimate of the accuracy of the method.

2. Tuning fork
A tuning fork with resonant frequency of about 100 Hz is struck and held horizontally, so that its prongs oscillate up and down. A drop of water is placed on the surface of the upper prong. During the oscillation of the tuning fork standing waves appear on the surface of the drop and change with time. Explain the observed phenomena.

3. Plasma
Investigate the electrical conductivity of the flame of a candle. Examine the influence of relevant parameters, in particular, the shape and polarity of the electrodes. The experiments should be carried out with a voltage not exceeding 150V.

4. Splash of water
Measure the height reached by splashes of water when a spherical body is dropped into water. Find a relationship between the height of the splashes, the height from which the body is dropped, and other relevant parameters.

5. Sparkling water
Bubbles in a glass of sparkling water adhere to the walls of the glass at different heights. Find a relationship between the average size of the bubbles and their height on the side of the glass.

6. Transmission of signals
Using a bulb, construct the optimum transmitter of signals without any modulation of the light beam between transmitter and receiver. Investigate the parameters of your device. The quality of the device is defined by the product of the information rate (bits/sec) and the distance between transmitter and receiver.

7. Merry-go-round
A small, light, ball is kept at the bottom of a glass filled with an aqueous solution and then set free. Select the properties of the solution, so that a moving up time of several seconds is achieved. How will this time change if you put your glass on the surface of a rotating disk?

8. Freezing drop
Drops of melted lead or tin fall from some height into a deep vessel filled with water. Describe and explain the shape of the frozen drops as a function of height of fall.

9. Radioactivity
Use efficient methods to collect as much radioactive material as you can in a room. Measure the half-life of the material you have collect

10. Liquid fingers
When a layer of hot salt solution lies above a layer of cold water, the interface between the two layers becomes unstable and a structure resembling fingers develops in the fluid. Investigate and explain this phenomenon.

11. Throwing stone
A student wants to throw a stone so that it reaches the greatest distance possible. Find the optimum mass of the stone that should be used.

12. Tearing paper
Tear a sheet of paper and investigate the path along which the paper tears

13. Rolling can
A can partially filled with water rolls down an inclined plane. Investigate its motion.

14. Illumination
Two bulbs, 100 and 40 watts, respectively, illuminate a table tennis ball placed between them. Find the position of the ball, when both sides of the ball appear to be equally lit. Explain the result.

15. Cooling water
Two identical open glasses, filled with hot and warm water, respectively, begin to cool under normal room conditions. Is it possible that the glass filled with hot water will ever reach a lower temperature than the glass filled with warm water? Make an experiment to investigate this and explain the result.

16. Coloured sand
Allow a mixture of differently coloured, granular materials to trickle into a transparent, narrow container. The materials build up in distinct bands. Investigate and explain this phenomenon.

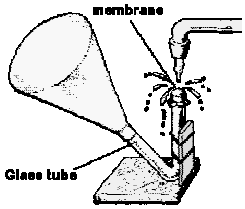
17. A strange sound
Pour hot water into a cup containing some cappuccino or chocolate powder. Stir slightly. If you then knock the bottom of the cup with a teaspoon you will hear a sound of low pitch. Study how the pitch changes when you continue knocking. Explain the phenomenon.

Problems for the 14th IYPT
Espoo, Finland, 2001

1. Electrostatic motor
Is it possible to create a motor which works by means of an electrostatic field? If yes, suggest how it may be constructed and estimate its parameters.

2. Singing saw
Some people can play music on a handsaw. How do they get different pitches? Give a quantitative description of the phenomenon.

3. Tuning dropper
Make the music resonator shown in the picture. Investigate the conditions that affect the pitch. Can you observe amplification of external sounds? If yes, how can you explain this?



4. Dancing sand clock
Investigate the trickling of sand when a sand clock (egg-timer) is placed on a vibrating base.

5. Rubber heat machine
Investigate the conversion of energy in the process of deformation of rubber. Construct a heat machine, which uses rubber as the working element and demonstrate how it works.

6. Fractal diffraction
Produce, demonstrate and analyse diffraction pictures of fractal structures of different orders.

7. Cracks
When drying a starch solution, you will see cracks forming. Investigate and explain this phenomenon.

8. Speedometer
Two electrodes of different metal are immersed in an electrolyte solution. Investigate the dependence of the measured potential difference on the relative motion of electrodes and their shapes.

9. Pouring out
Investigate how to empty a bottle filled with a liquid as fast as possible, without external technical devices.

10. Water stream pump
Construct and demonstrate a water stream vacuum pump. What is your record value for the minimum pressure?

11. Rolling balls
Place two equal balls in a horizontal, V-shaped channel, with the walls at 90 degrees to each other, and let the balls roll towards each other. Investigate and explain the motion of the balls after the collision. Make experiments with several different kinds of ball pairs and explain the results.

12. Reaction

Make an aqueous solution of gelatine (10g gelatine in 90ml of water), heat it to 80 degrees C in a water bath and mix it with a solution of potassium iodide. Pour the solution in a test tube and cool it. Pour a solution of copper sulphate on the surface of the gel. Find a physical explanation to the observed phenomena.

13. Membrane electrolyser

In an electrolyser, containing a membrane which completely divides the space between two inert electrodes, the pH-value of the diluted salt solution will change substantially after electrolysis. Investigate how this difference depends on the pore size of the membrane.

14. Thread dropper

One end of a thread is immersed in a vessel filled with water. The other end hangs down outside without contact with the outer wall of the vessel. Under certain conditions, one can observe drops on that end of the thread. What are those conditions? Determine how the time of appearance of the first drop depends on relevant parameters.

15. Bubbles in magnetie field

Observe the influence of an alternating magnetic field (50 or 60 Hz) on the kinetics of gas bubbles in a vessel filled with water. The bubbles can be generated by blowing air into the water.

16. Adhesive tape

Investigate and explain the light produced, when adhesive tape is ripped from a smooth surface.

17.Seiches

Seiching is a phenomenon known for long, narrow and deep lakes. For reasons of changes in the atmospheric pressure, the water of the lake can start moving in such a way that the water level at both ends of the lake makes periodic motions, which are identical, but out of phase. Make a model that predicts the period of seiching depending on the appropriate parameters and test its validity.

Problems for the 15th IYPT
Odessa, Ukraine, 2002

1. Heat engine
A tall glass cylinder is half-filled with hot water and topped up with cold water. A small ampoule, containing a few drops of ether or alcohol (and closed off by a rubber pipette cap), is then put in. Describe the phenomena occurring in the system. How does the motion of the ampoule change with time?

2. Spider's web
A spider's thread looks like a string of pearls. What is the reason for this? Make experiments to investigate the relevant parameters.

3. Flying colours
Why do flags flutter in the wind? Investigate experimentally the airflow pattern around a flag. Describe this behaviour.

4. Hazy
The colour of a distant forest appears not green, but hazy blue. What is the minimum distance at which this phenomenon is observed? How do weather conditions affect this? Is it possible that a forest can appear grey?

5. Pond skater
It is known that unwettable small bodies can float on water due to the surface tension force. Construct a floating raft based on this principle and determine its static and dynamic parameters.

6. Stop and start
Sometimes a flow of traffic can experience sudden stops and starts for no apparent reason. Build a physical model to explain why this occurs.

7. Ohm's Law for a liquid
It is said that electric current “flows”. Is this the only analogy between electric current and the flow of a liquid? Investigate theoretically and experimentally other analogies between these two.

8. Charged sand
Fine, well-dried quartz sand is poured out of a short thin tube into a conical metallic vessel connected to an electrometer. Investigate the behaviour of the sand stream as the vessel fills up. What changes if the stream is lit by a UV-lamp?

9. Chromatography
Put a drop of coloured liquid on a piece of absorbant paper. Describe quantitatively the observed phenomena.

10. Sound cart
Construct and demonstrate a device that can be propelled solely by sound. Investigate its properties.

11. Equilibrium
Fill a glass with water up to the point where a convex meniscus is formed. Place a table tennis ball on the surface of the water. Investigate and explain the stability of its equilibrium. Repeat your experiment with other liquids.

12. Electroconductivity
How can you measure the electroconductivity of salt solutions without using direct contact electrodes? Analyse the problem and demonstrate your device.

13. Spinning ball
A steel ball of diameter 2-3 cm is put on a horizontal plate. Invent and construct a device, which allows you to spin the ball at high angular velocity around a vertical axis. The device should have no mechanical contact with the ball.

14. Torn sail
Determine the dependence of the efficiency of a sail on its degree of perforation. What would be the effect of using a fishing net as a sail?

15. Pulsating air bubble
Trap an air bubble of radius 1-2 cm under an inverted watch glass beneath a water surface. Introduce alcohol into the bubble through a thin tube, controlling and adjusting the rate of flow until the bubble pulsates rhythmically. Study the phenomenon and explain your observations.

16. Elastic pendulum
Study and describe the behaviour of a pendulum where the bob is connected to a spring or an elastic cord rather than to a stiff rod.

17. Bottle battle
Take two opened glass bottles of cola and knock one against the other. After a short while, the cola spurts out of one of the bottles. Investigate and explain the phenomenon.

Problems for the 16th IYPT
Uppsala, Sweden, 2003

1. Motion of a kite
On windy days one can see kites flying in the wind. Often, one-string kites move on a stable track, which looks like a number 8. Why does a kite move in such a way? Are there other stable tracks?

2. Water drops
Investigate and explain the movement of raindrops on a window pane.

3. Transparent film
If you cover printed text with a piece of transparent polyethylene film you can still easily read it. As you gradually lift up the film, the text becomes increasingly blurred and may even disappear. Study the properties of the film. On what parameters of the film is the phenomenon based?

4. Bright spots
Blow a soap bubble and allow it to rest on a liquid surface or a glass plate. When illuminated by sunlight, bright spots can be observed on the bubble. Investigate and explain the phenomenon.

5. Bubbles at an interface
Certain liquids can be layered one above the other with a sharp interface between them. If the surface tensions of the liquids are different, then an interesting phenomenon can be observed. Blow bubbles of different sizes into the lower liquid and observe their behaviour near the interface. Investigate and explain the phenomenon.

6. Freezing soft drinks
On opening a container of cold soft (carbonated) drink the liquid inside sometimes freezes. Study the relevant parameters and explain the phenomenon.

7. Oscillating box
Take a box and divide it into a number of small cells with low walls. Distribute some small steel balls between the cells. When the box is made to oscillate vertically, the balls occasionally jump from one cell to another. Depending on the frequency and the amplitude of the oscillation, the distribution of the balls can become stable or unstable. Study this effect and use a model to explain it.

8. Heat engine
Construct a heat engine from a U-tube partially filled with water (or another liquid), where one arm of the tube is connected to a heated gas reservoir by a length of tubing, and the other arm is left open. Subsequently bringing the liquid out of equilibrium may cause it to oscillate. On what does the frequency of the oscillation depend? Determine the pV diagram of the working gas.

9. Falling chimney
When a tall chimney falls it sometimes breaks into two parts before it hits the ground. Investigate and explain this.

10. Tungsten lamp
The resistance of the tungsten filament in a light bulb shows a strong temperature dependence. Build and demonstrate a device based on this characteristic.

11. Light scattering
Construct an optical device for measuring the concentration of non-soluble material in the 'viscous' properties of hens' eggs that have been boiled to different extents.

12. Boiled egg
Construct a torsion viscometer. Use it to investigate and explain the difference in the 'viscous' properties of 'hens' eggs that have been boiled to different extends.

13. Electro-osmosis
Develop a device that will drain wet sand, whit the aid of an electrical voltage but without significant heating.

14. Rotating disk
Find the optimum way of throwing a 'frisbee' as far as possible. Explain your findings.

15. Vortices
Make a box that has a hole in its front wall and a membrane as its back wall. Hitting the membrane creates a vortex that propagates out from the hole. Investigate the phenomenon and explain what happens when two vortices interact.

16. Pot and ice
It is sometimes argued that to cool a pot effectively one should put ice above it. Estimate to what extend this is more effective than if the ice is put under the pot.

17. Prometheus problem
Describe and demonstrate the physical mechanism, based on friction, which allowed our ancestors to make fire. Estimate the time needed to make fire in this way.

Problems for the 17th IYPT
Brisbane, Australia, 2004

1. Misty

Invent and construct a device that would allow the size of a droplet of a mist to be determined using a sound generator.

2. Stubborn Ice

Put a piece of ice (e.g. an ice cube) into a container filled with vegetable oil. Observe its motion and make a quantitative description of its dynamics.

3. Electric Pendulum

Use a thread to suspend a ball between the plates of a capacitor. When the plates are charged the ball will start to oscillate. What does the period of the oscillations depend on?

4. Dusty Blot

Describe and explain the dynamics of the patterns you observe when some dry dust (e.g. coffee powder or flour) is poured onto a water surface. Study the dependence of the observed phenomena on the relevant parameters.

5. Sea-shell

When you put a sea-shell to your ear you can hear 'the sea'. Study the nature and the characteristics of the sound.

6. Seebeck Effect

Two long metal strips are bent into the form of an arc and are joined at both ends. One end is then heated. What are the conditions under which a magnetic needle placed between the strips shows maximum deviation?

7. Coin

Stand a coin on its edge upon a horizontal surface. Gently spin the coin and investigate the resulting motion as it settles.

8. Pebble Skipping

It is possible to throw a flat pebble in such a way that it can bounce across a water surface. What conditions must be satisfied for this phenomenon to occur?

9. Flow

Using a dc source, investigate how the resistance between two metallic wires dipped into flowing water (or water solution) depends upon the speed and direction of the flow.

10. Two Chimneys

Two chimneys stand on a box with one transparent side. Under each chimney there is a candle. A short period after the candles are lit one flame becomes unstable. Examine the case and present your own theory of what is happening.

11. String Telephone

How do the intensity of sound transmitted along a string telephone, and the quality of communication between the transmitter and receiver, depend upon the distance, tension in the line and other parameters? Design an optimal system.

12. Kundt's Tube

In a 'Kundt's Tube' type of experiment the standing waves produced can be made visible using a fine powder. A closer look at the experiment reveals that the regions of powder have a sub-structure. Investigate its nature.

13. Egg White

White light appears red when it is transmitted through a slice of boiled egg white. Investigate and explain this phenomenon. Find other similar examples.

14. Fountain

Construct a fountain with a 1m 'head of water'. Optimise the other parameters of the fountain to gain the maximum jet height by varying the parameters of the tube and by using different water solutions.

15. Brazil Nut Effect

When a granular mixture is shaken the larger particles may end up above the smaller ones. Investigate and explain this phenomenon. Under what conditions can the opposite distribution be obtained?

16. Small Fields

Construct a device based upon a compass needle and use your device to measure the Earth's magnetic field.

17. Didgeridoo

The 'didgeridoo' is a simple wind instrument traditionally made by the Australian aborigines from a hollowed-out log. It is, however, a remarkable instrument because of the wide variety of timbres that it produces. Investigate the nature of the sounds that can be produced and how they are formed.

Problems for the 18th IYPT
Winterthur, Switzerland, 2005

1. Dragonfly
Propose a model of how a dragonfly flies, investigate the major parameters and validate your model.

2. The two balls problem
Two balls placed in contact on a tilted groove sometimes do not roll down.
Explain the phenomenon and find the conditions, under which it occurs.

3. Avalanche
Under what conditions may an avalanche occur? Investigate the phenomenon experimentally.

4. Hydraulic jump
When a smooth column of water hits a horizontal plane, it flows out radially. At some radius, its height suddenly rises. Investigate the nature of the phenomenon. What happens, if a liquid more viscous than water is used?

5. Mirage
Create a mirage like a road or desert mirage in a laboratory and study its parameters.

6. Noise
When a droplet of water or other liquid falls on a hot surface, it produces a sound. On what parameters does the sound depend?

7. Bouncing plug
A bathtub or sink is filled with water. Remove the plug and place a plastic ball over the plughole. As the water drains the ball starts to oscillate. Investigate the phenomenon.

8. Wind car
Construct a car, which is propelled solely by wind energy. The car should be able to drive straight into the wind. Determine the efficiency of your car.

9. Sound in the glass
Fill a glass with water. Put a tea-spoon of salt into the water and stir it. Explain the change of the sound produced by the clicking of the glass with the tea-spoon during the dissolving process.

10. Flow rate
Combine powdered iron/ iron filings/ with a vegetable oil. Connect two containers with plastic tubing and allow the mixture to drain through the tube. Develop an external mechanism to control the flow rate of the mixture.

11. Water droplets
If a stream of water droplets is directed at a small angle to the surface of water in a container, droplets may bounce off the surface and roll across it before merging with the body of water. In some cases the droplets rest on the surface for a significant length of time. They can even sink before merging. Investigate these phenomena.

12. Ball spin
Spin can be used to alter the flight path of balls in sport. Investigate the motion of a spinning ball, for example a table-tennis or tennis ball, in order to determine the effect of the relevant parameters.

13. Hard starch
A mixture of starch /e.g. cornflour or cornstarch/ and a little water has some interesting properties. Investigate how its viscosity changes when stirred and account for this effect. Do any other common substances demonstrate this?

14. Einstein-de- Haas Experiment
When you apply a vertical magnetic field to a metallic cylinder suspended by a string it begins to rotate. Study this phenomenon.

15. Optical tunneling
Take two glass prisms separated by a small gap. Investigate under what conditions light incident at angles greater than the critical angle is not totally internally reflected.

16. Obstacle in a funnel
Granular material is flowing out vessel through a funnel. Investigate if it is possible to increase the outflow by putting an obstacle above the outlet pipe.

17. Ocean "Solaris"
A transparent vessel is half-filled with saturated salt water solution and then fresh water is added with caution. A distinct boundary between these liquids is formed. Investigate its behaviour if the lower liquid is heated

Problems for the 19th
Bratislava, Slovakia, 2006

1. Froth
Investigate the nature of the decay in height of the “froth” or “foam” on a liquid. Under what conditions does the froth remain for the longest time?

2. Shades
If small non-transparent objects are illuminated with light, patterns in the shadows are observed. What information can be obtained about these objects using these patterns?

3. Duck`s cone
If one looks at the wave pattern produced by a duck paddling across a pond, this reminds one of Mach`s cone. On what parameters does the pattern depend?

4. Whispering Gallery
The Whispering Gallery at St Paul`s Cathedral in London, for example, is famous for the fact that the construction of the circular gallery makes a whisper against its walls on the side of the gallery audible on the opposite side of the gallery. Investigate this phenomenon.

5. Probability
A coin is held above a horizontal surface. What initial conditions will ensure equal probability of heads and tails when the coin is dropped and has come to rest?

6. Wet cleaning
A wet rag is hard to drag when it is spread out and pulled across the floor. What does the resistive force depends on?

7. Airglider
A paper sheet is on the table. If one blows along the table the sheet begins to glide over it. Determine the flight characteristics of the paper.

8. Electrostatics
Propose and make a device for measuring the charge density on a plastic ruler after it has been rubbed with a cloth.

9. Sound and foam
Investigate the propagation of sound in foam.

10. Inverted pendulum
It is possible to stabilize an inverted pendulum It is even possible to stabilize an inverted multiple pendulum /one pendulum the top of the other/. Demonstrate the stabilization and determine on which parameters this depends.

11. Singing tube
A tube open at both ends is mounted vertically. Use a flame to generate sound from tube. Investigate the phenomenon.

12. Rolling magnets
Investigate the motion of a magnet as it rolls down an inclined plane.

13. Sound
Measure the speed of sound in liquids using light.

14. Cellular materials
Investigate the behaviour of a stream of liquid when it strikes the surface of a sponge-like material.

15. Heat and temperature
A tube passes steam from a container of boiling water into a saturated aqueous salt solution. Can it be heated by the steam to a temperature greater than 100°C? Investigate the phenomenon.

16. Hardness
A steel ball falls onto a horizontal surface. If one places a sheet of paper onto the surface with a sheet of carbon paper on top of it, a round trace will be produced after the impact. Propose a hardness scale based on this method.

17. Magnetohydrodynamics
A shallow vessel contains a liquid. When an electric and magnetic fields are applied, the liquid can start moving. Investigate this phenomenon and suggest a practical application.

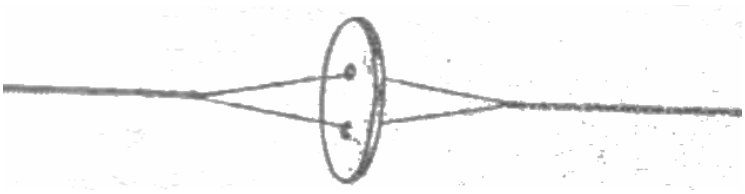
Problems for the 20th
Seoul, Korea, 2007

1. **Filament**
There is a significant current surge when a filament lamp is first switched on. Propose a theoretical model and investigate it experimentally.

2. **Slinky**
Suspend a Slinky vertically and let it fall freely. Investigate the characteristics of the Slinky's free-fall motion.

3. **Water jets.**
What can be observed when two water jets collide at different angles?

4. **Spring thread**
Pull a thread through the button holes as shown in the picture. The button can be put into rotating motion by pulling the thread. One can feel some elasticity of the thread. Explain the elastic properties of such a system.



5. **Razor Blade**
A razor blade is placed gently on a water surface. A charged body brought near the razor makes it move away. Describe the motion of the razor if an external electric field is applied.

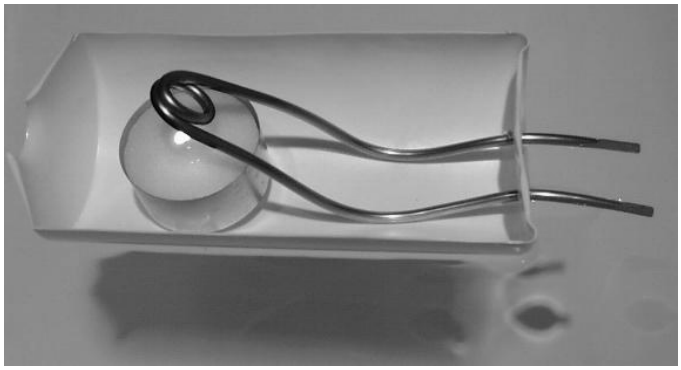
6. **Rheology**
It has been said that if you are sinking in soft mud, you should not move vigourously to try to get out. Make a model of the phenomenon and study its properties.

7. **Crickets**
Some insects, such as crickets, produce a rather impressive sound by rubbing together two parts of their body. Investigate this phenomenon. Build a device producing a sound in a similar way.

8. **Condensation**
Water droplets form on a glass filled with cold water. Explain the phenomenon and investigate the parameters that determine the size and number of droplets on the glass.

9**. Ink Droplet**
Place a droplet of ball pen ink on a water surface. The droplet begins to move. Explain the phenomenon.

10. *Steam Boat*
A boat can be propelled by means of a candle and metal tubing with two open ends (an example is shown in the picture). Explain how such a boat is propelled and optimize your design for maximum velocity.



11. **Water Ski**
What is the minimum speed needed to pull an object attached to a rope over a water surface so that is does not sink. Investigate the relevant parameters experimentally and theoretically.

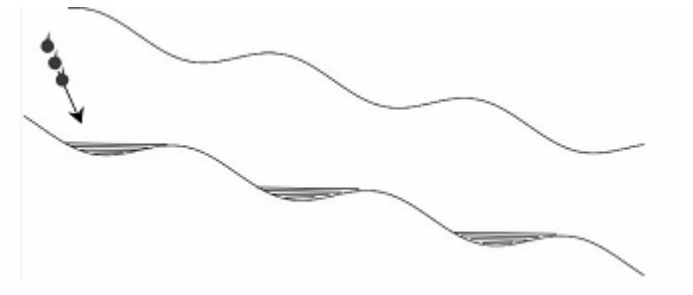
12. **Fluid lens**
Develop a fluid lens system with adjustable focus. Investigate the quality and possible applications of your system.

13. **Balloon**
Measure the change of the optical properties of the skin of a balloon during its inflation.

14. **Earthquake**
Suggest a mechanism that makes buildings resistant to earthquakes. Perform experiments and explain the results.

15. **Blowpipe**
Investigate the motion of a projectile inside a blowpipe. Determine the conditions for maximum exit velocity when blown by mouth.

16. **Water Cascade**
Arrange a corrugated drainage pipe, or similar, on an incline. Allow water to flow through the pipe and then carefully stop the flow. Investigate the behaviour of the system when water is dropped into the pipe.



17. **Ice Bulge**
Fill a plastic tray with water. When frozen, under certain conditions, a bulge can appear on the surface. Investigate this phenomenon.