Preparation to the Young Physicists’ Tournaments’ 2013

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The IYPT combines the qualities which fit very well for Audi:
• an international scientific and technical environment of highly qualified young people,
• dedicated and collaborative team work,
• examination of complex relationships and the ability to explain the considerations.
All these are the key skills which give birth to innovation.
For these reasons we have a particular interest to support this event.

Thomas Sigi,
AUDI AG, Board Member
The IYPT is seeking for sponsors

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Being a partner of the IYPT offers a unique and powerful publicity

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The IYPT impresses me.

Herwig Schopper, CERN, 10th Director General
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
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 be better!
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
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 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**?
- Are you at the same time a **team player**?
- Could you be left unsupervised?
Don’t Drink and Derive

\[ F = \sqrt{1 - \frac{v^2}{c^2}} \]

\[ E = mc^2 \]

\[ F = G \frac{M_1 M_2}{r^2} \]

\[ E = 4\pi \epsilon_0 \frac{Q^2}{2} \]

\[ \nabla \cdot E = \frac{\rho}{\epsilon_0} \]

\[ \nabla \times B = \mu_0 J + \frac{4\pi}{c^2} \frac{dE}{dt} \]

\[ \nabla \times E = -\frac{\partial B}{\partial t} \]

\[ \nabla \cdot B = 0 \]

\[ n_e n_i = n_0 \]

\[ \rho - \text{mass} \]

\[ v = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \]

\[ F = \frac{G M_1 M_2}{r^2} \]
“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 neither into the First Day Draft, nor into the Second 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 :-(  

There are more things in heav'n 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

- Physics Olympics: Paper Bridge Instructions (gravitykills.net), http://www.gravitykills.net/PhysicsOlympics/Bridge.htm
- Basic notes about bridges (brantacan.co.uk), http://www.brantacan.co.uk/starterpages.htm
Background reading

- Paper Bridge (1 Meter) by DF_Any, http://dfandy.blogspot.se/2008/12/papr.html
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”? 
as in the weaker form of the principle, but 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

case for all small objects in the almost-flat `spacetime' that
from a star. Close to the center, the curvature of the surface is large.
bearing in motion on the surface in a way analogous to the acceleration body in the vicinity of a star.

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.

[Harrison 2000]
Background reading

- Gravity: Space as a Rubber Sheet (G. Kunstatter, Univ. of Winnipeg, April 2002), http://theory.uwinnipeg.ca/users/gabor/black_holes/slide5.html
- C. M. Elliott and A. Friedman. The contact set of a rigid body partially supported by a membrane. Nonlin. Anal. 10, 251-276 (1986)
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.
The first paper focused on dampening and sloshing in a spherical shell upon impact, by T. Killian et al., seems to be yet under review as of September 2012!

In this high-speed video, two flexible spheres are dropped from the same height. The one on the left is filled with air, the other is partially filled with a liquid. Although both spheres rebound to nearly the same height after the first bounce, their behavior differs drastically after that. The sloshing of the liquid inside the sphere acts as a damper, absorbing energy that would otherwise cause the ball to continue bouncing. The effects of contained liquids sloshing are important for understanding the dynamics of tankers, fuel on spacecrafts, and even how to walk without spilling your coffee.

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.
IYPT history

1 (18.) Superball (2nd YPT, Problems for the Finalists, 1980)
   - Estimate the collision time of a superball (a caoutchouc ball) with floor as it falls from a height of 1 m.

8. Superball (4th YPT, Correspondence Rounds, 1982)
   - A superball falls from a height of 30 cm onto a horizontal surface of a steel plate. How many collisions will take place? What is the duration of each collision? For how long will the superball continue “jumping”? Consider that 20% of superball’s kinetic energy goes into heat upon each bounce.

4. Splash of water (13th IYPT, 2000)
   - 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.

7. Making a splash (21st IYPT, 2008)
   - A solid object is dropped into water from a height of 50 cm. Investigate the factors that would minimize the splash.
Background reading

Background reading

- W. Goldsmith and V. H. Kenner. Impact on a simple physical model of the head. J. Biomechanics 6, 1, 1-11 (1973)
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 cannot 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 $360^\circ$ revolution?
How to build such a complex system of pendula?

What is actually a solitary wave?
Background reading

- Alex Kasman. An Introduction to Solitons (College of Charleston), http://kasmana.people.cofc.edu/SOLITONPICS/index.html
- Kanehisa Takasaki. Many Faces of Solitons (Kyoto Univ.), http://www.math.h.kyoto-u.ac.jp/~takasaki/soliton-lab/gallery/solitons/sg-e.html
Background reading

- Thierry Dauxois and Michel Peyrard. Physics of solitons (Cambridge Univ. Press, 2006)
- А. В. Шаповалов, Л. А. Краснобаева. Солитоны уравнения синус-Гордона. — Томск: ТГУ, 2009
- А. Т. Филиппов. Многоликий солитон. — М.: Наука, 1990
- Solitons - kink and anti-kink collisions (vimeo.com, from Daniel Piker), http://vimeo.com/35462854
- Soliton-Test3 (youtube.com, from BTwaveNo, April 5, 2009), http://www.youtube.com/watch?v=SAbQ4MvDqEE
- Visualizing Solitons (youtube.com, from gravityandlevity, June 11, 2009), http://www.youtube.com/watch?v=Ud7STKWNmQw
- Storing solitons in a potential well (youtube.com, from Mariusz Karol Nowak, April 1, 2012), http://www.youtube.com/watch?v=tBMp373j6po
- Pendulum Chain, Part 1 (youtube.com, from Uwe Schwarz), http://www.youtube.com/watch?v=Ozt1VkeK52E
- Pendulum Chain, Part 2 (youtube.com, from Uwe Schwarz), http://www.youtube.com/watch?v=iOc3idE88LM
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

- Faire l'éviter une balle de ping-pong (youtube.com, from Unisciel, 03.02.2011), http://www.youtube.com/watch?v=WHXTumy4RQ
- Bruce makes a basket with the Bernoulli ball (youtube.com, from PhysicsFactory, 24.08.2008), http://www.youtube.com/watch?v=69LTmCR4qxg
- Bernoulli ball experiment || www.tomzooi.nl (youtube.com, from tomzooy, 21.06.2008), http://www.youtube.com/watch?v=pWlkAEpGkDQ
- suspended ping pong ball, Bernoulli's Principle (youtube.com, from iflamenko, 18.10.2006), http://www.youtube.com/watch?v=fgHvC55AKig
Background reading

- Bernoulli's Principle (youtube.com, from jason238967, 18.10.2007), http://www.youtube.com/watch?v=nQqJGEHx5eQ
- Jens Eggers. 3.5 Flow past a sphere (Univ. of Bristol), http://www.maths.bris.ac.uk/~majge/week6.pdf
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?

A piece of common plastic...

...reveals birefringence in transmission (not in reflection!)

That specific effect was topic for a problem at the 4th YPT (1982)
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.
Background reading

- Birefringence (youtube.com, from syme4284, 12.03.2009), http://www.youtube.com/watch?v=cLXaiuiX58s
- View Stress in Transparent Materials (youtube.com, from jeriellsworth, 30.06.2009), http://www.youtube.com/watch?v=FkXwNQwrxZ4
- Stress Makes Them Bi (Swans on Tea, September 7, 2008), http://blogs.scienceforums.net/swansont/archives/754
Background reading

- How Do We Know Light Behaves as a Wave? (physicsclassroom.com), http://www.physicsclassroom.com/class/light/u12l1e.cfm
- Stress analysis using photoelasticity (youtube.com, from valenciaupv, 23.09.2011), http://www.youtube.com/watch?v=Wgi2cSiHZJ8
- Photoelasticity: Introduction to photoelastic stress analysis apparatus (youtube.com, from flengets, 30.01.2011), http://www.youtube.com/watch?v=BdSaA9byKms
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.

IYPT history

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

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

- W. C. Röntgen. On Tones Produced by the Intermittent Irradiation of a Gas. Philos. Mag. 11, 308 (1881)
Background reading

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.
The first paper on the effect, by Geoffroy Kirstetter et al., is published on September 4, 2012.
Background reading

- Stable Kaye effect on a thin soap film (Devaraj van der Meer, Univ. of Twente), http://stilton.tnw.utwente.nl/people/devaraj/research_f.html
- F. Graner. Film de savon géant (2005), http://www-lsp.ujf-grenoble.fr/vie Scientifique/Annee Mondiale de la Physique/films savon/
Background reading

- C. V. Boys. Soap bubbles, their colours and the forces which mould them (Dover, New York, 1959)
- C. L. Stong. How to blow soap bubbles that last for months or even years. Sci. Amer. 220 (5), 128 (1969)
- C. L. Stong. How to blow bubbles that survive for years. Sci. Amer. 229 (1), 110 (1973)
- Flowing Soap Films (Univ. at Buffalo), http://www.mae.buffalo.edu/research/laboratories/combustionlab/Flowing%20soap%20films/Flowing%20soap%20films.htm
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.
Background reading

- Carbon Charcoal Microphone (youtube.com, from teacherinstitute, 13.05.2011), http://www.youtube.com/watch?v=uAnlmoei_Co
- The Double-Button Carbon-Granule Microphone (vias.org), http://www.vias.org/albert_ecomm/aec04_electroacoustic_devices_010.html
- Types of Microphones Part 1 (youtube.com, from 7rockey, 27.12.2009), http://www.youtube.com/watch?v=yMKP3q3KCBw
- home made carbon microphone (youtube.com, from sorrisoaperto, 01.07.2011), http://www.youtube.com/watch?v=2DcuEndIz4w
- Carbon Charcoal Microphone (youtube.com, from teacherinstitute, 13.05.2011), http://www.youtube.com/watch?v=uAnlmoei_Co
- Razor Blade and Graphite Microphone - Suicide Mic (youtube.com, from jeriellsworth, 01.06.2010), http://www.youtube.com/watch?v=BhDzyK3-RSU
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.
Background reading

- Egg in the Bottle Experiment with a Twist (youtube.com, SteveSpanglerScience, 19.08.2008), http://www.youtube.com/watch?v=mpC5zlmtm-g
- Wine in an upside down glass trick (youtube.com, from heyscuba, 22.05.2007), http://www.youtube.com/watch?v=znL5yLgDavk
Background reading

- Brian Rohring. The captivating chemistry of candles (myteacherpages.com),
  http://www.myteacherpages.com/webpages/CCPHS/files/captivating%20chemistry%20of%20candles.pdf
- Candle and Water - Cool science experiment (youtube.com, from igor30, 07.11.2011),
  http://www.youtube.com/watch?v=fzapvChi2iM
- Fire and Water Magic Trick (youtube.com, from futsang, 16.08.2011),
  http://www.youtube.com/watch?v=hd7vbYzodoo
- Robert Krampf. Candle in a Bottle Experiment #440 (atozteacherstuff.com),
  http://www.atozteacherstuff.com/pages/5879.shtml
  http://home.ntelos.net/~rollinso/Candle/CandleExpt.html
- Why does the water rise after candle goes out? (wiki.answers.com),
  http://wiki.answers.com/Q/Why_does_the_water_rise_after_candle_goes_out
- Thirsty candle (sciencesquad.com),
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!)
I. INTRODUCTION

In a brief note, Milroy\textsuperscript{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.
Background reading

Background reading

- Mike Harrison. The Ball-Bearing electric motor (Mike's Electric Stuff), http://www.electricstuff.co.uk/bbmotor.html
- Ball bearing motor (youtube.com, from mcallister61407, 14.04.2011), http://www.youtube.com/watch?v=tHZbHMFWS2k
- Ball Bearing Motor (youtube.com, from progressivetech1, 11.06.2011), http://www.youtube.com/watch?v=o0ktomInqp8
- Ball bearing motor(None magnet motor) (youtube.com, from ddserpop, 10.06.2012), http://www.youtube.com/watch?v=d4SK1Q00FrA
- Ball-bearing Motor Or How to confuse people with a simple machine (fdscience.org), http://www.fdscience.org/uneiko/bbmotor.htm
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 mettallene Hohlkugeln oder Röhren mit zwei Öffnungen, abgebildet in Fig. 16a und b. Die eine Öffnung 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 mettallene Hohlkugeln oder Röhren mit zwei Öffnungen, abgebildet in Fig. 16a und b. Die eine Öffnung a hat scharf abgeschnittene Ränder, die andere b ist trichtерförmig und so geformt, dass man sie in das Ohr einsetzen kann. Die letztere pflege ich mit geschmolzenem Siegelzink zu umgeben, und wenn dieser so weit erkalten ist, dass er zwar mit den Fingern ungefähr begehrt werden kann, aber doch noch weich ist, drücke ich diese Öffnung in den Gehörgang.

§160]  АКУСТИЧЕСКИЕ РЕЗОНАТОРЫ

Для в этом выражение найденные значения $k$ и $m$, получим:

$$\omega = \sqrt{\frac{S \cdot p}{V \cdot \rho}}$$

или, так как $V \cdot \rho \cdot p = \epsilon$,

$$\omega = \epsilon \sqrt{\frac{S}{V}}.$$  \hspace{2cm} (21.15)

Изменя размеры сосуда и горла, можно получить резонаторы с собственными частотами, охватывающими весь диапазон звуковых частот.

Из выражения (21.15) частоты собственных колебаний резонатора для соответствующей длины волны получаем:

$$\lambda = 2\pi \sqrt{\frac{V}{S}}.$$  \hspace{2cm} (21.16)
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!"

E. Mach. Die Mechanik in Ihrer Entwicklung Historisch-Kritisch Dargerstell (1883)
Is there a specific air flow close to the neck of the Christmas tree ball?
Background reading

- Moving objects by sound (youtube.com, from LjudochVibrationer, 24.08.2011), http://www.youtube.com/watch?v=SemQS4RLeFU
- Daniel A. Russell. Acoustic Propulsion (youtube.com, drdanku, 04.01.2011), http://www.youtube.com/watch?v=je7eLZS6GG0
- Daniel A. Russell. Acoustic Propulsion Part 2, measurement of thrust (youtube.com, drdanku, 06.01.2011), http://www.youtube.com/watch?v=uJ8B8k1ISQg
- Joe Wolfe. Helmholtz Resonance (Univ. of South Wales), http://www.phys.unsw.edu.au/jw/Helmholtz.html
Ernst Mach. Die Mechanik in Ihrer Entwicklung Historisch-Kritisch Dargerstellt, (Leipzig: Brockhaus, 1883), pp. 299-301
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.
Congratulations to Jan Binder and Andreas Landig!

First IYPT-driven research paper in a journal included in the Web of Science (Eur. J. Phys.)

First among IYPT-driven papers to get cited by a journal included in WOS (Ann. Rev. Fluid Dyn.)

Serious citation by a major group in a journal with the 2011 impact factor of 12!

Citation related to the IYPT 2013 problem :-(
Background reading

- The Liquid Rope-Coil Effect (youtube.com, from psidot, 30.06.2007), http://www.youtube.com/watch?v=rEkuhC9eJIM
- MATH is SWEET! (High Speed Honey Coiling) - Smarter Every Day 53 (youtube.com, from destinws2, 03.06.2012), http://www.youtube.com/watch?v=zz5lGkDdk78
- Honey Study - Rope Coil Effect Raw Phantom Footage (youtube.com, from FunnerEveryDay, 02.06.2012), http://www.youtube.com/watch?v=9rC1x3zJbjM
Background reading

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.
Background reading

- Flying Tea Bag Rocket! (youtube.com, from MCExperiments, 13.02.2010), http://www.youtube.com/watch?v=Z14DpRre5Mk
- Home Experiment: Flying Tea Bag (youtube.com, from ThirstForScience, 07.09.2009), http://www.youtube.com/watch?v=TKF3OKxwM8g
- how to make a tea bag hot air balloon (youtube.com, from rishibalasaria, 17.05.2010), http://www.youtube.com/watch?v=PAswT9wqQwo
- Tea Bag Rockets Convection Current fire Experiment (youtube.com, from coolvids317, 13.11.2011), http://www.youtube.com/watch?v=GkkrXxJ4db8
- Tea Bag Rocket: a fun, at-home science experiment (from scienceoffcenter, 15.09.2011), http://www.youtube.com/watch?v=_st7NWnNtoY
- Flying Tea Bag Rocket (from JaySummer1, 03.11.2011), http://www.youtube.com/watch?v=YPp0JwHnSOA
- Thermal Convection of a Gas - Paper Chimney (Univ. of Iowa), http://faraday.physics.uiowa.edu/heat/4B20.35.htm
- How to Make a Tea Bag Rocket (wikihow.com), http://www.wikihow.com/Make-a-Tea-Bag-Rocket
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.
Background reading

- Eugene Hecht. Optics (Addison-Wesley, 4ed, 2001)
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 ebenern 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. © 2012 American Association of Physics Teachers.
[DOI: 10.1119/1.3633700]
Background reading

- R. Hoppe. Vibrationen eines Ringes in seiner Ebene. Journal für die reine und angewandte Mathematik 73, 158-170 (1871)
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.
Background reading

- Garden Hose instability: Slow Motion (youtube.com, from Olivier Doaré, 20.07.2012), http://www.youtube.com/watch?v=KMxyy5NrZ-o


Water Jet Pack: Get High with Jetlev! (youtube.com, from devinsupertramp, 12.04.2011), http://www.youtube.com/watch?v=im1iNq02Kz0

Firemen lifting a car with WATER HOSES! (youtube.com, from animes25, 12.09.2007), http://www.youtube.com/watch?v=zP53h5yrE48
(a) What are its $x$, $y$, and $z$ components in terms of the unit vectors?
(b) Compute $(\hat{r} \cdot \nabla)\hat{r}$, where $\hat{r}$ is the unit vector.
(c) For the functions in Prob. 1.15, evaluate the definition of $(A \cdot \nabla)B$.

**Problem 1.22** (For masochists only.) Prove the definition of $(A \cdot \nabla)B$.

**Problem 1.23** Derive the three quotient rules.

**Problem 1.24**
(a) Check product rule (ii). (b) Evaluate...
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.”

R.P. Feynman. Surely You’re Joking, Mr. Feynman (Norton, New York, NY, 1985)
Preparation to 26th IYPT’ 2013:
references, questions and advices

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