

Preparation to the Young Physicists' Tournaments' 2013

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How to tackle the IYPT problems?

- How to structure a report?
- What level is competitive?
- How to set the goals, fix the priorities, and set the direction of the work?
- How were people resolving particular issues in the past?

- Look through the historical solutions in the Archive :-)
  - an opportunity for goal-oriented critical learning
  - examples, not guidelines
  - those solutions were good, but yours should become better!

iypt archive mc^2 hv

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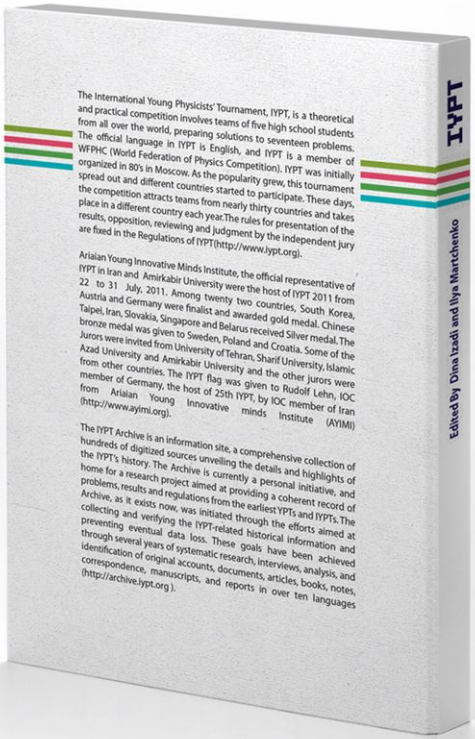
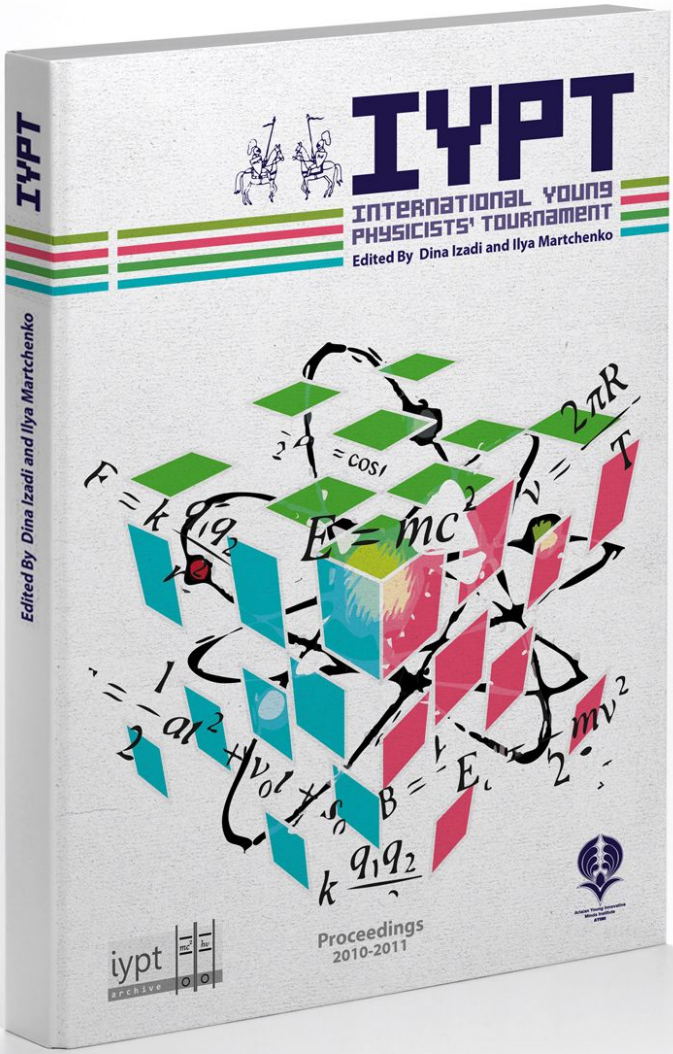




- the first IYPT-themed book where all articles underwent rigorous peer review
- 98 reviews from 25 reviewers
- 32 papers selected
- revisions, resubmissions before getting accepted

Call for cooperation

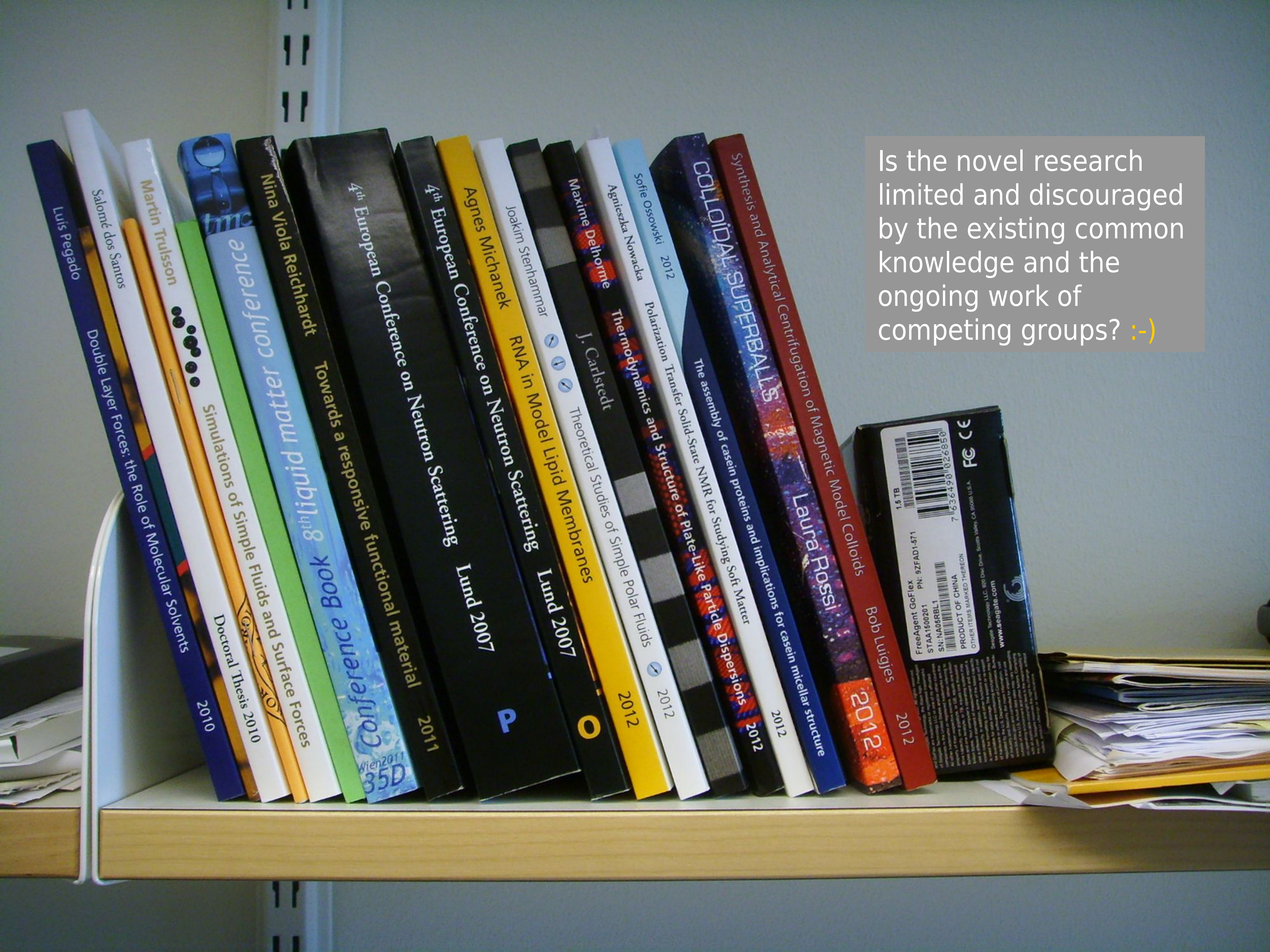
- If you are interested in the idea behind the Kit — to structure some earlier knowledge about the physics behind the problems and to encourage students to contrast their personal contribution from this knowledge — your cooperation is welcome
- If more contributors join the work on the Kit for 2013, or plan bringing together the Kit for 2014, good editions may be completed earlier
- It would be of benefit for everybody,
  - students and team leaders, who would have an early reference (providing a first impetus to the work) and a strong warning that IYPT is all about appropriate, novel research, and not about “re-inventing the wheel”
  - jurors, who would have a brief, informal supporting material, possibly making them more skeptical and objective about the presentations
  - the audience outside the IYPT, who benefits from the structured references in e.g. physics popularization activities and physics teaching
  - the IYPT, as a community and a center of competence, that generates vibrant, state-of-the-art research problems, widely used in other activities and at other events
  - and also the author(s) of the Kit, who could rapidly acquire a competence for the future activities and have a great learning experience

“Key questions”: status update

- Following the discussions at the IYPT 2012, we are now deciding on whether to discontinue the “Key questions” section in the Reference Kit. We are not including this section into the First Day Draft.

- **Benefits**
- Students, including newcomers, are implicitly encouraged to start work and to dig deeper :-)
- Jurors may use the “Key questions” as brief and informal reference :-)
- The standards are improved in an open-ended, delicate manner, without any “guidelines” or “expectations” for the teams :-)

- **Objections**
- “Key questions” may be getting less necessary: e.g. all IYPT 2012 finalists perfectly contrasted their contribution against existing knowledge and articulated their vision :-)
- A few jurors *may* feel that the “Key questions” are *binding* or *mandatory*, despite their open-ended nature :-(
- A few teams *may* unconsciously rely on the “Key questions” when working on their own oppositions and reviews, which would contradict the basic aims of our project :-(



Is the novel research limited and discouraged by the existing common knowledge and the ongoing work of competing groups? :-)

Important information

- The basic goal of this Kit is not in providing students with a start-to-finish manual or in limiting their creativity, but in encouraging them to
  - regard their work critically,
  - look deeper,
  - have a better background knowledge,
  - be skeptical in embedding their projects into the standards of professional research,
  - and, as of a first priority, be attentive in not “re-inventing the wheel”
- An early exposure to the culture of scientific citations, and developing a responsible attitude toward making own work truly novel and original, is assumed to be a helpful learning experience in developing necessary standards and attitudes
- Good examples are known when the Kit has been used as a concise supporting material for jurors and the external community; the benefits were in having the common knowledge structured and better visible
- Even if linked from iypt.org, this file is not an official, binding release of the IYPT, and should under no circumstances be considered as a collection of authoritative “musts” or “instructions” for whatever competition
- Serious conclusions will be drawn, up to discontinuing the project in its current form, if systematic misuse of the Kit is detected, such as explicit failure of citing properly, replacing own research with a compilation, or interpreting the Kit itself as a binding “user guide”
- All suggestions, feedback, and criticism about the Kit are warmly appreciated :-)

Habits and customs

- Originality and independence of your work is always considered as of a first priority
- There is no “correct answer” to any of the IYPT problems
- Having a deep background knowledge about earlier work in a given field may certainly be a plus
- Taking ideas without citing will seemingly be a serious misconduct
- Critically distinguishing between personal contribution and common knowledge is likely to be appreciated
- Reading more in a non-native language may be very helpful
- Local libraries and institutions can always help in getting access to paid articles in journals, books and databases
- Is IYPT all about reinventing the wheel, or innovating, creating, discovering, and being able to contrast own work with earlier knowledge and the achievements of others?
- Is IYPT all about competing, or about developing professional personal standards?

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)

Requirements for a successful IYPT report

- A novel research, not a survey or a compilation of known facts
- A balance between experimental investigation and theoretical analysis
- A comprehensible, logical and interesting presentation, not a detailed description of everything-you-have-performed-and-thought-about
- A clear understanding of the validity of your experiments, and how exactly you analyzed the obtained data
- A clear understanding of what physical model is used, and why it is considered appropriate
- A clear understanding of what your theory relies upon, and in what limits it may be applied
- Comparison of your theory with your experiments
- Clear conclusions and clear answers to the raised questions, especially those in the task
- A clear understanding of what is your novel contribution, in comparison to previous studies
- Solid knowledge of relevant physics
- Proofread nice-looking slides
- An unexpected trick, such as a demonstration *in situ*, will always be a plus

The jury would like to understand...

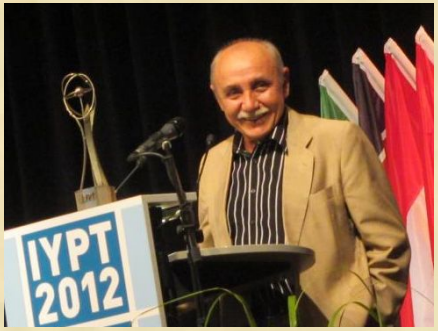
- What did you actually do?
- Why did you do it?
- How well did you do it?
- Were you able to voice important questions and provide grounded answers?
- What was your major contribution to the understanding of the phenomenon?
- Can you judge the achievements and limits of your work in an objective, skeptical and self-confident manner?
- Are you proficient in relevant physics concepts?
- Were you a self starter?
- Could you be left unsupervised?


Don't Drink and Derive
$E = mc^3$

There are more things in heauen and earth *Horatio*
Then are dream't of in your philoſophie

Shakeſpeare. *

* The epigraph for the problems selected by the IYPT Founder Evgeny Yunosov on July 4, 2012



Problem No. 1 “Invent yourself”

It is more difficult to bend a paper sheet, if it is folded “accordion style” or rolled into a tube. Using a single A4 sheet and a small amount of glue, if required, construct a bridge spanning a gap of 280 mm. Introduce parameters to describe the strength of your bridge, and optimise some or all of them.

Background reading

- Bill Gaughran. Folded plates and shell (Structural Forms and Concepts Website University of Limerick), http://www3.ul.ie/~gaughran/Gildea/page10.htm, http://www3.ul.ie/~gaughran/Gildea/indexmain.htm
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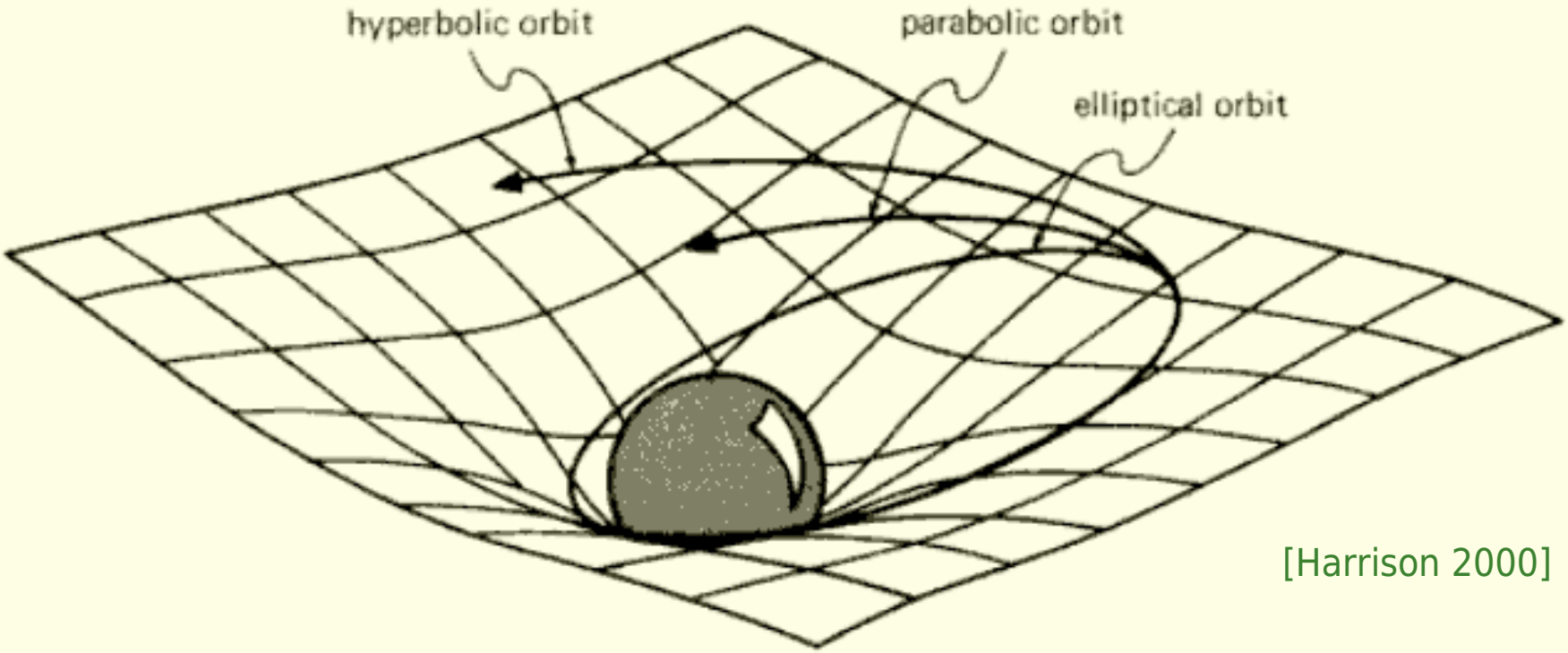
Problem No. 2 “Elastic space”

The dynamics and apparent interactions of massive balls rolling on a stretched horizontal membrane are often used to illustrate gravitation. Investigate the system further. Is it possible to define and measure the apparent “gravitational constant” in such a “world”?

also in all conceivable physical experiments in every branch of science. Hence, special relativity, and not just Newtonian mechanics, may be used in free-falling systems as well as in inertial systems, and this is the

from a star. Close to the cent curvature of the surface is larg bearing in motion on the surfac in a way analogous to the acce body in the vicinity of a star



[Harrison 2000]

Figure 12.7. A horizontal, stretched rubber sheet is depressed by a heavy spherical body. The curvature of the sheet mimics the effect of gravity, and a ball bearing follows an orbit that is either elliptical, parabolic, or hyperbolic.

Background reading

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- Geometry and gravity. In: Edward Robert Harrison. Cosmology: The Science of the Universe (Cambridge University Press, 2000), pp. 224-225, http://books.google.se/books?id=kNxeHD2cbLYC
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- Gravity: Space as a Rubber Sheet (G. Kunstatter, Univ. of Winnipeg, April 2002), http://theory.uwinnipeg.ca/users/gabor/black_holes/slide5.html
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Problem No. 3 “Bouncing ball”

If you hold a Ping-Pong ball above the ground and release it, it bounces. The nature of the collision changes if the ball contains liquid. Investigate how the nature of the collision depends on amount of liquid inside the ball and other relevant parameters.

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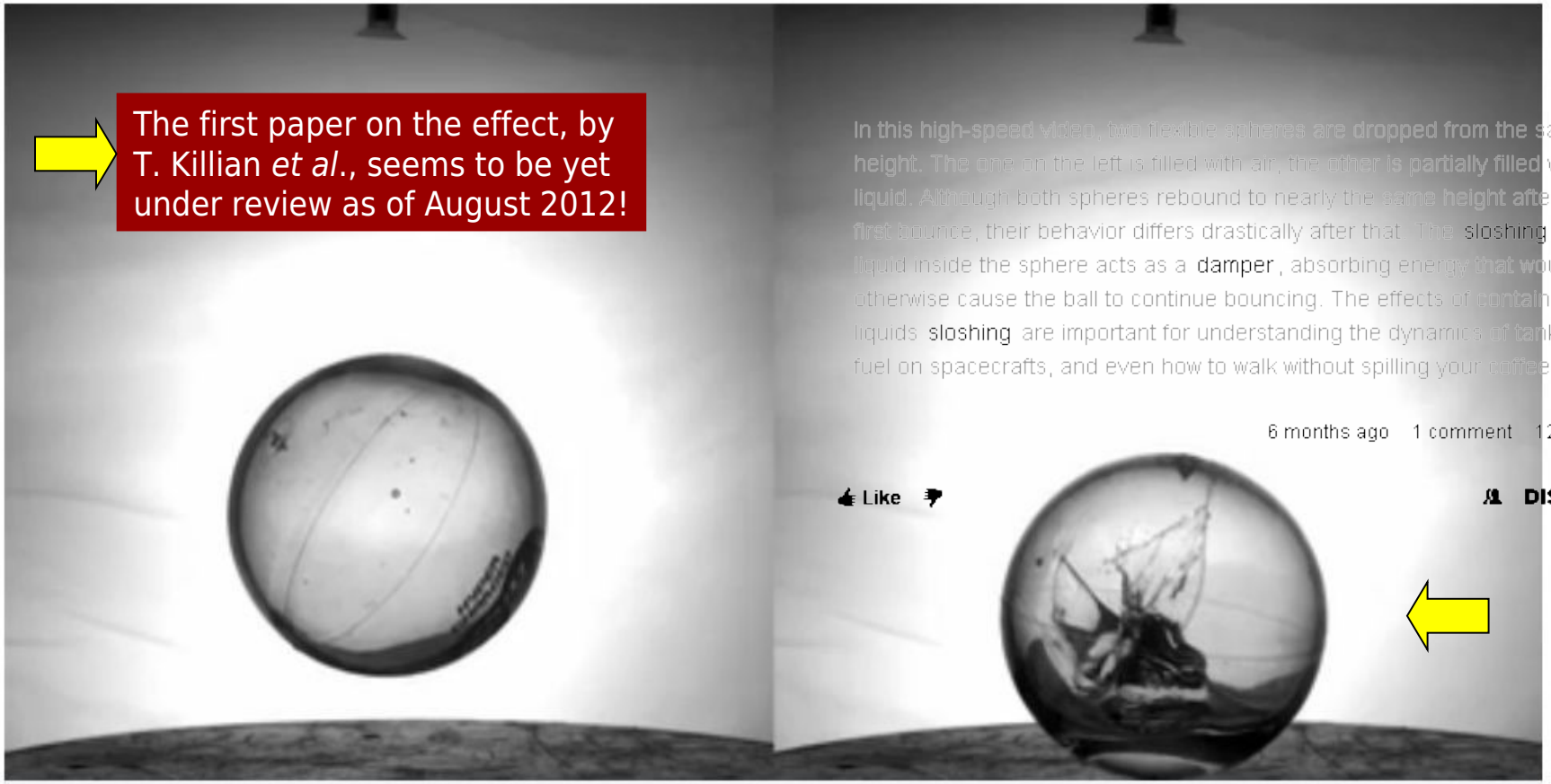
The first paper on the effect, by T. Killian *et al.*, seems to be yet under review as of August 2012!



Effect of sloshing on partially filled ball

by **Tadd Truscott** 9 months 3 weeks ago

These two Skyballs are falling from the same height, the one on the left is empty while the one on the right is partially filled. Notice that they have nearly the same rebound on the first bounce, however, after the second rebound the fluid motion mitigates a significant portion of the bounce.

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Background reading

- T. Killian, R. Klaus, and T. T. Truscott. Rebound and jet formation of a fluid-filled sphere. Physics of Fluids (in Review, 2012)
- Robert Klaus, Taylor Killian & Tadd Truscott. Sphere Rebound-Suppression from Sloshing (APS 2010 Conf. poster), http://www.taddtruscott.com/APS2010/Poster_V4.pdf
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- P. G. Young. An analytical model to predict the response of fluid-filled shells to impact—a model for blunt head impacts. J. Sound Vibration 5, 1107-1126 (2003), http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA159324
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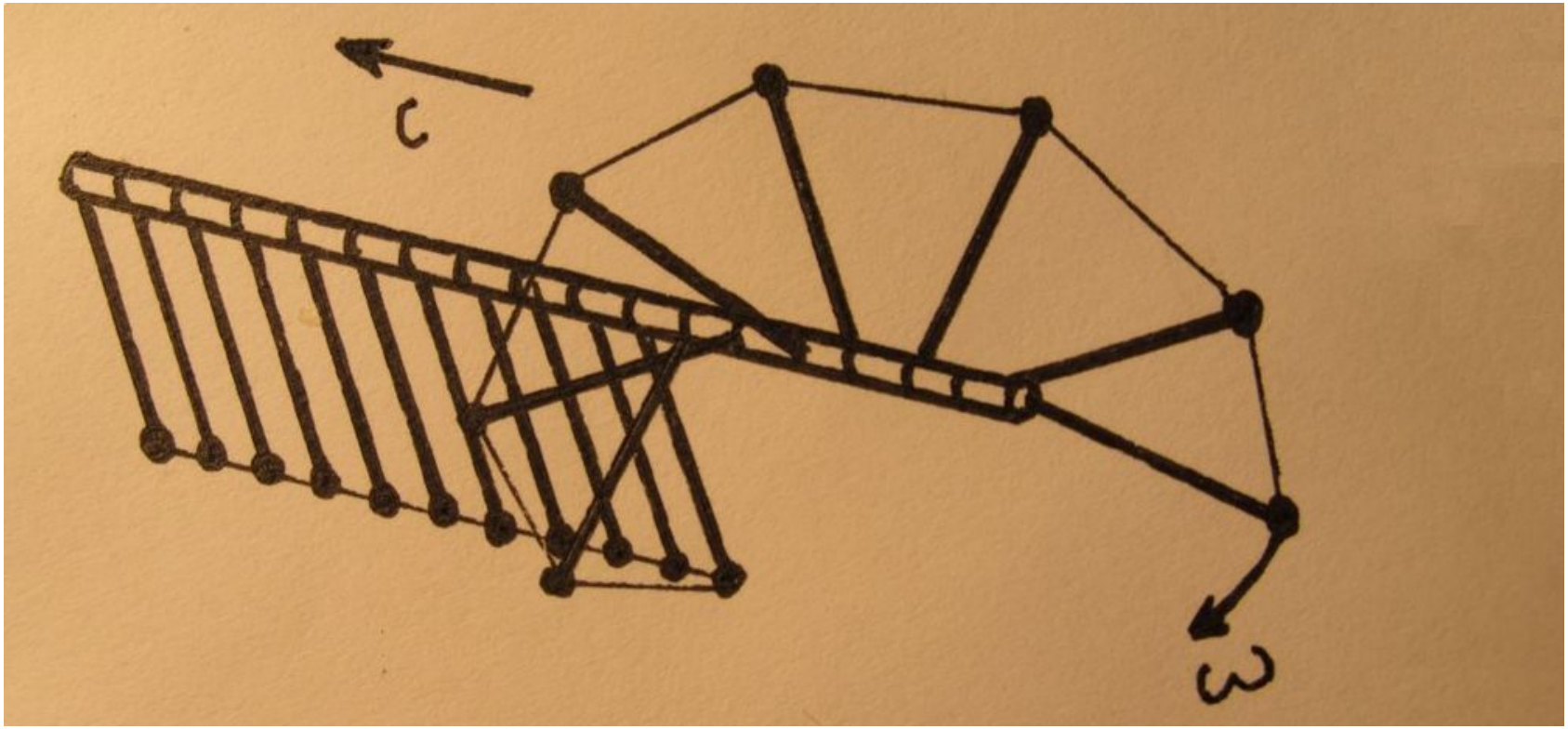
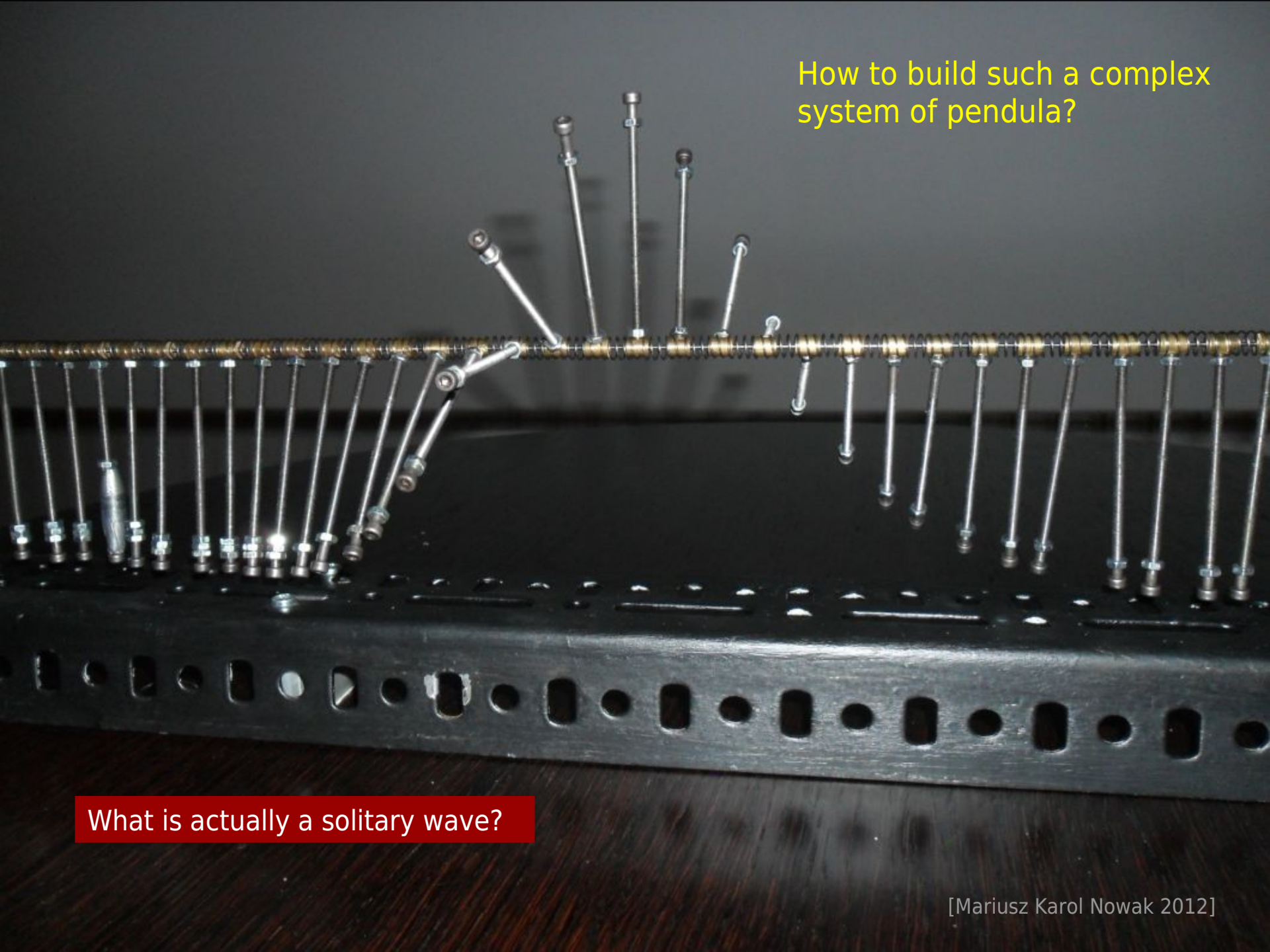


Problem No. 4 “Soliton”

A chain of similar pendula is mounted equidistantly along a horizontal axis, with adjacent pendula being connected with light strings. Each pendulum can rotate about the axis but can not move sideways (see figure). Investigate the propagation of a deflection along such a chain. What is the speed for a solitary wave, when each pendulum undergoes an entire 360º revolution?


How to build such a complex system of pendula?
What is actually a solitary wave?
[Mariusz Karol Nowak 2012]

Background reading

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- Ramaz Khomeriki and Jérôme Leon. Tristability in the pendula chain. Phys. Rev. E 78, 057202 (2008), arXiv:0810.3621v1 [nlin.PS]
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Problem No. 5 “Levitation”

A light ball (e.g. a Ping-Pong ball) can be supported on an upward airstream. The airstream can be tilted yet still support the ball. Investigate the effect and optimise the system to produce the maximum angle of tilt that results in a stable ball position.

Background reading

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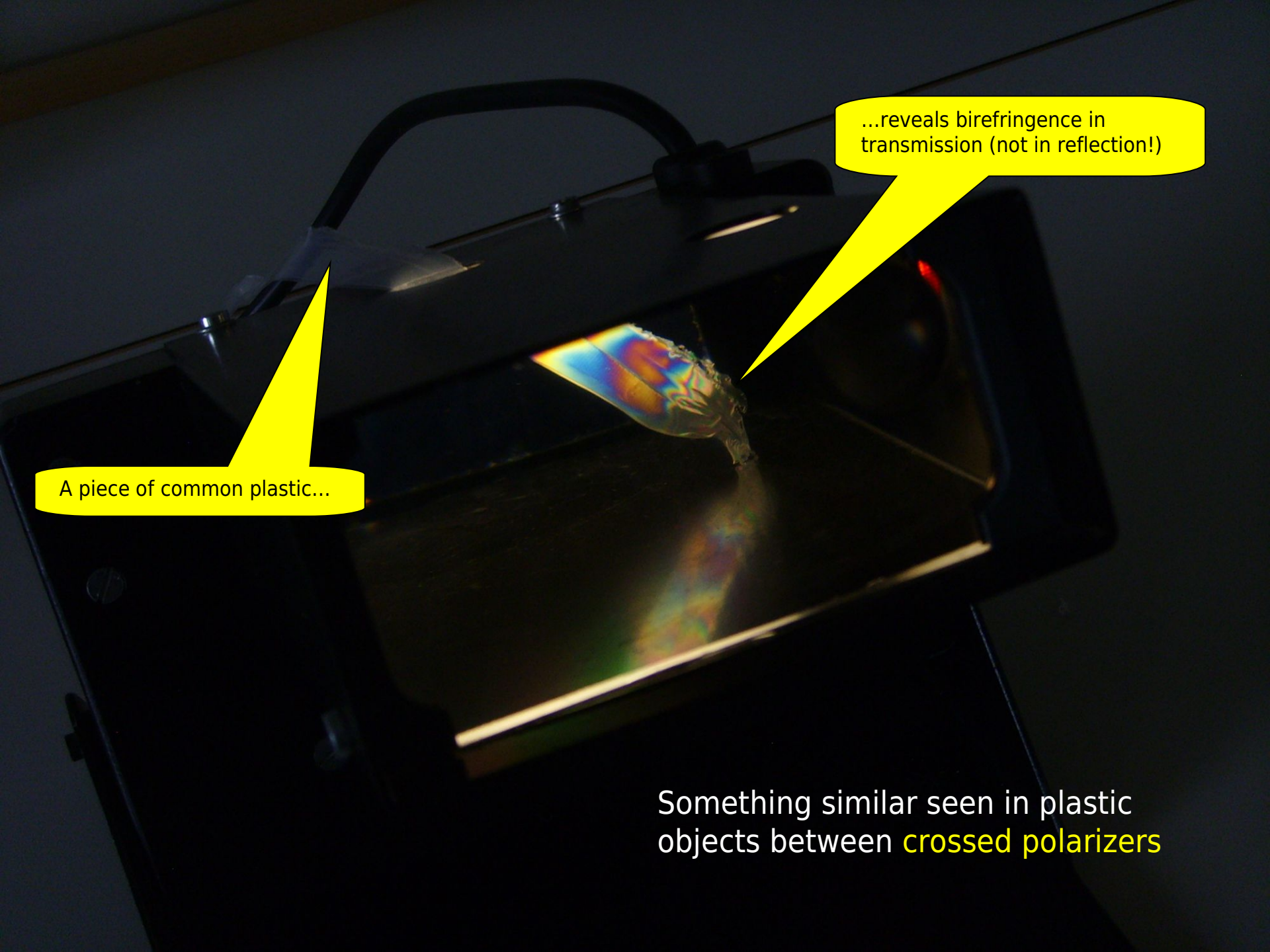
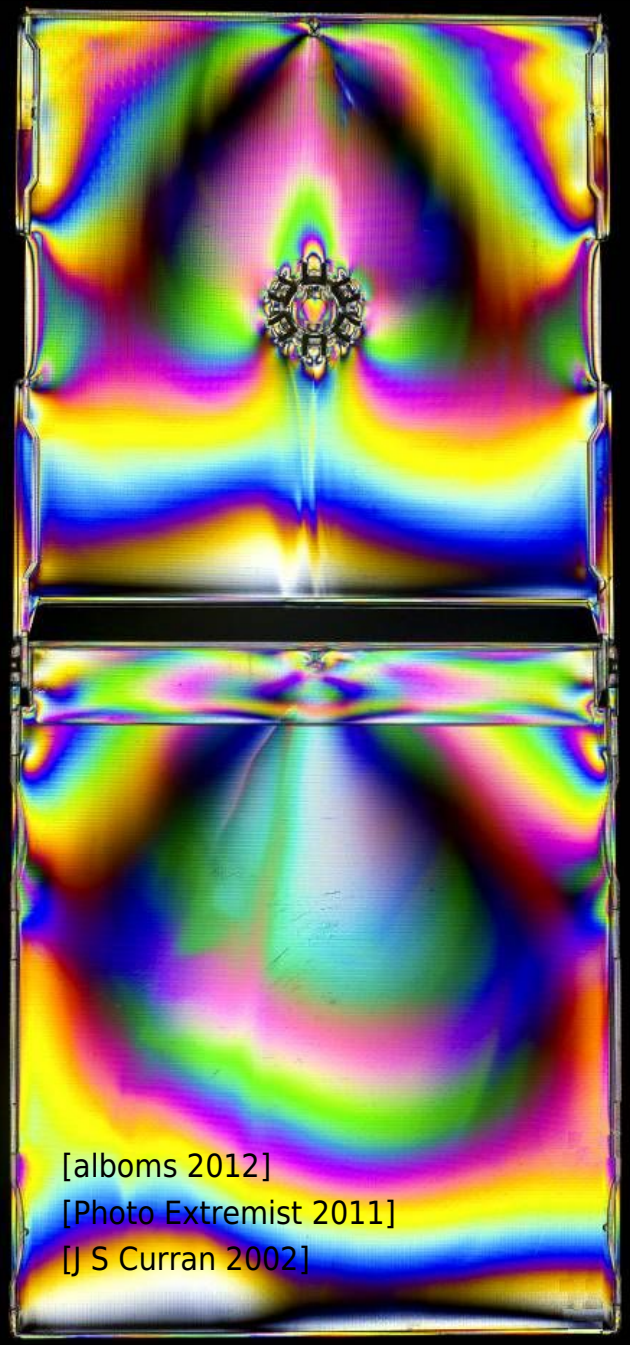
Problem No. 6 “Coloured plastic”

In bright light, a transparent plastic object (e.g. a blank CD case) can sometimes shine in various colours (see figure). Study and explain the phenomenon. Ascertain if one also sees the colours when various light sources are used.



Something similar seen in plastic objects between crossed polarizers



?

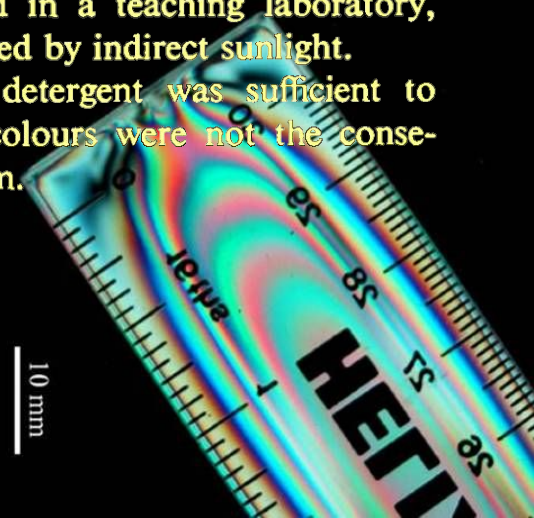
- Yes: residual strain in industrially stamped plastic objects may result in stress birefringence
- It is well visible with crossed polarizers

- Why the colors are seen when no extra polarizers are used?

Look—no polaroids!

We had often noticed that when certain plastic articles were viewed by reflected light it was sometimes possible to see faint diffuse coloured patches, looking rather like the interference pattern caused by thin films. The colours were relatively clear for the transparent shield over the magazine in a Leitz Pradolux slide projector, when viewed by extraneous light from the projector lamp, and also for some cheap set squares used in a teaching laboratory, when they were examined by indirect sunlight.

A little work with detergent was sufficient to demonstrate that the colours were not the consequence of a surface film.



[alboms 2012]
[Photo Extremist 2011]
[J S Curran 2002]

Background reading

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Problem No. 7 “Hearing light”

Coat one half of the inside of a jar with a layer of soot and drill a hole in its cover (see figure). When light from a light bulb connected to AC hits the jar’s black wall, a distinct sound can be heard. Explain and investigate the phenomenon.

ART. XXXIV.—*On the Production and Reproduction of Sound by Light;* by ALEXANDER GRAHAM BELL, Ph.D.

[Read before the American Association for the Advancement of Science, in Boston, August 27, 1880.]

IN bringing before you some discoveries made by Mr. Sumner Tainter and myself, which have resulted in the construction of apparatus for the production and reproduction of sound by means of light, it is necessary to explain the state of knowledge which formed the starting point of our experiments.

I shall first describe that remarkable substance "selenium," and the manipulations devised by previous experimenters; but the final result of our researches has widened the class of substances sensitive to light vibrations, until we can propound the fact of such sensitiveness being a general property of all matter.

We have found this property in gold, silver, platinum, iron, steel, brass, copper, zinc, lead, antimony, german-silver, Jenkin's metal, Babbitt's metal, ivory, celluloid, gutta-percha, hard rubber, soft vulcanized rubber, paper, parchment, wood, mica, and silvered glass; and the only substances from which we have not obtained results, are carbon and thin microscope glass.*

* Later experiments have shown that these are not exceptions.

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THIRD SERIES.

VOL. XX.—[WHOLE NUMBER, CXX.]

Nos. 115—120.

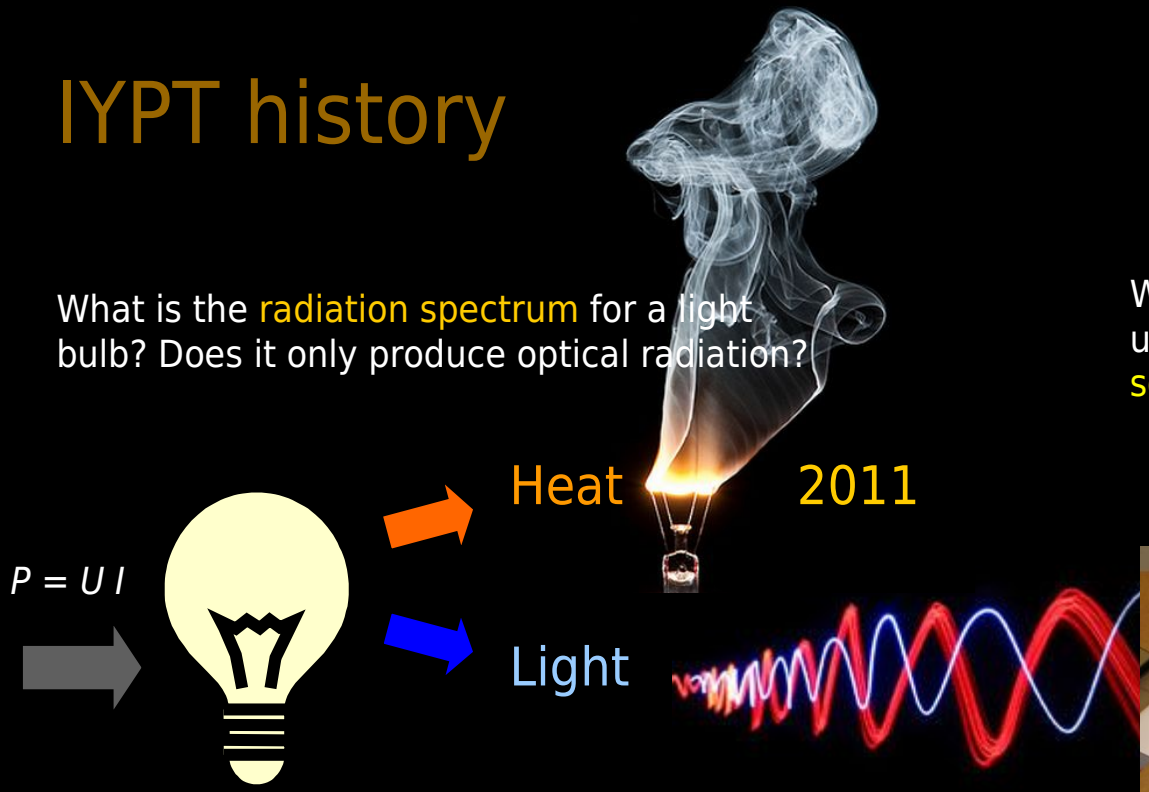
JULY TO DECEMBER, 1880.

WITH NINE PLATES.

NEW HAVEN, CONN.: J. D. & E. S. DANA.
1880.

IYPT history

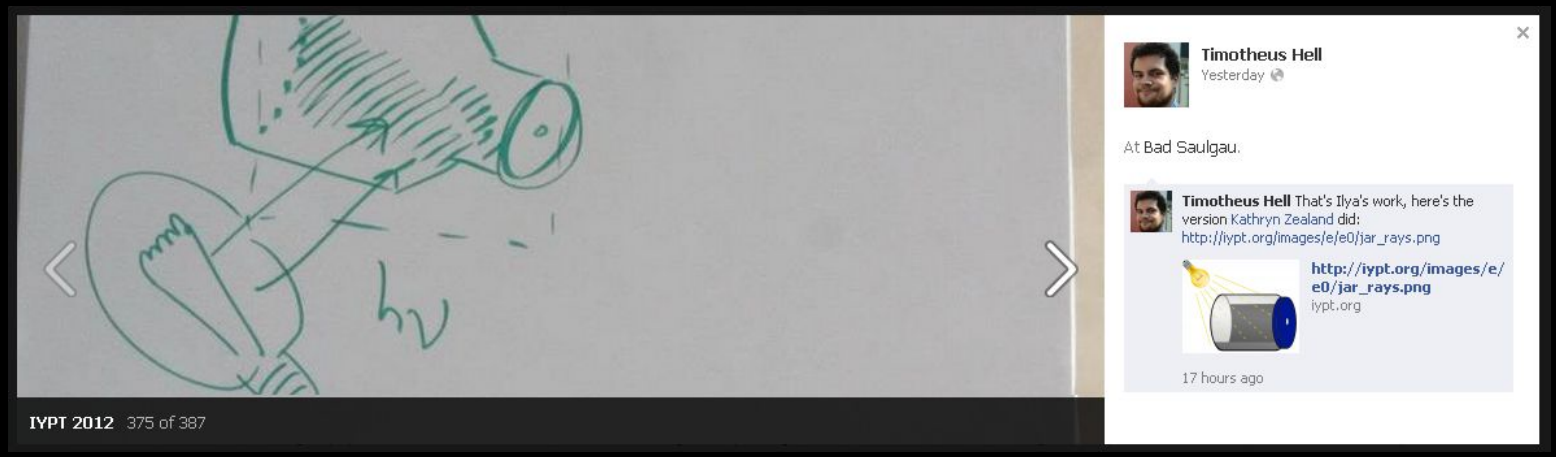
What is the radiation spectrum for a light bulb? Does it only produce optical radiation?



2011

Why discharging an electronic flash unit near a cymbal will produce a sound from the cymbal?

2008



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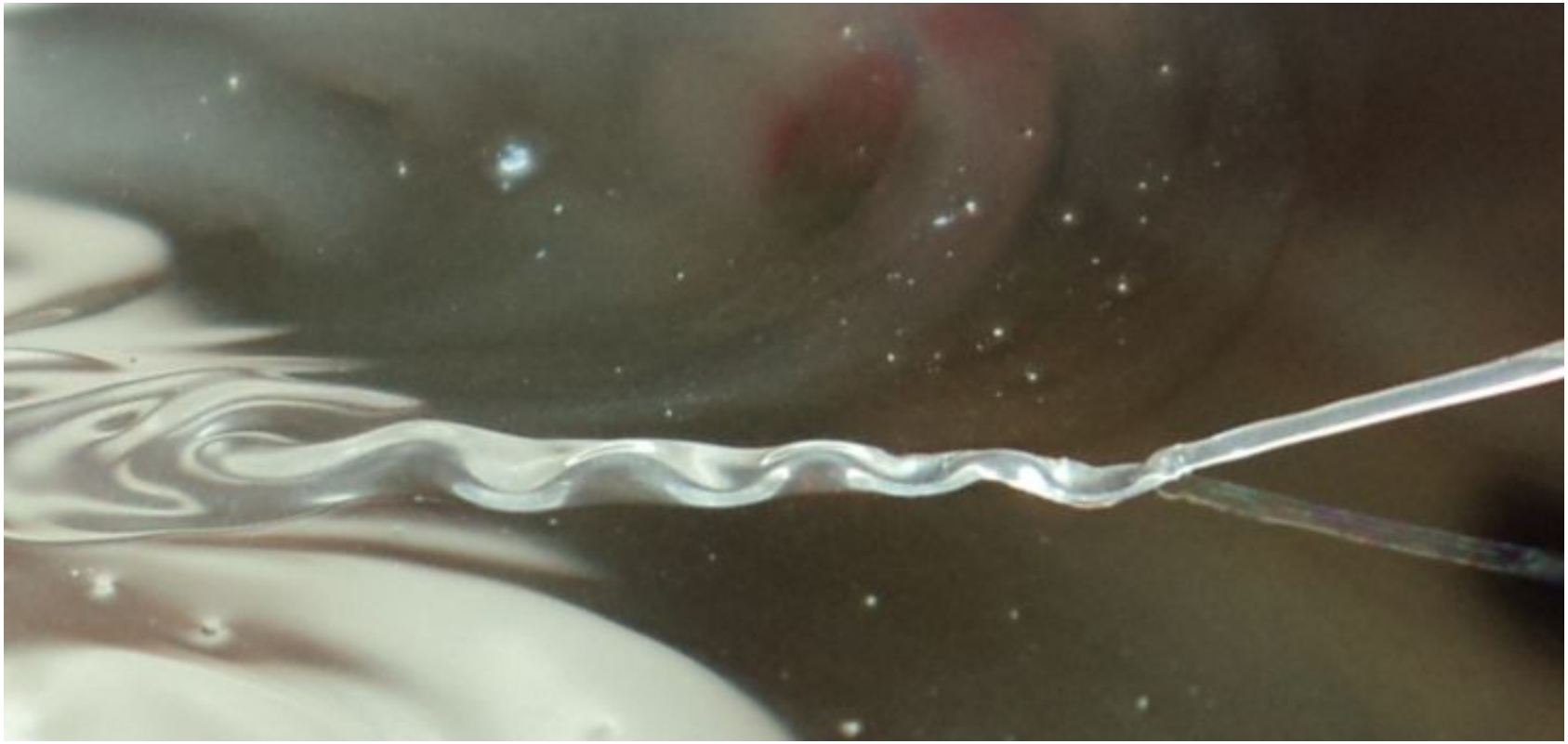

Problem No. 8 “Jet and film”

A thin liquid jet impacts on a soap film (see figure). Depending on relevant parameters, the jet can either penetrate through the film or merge with it, producing interesting shapes. Explain and investigate this interaction and the resulting shapes.


Christophe Raufaste, 2011
http://www.ae.utexas.edu/IUTAM2011/Raufaste.pdf
The first paper on the effect, by Geoffroy Kirstetter *et al*., seems to be not yet submitted as of August 2012!
Transient rebound of the jet on the soap film

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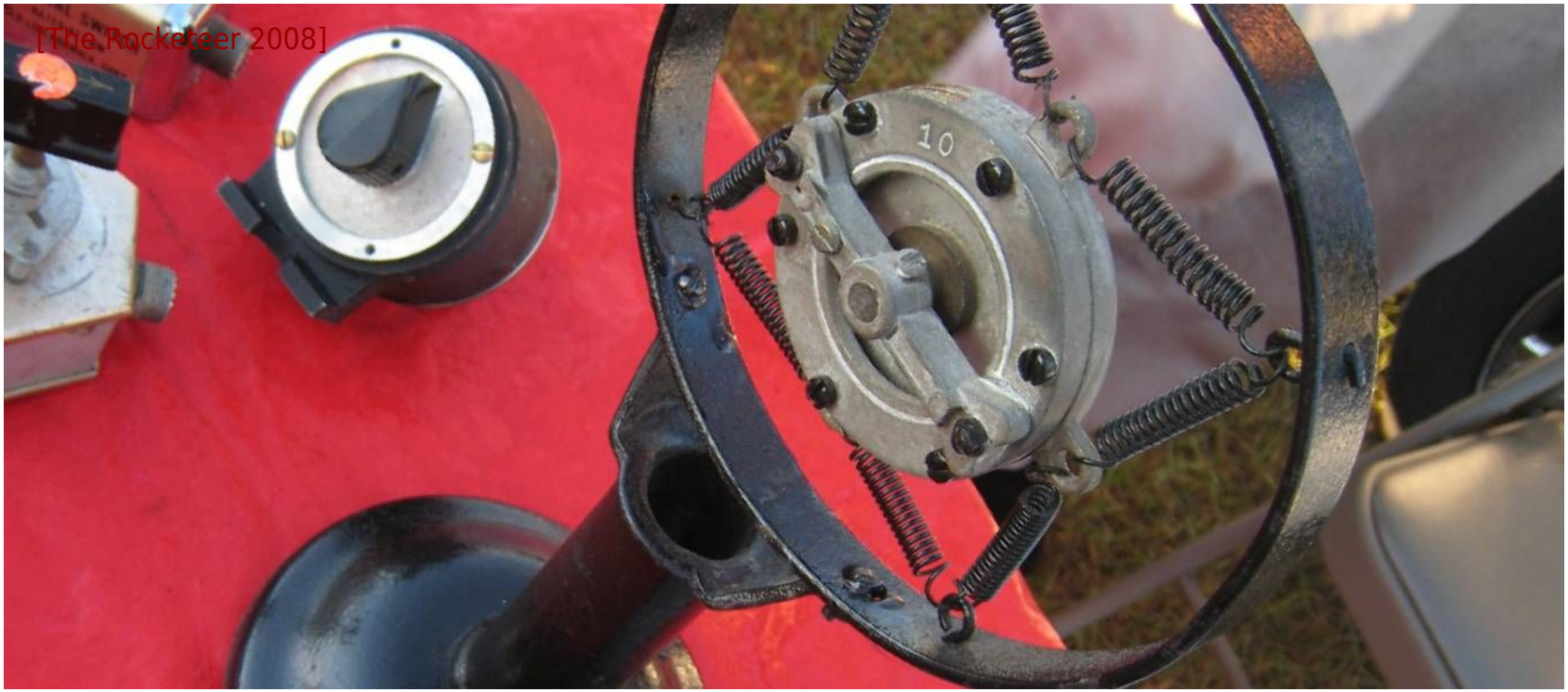

[The Rocketeer 2008]

Problem No. 9 “Carbon microphone”

For many years, a design of microphone has involved the use of carbon granules. Varying pressure on the granules produced by incident sound waves produces an electrical output signal. Investigate the components of such a device and determine its characteristics.

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Problem No. 10 “Water rise”

Fill a saucer up with water and place a candle vertically in the middle of the saucer. The candle is lit and then covered by a transparent beaker. Investigate and explain the further phenomenon.

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Problem No. 11 “Ball Bearing Motor”

A device called a “Ball Bearing Motor” uses electrical energy to create rotational motion. On what parameters do the motor efficiency and the velocity of the rotation depend? (Take care when working with high currents!)

Hydrodynamic Gyroscope[1]

R. A. MILROY.[2] In December, 1959, I completed an electrical circuit by passing current through ball bearings just as Mr. Then did in building his hydrodynamic gyroscope. Obviously, Mr. Then was as unaware of the motoring effect generated by passing current through ball bearings as I was. Fortunately, I was working on a smaller mechanism where the effect was more pronounced; however, there are two ways I can read Mr. Then's statement, "The whole assembly is remarkably free of friction about the vertical and horizontal axes, spinning completely around." Mine did spin around at nearly 1000 rpm with nothing driving it but the electrical current passing through the ball bearings.

A ball-bearing motor can be easily constructed by placing two bearings on a conductive shaft and passing current into the outer race of one, through the balls to the inner race, down the shaft to the inner race of the other bearing, through the balls, and out of the outer race. The motor requires practically no voltage but rather high current and will run in either direction on a-c or d-c current, Fig. 1.

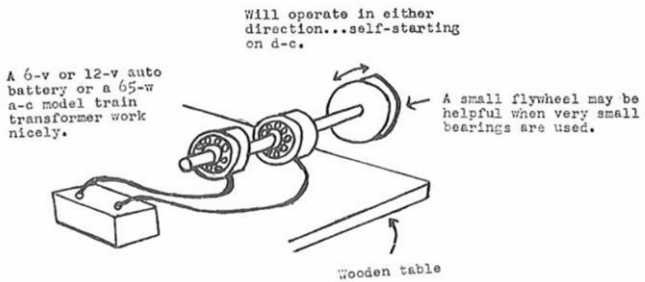

Fig. 1

Starting from these ideas I calculated the fields and the corresponding torques for a cylinder and a sphere in 1976. I was surprised to find a zero torque. A closer look revealed why the analogy with the kink instability is incomplete. Apparently another yet unknown phenomenon is responsible for the torque. In 1978 Gruenberg published an article in the American Journal of Physics [1] in which he started from the same set of equations and used the same analysis as I did. He did find a torque already in first order of an expansion with the angular velocity as the expansion parameter. Unfortunately, this nonzero torque turned out to be due to an algebraic error.

I. INTRODUCTION

In a brief note, Milroy[1] describes an experiment in which a current is passed through a pair of ball bearings. The experimental setup is reproduced in Fig. 1. Milroy noted that when sufficiently large currents are applied the bearings will act as motors. The ball bearing motor will run in either direction on both ac and dc. It is often self-starting on dc. When it is self-starting, the direction of rotation may be clockwise or counterclockwise. When it is not self-starting, it can be started by a push in either direction.

The author has repeated and confirmed these experiments. Since he was not able to find a theoretical explanation of the effect in the literature, the following theory was developed. It appears to explain all the observed phenomena. While the mathematics is somewhat involved, the basic ideas are quite simple.

?

***Abstract*— We discuss and clarify a number of very serious mistakes and misunderstandings concerning the mechanism of the ball bearing motor. Specifically we show that Gruenberg's mechanism, which is equivalent to the phenomenological model of Watson, Williams, and Crimp, does not explain the ball bearing motor behavior at all, because the predicted total torque T acting on the ball is $T = 0$. In addition, another wrong conclusion obtained by WWC is their interpretation of their experimental results concerning the relation of speed versus current.**

Abstract: Two different ball-bearing motors have been investigated. The experimental results do not agree with the prevailing electromagnetic theories of ball-bearing motor operation. The results suggest that the driving force arises from an electromagnetic interaction between the ball race and the surface of the ball in the region of their contact point.

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Problem No. 12 “Helmholtz carousel”

Attach Christmas tree balls on a low friction mounting (carousel) such that the hole in each ball points in a tangential direction. If you expose this arrangement to sound of a suitable frequency and intensity, the carousel starts to rotate. Explain this phenomenon and investigate the parameters that result in the maximum rotation speed of the carousel.

Dergleichen gespannte Membranen sind nun zu diesen und ähnlichen Versuchen über Partialtöne von zusammengesetzten Klangmassen sehr brauchbar. Sie haben den grossen Vorzug, dass bei ihrer Anwendung das Ohr gar nicht ins Spiel kommt, aber sie sind nicht sehr empfindlich gegen schwächere Töne. In der Empfindlichkeit werden sie bei weitem übertroffen durch die von mir angegebenen Resonatoren. Es sind das gläserne oder metallene Hohlkugeln oder Röhren mit zwei Oeffnungen, abgebildet in Fig. 16a und b. Die eine Oeffnung *a* hat scharf abgeschnittene Ränder, die

nicht sehr empfindlich gegen schwächere Töne. In der Empfindlichkeit werden sie bei weitem übertroffen durch die von mir angegebenen Resonatoren. Es sind das gläserne oder metallene Hohlkugeln oder Röhren mit zwei Oeffnungen, abgebildet in Fig. 16a und b. Die eine Oeffnung *a* hat scharf abgeschnittene Ränder, die andere *b* ist trichterförmig und so geformt, dass man sie in das Ohr einsetzen kann. Die letztere pflege ich mit geschmolzenem Siegellack zu umgeben, und wenn dieser so weit erkaltet ist, dass er zwar mit den Fingern ungestraft berührt werden kann, aber doch noch weich ist, drücke ich diese Oeffnung in den Gehörgang

Fig. 16a.

DIE LEHRE

VON DEN

TONEMPFINDUNGE

ALS

PHYSIOLOGISCHE GRUNDLAGE

FÜR DIE

THEORIE DER MUSIK.

VON

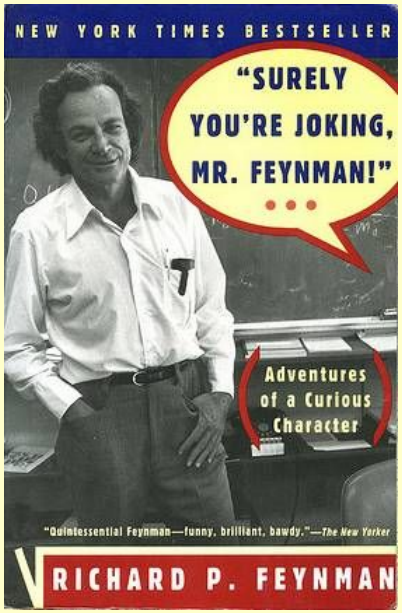
H. HELMHOLTZ,
Professor der Physiologie an der Universität zu Heidelberg.

MIT IN DEN TEXT EINGEDRUCKTEN HOLZSTICHEN.

DRITTE UMGEARBEITETE AUSGABE.

BRAUNSCHWEIG,
DRUCK UND VERLAG VON FRIEDRICH VIEWEG UND SOH
1870.

Is there a specific air flow close to the neck of the Christmas tree ball?



- 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!"

R. P. Feynman, Surely You're Joking, Mr. Feynman, (Norton, New York, NY, 1985), pp. 63–65
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Problem No. 13 “Honey coils”

A thin, downward flow of viscous liquid, such as honey, often turns itself into circular coils. Study and explain this phenomenon.

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Problem No. 14 “Flying chimney”

Make a hollow cylindrical tube from light paper (e.g. from an empty tea bag). When the top end of the cylinder is lit, it takes off. Explain the phenomenon and investigate the parameters that influence the lift-off and dynamics of the cylinder.

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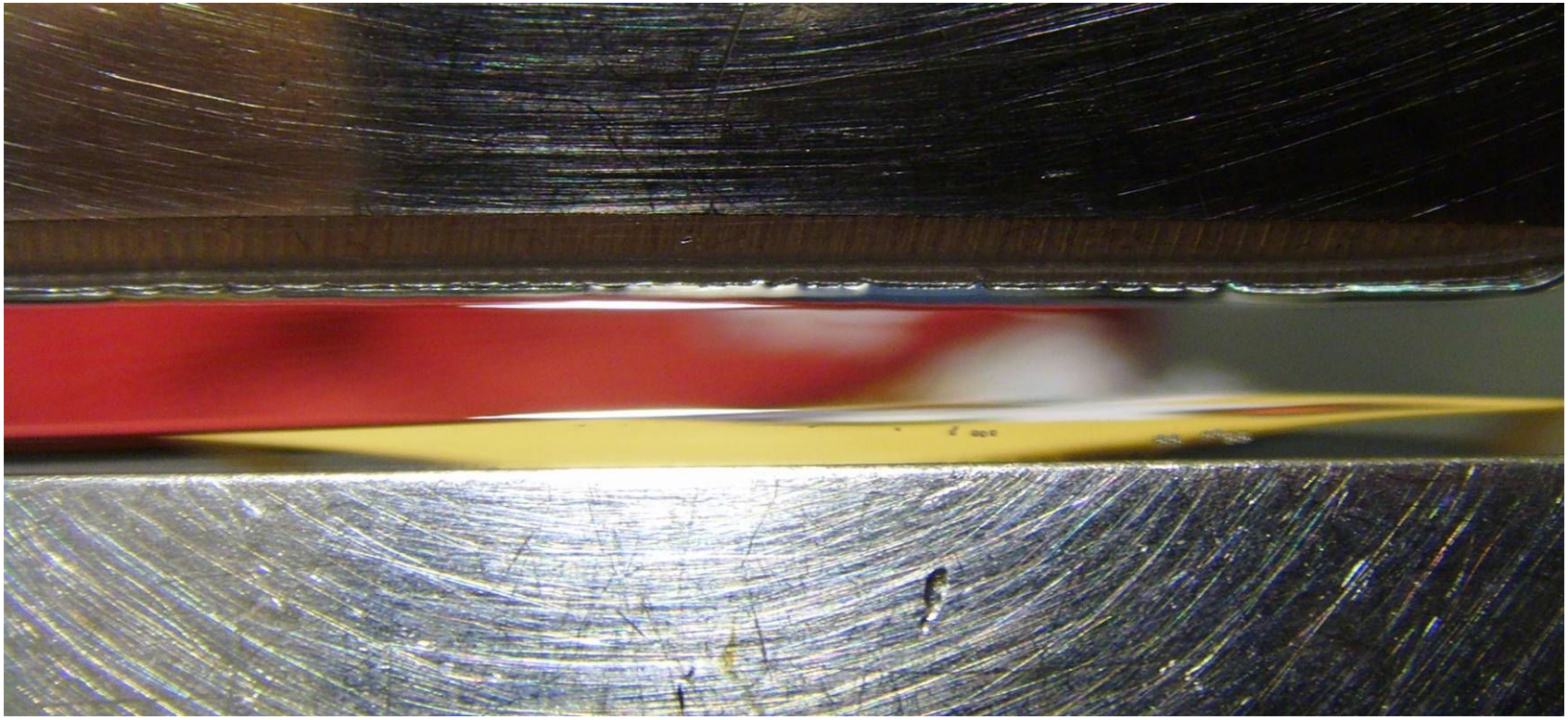

Problem No. 15 “Meniscus optics”

Cut a narrow slit in a thin sheet of opaque material. Immerse the sheet in a liquid, such as water. After removing the sheet from the liquid, you will see a liquid film in the slit. Illuminate the slit and study the resulting pattern.

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Problem No. 16 “Hoops”

An elastic hoop is pressed against a hard surface and then suddenly released. The hoop can jump high in the air. Investigate how the height of the jump depends on the relevant parameters.

Vibrationen eines Ringes in seiner Ebene.

(Von Herrn *R. Hoppe.*)

Ein elastischer Ring, dessen Figur durch Rotation eines kleinen ebenen Flächenstücks um eine entferntere Axe entsteht, ist im allgemeinen für jede gerade Knotenzahl zweier Arten ebener Vibrationen fähig; bloss für keinen und für zwei Knoten giebt es nur je eine periodische Bewegung. Die radiale und die peripherische Verschiebung bedingen sich gegenseitig und sind von gleicher Ordnung der Kleinheit. Mit wachsender Knotenzahl geht die langsamere der zwei unabhängigen Vibrationen in eine rein radiale, die schnellere in eine rein peripherische als Grenze über, so dass beide einzeln den Charakter der Transversal- und Longitudinalschwingungen gerader Stäbe annehmen.

Jumping hoops

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(Received 24 April 2011; accepted 17 August 2011)

We investigate the dynamics of an elastic hoop as a model of the jumps of small insects. During a jump the initial elastic strain energy is converted to translational, gravitational, and vibrational energy, and is dissipated by interaction with the floor and the ambient air. We show that the strain energy is initially divided into translational, vibrational, and dissipation energies with a ratio that is constant regardless of the dimension, initial deflection, and the properties of a hoop. This novel result enables us to accurately predict the maximum jump height of a hoop with known initial conditions and drag coefficient without resorting to a numerical computation. Our model reduces the optimization of the hoop geometry for maximizing the jump height to a simple algebraic problem.
[DOI: 10.1119/1.3633700]

Background reading

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Problem No. 17 “Fire hose”

Consider a hose with a water jet coming from its nozzle. Release the hose and observe its subsequent motion. Determine the parameters that affect this motion.

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- firemen lifting a car with WATER HOSES! (youtube.com, from animes25, 12.09.2007), http://www.youtube.com/watch?v=zP53h5yrE48

what are its x, y, and z components in te

(b) Compute $(\hat{\mathbf{r}} \cdot \boldsymbol{\nabla})\hat{\mathbf{r}}$, where $\hat{\mathbf{r}}$ is the uni

(c) For the functions in Prob. 1.15, evalu

Problem 1.22 (For masochists only.) P
the definition of $(\mathbf{A} \cdot \boldsymbol{\nabla})\mathbf{B}$.

Problem 1.23 Derive the three quotien

Problem 1.24

The ultimate response to all "What for?"-questions:

" If we knew what we were doing,
it wouldn't be called research! "

Albert Einstein

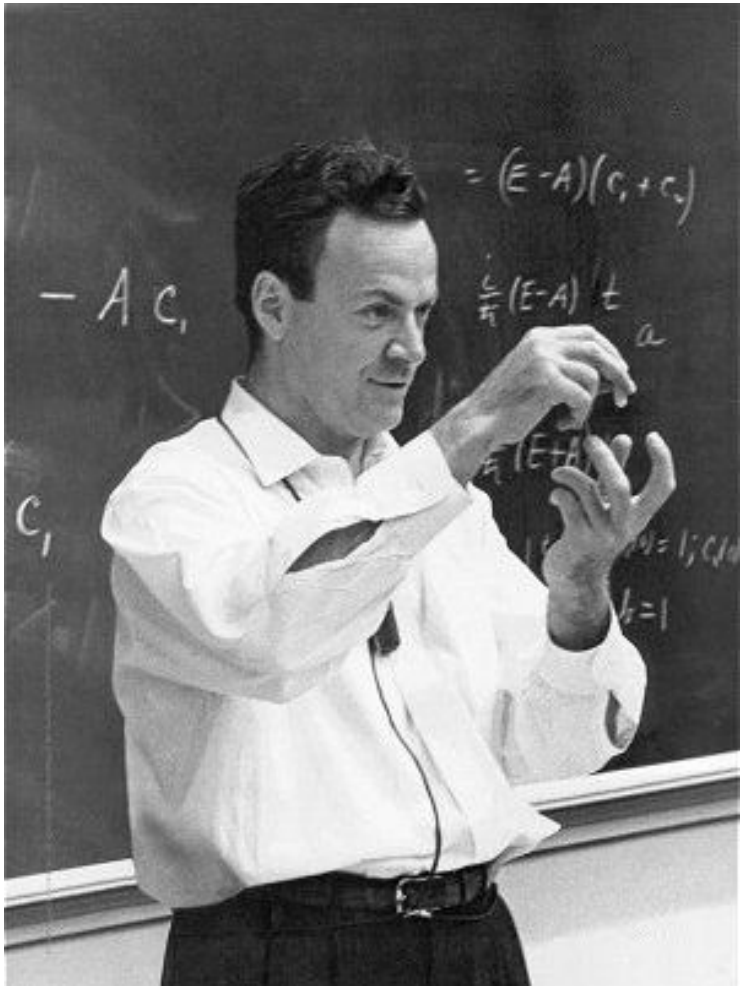
To work towards results?

- 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!
- Procrastination is definitely a risk :-)

Feynman: to be 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.”



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Preparation to 26th IYPT' 2013: references, questions and advices

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July 28...August 1, 2012

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