* enhanced, updated, and translated from the Russian

Preparation to the Young Physicists' Tournaments' 2007 *

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Changes made to 2006/07 editions:

- ⊗ straightforward hints removed
  - theoretical intros reduced or removed
  - *Key Questions* reduced
- ✓ more references added
  - fully translated into English

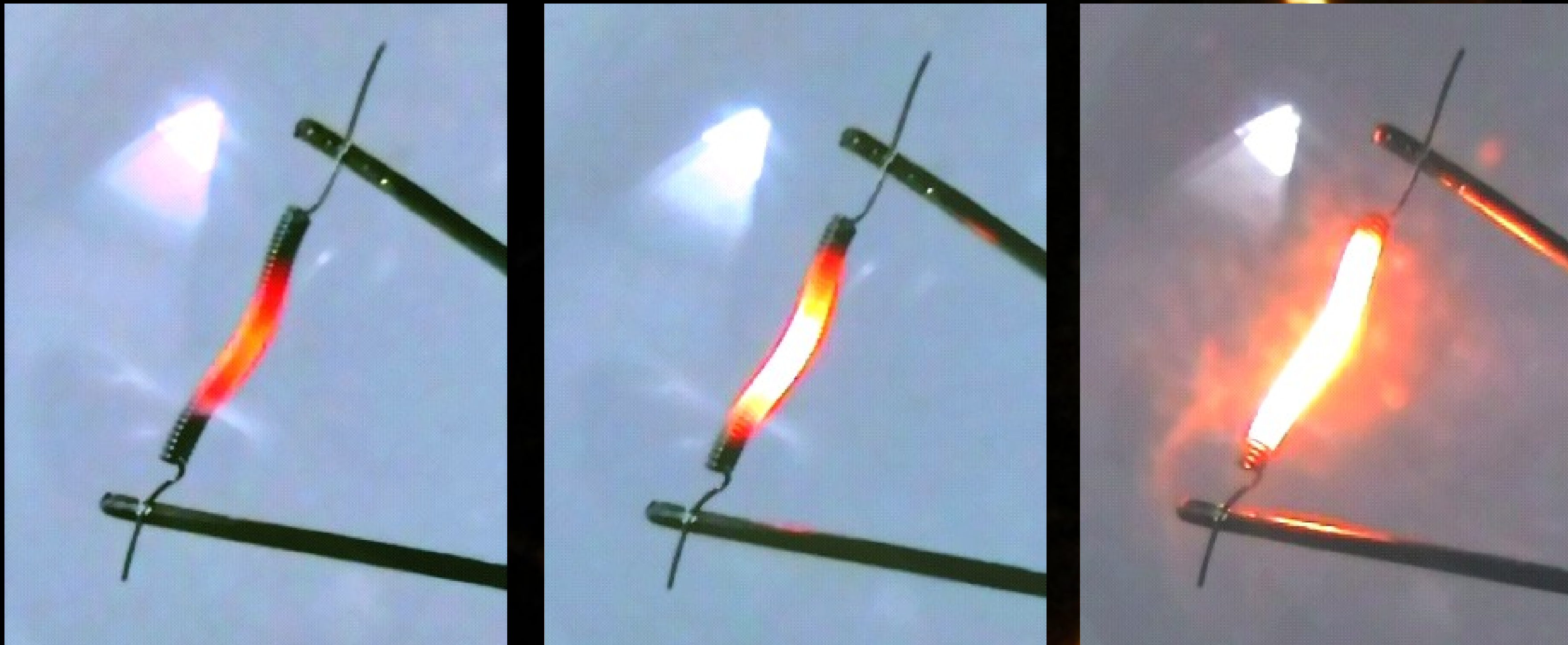
Timeline of talks and early drafts:

September 29, 2006:	Nos. 1, 2, 3, 6, 7, 9, 10, 12
December 8, 2006:	Nos. 5, 12, 14
January 30. 2007:	Nos. 13, 15, 16
February 23, 2007:	Nos. 4, 8
March 2, 2007:	Nos. 11, 17

Problem No. 1 “Filament”

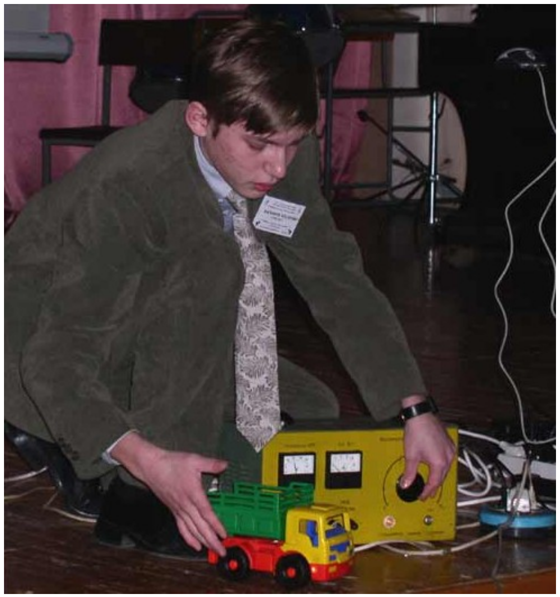
There is a significant current surge when a filament lamp is first switched on. Propose a theoretical model and investigate it experimentally.

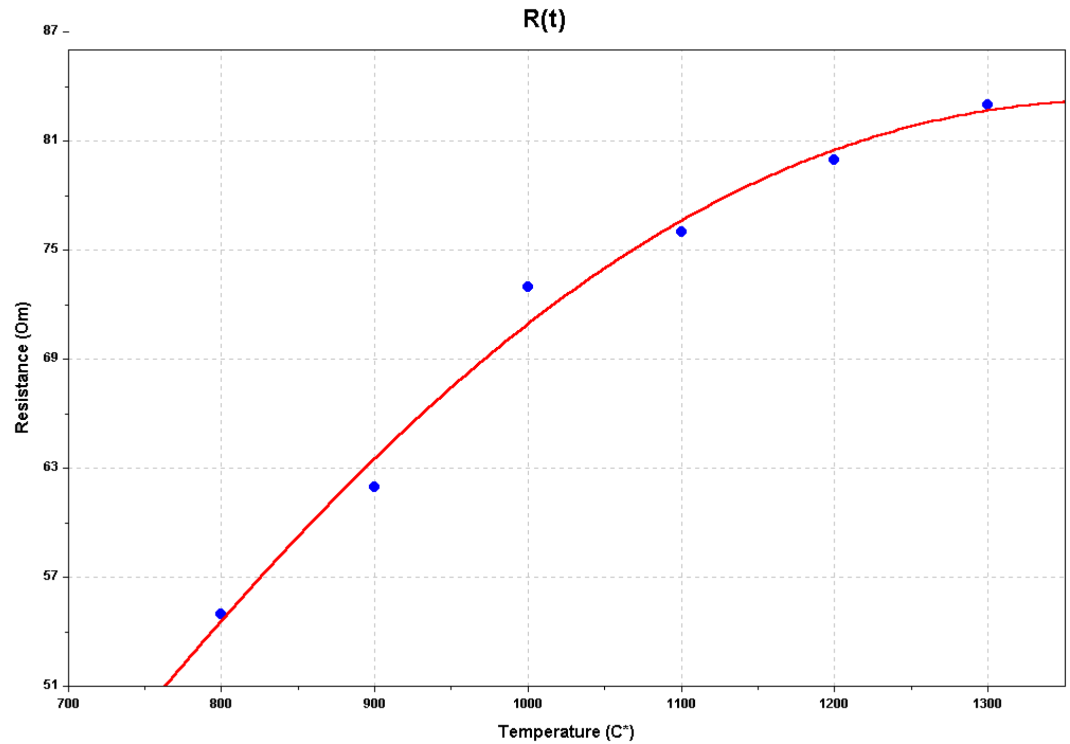
http://www.kapturegroup.com/ph_ka_htmls/bulb.html



- What physical parameters of the system may be relevant? (voltage of the power supply? resistance of the filament as a function of temperature? inductance of the filament? heat conductivity of contact wires and the gas? surface properties of the filament?)
- What is the time dependence of current and temperature in the filament as the lamp is switched on? Can a simple theoretical model be proposed?
- Is there a way to directly measure the temperature of the filament and other elements of the lamp?
- What are the maximum possible values of inrush current in a real filament?

IYPT history





- No. 10 “Tungsten lamp” (IYPT 2003): “The resistance of the tungsten filament in a light bulb shows a strong temperature dependence. Build and demonstrate a device based on this characteristic.”

(опытъ *Ленца*).)

234. Лампы накаливанія. Проводникъ (проволока), накаленный до бѣла гальваническимъ токомъ, можетъ служить источникомъ свѣта. Такъ какъ въ бѣлокалильномъ жару металлы, за исключеніемъ платины, плавятся, то были попытки примѣнить платиновую проволоку для электрическаго освѣщенія. *Ладыгинъ* (1873 г.) предложилъ накаливать тонкіе угольные стерженьки, а чтобы они не сгорали, помѣщать ихъ въ пустотѣ или въ атмосферѣ газа, не имѣющаго химическаго сродства съ углеродомъ, напр., въ углекисломъ газѣ; эта мысль не была доведена имъ до надлежащей степени примѣнимости, что было выполнено позднѣе *Эдиссономъ* (1879 г.). Всѣ лампы накаливанія (Эдиссона, Свана, Максима и др.), отличаясь въ подробностяхъ, имѣютъ слѣдующее общее устройство. Весьма узкая и тонкая угольная пластинка или нить *c* (обугленное безъ доступа воздуха волокно бамбука) (рис. 327) вводится въ стеклянный сосудъ сферической или овальной формы. Концы угольной нити прикрѣпляются къ платиновымъ проволокамъ *a* и *k*, которыя оплавлены стекломъ, выходятъ наружу и соединяются съ электродами гальванической батареи. Чрезъ отверстіе *o* помощію ртутнаго насоса [93] вытягивается воздухъ, и затѣмъ отверстіе запаивается. Эти лампы могутъ выдерживать 800—1000 часовъ непрерывнаго накаливанія. Уголь мало по малу разрыхляется и разрушается, а стѣнки сосуда покрываются изнутри черным налетомъ.

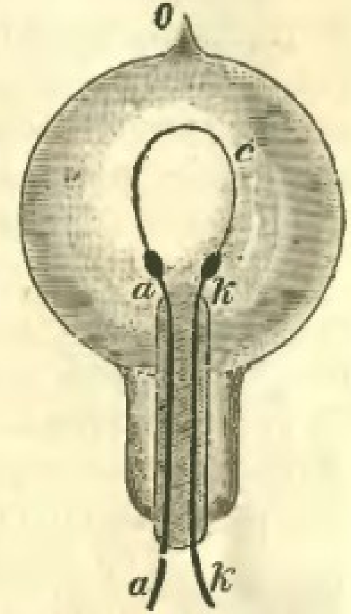


Рис. 327.

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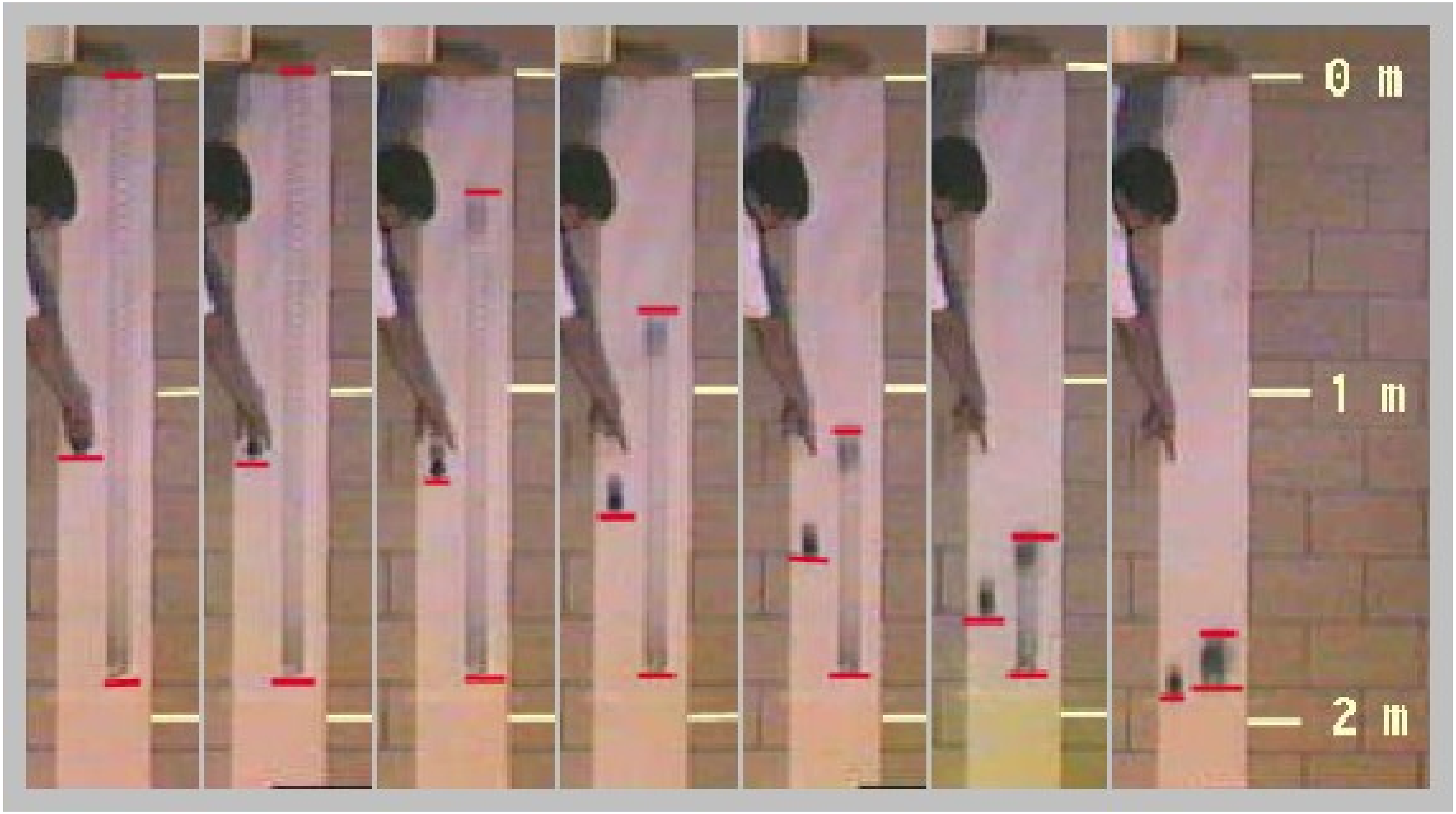
Problem No. 2 “Slinky”

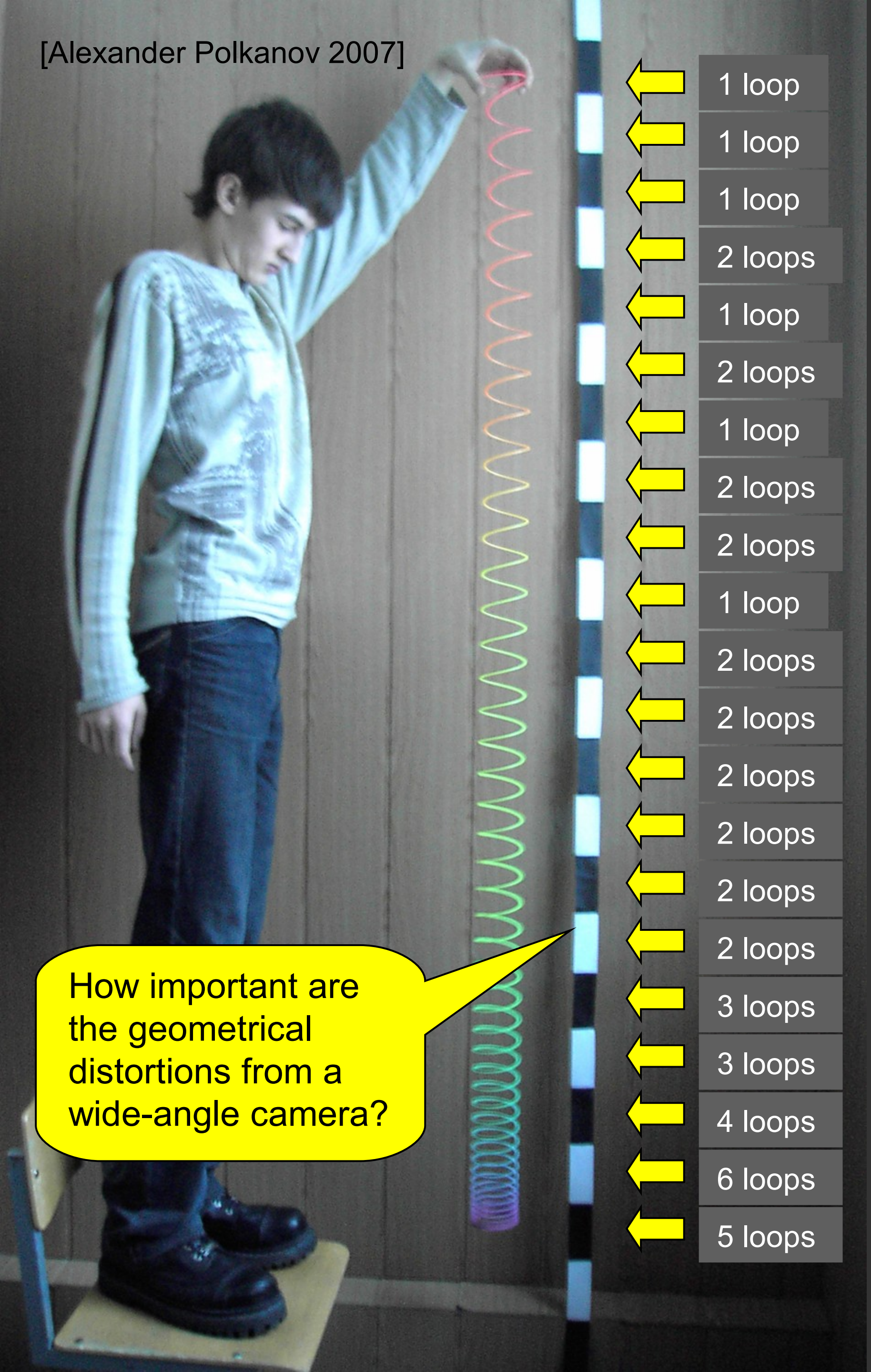
Suspend a Slinky vertically and let it fall freely. Investigate the characteristics of the Slinky's free-fall motion.

http://de.wikipedia.org/wiki/Slinky



- Time interval of 1/15 s. Total duration of ca. 0.4 s. Height of one brick of 20 cm.

http://www.clemson.edu/phys-car/fun/slinky/index.html



- Does the spring follow the Hook's law? Is there a dependence of total elastic force on elongation?
- What parameters may be experimentally controlled as the Slinky is suspended? (initial length, stiffness and mass of the Slinky? forces and mechanical tensions in different points of the Slinky?)
- What is the "density distribution" of a suspended Slinky? Can it be defined as a number of loops per unit length?
- Where is the center of masses of a suspended Slinky?
- When the Slinky is released, how do the bottom end and the top end move?
- When the Slinky is released, what is the displacement and the acceleration of the center of masses? How does the moment of inertia and other relevant parameters depend on time?
- How stable is the vertical orientation of a falling Slinky? Is there a rotation around the center of masses during the free fall? Is the angular speed of such a rotation constant over the time span of a free fall? How and when do possible transitions of rotational and oscillatory modes take place?
- Can a Slinky undergo oscillations at zero gravity?
- Is it worth modeling the system numerically? Is it difficult to compile a program having all important parameters as input values?

Time, ms

What information can be retrieved from such movies?

Coordinates, speeds and accelerations of the bottom and the top ends, but also of the individual loops?

Compression in the propagating shock wave?

Rotational motion before and after Slinky's collapse?

Why the bottom end is immobile?

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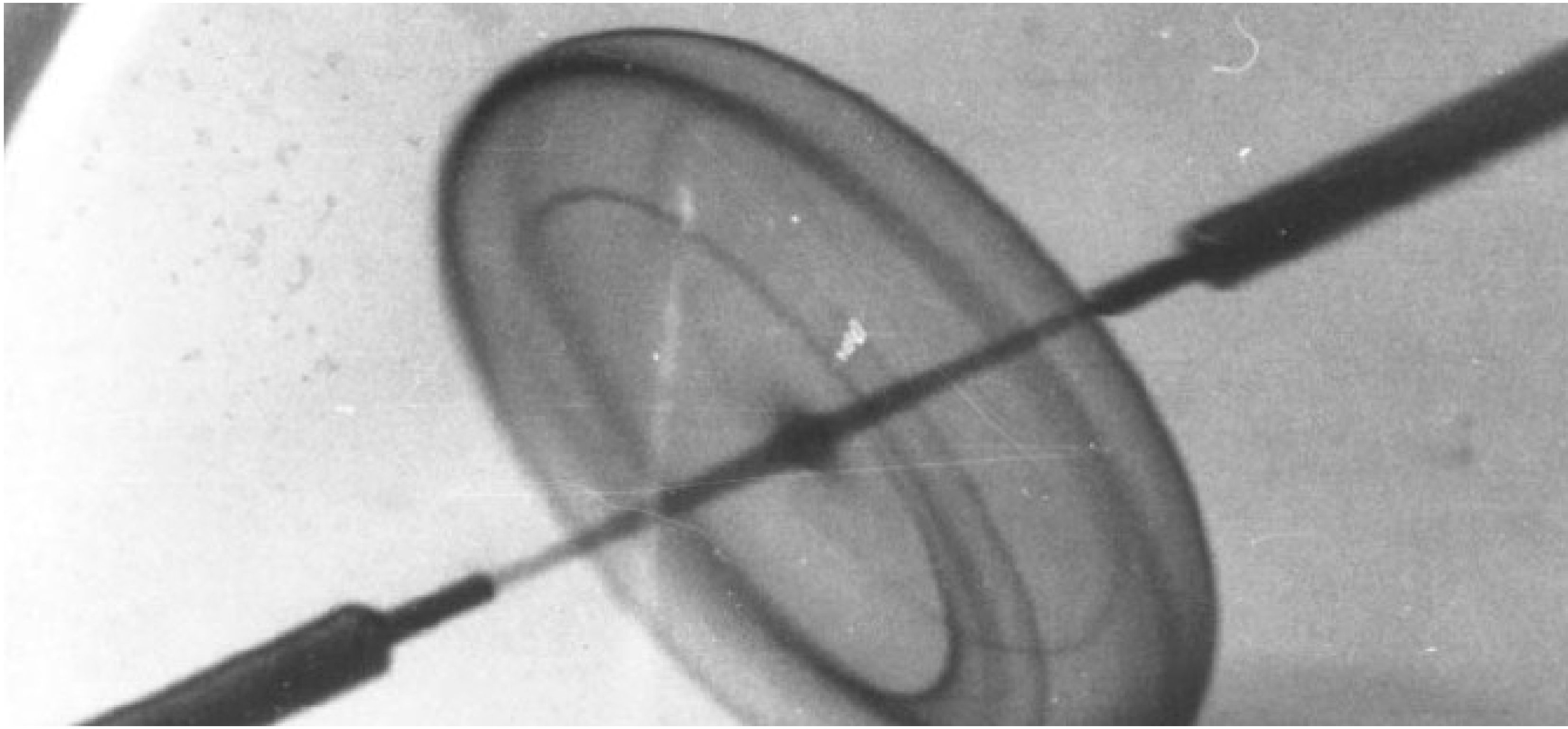
Problem No. 3 “Water jets”

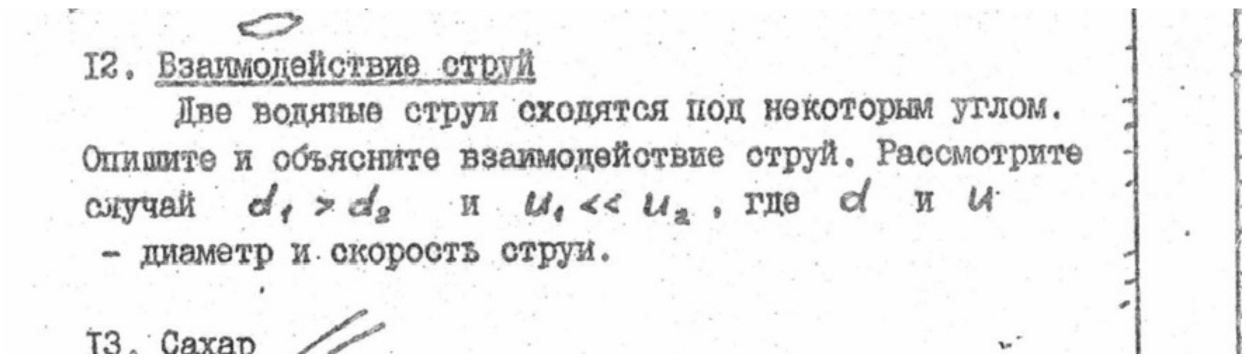


What can be observed when two water jets collide at different angles?

S. I. Voropayev *et al*. Phys. Fluids, 15, 11, 3429–3433 (2003)

IYPT history

- Interaction of jets (3rd YPT, 1981)
- "Two water jets collide at a certain angle. Describe and explain the interaction of the jets. Consider the case $d_1 > d_2$ and $u_1 \ll u_2$, where d and u are diameter and speed of a jet."



12. Взаимодействие струй

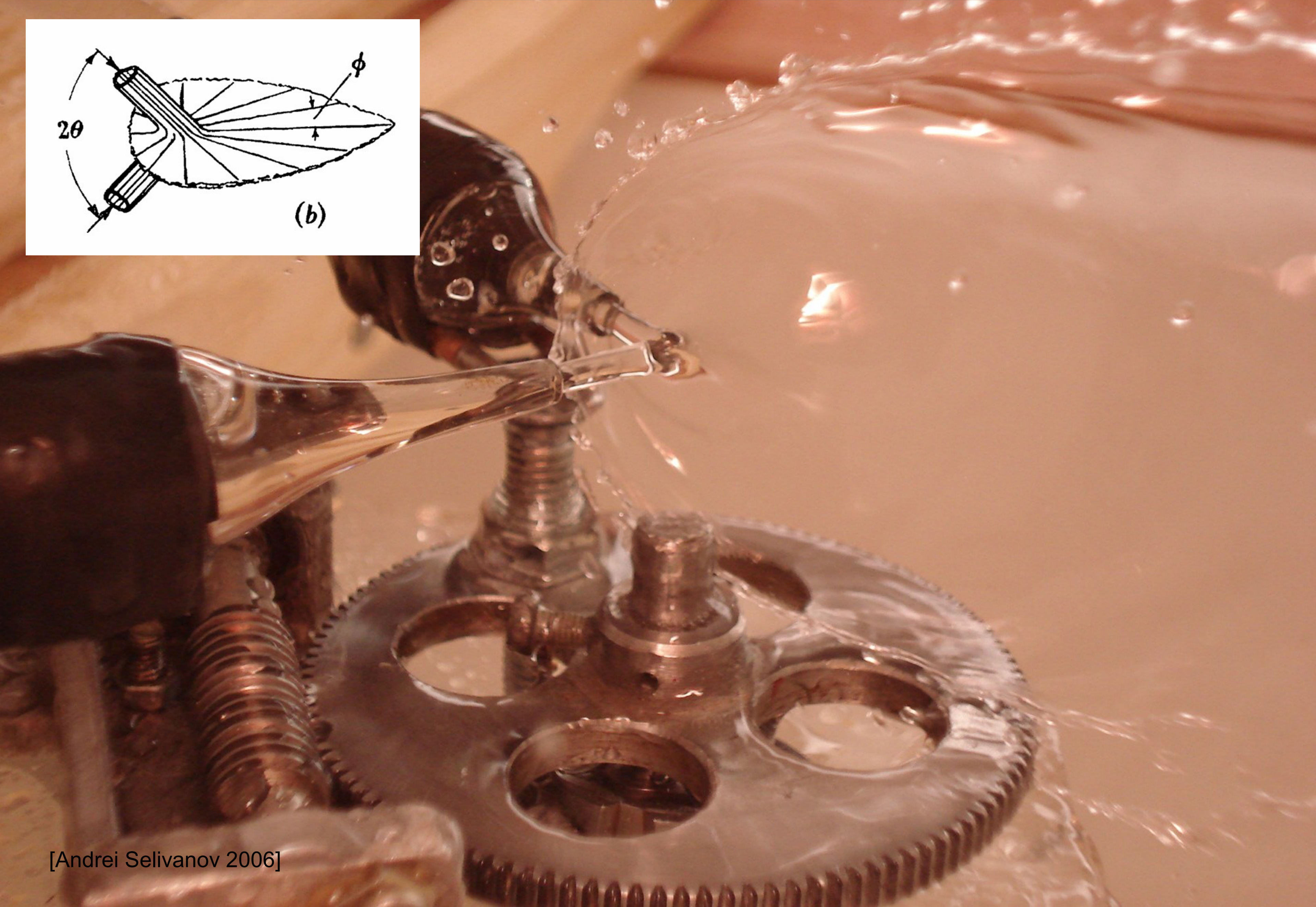
Две водяные струи сходятся под некоторым углом. Опишите и объясните взаимодействие струй. Рассмотрите случай $d_1 > d_2$ и $u_1 << u_2$, где d и u – диаметр и скорость струи.

13. Сахар

Coaxial, frontal collision of cylindrical jets leads to a disk…

[Andrei Selivanov 2006]

Coplanar angle impact leads to an asymmetrical water sheet…



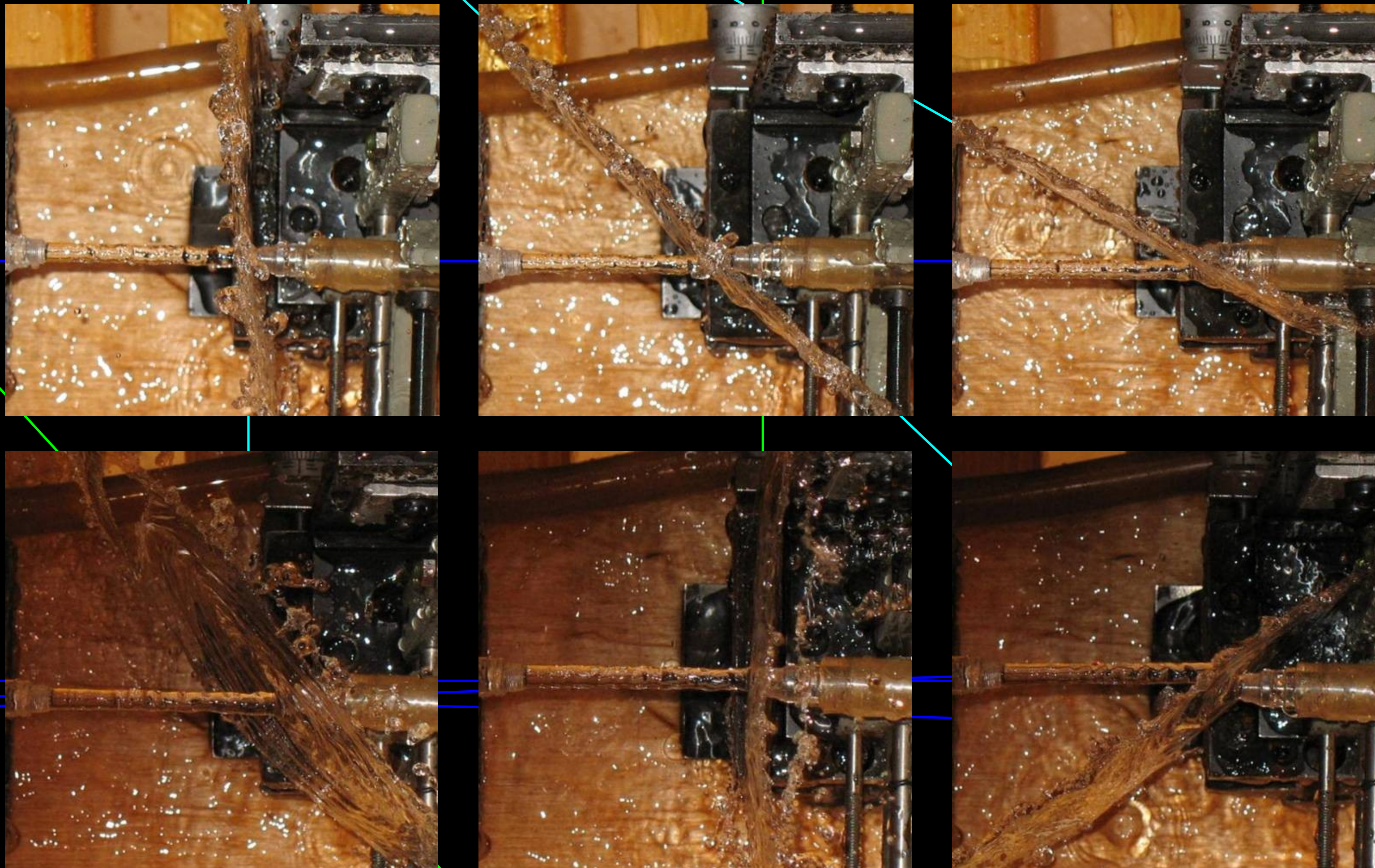
[Andrei Selivanov 2006]

Jets merge and demonstrate a “drill bit” effect at side impact…

[Andrei Selivanov 2006]

Questions

- Hey, the problem does not say a word of where do the jets collide, in air or in water. Should both cases be investigated, or there are particular grounds for a choice?
- What possible types of post-collision patterns can be observed? Is a logical, physically validated classification possible? (circular sheets? asymmetrical sheets? merging into a single jet? more?)
- What initial parameters can be tuned (translational, angular displacement of the jets? linear speed, diameter, cross-section profile of the jets? surface tension?)
- What parameters of the appearing sheets, or other structures, should be investigated? (critical radius? spatial orientation? shape? velocities? stability?)
- What is the total energy of a jet before impact, and can it be described as a sum of a few contributions? (kinetic, surface energies?) How is the energy re-distributed after collision?
- What physical interactions determine the ultimate shape and size of a water sheet? Why the sheet splits into droplets at a certain point?
- How to best record and analyze the formation or the stability of the post-collision patterns? How stable and reproducible they are, if the experiment is repeated? Are there any parameters that are appropriately described by a statistical distribution?



How do the orientation and shape of liquid sheets depend on translational or angular displacement of jets, on their velocity, cross-section, and other relevant parameters?

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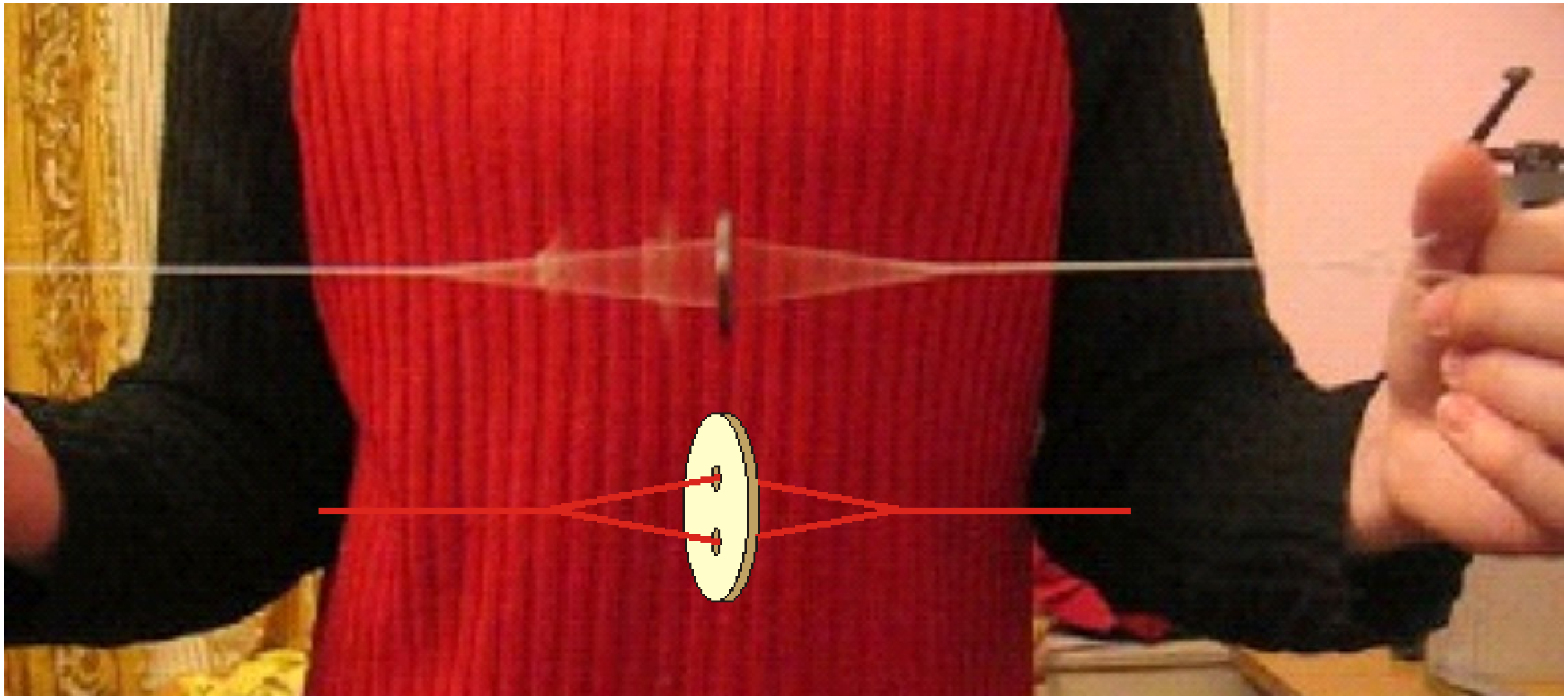
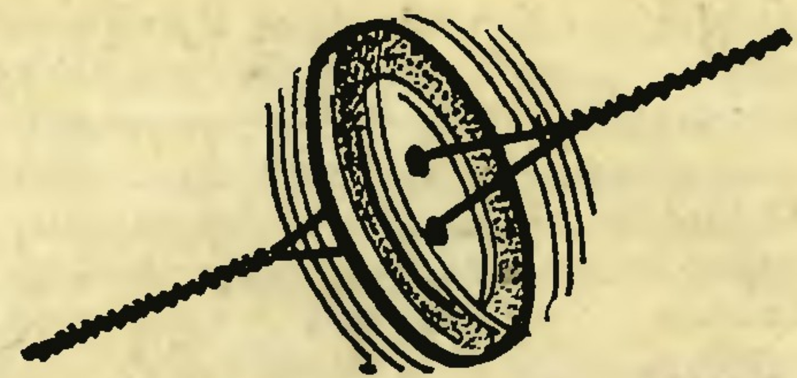
Problem No. 4 “Spring thread”



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.

ИГРУШКИ НАШИХ ДЕДУШЕК

Вот так пуговица!



На Рижском рынке, где торгуют кооператоры, у одного из ларьков столпились люди. Дети теребили пап и мам: «Купи-купи!..» А торговец вовсю расхваливал продукцию: «Лучший подарок ребенку! Забавляет, удивляет, отвлекает!»

Подошел, заглянул через головы и увидел... пуговицы! Большие и маленькие, нанизанные на разноцветные нити. Торговец брал выбранную покупку, растягивал нить на пальцах, раскручивал пуговицу, и она оживала: на-душки и бабушки. Стоит она на рынке немало — до рубля. А дел-то — две минуты. Думаем, лучше взяться за них самому, тогда и принцип действия игрушки станет яснее.

Возьмите обычную пуговицу, проденьте в ушко крепкую нить, свяжите концы (рис. 3а). Растянем теперь нить на пальцах и станем по кругу вращать пуговицу. Нить закрутится, сожмется в пружину. Если потянуть ее в разные стороны, нить начнет раскручиваться, а вместе с ней и

Н. Светов. Вот так пуговица! // Юный техник, № 9, 65-66 (1989)

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Problem No. 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.

J. Fluid Mech. (1965), *vol.* 22, *part* 1, *pp.* 1–15
Printed in Great Britain

The stability of a horizontal fluid interface in a vertical electric field

By G. I. TAYLOR AND A. D. McEWAN
Cavendish Laboratory, Cambridge

(Received 21 September 1964)

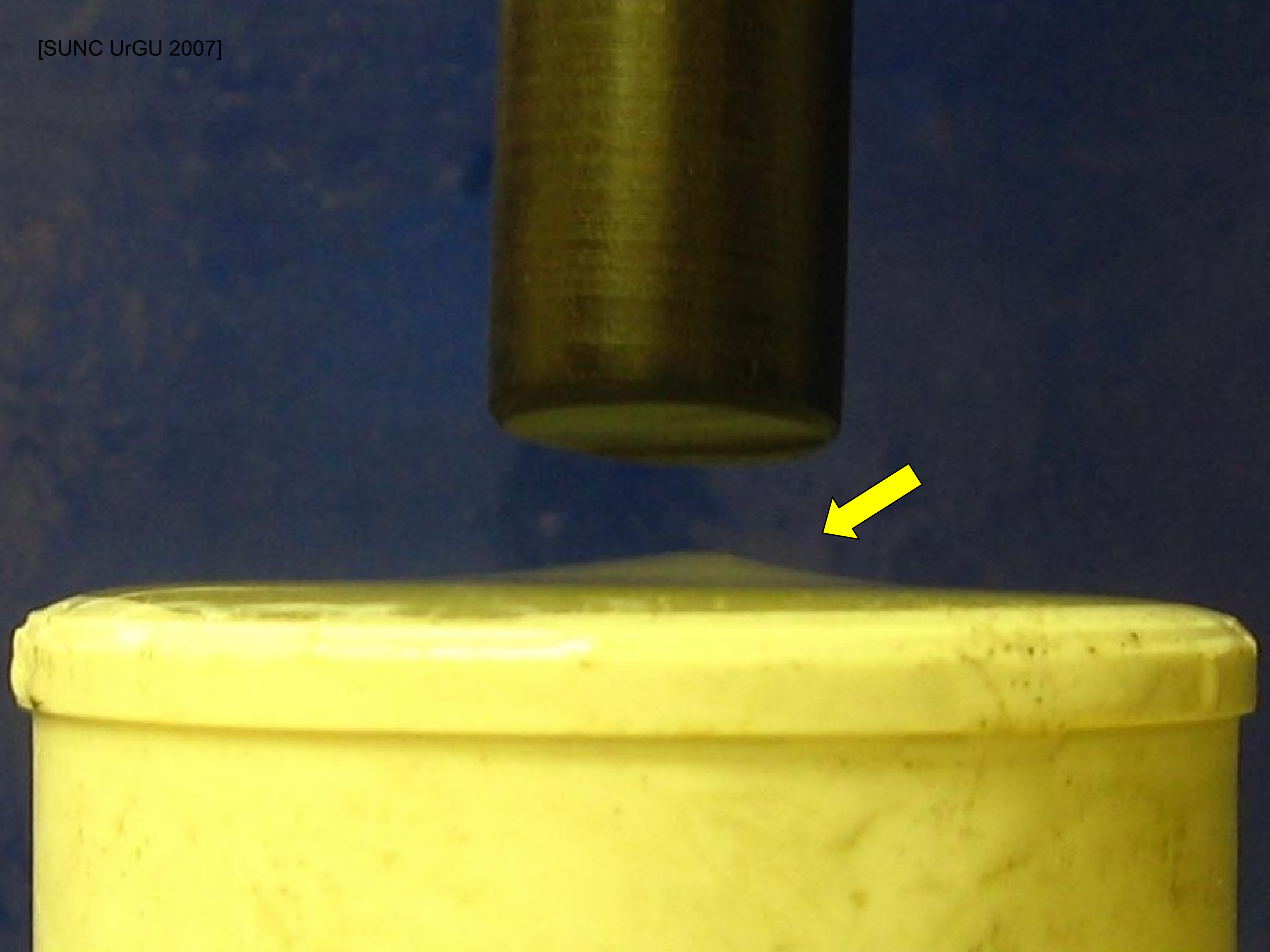
The stability of the horizontal interface between conducting and non-conducting fluids under the influence of an initially uniform vertical electric field is discussed. To produce such a field when the conducting fluid is the heavier it is imagined that a large horizontal electrode is immersed in the non-conducting fluid. As the field increases the part of the interface below the electrode rises till at a voltage V, which depends on the interfacial tension, the height of the electrode above the interface and the density difference, the interface becomes unstable for vertical displacements Z which satisfy the equation

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+k^2\right)Z=0.$$

The value of k consistent with the lowest value of V is found. When the electrode is situated above the interface at less than a certain distance the lowest value of V is attained when $k=0$ so that the horizontal extent of an unstable crest is likely to be great. As the electrode height increases above this critical value k increases and the unstable crests become more closely spaced till an upper limiting value of k is obtained.

Questions

- Above all, what is the cause for the motion of the razor blade? If you propose an explanation, does it look as a subject to direct experimental proof or disproof?
- What are the “repulsive” and “attractive” forces relevant to the effect? What are their values or relative ratios?
- Is there anything special about the razor? Is the phenomenon possible with metal needles, or any other metal, or non-metal objects? Are the sharp edges or the razor material essentially important?
- What is the influence of the spatial position, size, shape, charge distribution and total charge of the charged body? How to best charge a body (with a Wimshurst machine?) Are there boundary conditions for electric field near the (dielectric?) water surface?
- How to best measure the shape of the water surface at any moment of time (with a camera from a relevant angle? with a laser beam?)
- Is it possible to describe mathematically the shape of the deformed surface? Is the math describing the deformations for the surface similar to that of an elastic circular membrane? Does the sufrace oscillate when the charged body is rapidly removed? Is it worth modeling the system numerically?
- Is the razor blade polarized in an electric field? It is relevant to the phenomenon?
- What is the role of the surface tension in the problem? The surface tension of the water is dependent on the electric field. Does it influence on the effect?
- How do the acceleration, speed and position of the razor blade depend on the key parameters? In a long run, would the razor move with the same speed as the charged body?
- How significant are energy losses, such as the viscous friction? How fast is the body discharged, and how it influences on the effect?


[SUNC UrGU 2007]

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Problem No. 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.

Katya Gorelova, Oleg Kuvaev, *Magazinčik BO*, September 1, 2004

“It has been said…”

- Why aren’t you getting out?
- If I try to get out I’ll drown much faster, it’s obvious!

La Chêvre, Francis Veber, Gaumont-Fideline films-Conaciné, 1981

Major mud myths

1. If stuck, don’t move;
2. If stuck, impossible to get out;
3. If stuck, one drowns ;-)

Questions

- What model system is reasonable for experiments (mud? clay?...)
- What are the rheological properties exhibited by the system, and how to describe and measure them?
- What is the physical cause for such a rheological behavior? Is the fluid in question Newtonian or non-Newtonian, and why?
- What is the average density of a human vs average density of mud? What are the interactions between the human body and the fluid?
- How to describe and visualize the flow lines and pressure fields around the immersed body?
- Is the viscosity or other mechanical properties constant under shearing, or other mechanical agitation, or under no agitation? What are the time dependences?
- Are the experiments reproducible?
- Is it grounded to speak of similarity between your model and a real sinking human, and how to validate such a conclusion?

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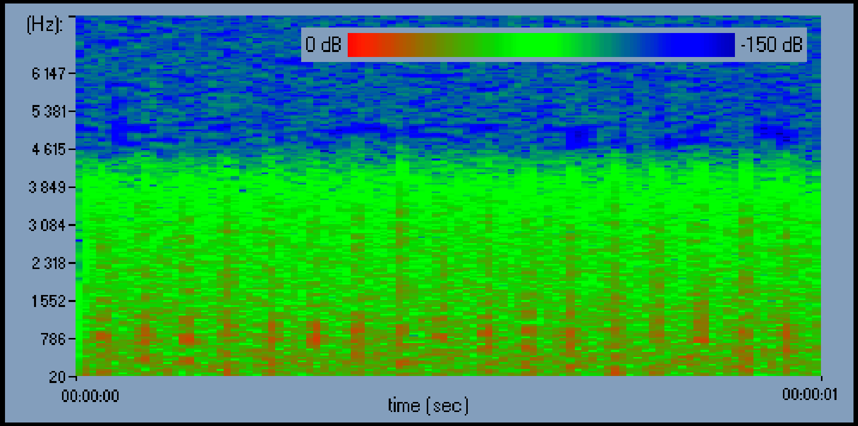
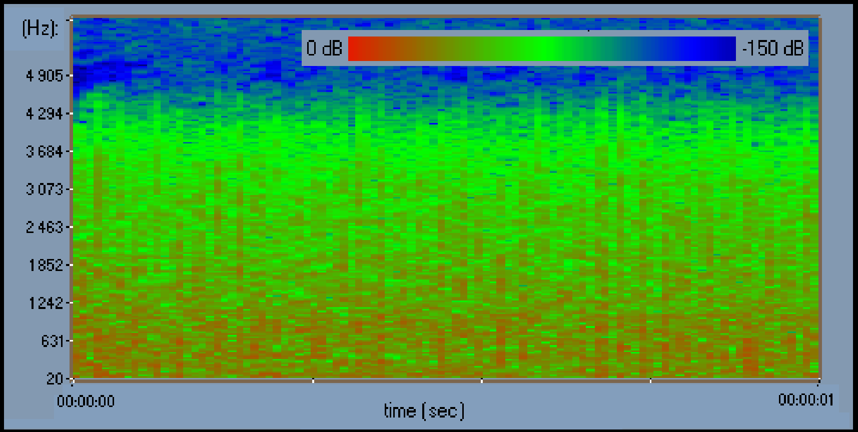
Problem No. 7 “Crickets”

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.


Hory, Belarus, August 27, 2006

Open air observations

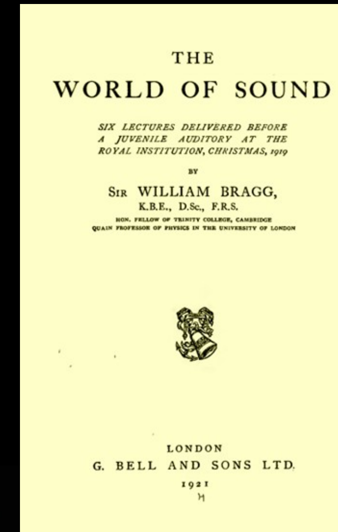




- A night grasshopper (?) hidden in *Artemisia* in Hory, Belarus on August 17, 2006
- Periodic chirps, or intensity pulsations, each 1/17 s
- The signal is noisy, no carrier frequency visible

- An unidentified grasshopper (?) at Lyoni Golikova, St Petersburg, Russia on September 18, 2006
- Periodic chirps, or intensity pulsations, each 1/38 s
- The signal is noisy, no carrier frequency visible

The ways and mechanism employed by insects of all kinds in making noises are very varied and interesting; but it would need a naturalist to tell you about them at any length, because so much depends on why each particular way has been chosen, and that again on the life and history of the creature.


THE
WORLD OF SOUND
SIX LECTURES DELIVERED BEFORE A JUVENILE AUDITORY AT THE ROYAL INSTITUTION, CHRISTMAS, 1919
BY
SIR WILLIAM BRAGG,
K.B.E., D.Sc., F.R.S.
HON. FELLOW OF TRINITY COLLEGE, CAMBRIDGE
QUAIN PROFESSOR OF PHYSICS IN THE UNIVERSITY OF LONDON
LONDON
G. BELL AND SONS LTD.
1921

The sound produced by crickets is covered extensively in the literature.

How to approach the problem from a physical perspective, and adequately classify the features, mechanisms, and types of sound for various species?

Дзівосныя конікі

… Казакевіч,
«НС».

…нечик…» … забаўнай … шы яе да … ы, я рап- … баўная, а … Канцавы … кузнеца» … зу. І сам … ну. Тым … лагодны … ер-тыстычна агучаны заспакаяльным цвырканнем зялёных беларускіх конікаў (кажуць яшчэ «стрыгунчык туркоча»). Дарэчы, перакласці на беларускую гэту песеньку таксама цяжка. Можа, якраз з прычыны такога бязлітаснага фіналу. Хочацца зрабіць хэпі-энд (хаця б для сваёй дачушкі)…

Як бы там ні было, а праігнараваць конікавыя жнівеньскія канцэрты, слухачамі якіх ёсць кожны з нас, ніяк не выпадае. Зрэшты, трэба памятаць, што канцэрты гэтыя ладзяцца зусім не для людзей і маюць, так бы мовіць, спакушальна-любоўны характар. Так-так, менавіта гэткім чынам самцы-конікі прываблівають да сябе самак. На надкрыллях самцоў ёсць пара адмысловых музыкальных органаў: на правым – люстэрка (маленькая хіцінавая пляцовачка), на левым – такая ж пляцоўка, толькі матавая і з зазубрынкамі. Правае люстэрка выконвае ролю скрыпкі, левая пляцоўка – смычка. Застаецца правесці смычком па наладжанай ужо самой прыродай скрыпцы і… Такім чынам, кожны вечар мы слухаем своеасаблівыя любоўныя серэнады маэстраў-конікаў. Праўда, гэта вельмі дзівосныя скрыпачы: органы слыху ў іх знаходзяцца на пярэдніх лапках!

Шмат хто блытае стракатанне конікаў з цвыркуновым, а па знешняму выгляду – конікаў з саранчой. Тым больш што энтамолагі адносяць іх усіх да аднаго сямейства (атрад прамакрылых). Адрозненне конікаў ад цвыркуноў (сверчок – рус.) дакладна перадае беларуская мова, бо конікі, як вядома, – выдатныя скакуны (адсюль і назва), а цвыркуны ж здольнасці скакаць не маюць – проста ходзяць. Саранча, ці, як кажуць яшчэ – кабылкі, хоць і скача таксама, але ў адрозненне ад даўгавусых конікаў мае больш кароткія вусы (удвая карацейшыя за цела). Дарэчы, ненажэрная саранча цалкам не вартая нашага жалю – хай бы ўжо менавіта яе і схрупала «прожорливое брюшко» з песенькі.

Зрэшты, конікі – вусякі драпежныя (ловяць кузурак), хоць не грэбуюць і травой. Кажуць, што могуць і чалавека цапн… мной та…

Цікав… конікі – … ратварэ… няма стадыі кукалкі – лічынкі вельмі падобныя на дарослых конікаў, але меншыя па памерах і без крылаў. Каб стаць дарослымі, яны некалькі разоў ліняюць, а зімуюць у зямлі. Тут дарэчы будзе ўспомніць карціну Сальвадора Далі «Я ва ўзросце 10 гадоў, калі я быў кукалкай коніка». Мусіць, схлусіў Далі. Але праўда тое, што вобраз коніка са сваімі заднімі, такімі «канструктыўнымі» лапкамі-мыліцамі проста пераследаваў геніяльнага іспанца. Дый не толькі яго. Твор рускага паэта-футурыста Веліміра Хлебнікава «Кузнечик» («Крылышкуя золотописьмом тончайших жил…») падаецца мне недасягнутым узорам лірычнай словатворчасці. Агучаны стракатаннем конікаў верш і нашага Багдановіча: «Кажан пранёсся на крылах; Стракочуць конікі ў траве…» Як бачым, вельмі папулярны быў конік менавіта ў мадэрністаў.

А яшчэ па коніку можна разгадваць сны і прадказваць дождж. Звычайна перад даждом яны хаваюць свае скрыпачкі і змаўкаюць… Кажуць, што калі маладзіца сніць коніка, то ёй можа дастацца сварлівы муж ці каханак, а калі ўва сне вы чуеце конікавае стракатанне, то, магчыма, трапіце ў нейкую не зусім прыемную для вас залежнасць ад чужых людзей…

… гэта насамрэч не конік, а марсіянскі разведчык. Гляджу – і праўда, падобны на марсіяніна. Дзецям жа трэба верыць…

Цікава, што яны перадаюць у бязмежны космас пра нашае чалавечае і зямное жыццё…

Is a popular essay on entomology
a credible source? :-)

Зміцер Казакевіч, Народнае Слова, №94 [2268], 15 жніўня 2006 г.

Questions

- What is a stridulation, and how well is it investigated in crickets and other insects? While the crickets rub their wings together, the exact mechanism may be quite different in other species. How are the oscillations generated?
- Nocke has shown that the harp, or the sound-emitting element, in cricket *Gryllus campestris*, is a resonator sharply tuned to 4.5 kHz with a Q-factor of 25. What modes of oscillations are dominant? How are the oscillations excited? What determines the natural frequency (size, shape, thickness, spatial orientation, mechanical properties of a body part? contact area, profile, friction factor?)
- What are the spectra and the time-resolved features of the produced sounds? How reproducible it is the sound? How the properties of the sound may be matched with the actual motion of particular body parts, and with their structure?
- If a particular experimental devise is developed and constructed, how can it be compared with a real insect? What are the parameters and criteria to compare the real and the artificial sounds? Should we aim only at having an appropriate mechanism, or also at having a close or an identical sound?
- What total acoustic energy is produced by a cricket? Why the singing of the crickets appears quite a loud?
- What parameters describe the sound produced by the cricket? Which of them are “physical” and which are “subjective”? (timber? pleasantness? tone color? volume? pitch?)
- It seems to be reasonable to record the sound produced by the real insects. It is possible to locate them in the field? Would they produce the same sound in captivity? What should be the requirements for the sound-recording equipment?
- Is there a room for theoretical investigation and/or modeling?
- What new we can add to this profoundly researched problem, besides building a device with tooth-scraper contacts and a membrane?

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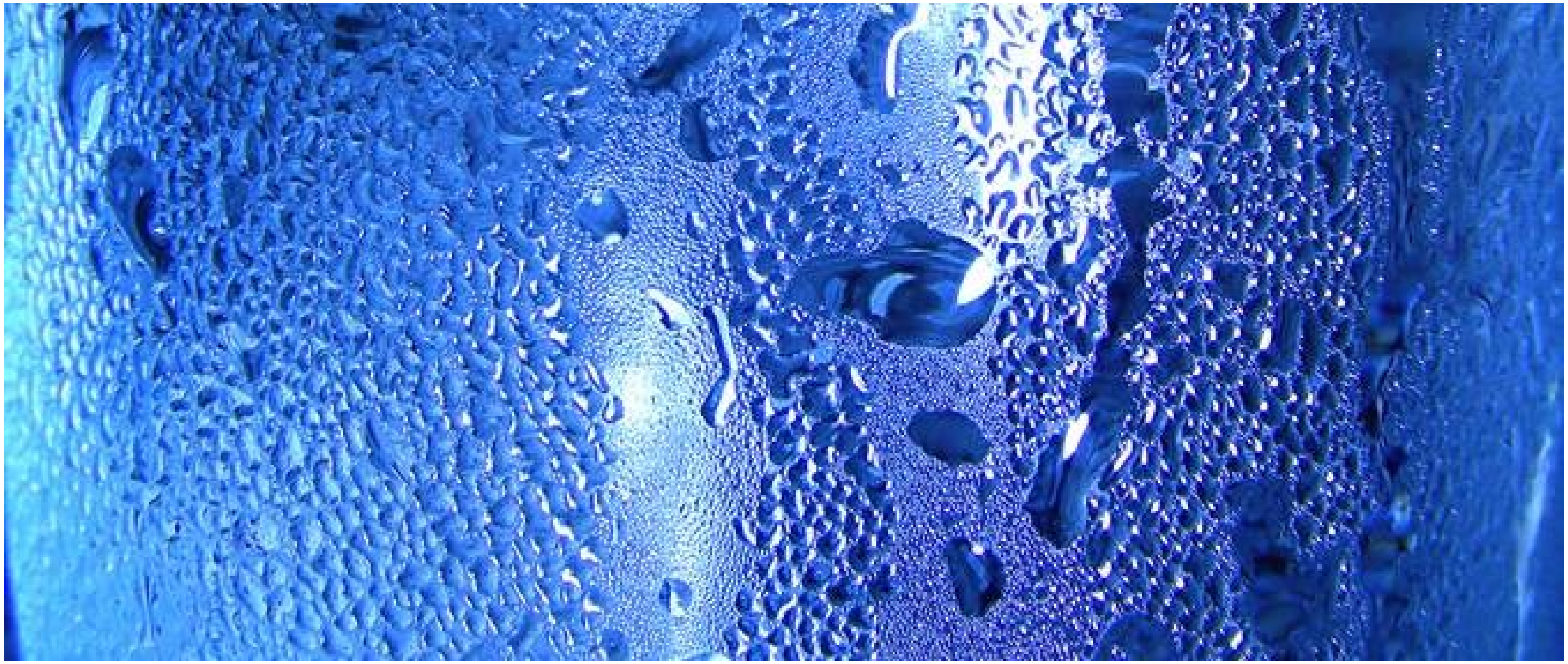
Problem No. 8 “Condensation”



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.

Questions

- How to define “condensation”? Is it a first-order, or second-order phase transition? What happens to entropy of the system during a condensation?
- What is the temperature dependence for maximum density of water vapor? How to measure or derive such a dependence?
- What is common and what is different between natural due formation in the mornings and our problem?
- Is the condensation possible on an ideally smooth glass?
- Is the molecular mean free path relevant to the average distance between droplets at the beginning of condensation? What are the values for mean free path in saturated and oversaturated vapor?
- What determines the shape of droplets? At what visible radius a droplet can be considered a spherical segment? Is there a way to directly measure the exact 3D shape of droplets?
- If volume is fixed, what has a larger surface area, a single large drop or multiple small droplets? What about the mass?
- How to maintain and measure the water temperature?
- Are the air flows around the glass relevant? Is condensation possible at zero air flows? Is it possible that condensation stops under certain air flow speed?
- Is the curvature of the glass relevant?
- Why droplets do not immediately slide downwards?
- What is the role of the contact angle for the surface?
- Does the observed condensation initially lead to individual droplets (droplet condensation) or thin film (film condensation)? What is the difference between them? Under what contact angles the droplet condensation becomes a film one?

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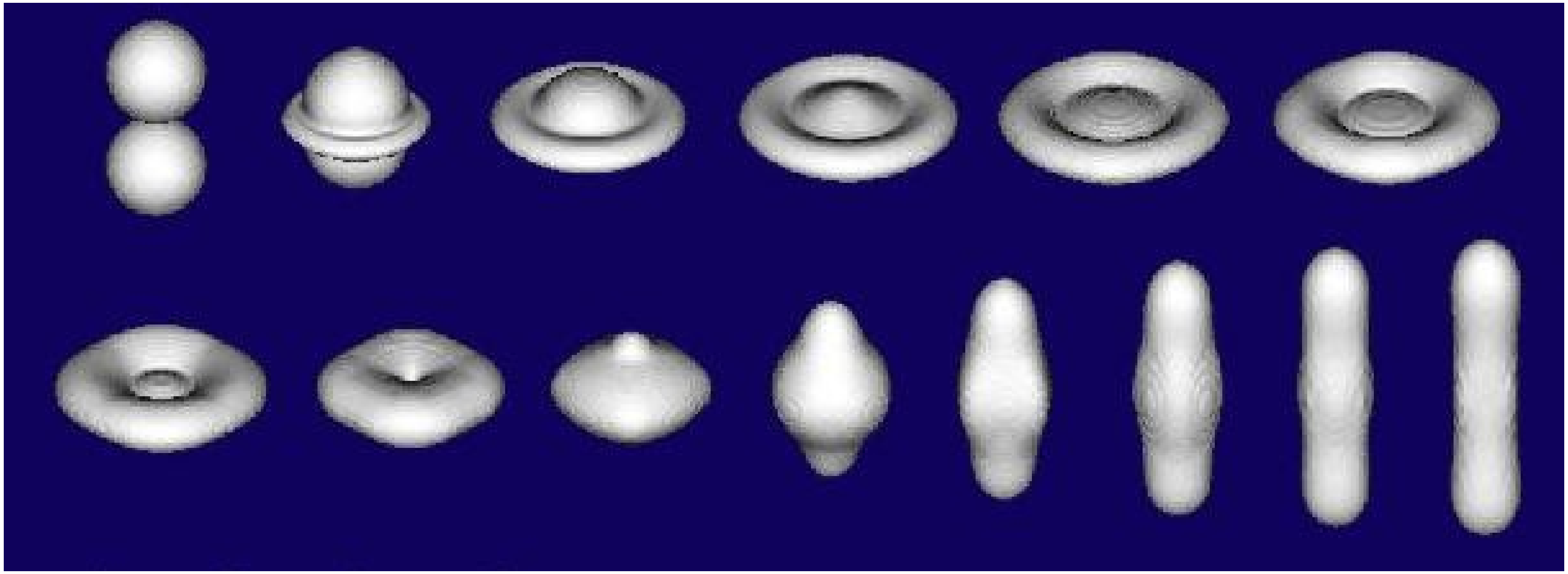
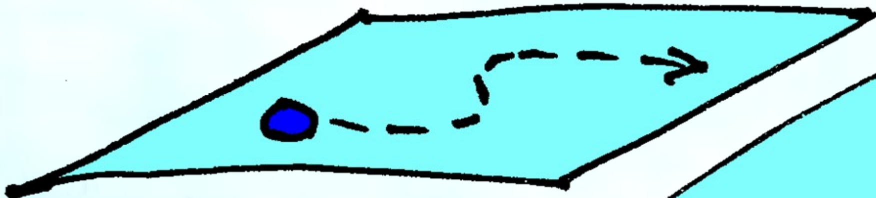
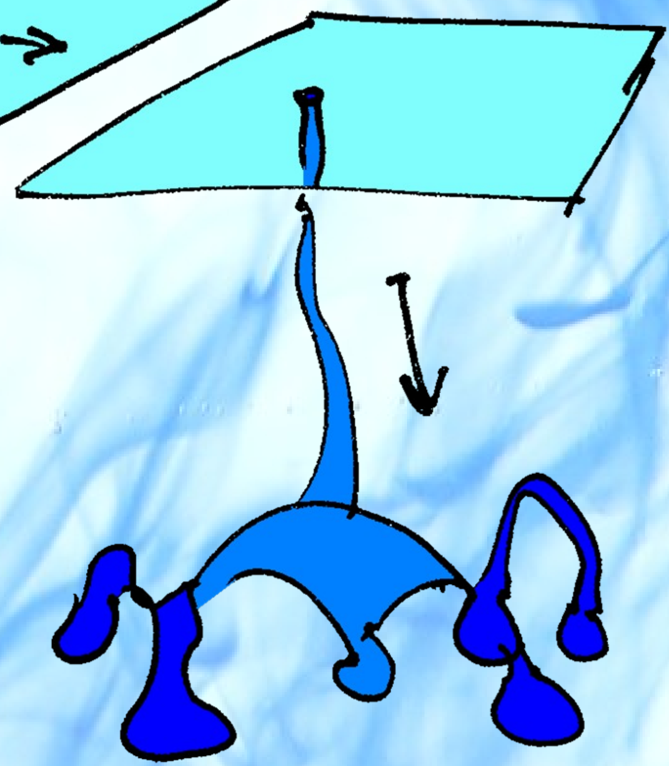
Problem No. 9 “Ink droplet”



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

Where does the droplet move to?





- On the surface?
- Similar to camphor on water?
- Ink is not easily miscible?
- Interfacial tension gradient?

- Down the surface?
- Vortex rings and fragmentation?
- Ink is easily miscible?
- Similar to miscible Rayleigh-Taylor instability?

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MOUVEMENTS SPONTANÉS

DE CERTAINS CORPS A LA SURFACE DE QUELQUES LIQUIDES

Le camphre, diverses substances solides odorantes, les corps poreux imbibés de liquides volatils, offrent à la surface de l'eau des mouvements singuliers de rotation et de translation, qui ont beaucoup préoccupé le monde savant dans la première moitié du siècle. On a voulu les attribuer tantôt à l'électricité, et tantôt à de simples phénomènes mécaniques de recul produits par le dégagement des vapeurs ou de parties fluides émanées du corps et venant frapper l'air ou l'eau; mais aucune solution définitive, aucune explication claire et satisfaisante n'a été donnée pour ces phénomènes.

Dutrochet, l'illustre auteur de la découverte de l'endosmose, après des études malheureusement entachées de graves erreurs à leur début (1841), mais aussi appuyées à la fin (1843) sur des expériences d'une haute valeur, ne trouva rien d'autre, pour expliquer les mouvements qui nous occupent, que l'existence hypothétique d'une force inconnue, apparaissant à la surface de séparation de deux liquides quelconques et qu'il nomma force épipolique (ἐπιπολῆ, surface). Cette notion d'une nouvelle force quelconque est aussi le siège d'une force qui agit exactement comme si la masse liquide se terminait par une membrane très mince, élastique et tendue. On a reconnu que c'est à cette force que sont dus les phénomènes de la capillarité et peut-être bien d'autres moins connus; disons même, pour terminer ces notions succinctes, que cette *tension superficielle* des liquides n'est très probablement qu'un cas particulier de l'attraction qui s'exerce entre tous les corps.

Nous savons donc qu'il existe constamment à la surface de tous les liquides une force parfois puissante dans ses effets. Mais il e[...] que l'intensité de cette force c[...] du liquide considéré; on le re[...] un même tube capillaire dans [...] voit ceux-ci monter à des niv[...] Il suffit même de répandre une [...] liquide quelconque sur l'eau po[...] superficielle; presque toujours [...] une diminution, à cause de la t[...] l'eau à sa surface, supérieur[...] tous les autres liquides.

C'est guidé par ces notions th[...] de construire le petit jouet s[...] sur la figure (fig. 1). C'est un bateau taillé avec des

Reading (vortex rings, miscible instabilities)

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Reading (vortex rings, miscible instabilities)

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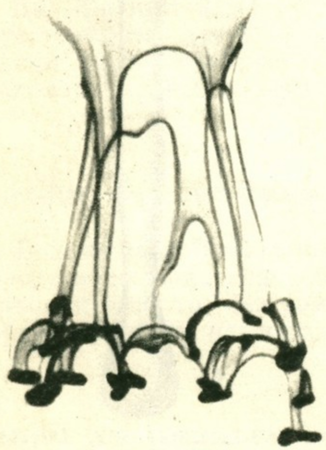
НЕВЕДОМОЕ РЯДОМ



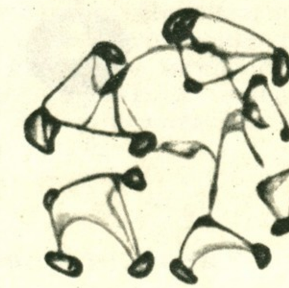
7

КАПЛЯ ВОДЫ, УПАВШАЯ В ВОДУ

Это изящное и загадочное явление каждый из вас может увидеть сам. Для этого нужно очень осторожно уронить подкрашенную каплю с высоты 1—2 *см* в прозрачную банку с водой, которая перед опытом простояла несколько часов вдали от источников тепла, и в ней прекратилось конвекционное движение.

На этих фотографиях, сделанных специально для Детской энциклопедии, показано, что происходит с каплей. Капля (*1*), упав с кончика пипетки в воду, превращается в вихревое кольцо (*2*). Оно расширяется, и в нем возникают утолщения (*3*). Постепенно они развиваются во вторичные вихревые колечки (*4*, *5*, *6*). Процесс повторяется, и число колечек быстро растет (*7*, *8*, *9*, *10*). В такую сложную систему вихревых потоков капля превращается всего за несколько минут.

В правом ряду фотографий процесс снят сверху, в левом — сбоку. Это удивительное явление еще почти неизвестно и неизучено. Может быть, кто-либо из читателей исследует его и откроет законы, которые им управляют? Кто знает, к каким последствиям это приведет в будущем.



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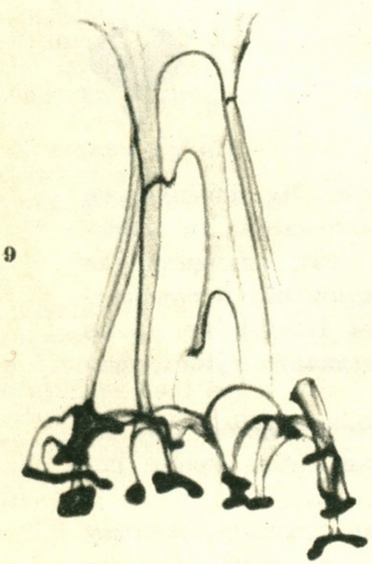

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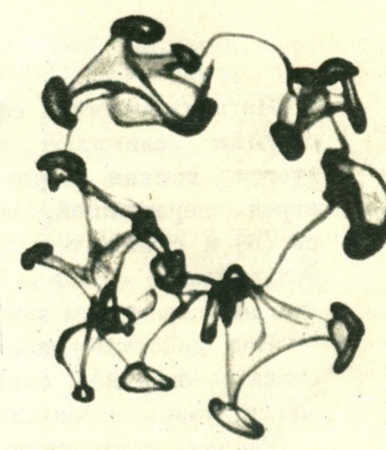
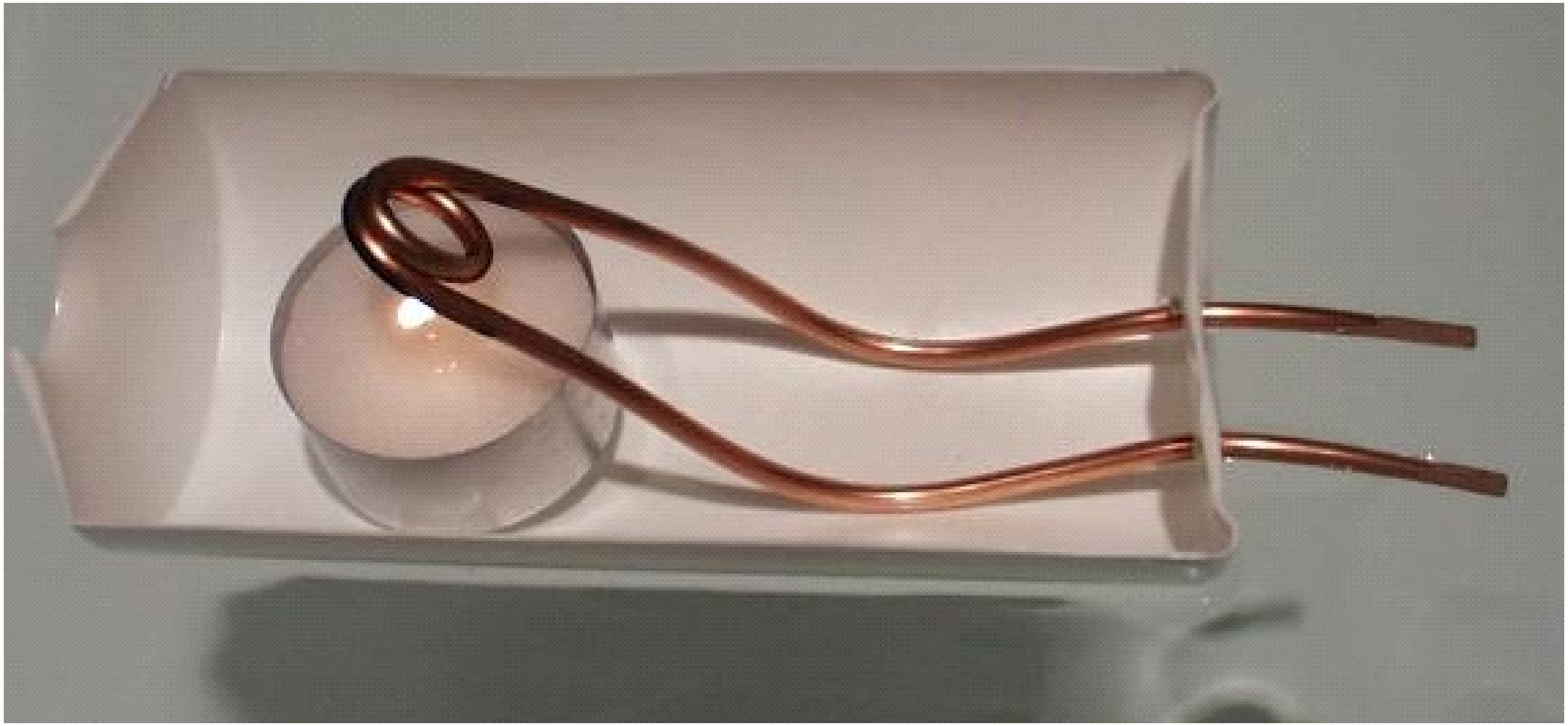


10

Problem No. 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.

Physics in a Toy Boat

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AND
R. L. CURL
University College, London, England

(Received 22 August 1962; in final form 19 December 1962)

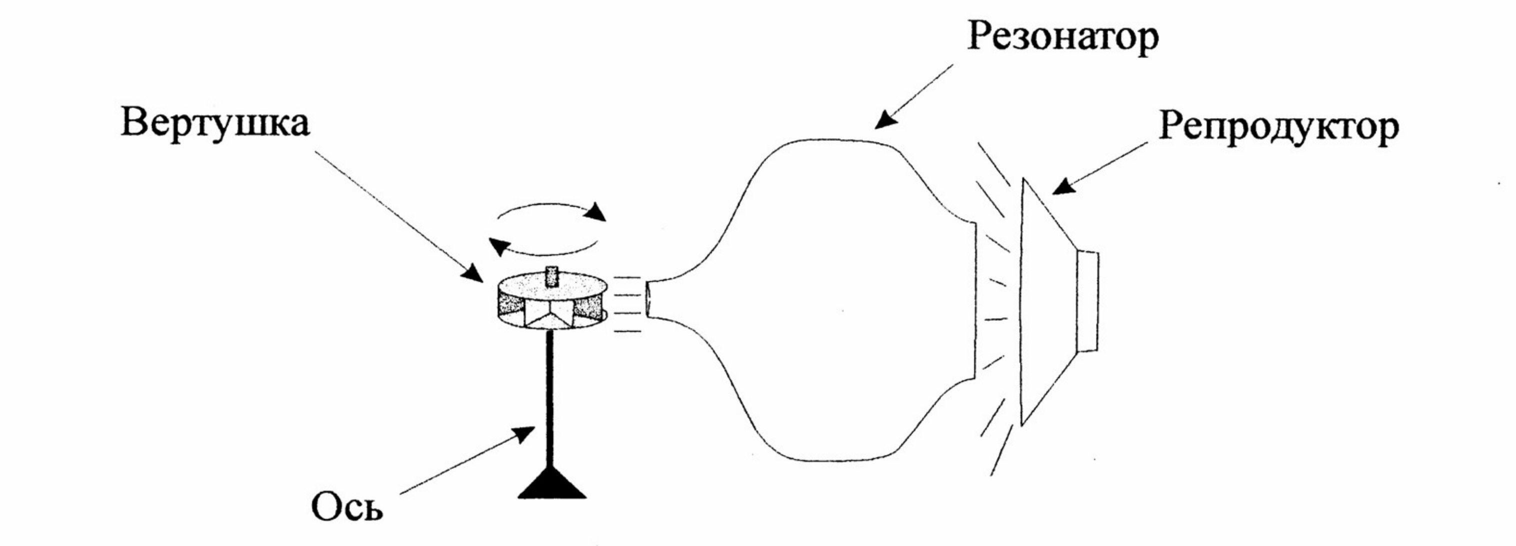
A method of propulsion commonly used in toy boats consists of a shallow chamber, covered by a thin diaphragm, which is connected to the water astern of the boat by pipes. Filling the chamber with water and then heating it's base leads to vigorous self-induced vibration of the diaphragm and water column in the pipes with resulting forward motion of the boat. The paper describes the mechanisms of self-induced vibration and of propulsion. It is shown that this inexpensive toy demonstrates a number of physical principles and provides opportunities for further research.

THERE is a child's toy known as the putt-putt boat, which demonstrates a remarkable number of physical principles. For the benefit of those who have not experimented with such a boat, its operation may be described with respect to Fig. 1. A thin diaphragm E covers a shallow chamber A. From the base of the chamber, a pipe, or usually two pipes, lead to the rear of the boat at C. If the chamber and pipes

sion, while the second is a more complete discussion in which some of the conclusions are similar to those obtained independently in reference 2. Despite the amount of attention this small boat has received, none of the references appear to be suitable for an elementary, yet fairly complete, explanation of the boat's main features. The present article is an attempt to supply this information.

As a starting point, it is best to refer to an

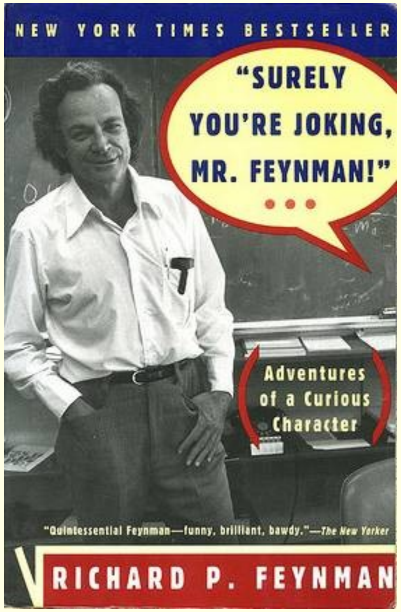
IYPT history

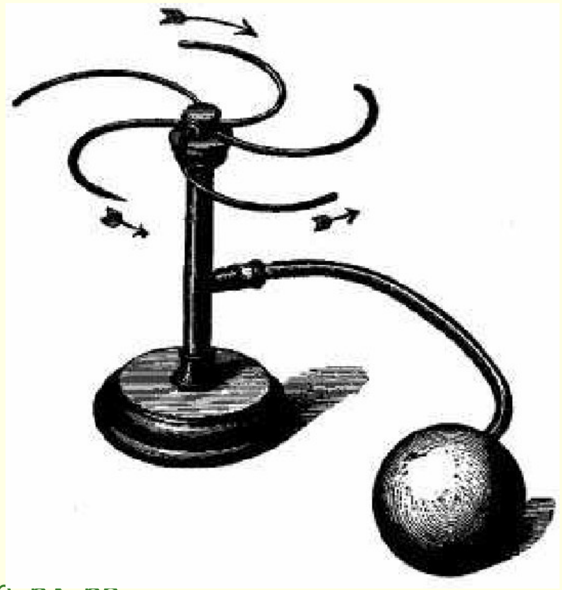


- Problem No. 10 “Sound cart” (IYPT 2002)
- Construct and demonstrate a device that can be propelled solely by sound. Investigate its properties.

- There was a problem in a hydrodynamics book that was being discussed by all the physics students.
- The problem is this: You have an S-shaped lawn sprinkler - an S-shaped pipe on a pivot - and the water squirts out at right angles to the axis and makes it spin in a certain direction. Everybody knows which way it goes around; it backs away from the outgoing water.
- Now the question is this: If you had a lake, or swimming pool - a big supply of water - and you put the sprinkler completely under water, and sucked the water in, instead of squirting it out, which way would it turn? Would it turn the same way as it does when you squirt water out into the air, or would it turn the other way?
- The answer is perfectly clear at first sight.
- The trouble was, some guy would think it was perfectly clear one way, and another guy would think it was perfectly clear the other way.
- So everybody was discussing it.

- I remember at one particular seminar, or tea, somebody went nip to Prof John Wheeler and said, "Which way do *you* think it goes around?"
- Wheeler said, "Yesterday, Feynman convinced me that it went backwards. Today, he's convinced me equally well that it goes around the other way. I don't know *what* he'll convince me of tomorrow!"





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Problem No. 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.

Studying the effects of a centrifugal force on a body balanced on water surface

Turns are the most fun and challenging parts of the run for a beginner. I don't have the physics formulas handy, but basically the speed drops to almost zero and then picks up drastically. Besides, you are forced to go over the wake, which always adds to the excitement.

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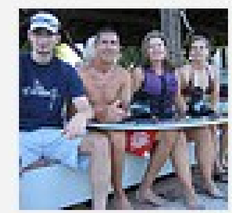
This photo also

Water Spor
Linda (Set)



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Tags

waterskiing

Additional Infor

The physics of stone skipping

Lydéric Bocquet
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(Received 11 March 2002; accepted 16 September 2002)

The motion of a stone skimming over a water surface is considered. A simp
collisional process of the stone with water is proposed. The maximum
estimated by considering both the slowing down of the stone and its angular
for a successful throw are discussed.
[DOI: 10.1119/1.1519232]

I. INTRODUCTION

Nearly everyone has tried to throw a stone on a lake and count the number of bounces the stone was able to make. Of course the more, the better.[1] Our intuition gives us some empirical rules for the best throw: the best stones are flat and rather circular; one has to throw them rather fast and with a small angle with the water surface; a small kick is given with a finger to give the stone a spin. Of course these rules can be

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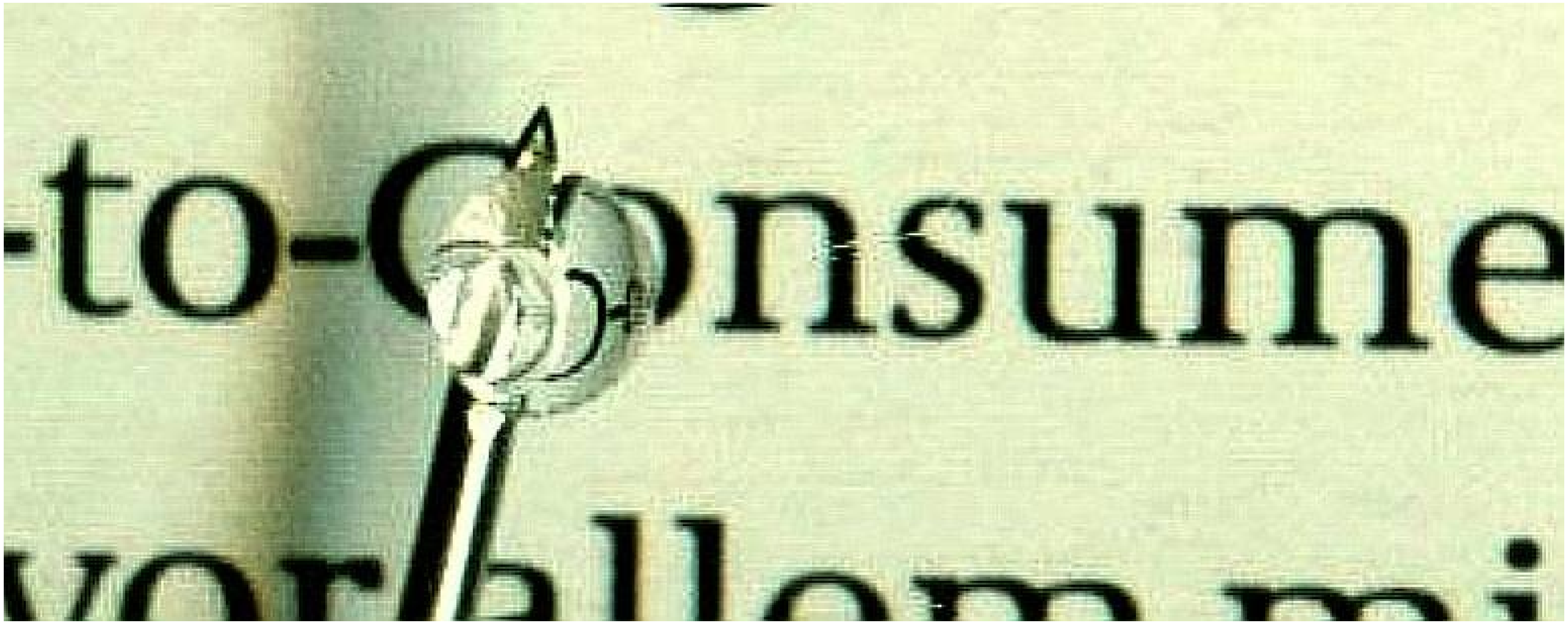
Problem No. 12 “Liquid lens”



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

How to obtain high-quality imagery?

- What methods can be used to record the refractions in a lens?

Questions

- Can possible designs of such a lens be classified into types? Are they thick or thin lenses?
- What shape has the lens in each case, depending on relevant parameters? How to describe this shape mathematically?
- How is it possible to control the shape of the lens? (charge a droplet? pump water? contain the droplet with a movable diaphragm? rotate the liquid mass? …?)
- Is it possible to describe theoretically the light refraction in the lens, using the information on shape and the Snell's law? What are the optical parameters of the lens? Is it correct to speak e.g. of a focus distance?
- What is a caustic and a catastrophe in optics? Are they relevant to the problem? Does the system allow approaching wave effects, such as interference or diffraction?
- What are the parameters describing features and quality of any lens?
- How such a lens can be used? (assemble a CCD camera? observe Newton's rings? study rainbows? …?)

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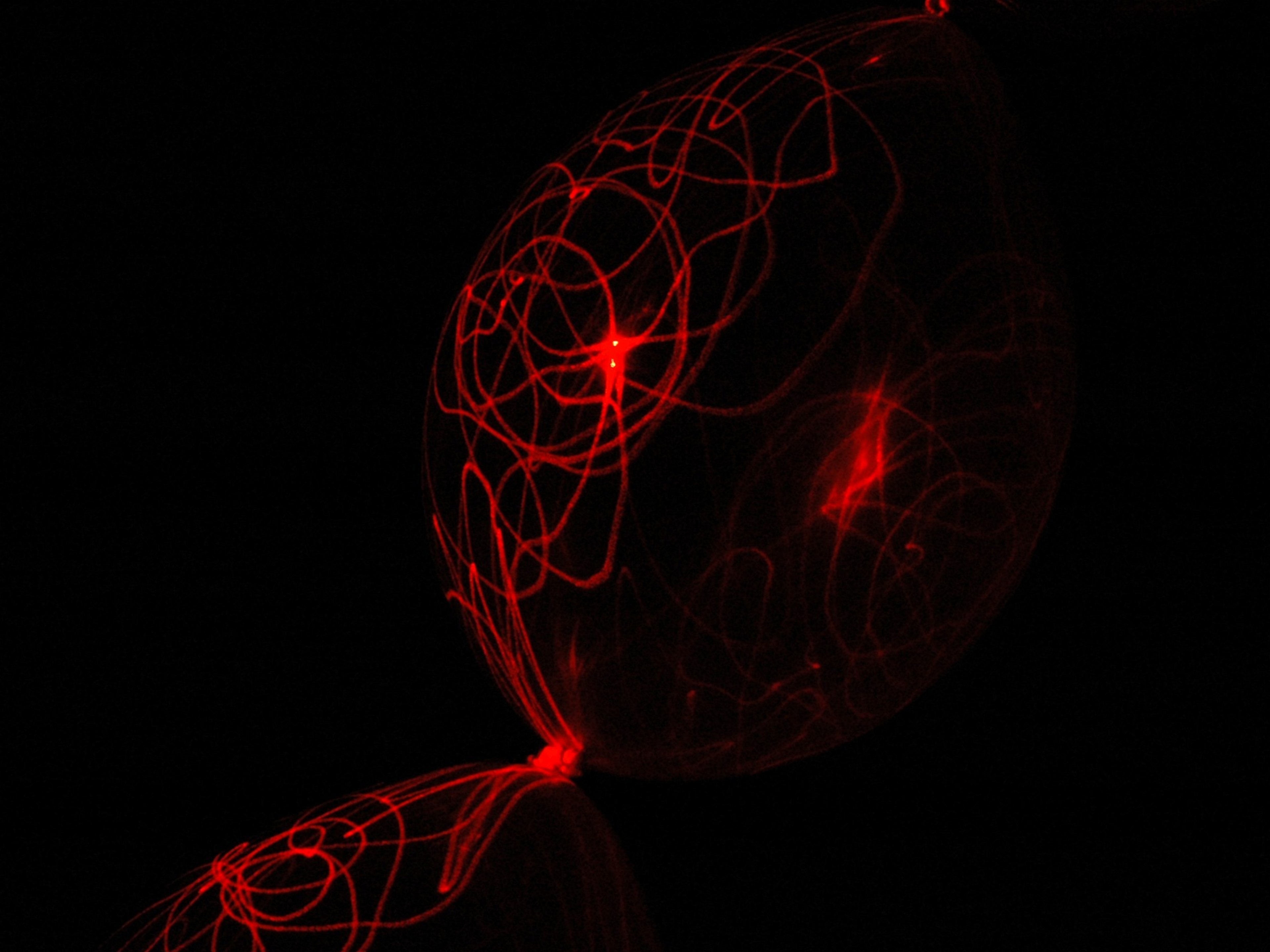
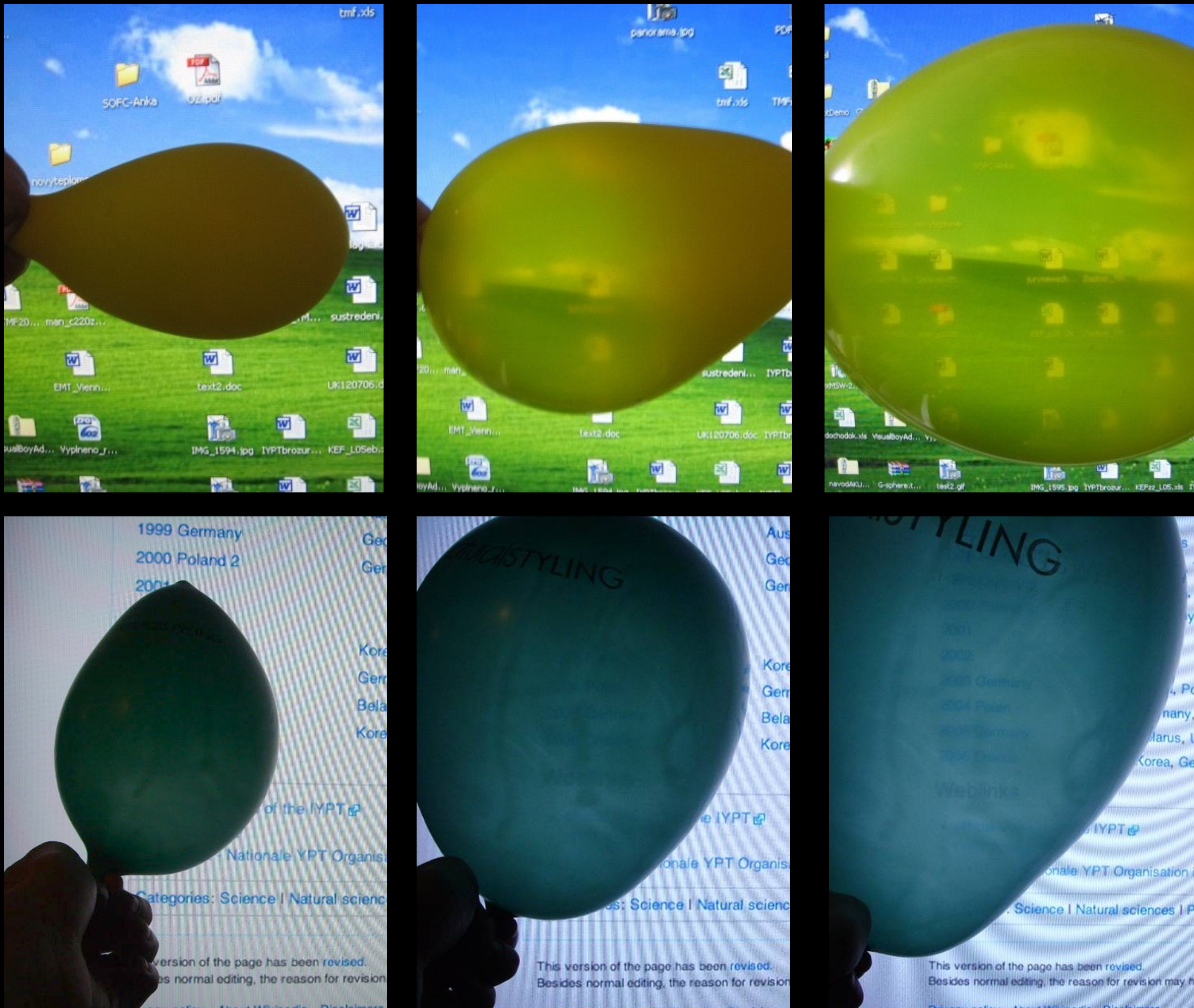
Problem No. 13 “Balloon”

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

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Questions

- What physical effects may be relevant to describe the change of optical properties of the balloon:
  - light polarization?
  - light absorption?
  - light scattering?
- What is the transmitted, reflected, and scattered light intensity as a function of deformation? As a function of optical path length? As a function of anisotropy? As a function of incident light polarization?
- What are the key optical properties of rubber films?

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Problem No. 14 “Earthquake”

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


[Andrei Selivanov 2007]

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Problem No. 15 “Blowpipe”

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

International Journal of Pediatric Otorhinolaryngology (2007) 71, 307—310

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International Journal of Pediatric Otorhinolaryngology

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Choking on pins, needles and a blowdart: Aspiration of sharp, metallic foreign bodies secondary to careless behavior in seven adolescents☆

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The other boy (age 15 years) had been playing with friends, taking turns propelling a homemade blowdart (Fig. 1) through plastic tubing. He accidentally inspired the blowdart to his carina, then, while in transfer from another hospital, coughed the dart up to his larynx (Fig. 2).

Questions

- The projectile is not an ideal piston, and the compressed air is likely to leak through the gap between the tube and the projectile. How to characterize these leaks and their influence on the motion of the projectile?
- What are the natural limitations of the human lungs in achieving the maximum compression in the tube, in controlling the compression over time, and in other relevant parameters? What of these parameters can be measured, e.g. the minimum discharge time, total volume of the air in the lungs, or skills to control air flow?
- How does the effective compression depend on the diameter or length of the tube? What is the time dependence of the air pressure inside the tube as the projectile moves ahead, but some new air is blown in at the same time?
- What strategy of blowing air inside the tube should be chosen to achieve the optimum acceleration of the projectile? (blowing first faster, then slower? first slower, then faster? the optimum timeline for changing the intensity? at what moment to apply the maximum intensity?)
- What is the overall lag time between creating a compression and the shot?
- What parameters of the tube (diameter? length? surface properties?) may be controlled?
- What parameters of the projectile (mass? shape?) may be controlled? What material is best for the projectiles, and what aerodynamic properties should it have?
- What is the role of the friction between the projectile and the tube surface, and the air resistance?
- Would it be difficult to develop a theory including all relevant parameters as tunable variables? Is it worth modeling the system numerically?
- How to best measure the speed of the projectile at different points (with a ballistic pendulum? a high-speed camera? an induction coil?) At what degree the exit speed is reproduced, if the experiment is repeated?
- Overall, what is your conclusion on the problem? What parameters need to be tuned to maximize the exit speed? What are the optimum time dependences for achieving this speed?

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Problem No. 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.

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Problem No. 17 “Ice bulge”

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

Peculiar Ice Formations.

By Herbert Grove Dorsey.

The first of these formations of ice occurred on the night of December 15, 1916. The night was clear and calm and some water had been left in a pan placed on a chair on a small uncovered porch. The temperature the following morning was 22° Fahrenheit.

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The pan was an ordinary tin coated iron pan, 17 inches in diameter at the top, 12 inches at the bottom and six inches deep. About one inch of unboiled hydrant water was in the pan, and when it froze a thin irregular column of ice was formed near the side of the pan next to the back of the chair.

Fig. 1 shows a front view of the formation, Fig. 2 a side view of it and Fig. 3 is a larger photograph to show the details. The photographic dark slide was placed back of it to give contrast. The steel scale was in the plane of the edge of the ice column and melted the ice so that it was resting on the bottom. It appears nearer than the column because the ice is melted in front of the scale.

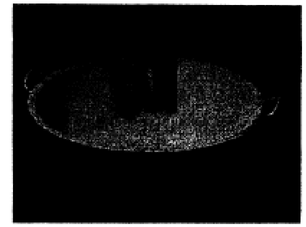

Fig. 1.

Fig. 2.

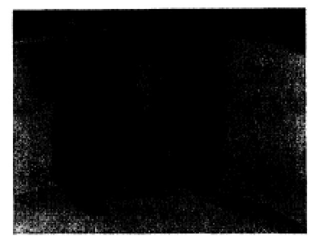

Fig. 3.

Fig. 4.

The maximum height of the ice column was four and one half inches and the breadth at the bottom was three inches, narrowing irregularly to one and three eighths inches near the middle and to one inch at the top. The average thickness was about one half inch, and instead of being vertical it leaned towards the center of the pan. It will be noticed that while the air bubbles in the pan were in vertical lines, they arose near the middle of the column and then separated out laterally into almost horizontal lines. Near the top the air bubbles were grouped together so closely that it gave the appearance of white ice or snow; the rest of the ice in the pan and in the formation was transparent except for the bubbles.

Water had been frozen in this same pan several nights previously and after the unusual formation occurred, it was tried under nearly similar conditions many times that winter and the following winter, but the only approach to

anything so unusual occurred four nights later in a small wooden chopping bowl about ten inches in diameter. As shown in Fig. 4 the formation in this case was almost egg-shaped, the maximum length of the egg being seven eighths of an inch. The bowl was cracked when this occurred.

Gloucester, Mass.,
April 1, 1921.

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- Occasionally the ice cubes in my freezer's ice trays will develop a stalagmitelike shape without any obvious, unusual interference. Can you please explain what causes this? Sci. Am. (April 30, 2007), http://www.scientificamerican.com/article.cfm?id=experts-ice-spikes

Questions

- Is the problem about formation of a curved ice surface in the vessel (“low hill”), or thin and high “ice spike”?
- What parameters of the system influence the water freezing process:
  - ambient temperature in the refrigerator vs initial water temperature, heat flux, presence of airflows, and the cooling rate overall?
  - purity of water, and its properties such as heat conductivity, density and specific heat capacity?
  - linear dimensions and material of the vessel?
- How to directly observe the freezing process? (place a camera into the refrigerator?) What key effect are visible?
- Are supercooling effects of any relevance?
- What is the reproducibility of results, if the experiment is repeated? Is it possible to approach statistically the size distributions of “ice bulges”?

* * *

…I wish you were aware from what stray matter
Springs poetry to prosper without shame,
Like dandelions which the children scatter
Or pigweed of the lowly name.

An angry shout, the molten tar’s hot stinging,
A magic growth of mould upon a wall...
And straightaway the verse is gaily ringing
To gladden one and all.

Anna Akhmatova, *The Secrets of Craft*

21 January, 1940
Translated by Peter Tempest

Анна Ахматова. Стихотворения.
На англ. яз. с параллельными
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1988. Стр. 151, 153


Задача №1 «Нить накаливания»

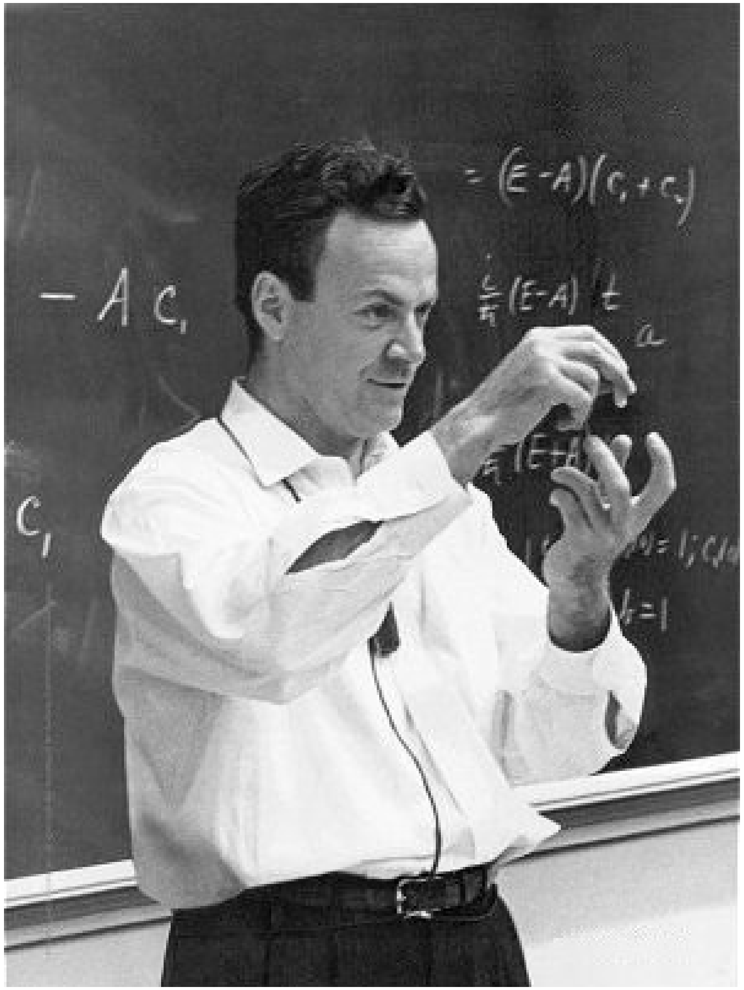
To work towards results?

- Nobody needs an infinitely perfect report in an infinite time!

- If you cannot solve the entire problem, decide what is really necessary and solve a partial problem
- If you can solve the entire problem, nevertheless decide what partial case is sufficient, and your solution will be much better
- Be brave in what you do, but always reserve a great degree of scientific skepticism!

Feynman: being self-confident?

- I've very often made mistakes in my physics by thinking the theory isn't as good as it really is, thinking that there are lots of complications that are going to spoil it
- - an attitude that anything can happen, in spite of what you're pretty sure should happen.



R. P. Feynman. *Surely You're Joking, Mr. Feynman* (Norton, New York, NY, 1985)

These problems have no solution?

- “But, my dear fellows,” said Feodor Simeonovich, having deciphered the handwriting. “This is Ben Beczalel's problem! Didn't Cagliostro prove that it had no solution?”
- “We know that it has no solution, too,” said Junta. “But we wish to learn how to solve it.”
- “How strangely you reason, Cristo… How can you look for a solution, where it does not exist? It's some sort of nonsense.”
- “Excuse me, Feodor, but it's you who are reasoning strangely. It's nonsense to look for a solution if it already exists. We are talking about how to deal with a problem that has no solution. This is a question of profound principle…”

Arkady Strugatsky and Boris Strugatsky

Quote from: Arkady Strugatsky and Boris Strugatsky. *Monday Begins on Saturday.* Translated from the Russian. (The Young Guard Publishing House, Moscow, 1966)

The best physicist is Yakov Frenkel, who uses only quadratic equations in his papers. I am slightly worse, because I need ordinary differential equations. Fock, however, always needs partial differential equations.

A quote attributed to Lev Landau

Preparation to the Young Physicists' Tournaments' 2007:

ideas on the problems and advices

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