International Young Physicists' Tournament

Committee for Problem Selection 2013

Final Committee Report

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Contents

Report prepared by: Ilya Martchenko
Verified by: Samuel Byland
First draft disseminated on July 12, 2012
Final version compiled on August 29, 2012 with updates on the approved problems

General information

1. Tasks and criteria

1.1. Tasks

The key task of the Committee is to prepare a "reasonable set of problems with improved wording, to reflect the need of having all fields of physics represented". The Committee is directed by the EC to collect, rank, verify, and propose a selection of problems *before* the IOC meeting in close cooperation with the EC, IOC, and invited experts.

The Committee specifically aims at improving the quality of the problems by evaluating relevant facts and information over a sufficient time span.

1.2. Binding criteria for the selection

1.2.1. No repeated, dangerous, trivial or solved problems.
1.2.2. Relevance, consistency, feasibility from the IYPT perspective, and reasonable novelty.
1.2.3. Balanced coverage of various areas of physics.

2. Collecting the proposals

2.1. The call to all IOC members was sent by the EC on February 29 with the deadline set to April 30. We sent several reminders between April 19 and May 3. The last proposal was formally submitted on May 3, 2012. Upon thorough consideration, we kindly ask the EC to shift the deadline to an earlier time, possibly February.

2.2. In the call, the EC asked each contributor to fill a special form. The requested information was the contact details of the problem author, the source of the problem (e.g. a particular journal article, a personal observation, etc.), and the confirmation of the copyright transfer. This requirement was of a special importance to improve the awareness about each proposal and to allow the community to be sufficiently informed about the background of each text.

2.2. We received a complaint from a highly experienced problem author on May 8. This person regretted that he did not timely receive the call and missed opportunity to prepare his proposals. The requirement to "call on interested physicists to list problems for next year's competition" is bound by the IYPT Statutes. The Committee therefore suggests making the call wider and more transparent, by using all available media to disseminate the invitation, including the IYPT's webpage, extended mail lists, Facebook, and personal informal invitations, when possible.

2.3. A small accident occurred on May 7, when nine proposals submitted on April 29 were found lost in transit and not timely included into the database. Upon a corrective action, all proposals were then indexed well. An improvement should be done to avoid similar issues. The current guidelines read, "We advise the authors to submit the problems via national coordinators, so that they know how many problems were submitted from their country. However we surely will accept also submissions made directly to any of the EC members."

With such a strategy, the transfer of a single proposal from the end author to the central database may be unnecessarily complicated.

2.4. Altogether, 89 proposals from 18 countries were received. Each proposal was given index from ID 2013-01 to ID 2014-89. The Committee is ready to disclose all necessary details, including "the countries not submitting problems."

2.5. Before taking any further step, by removed 10 proposals that were fully identical to some recent IYPT problems.

3. Ranking the proposals via a vote

3.1. On May 8, we invited all IOC members to give a rating to the proposals and evaluate each of them. We distributed the original forms provided by the contributors (with names, emails and countries deliberately hidden), and invited the voters to consider the following suggestions:

"To have a more informed judgment about the proposals, please refer to the commentaries and explanations in the original forms from the contributors."

"A short wording of a problem is often tricky, and it can pose quite a daunting challenge to evaluate the feasibility and relevance of a problem. We hope that the metadata will help us to understand if the expected effects are truly reproducible yet intriguing and thought-provoking. It would be good if the tasks concern practical and conceptual approaches. A problem about a fully abstract conjecture or about a well known textbook demonstration is probably not well suited for the IYPT."

"When evaluating the proposals, please use all spectrum of marks from 1 to 5 but stay centered around the average mark of 3. To improve statistical significance of the results, we kindly ask you to roughly distribute your marks normally. An average and ordinary problem deserves a most probable mark of 3. The mark 5 goes to a few most brilliant problems on the list that you would happily see at the IYPT. Similarly, use the mark 1 only for a few exceptionally inconsistent problems. With these uniform criteria we would better separate problems and reduce the statistical uncertainty of the ranking."

"This year we also kindly ask you not to hesitate, at all times, to make commentaries, report your concerns, share further details and otherwise improve awareness about each proposal we have."

3.2. We used a protected web interface to collect the votes. Due to the time constraints, no customized system was developed, and we used a web system powered by *limesurvey.org*. With such a system we could automatically get advanced statistics on the results, without having to invoke multiple separate Excel sheets.

The majority of the voters did not report inconvenience when using the system. One voter did not receive the token timely due to an unrelated email problem. One voter insisted on filling an offline Word sheet (his votes were then manually introduced into the system.) Two voters reported a technical issue as their browser session was expired due to a long inactivity time. One voter declined to read the commentaries from the problem authors, prior to submitting his vote.

3.3. By May 24, we received the complete votes from 26 voters. The following documents were then distributed in the Committee and in the EC:

* Raw data used for the statistical analysis (.xls)
* Automatically generated statistics on all votes (.pdf)
* The leading proposals sorted descending by the score, and graphs, descriptions, and up-to-date supporting information (.pdf)

4. Discussion and selection of the short list

4.1. We stayed focused on the following key criteria: **ranking, coverage of various branches of physics, feasibility, relevance, reviews, originality, safety.**

We discussed various aspects of the problems on a daily basis between May 24 and July 12. During this time, we requested authors for necessary clarifications, sought commentaries from experts in specific areas, shared our remarks and concerns, and performed experimental checks.

4.2. The top proposals had an especially high ranking and were of a very strong interest for the IOC members. We did not doubt their presence on the final list unless we would find that they are repeated, not entirely feasible, or dangerous.

4.3. The top proposals covered mostly mechanics and fluid dynamics. We then took care to allow problems from other areas of physics onto the final list. To ensure this balance we gave an equitable preference to the best problems on electromagnetism, heat and thermodynamics, optics etc. and avoided an excessive number of problems from one specific area.

4.4. To do so, we descended down the ranking and attentively chose those proposals that (a) would cover various areas of physics in a reasonable balance, (b) would however have highest possible ranking among their direct competitors, (c) had no objective concerns about safety, relevance and other strong criteria, (d) would be supported by independent credible sources about their feasibility and similar important qualities.

The Committee went through a number of iterations to arrive at a stable shortlist that would fully satisfy all Committee members. We then revised the list by analyzing further qualities and features of the proposals and considering good replacements that would allow the entire list staying balanced.

4.5. We applied the same criteria to select 5 possible substitutes from various areas of physics.

4.6. In one of the last steps, we put the problems in random order using *random.org/lists*. However, we put “Invent yourself” as No. 1 and “Fire hose” as No. 17 in order to resume two informal traditions the IYPT had over a span of its first years. “Invent yourself” was the most open-ended task in the set (and placed first) where the least number of conditions or parameters were specified or fixed. The problem No. 17 featured humorous narrations and could involve especially simple and entertaining experiments. By acclamation, we invited Evgeny Yunosov to decide on another traditional feature of the IYPT problems, the epigraph.

4.7. We finally improved wording and style of the selected texts, double-checked the copyright status of images and text fragments, and made proofreading with the authors, when it was necessary.

4.8. A few examples below summarize the considerations that led to a particular decision.

4.8.1: "Water rocket" received scattered marks and quite a high average score. The highest grades were due to simplicity, nearness and fun of the topic [1]; but the lowest grades were because pressurized plastic bottles were considered unsafe [2, 3]. Our informed decision would then rely on the credible sources to check the risks for participants if a plastic bottle is overpressurized and bursts for example. The sources mention such precaution measures as earplugs and goggles [4, 5] ("bottles do not throw shrapnel but they make a bang so loud it would undoubtedly cause ear damage if you were next to it without hearing protection"), maximum allowed air pressure of 3 bar [6] and distantly operated launch pads [4, 5].

If selected, this problem would be the most "explosive" in the IYPT history but focus on roughly the same effects as the recent "Balloon-powered car" (IYPT 2011) where a propulsed projectile now undergoes simple ballistic motion and experiences air drag.

4.8.2: "Hearing Sound" also received mixed grades and quite high average score. Some voters were fascinated by the wording but others had doubts if the effect is sufficiently pronounced or existent at all. To independently check the feasibility, an experimental check was performed. The effect is indeed strong, and it takes almost no time to produce an operating prototype of the device. This problem therefore seems to be perfect, ideally suited and really valuable for the IYPT.

4.8.3: "Climbing droplets" is a very interesting problem with a good score. However, an attentive verification (including communication with members of David Quéré's group) suggested that effect is feasible for very small, regular and well-defined teeth of a ratchet (1.5 mm wide, 0.2 mm deep) [8, 9, 10]. This makes it very difficult to perform the requested task at home from the technical point of view. A droplet is likely to stuck in one tooth of the ratchet and only undergo Leidenfrost levitation ("Noise", IYPT 2005), if these special requirements are not fulfilled.

5. Discussion and approval by the IOC

5.1. On July 12, we distributed the early version of this report to all IOC and EC members.

5.2. On July 24, the Secretary-General suggested making a last-minute replacement in the proposed problem set, citing his concerns on the feasibility of one problem. In the following discussion, the President advised not to take such a step citing the fact that the draft of the report had been already disseminated among the IOC members.

5.3. On July 28, the IOC discussed and approved the proposed selection of the problems. Minor edits were done to improve sense and style. Two images were added to improve clarity of the problems, one of them was produced during the IOC meeting.

5.4. On July 30, an experienced problem author suggested replacing the word *produced* with the word *created* in the problem No. 9 "Carbon microphone", citing issues of style. On the same day, an experienced Committee member suggested replacing the word *strings* with the word *springs* in the problem No. 4 "Soliton", citing a recent discussion with the problem author, feasibility, and necessity to have entirely elastic coupling between the pendula. Both proposals were objected by roughly half of the EC members, citing the earlier vote by the IOC.

5.5. On July 30, a few EC members questioned the agreement in the submission form that stated, "IYPT will credit all authors of selected problems for respective year en block." The rationale was that the IYPT participants may put unnecessary attention to the list of authors, instead of the problems themselves. The objections to this opinion were that the IYPT cannot disrespect their agreements with the problem authors as stated in the submission form; the authors deserve proper credit to their input; such a credit was the standard policy of the IYPT until 1999; no controversial information would be revealed to the teams if the authors are only credited en block. A compromise was reached by removing the list of authors from the official PDF-file released on August 1.

5.6. The problems were officially published at *iypt.org* on August 1, 2012 following the time framework decided on July 28.

6. Further remarks

6.1. On July 12, we retrospectively checked the background of all 89 proposals. They constituted two large groups: 68 proposals submitted by IOC members and 21 proposals submitted by independent contributors, often not affiliated with any national organization. We acknowledge the fraction of such independent submissions (24%) and their eventually high ranking. We believe this corroborates the need to widely disseminate the call for proposals. This would improve the quality, originality and diversity of the IYPT problems in the future.

6.2. Following a question raised at the IOC meeting and a concern that the problems from non-IOC contributors may be of inferior quality, we checked the fraction of the selected problems that were submitted by non-IOC contributors. There was no positive correlation found between the quality of the proposal (as rated by the IOC) and the fact of submission by an IOC member. An experienced Committee member cited his experiences since 2009 when (a) his contributions were always selected by the IOC into the final problem sets and were thus of a reasonable quality, (b) he however never made his contributions as an IOC member or via an IOC member. The requirement to "call on interested physicists to list problems for next year's competition" is bound by the IYPT Statutes. We encourage submissions from any "interested physicist".

6.3. A web-based platform to receive the proposals, handle the vote, and facilitate the discussion between the Committee members, would be a benefit in the future.

6.4. It would be beneficial to invite future contributors to fill the following check-boxes in the submission form:

> **Checkbox: is the problem new at the IYPT? ***
> Please check the appropriate boxes below
> * I have checked archive.iypt.org/problems and confirm that the proposal has never been an IYPT problem before
> * There was a similar IYPT problem in the past, but I endorse the new proposal as interesting and important
> * I am not sure whether a similar problem has been at the IYPT in the past
>
> **Checkbox: is the problem feasible for IYPT participants? ***
> Please check the appropriate boxes below
> * Experiments are clearly feasible, effects are reachable, no extraordinary equipment needed, I did tests on my own (or feel confident that any experiment will run well)
> * I trust literature or information from my colleagues that the problem is apparently feasible at the IYPT level
> * I am not sure how feasible is the problem from the IYPT perspective

6.5. We immediately started receiving submissions for the IYPT 2014. The updated submission form was published at *iypt.org* on August 3. By August 4, we received two submissions for the IYPT 2014.

[1] Commentary no. 1: "it's easy to understand what to do. the experiment is rather simple, e.g. it's easy to achieve good results (meaning something fun to see). all in all it's one of the motivating problems, something even weak teams might immediately want to try. however, as always, once motivated there's enough physics there so that you can make it physically interesting and complex. still the basic idea is fundamental - momentum conservation. on the experimental side also there's lots to excel at - as it's an optimization task too. i love these, as teams can compete also in something easily measurable - highest altitude. finally it's something that makes some noise, involves movement, water, pressure - while still not being too much danger. an iypt with only problems like this one might not be perfect. but an iypt without at least 2 or 3 of these would be worse."
[2] Commentary no. 2: "May be unsafe because of high pressure applied."
[3] Commentary no. 3: " The highest altitude is reached at highest pressure if all other parameters are fixed. The physics behind is not tricky. However, the highest pressure has highest chances to knock out teeth."
[4] http://en.wikipedia.org/wiki/Water_rocket#Safety
[5] http://www.sciencetoymaker.org/waterRocket/safetyWaterRocket.htm
[6] R Barrio-Perotti et al. Theoretical and experimental analysis of the physics of water rockets. Eur. J. Phys. 31 (2010) 1131–1147, http://iopscience.iop.org/0143-0807/31/5/015/pdf/0143-0807_31_5_015.pdf
[7] Euler M., Niemann K., "Hearing Light", The Physics Teacher, Vol. 38, pp 356-358, http://www.uni-landau.de/physik/Hearing%20Light.pdf
[8] http://www.pmmh.espci.fr/fr/gouttes/Publications_files/Dupeux2011b.pdf
[9] http://www.pmmh.espci.fr/fr/gouttes/Publications_files/Dupeux2011a.pdf
[10] http://www.pmmh.espci.fr/fr/gouttes/Publications_files/Lagubeau2011.pdf

Statistical analysis of the votes

1. Ranking of the proposals

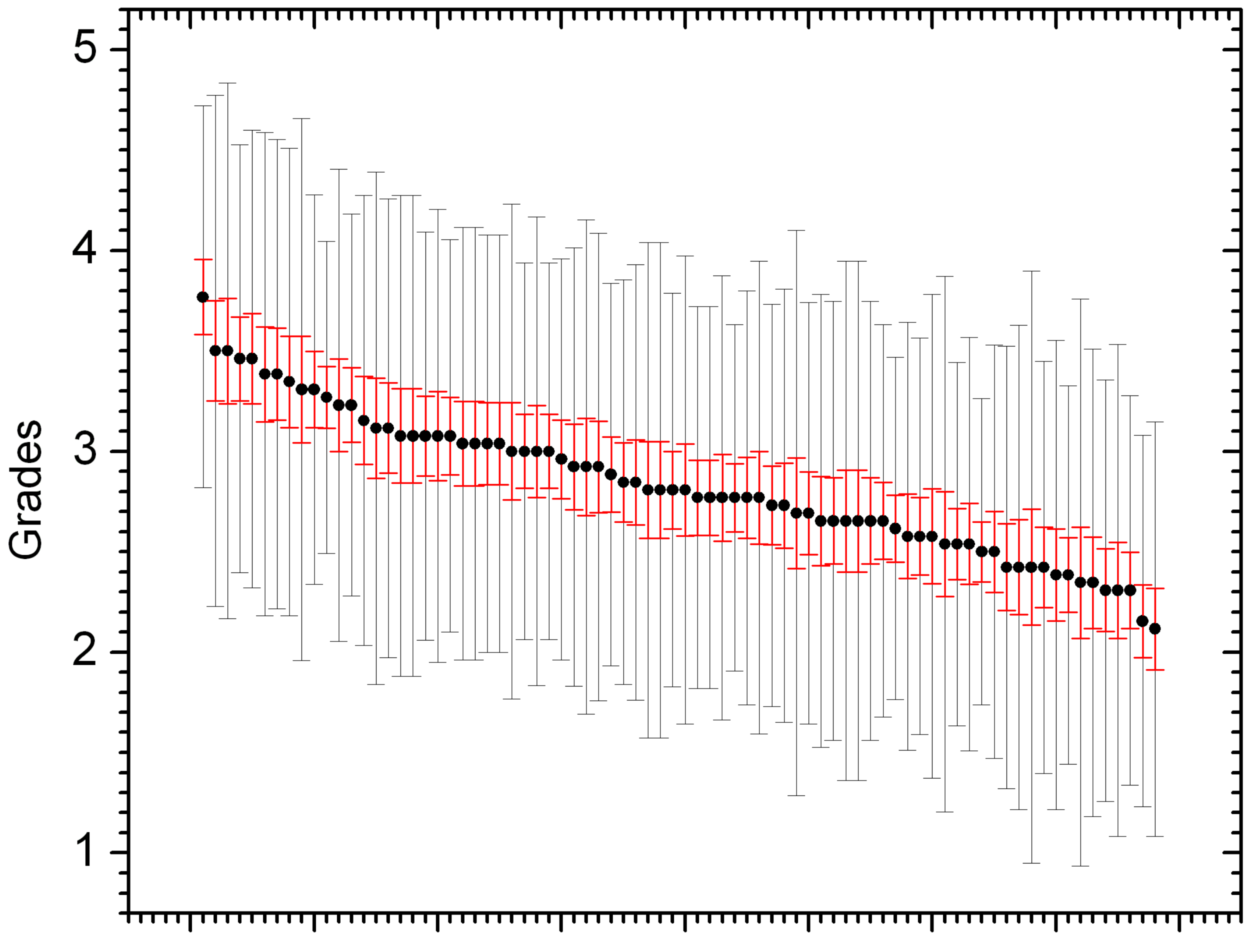


Figure 1. The distribution parameters for the grades given to each proposal, sorted descending.

Circles represent the arithmetic mean $\langle\mu\rangle$ of the marks given to each proposal.

Black error bars represent the standard deviation σ across the population of marks μ_i for a specific proposal.

Red error bars represent the *biased standard deviation of the sample* $\sigma/\sqrt{n}$ which may estimate the statistical uncertainty to determine the mean from a finite data set of n=26 observations. The red bars may roughly represent therefore the *utmost* "resolution" we may achieve when distinguishing between average grades for neighbor proposals. In average, $\sigma/\sqrt{n}$ =0.22.

Stability of the ranking: a few tests were performed to check how sensitive is the ranking to the number of votes, i.e. how significantly it changes when a new vote is added to an existing statistics from ca. 20-25 voters. Ca. 5 top problems are especially stable and keep their place in the ranking. The top 10-20 problems are quite stable but often shift a few positions up or down. Central part of the ranking seems to be the least stable and prone to significant changes when a new vote is included to the set of ca. 20-25 votes.

2. Individual grading parameters of the voters

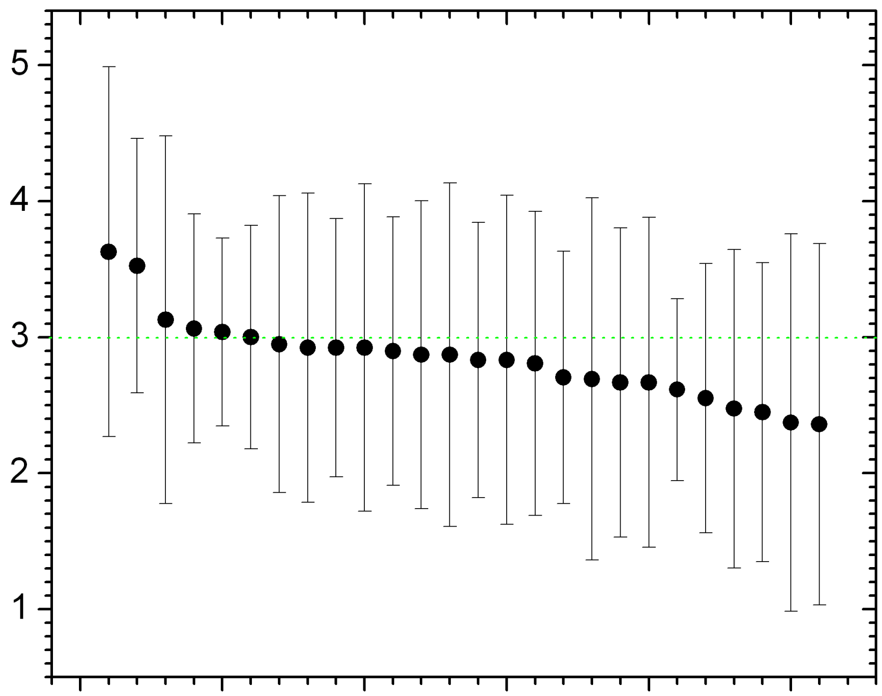


Figure 2. The distribution parameters for the grades given by each voter, sorted descending.

Circles represent the arithmetic mean $\langle\mu\rangle$ of the marks given by a voter to all proposals.

Black error bars represent the standard deviation σ across the population of marks μ_j for a specific voter.

Stability of the ranking: a few tests were performed to check how sensitive the ranking is to the fact that the arithmetic mean is not the same for all voters and can be found in the range from ca. 2.4 to ca. 3.6. A weighting coefficient was then considered as a possible improvement.

However, the ranking *is* stable, most probably due to the fact that *each* voter votes on *each* proposal.

3. Test of human bias: number in the list

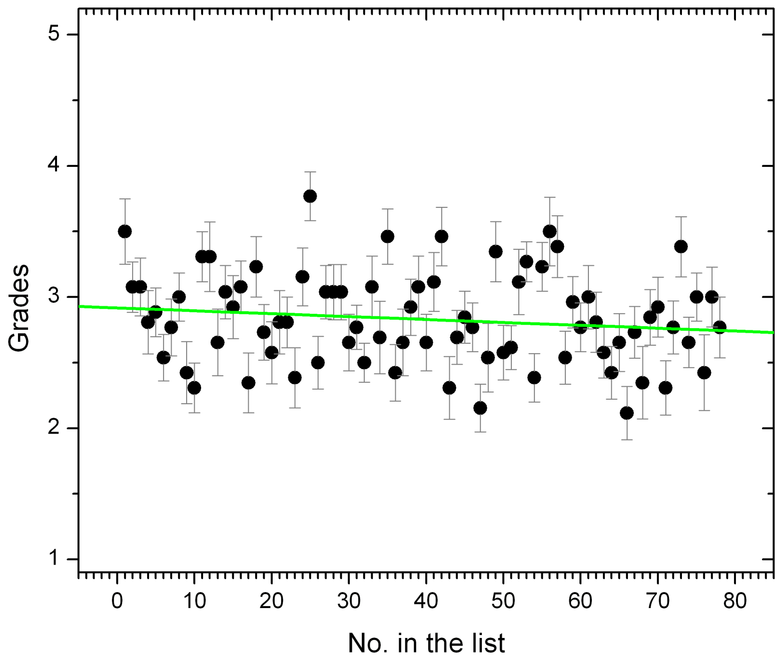


Figure 3. The distribution parameters for the grades given to each proposal as a function of the proposal number in the list.

The test is performed to understand if the ranking is influenced by such factors as human fatigue of seeing many proposals at once, or tending to under- or overestimate the proposals in the middle, in the beginning or in the end of the list. (The proposals were sorted by their submission date.)

The **green line** shows a linear fit across the mean grades as a function of proposal number. The data is not showing a convincing trend.

The apparent slight decrease of *expected* grades (from ca. 2.9 for *first* proposals to ca. 2.7 for the *last* proposals) is well within the inherent statistical uncertainty $\sigma/\sqrt{n}$ to determine the arithmetic mean for any proposal (cf. gray error bars.)

Proposed selection of problems for the 26th IYPT (2013)

Selected on July 12, 2012

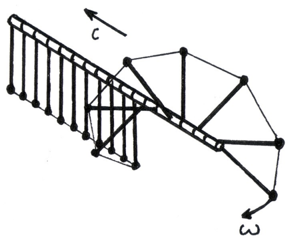
* red is for the edits made by the IOC on July 28, 2012 and final grammar checks

There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy
Shakespeare

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 ~~maximise~~ optimise some or all of them.

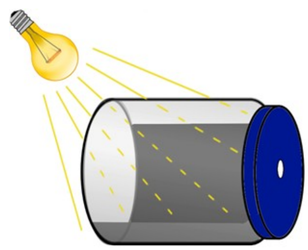
2. Elastic space
The dynamics and apparent interactions of massive balls rolling on a stretched horizontal membrane are often used to illustrate gravitation. Investigate the system further. Is it possible to define and measure the apparent “gravitational constant” in such a “world”?

3. ~~Ping-Pong ball~~ 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 nature of the collision depends on amount of liquid inside the ball and other relevant parameters.



4. Soliton
A chain of similar pendula ~~are~~ 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 ~~F~~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?

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 ~~so as~~ to produce the maximum angle of tilt that results in a stable ball position.



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

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 ~~ae~~ AC hits the jar’s black wall, a distinct sound can be heard. Explain and investigate the phenomenon.

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 ~~of the jet~~.

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.

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.

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 ~~to avoid short circuiting at~~ when working with high currents!)

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.

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

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 on the lift-off and ~~the~~ dynamics of the cylinder.

15. Meniscus ~~diffraction~~ optics
Cut a narrow slit in a ~~metal sheet~~ thin sheet of opaque material. Immerse the ~~metal~~ sheet in a liquid~~,~~ such as water. ~~On~~ After removing the sheet from the liquid, you will see a liquid film in the slit. Illuminate the slit and study ~~its diffraction~~ the resulting pattern.

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.

17. Fire hose
Consider a ~~fire-~~ hose with a water ~~-~~ jet is coming from its nozzle. ~~If the fireman were to drop it, you may see the motion of the hose.~~ Release the hose and observe its subsequent motion. Determine the parameters that affect this motion.

Possible substitutes for the 26th IYPT (2013)

Selected on July 12, 2012

i. Substitute for Chaos theory, electromagnetism, mechanics
Magnetic pendulum
Make a pendulum with a magnet attached to its end. Place it over base containing magnets, and move it out of its equilibrium position. When is it possible to determine the final position of such pendulum?

ii. Substitute for Mechanics
Twisted rope
Hold a rope horizontally and twist one of its ends. At some point rope will form a helix or a loop. Investigate and explain the phenomenon.

iii. Substitute for Fluid Dynamics
Pulsating fountain
Investigate the rise and fall of a fluid jet, which is directed vertically upwards.

iv. Substitute for Optics
Spy glass
If you look in a one-way mirror (e.g. in cars or buildings), you just see your reflection. But by taking photos, under certain conditions, you can see the background through the mirror in the picture.

v. Substitute for Acoustics
Chirping ribbons
Investigate and compare the sounds produced by tightening rubber bands in contrast to those of e.g. tightening threads. Determine the relevant parameters that are responsible for the differences in the sounds produced.

Authors of the selected problems

Disclosed on August 1, 2012

Ivan Antsipau, John Balcombe, Samuel Byland, Jürgen Durst, Łukasz Gładczuk, Gavin Jennings, Heinz Kabelka, Rudolf Lehn, Maciej Malinowski, Ilya Martchenko, Björn Miksch, Florian Ostermaier, Stanisłaŭ Piatruša, Martin Plesch, Qian Sun, Hassan Bagheri Vloujerdi.

In alphabetical order.

Authors of the selected illustrations

Disclosed on August 1, 2012

4. Soliton
Andrei Klishin

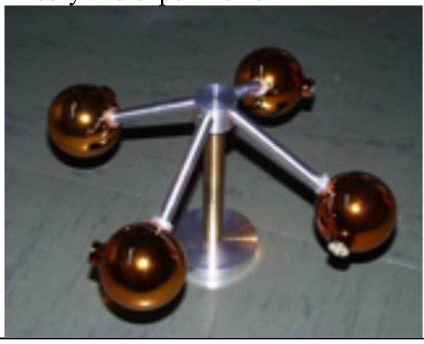
6. Coloured plastic
Evgeny Oleinik

7. Hearing light
Kathryn Zealand

8. Jet and film
Stanisłaŭ Piatruša

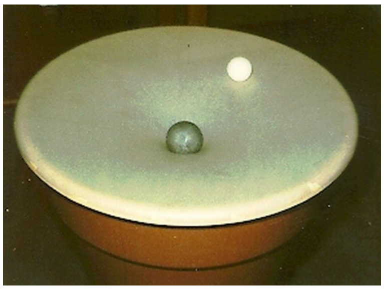
Working sheets (ranked original proposals, discussion)

ID 2013-32
Received on April 29, 2012
3.77
Acoustics, mechanics

Title of the problem	Helmholtz carousel
Suggested phrasing	Attach Christmas tree balls on a preferably frictionless mounting suspension (carousel) while the hole of each ball looks in a tangential direction to the rotation circle of the carousel. If you expose this setup to sound of a reasonable frequency with sufficient intensity, then the carousel starts to rotate. Explain this phenomenon and investigate the parameters leading to a maximum rotation frequency of the carousel.
Source (full citation of any paper, book or webpage used)	1. Einführung in die Akustik; Hans Borucki; BI-Wissenschaftsverlag; 3. Auflage 1989 2. Technische Akustik: Grundlagen Und Anwendungen; Reinhard Lerch, Gerhard Sessler, Dietrich Wolf; Springer; 2008 3. The reaction force on a Helmholtz resonator driven at high sound pressure amplitudes, Ricardo R. Boullosa and Felipe Orduna-Bustamante, Am. J. Phys. 60, 722 (1992)
Physical background of the problem	Helmholtz resonator
Expected contribution of students (theory / experiment / both)	Theory and experiments 

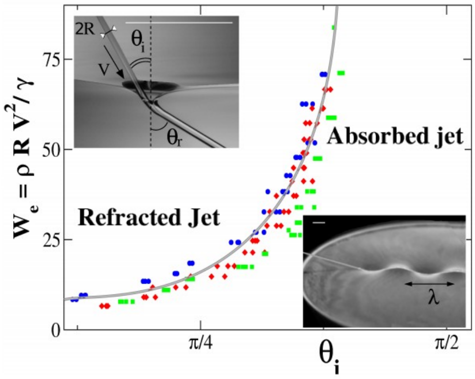
Commentary (I. M.): request the author if the photo is of own work and can be used in the problem set. Shorten, clarify the wording?
Commentary (S. B.): Very interesting problem. I just wonder how difficult it is to build a working setup (friction).
Commentary (I. M.): In response to the previous commentary, the problem can be re-formulated with only focus on rotation, not necessarily using a mechanical rotor on a shaft. There are a few videos on Youtube where a very similar carousel is produced with a spinner suspended on wires to reduce friction.
http://www.youtube.com/watch?v=SemQS4RLeFU
http://www.youtube.com/watch?v=je7eLZS6GG0
Suggested improved wording: "Several Christmas tree balls are attached to a horizontal circular frame that can rotate with little friction around a vertical axis (e.g. if suspended on wires.) The open hole of each ball is aligned tangentially to the frame. If the setup is exposed to a sound of a specific frequency, the carousel starts to rotate. Explain this phenomenon and investigate the parameters leading to maximum angular speed of the carousel."
Commentary (J. B.): Could other balls be substituted. Do all countries have access to Christmas tree balls?
Commentary (I. M.): I think it would be easy to acquire Christmas tree balls in any country. It is difficult to find other (cheap) balls shaped as Helmholtz resonators.
Could you please kindly suggest if the current wording is enough flexible to allow students choosing any suitable design of the carousel?
Commentary (J. B.): I think the idea of low friction is clearly stated, but how this is implemented is up to the students themselves. I don't think we should be too prescriptive on these occasions as it is important to encourage original approaches and solutions. If they cannot make it work, they have done a bad job!
Commentary (S. B.): I agree with John that this problem is clearly stated as it is. We have to be careful that the description we offer is not actively leading the students in a wrong direction, but in this case this doesn't seem to be the case (at least if the photo won't be included).

ID 2013-65
Received on April 30, 2012
3.50
Mechanics, introductory general relativity

Title of the problem	Elastic space
Suggested phrasing	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"?
Source (full citation of any paper, book or webpage used)	Inspired by a demonstration at Technorama Science Center in Winterthur and a related problem considered, but never selected for the IYPT 2008 https://wiki.brown.edu/confluence/display/physlecdemo/1L20.10+Gravitational+Well http://en.wikipedia.org/wiki/Gravity_well
Physical background of the problem	 (Figure courtesy of brown.edu, used here **only** as an **internal** illustration.) The two balls appear to experience an attractive force, while both can move only on an curved "2D" surface. If pushed aside, the lighter ball would start evolving around the heavier ball like a satellite around a planet. The instrumentation is extremely easy-to-made. Three or more balls would demonstrate complex and even more interesting behavior. The problem appears highly promising for the IYPT since it opens a plethora of opportunities for observations, measurements, interpretations, and serious analogies to complex models of gravitation (gravity wells in general relativity, shape of the rubber sheet vs field of a gravitational potential etc.) The participants are expected to develop understanding of idealized elastic membranes, "distorted" 2D or 3D spaces, interaction potentials, bases of field theory, complex dynamics, and draw analogies between systems of different nature that are governed by the similar mathematical laws.
Expected contribution of students (theory / experiment / both)	Both

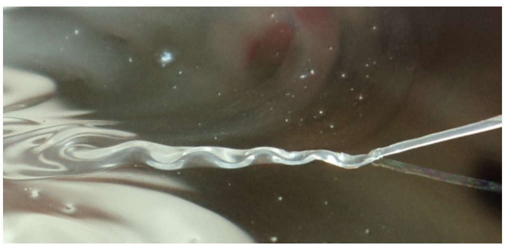
Commentary (S. B.): Good problem.
Commentary (J. B.): Not a problem – should be fine.

ID 2013-01
Received on September 9, 2011
3.50
Fluid dynamics, capillary phenomena

Title of the problem	Jet and film
Suggested phrasing	A thin water jet is impacting on a soap film. Investigate how the jet interacts with the film as a function of relevant parameters.
Source (full citation of any paper, book or webpage used)	The phenomenon was very recently discovered by Christophe Raufaste et al. at the University of Nice. This proposed task was formulated during the Liquid Matter 2011 conference in Vienna, Austria. Geoffroy Kirstetter, Christophe Raufaste, and Franck Celestini. Jet impact on a soap film. arXiv:1203.0842v1 [cond-mat.soft] 5 Mar 2012, **http://arxiv.org/pdf/1203.0842.pdf**
Physical background of the problem	Depending on the incident angle and other parameters, the jet may either coalesce with the film, or penetrate it without bursting it. In the case of coalescence, the jet bends into a sinusoid-shape curve. In the case of penetration, the jet is physically refracted.  (Figure courtesy of Raufaste et al., used here **only** as an **internal** illustration.) The problem is recommended for the IYPT given the novelty and relevance of the phenomenon; a realistic possibility for the students to acquire new, state-of-the-art results; simplicity of conducting experiments at home; and possibility to interpret the data at various depth levels. Furthermore, the effect is believed to be very visual and though-provoking.
Expected contribution of students (theory / experiment / both)	Both

Commentary (S. B.): How easy is it to reproduce the effect? Has anyone tried? What are the students expected to do beyond what already has been done?
Commentary (I. M.): The students can go beyond in investigating further interesting parameters and providing own explanation and/or theory (since the explanation in the paper is not exhaustive.) The topic seems to be *hot* (i.e. a recently discovered phenomenon not exposed in literature) so going beyond is much easier than with e.g. “Flying Circus of Physics” problems.
Commentary (S. E.): I'm concerned that "Jet and Film" will be too difficult from a theoretical point of view.
Commentary (J. B.): Tricky physics, but otherwise a fine problem.

An experimental check performed: the phenomenon easy to produce, well pronounced!
Comm entary (S. P.): The jet coalescence itself can be reproduced very easily (appropriate combination of liquid for jet and film is required). Sine waves can be trickier to observe, but there are many interesting aspects to be studied besides (reflection / refraction / coalescence).
Quick & dirty test that yielded all necessary effects:
Jet: diameter 0.2 mm (Syringe needle), speed: ~2-4 m/s
Film: equal quantities of water and liquid soap (shampoo): about 40 ml each + 30 g ordinary soap.
Jet can be either of pure water (then mostly reflection and refraction, sometimes coalescence are observed) or the same surfactant solution as for the film (then almost no reflection, strong pronounced coalescence, sometimes refraction are observed.)

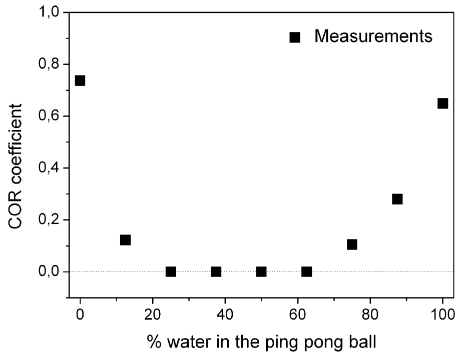


ID 2013-43
Received on April 29, 2012
3.46
Mechanics, fluid dynamics

Title of the problem	Pingpong ball
Suggested phrasing	When you let a ping-pong ball go, it bounces of the ground. Character of the collision changes when ball is filled with water. Investigate how character of the collision depends on amount of water inside the ball and other relevant parameters.
Source (full citation of any paper, book or webpage used)	My own idea.
Physical background of the problem	When two objects collide part of the kinetic energy is transformed into heat and vibration. Depending on the amount of transformed energy collision may be elastic, inelastic or ideally inelastic. The Character of the collision is described by coefficient of restitution (COR). As I conducted a simple experiment I found that for empty ball collision with the ground has high COR (it is almost ideally elastic), when ball is partially filled with water at some point ball barely bounces (low COR), but when ball if fully filled with water it again bounces similarly as the empty one did.
Expected contribution of students (theory / experiment / both)	Student should investigate qualitatively how dose coefficient of restitution depends on amount of water inside the ball. Explain way there is an elastic collision or inelastic collision, why for some amounts of water COR is higher and for some lower. What is the reason for energy dissipation in the system? Theoretical model explaining this phenomenon should be proposed if possible.
Further explanations or comments	Student who solves the problem will gain a great knowledge about collisions and waves.

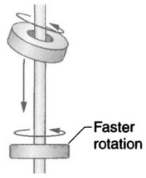
Commentary (I. M.): double-check with the author about the simple experiments.
Commentary (S. B.): Interesting problem, requires only basic setup.

Author's commentary: I understand there is a doubt about simple experiment. The way i put water into the ball is following. I use a thin needle, which is heated with a lighter, to form a small hole in the ball. Then I use syringe with a needle to pump water into the ball. As I checked forming a small hole in the ball dose not influence mechanical properties of the ball. Experiments are repeatable, i checked three different types of balls. Two cheap ones, and one for pro-players. Results were very similar. I am sure that key parameter that the collision depends on is volume of water inside the ball, as it is the only parameter i changed during the experiment. There are also other parameters that influence the phenomenon, for example hardness of the floor, or type of liquid. In the attachment I sent you graph of results from my experiments. I did not include error bars, the uncertainty of water inside the ball is about 1%, and uncertainty of COR is about 0.05.



Commentary (J. B.): Nice problem.
Commentary (I. M.): Water changed to liquid, as agreed with the author.

ID 2013-50
Received on April 29, 2012
3.46
Mechanics

Title of the problem	Falling ring
Suggested phrasing	Hold a wooden rod vertically with plastic ring at the top and then spin the ring – it will gradually move down the rod. Its rate of descent decreases and spin increases. Explane and investigate influence of different parameters on this penomenon.
Source (full citation of any paper, book or webpage used)	www.flyingcircusofphysics.com 
Physical background of the problem	At any given instant, the ring is at a slant, with part of its inner surface touching the rod. In the next instant, the point of touch has moved around the rod and also down it. The point of touch continues to spiral down the rod. As the ring descends, it converts potential energy into the kinetic energy for the spinning. The rate of descent is set by the pitch of the spiral, which is fixed by the slanted orientation of the ring. As the ring spins faster, it becomes more horizontal, and the pitch of the spiral and the rate of descent both decrease. If two rings are set spinning near the top of the rod, the higher ring might happen to catch up with the lower ring. When they touch, the higher ring bounces upward from the collision, spiraling upward.
Expected contribution of students (theory / experiment / both)	Both

Commentary (S. B.): Interesting problem, requires only basic setup. In some ways similar to this year's Woodpecker toy.

Commentary (I. M.): similar to a topic at the IYPT 1998 and is a popular demonstration well exposed in literature ("Flying Circus of Physics", a large chapter in "Flying Bazookas" available online and giving a complete analytical solution.) **IYPT 1998: 3. Spinning disc:**
"Investigate and explain the phenomenon of spinning annular disc as they progress down a straight, cylindrical rod. If the rod is moved upwards at a defined velocity, the disc spins at constant height. Investigate the mechanism."

http://ilyam.org/proc1998/03_Spinning_disc_Finland_Jeremias_Seppa_89-92_Proc_IYPT_1998.pdf (Finland)
http://ilyam.org/proc1998/03_Spinning_disc_Georgia_G._Dalakishvili_and_Z._Osmanov_103-107_Proc_IYPT_1998.pdf (Georgia)
http://ilyam.org/proc1998/03_Spinning_disc_Russia_I_Dmitri_Vaguin_169-172_Proc_IYPT_1998.pdf (Russia)

ID 2013-66
Received on April 30, 2012
3.38
Fluid dynamics

Title of the problem	Honey coils
Suggested phrasing	A thin downward flow of viscous liquid, such as honey, often turns itself into circular coils. Study and explain this phenomenon.
Source (full citation of any paper, book or webpage used)	http://www.youtube.com/watch?v=rEkuhC9eJlM http://ajp.aapt.org/resource/1/ajpias/v27/i2/p112_s1 http://ajp.aapt.org/resource/1/ajpias/v26/i4/p205_s1 http://www.annualreviews.org/doi/abs/10.1146/annurev-fluid-120710-101244 http://hal.archives-ouvertes.fr/docs/00/12/93/93/PDF/ribeetal_text.pdf http://rspa.royalsocietypublishing.org/content/460/2051/3223.full.pdf
Physical background of the problem	 (Figure courtesy of psidot, used here **only** as an **internal** illustration.) The coiling of viscous jets or rope-coil effect is proposed as a nearly ideal problem for the IYPT. Feasible and easily reproducible, it can be investigated and explained at different depth levels. The participants are expected to analyze the apparent hydrodynamic instability and the influence of such parameters as viscosity, surface tension and density on the stability and radii of the coils. The phenomenon is believed to be though-provoking and reflecting the sprit of "everyday life physics". Despite an existing number of past and recent publications, there are many unclear details about the phenomenon, and the participants have even a realistic opportunity to develop their projects beyond the state-of-the-art and come up with entirely novel results and make a good publication after the competition.
Expected contribution of students (theory / experiment / both)	Both

Commentary (S. B.): Experimentally adequate for IYPT (simple setup, various parameters). Not so sure about theoretical part.
Commentary (J. B.): Reminds me of previous shampoo problem (10. Kaye effect, 2008), but sufficiently different. Physics tricky.

ID 2013-83
Received on May 3, 2012
3.38
Electromagnetism, mechanics, thermodynamics

Title of the problem

“Ball Bearing Motor”

Suggested phrasing

A device called “Ball Bearing Motor” uses electrical energy to create rotational motion. What parameters do the motor efficiency and the angular velocity of the rotation depend on?

Source (full citation of any paper, book or webpage used)

Inspired by problem, proposed in 2008.
The device itself looks like this:

Two ball bearings with a conductive shaft placed through them (inside the vice). High current, low voltage DC power supply connected to outer rings. The shaft rotates.
Further information available:
http://en.wikipedia.org/wiki/Ball_bearing_motor
http://www.youtube.com/watch?v=tHZbHMFWS2k
http://www.youtube.com/watch?v=o0ktomInqp8
http://www.fdscience.org/uneko/bbmotor.htm

Physical background of the problem

The main point is origin of rotation. Some sources (as Wikipedia), point that the only source is thermal effect of current (no magnetic effects).

Expected contribution of students (theory / experiment / both)

Both. Theoretical approach needed to determine the main reasons of motion, but neither reliable prove nor efficiency assumptions can be done without working model and sufficient number of experiments.

Further explanations or comments

The problem is going to be quite challenging because of lack of information on unusual electric devices on the web and the controversy (thermal/magnetic) of the problem itself. Small voltages are safe for health, but using such a supply should be accurate do to high risk of short circuit.

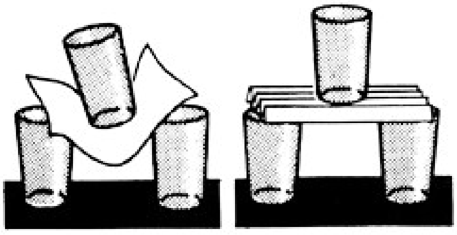
Commentary (I. M.): check with the author how easy it is to construct the device.
Author’s commentary: “Extra experimental tests were now performed. The phenomenon can require some extra engineering work to get reproduced. However, multiple Youtube videos show that the effect is entirely feasible”
Author’s commentary: Safety warning to add, **“Take care to avoid short circuiting at high currents”**.
Commentary (S. B.): Interesting problem, no objections.
Commentary (S. E.): From a saftey point of view and from the point of view of apparatus, I'm not sure about the one with the high current low voltage power supply is good from a school's perspective.
Commentary (J. B.): A student of mine did this as a project about 20 years ago. Good problem, but technical difficulties to overcome.

ID 2013-57
Received on April 30, 2012
3.35
Fluid dynamics, mechanics

Title of the problem	Levitating ball
Suggested phrasing	A light ball (eg 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 optimize the system to produce the maximum angle of tilt of the airstream to produce a stable ball position.
Source (full citation of any paper, book or webpage used)	
Physical background of the problem	Fluid flow, pressure, Bernoulli effect, Koanda effect, surface drag, aerodynamics, force diagrams, balanced forces
Expected contribution of students (theory / experiment / both)	Both
Further explanations or comments	This stems from a well-known demonstration of the Bernoulli effect. To maximize the angle balls of different sizes, masses, surface properties etc will have to be investigated

Commentary (I. M.): suggest a shorter title (“Levitation”?) to avoid any overlapping with another problem about ping pong balls?
Commentary (S. B.): Good problem.
Commentary (J. B.): Nice problem.

ID 2013-17
Received on April 18, 2012
3.31
Mechanics, material science

Title of the problem	Paper bridge
Suggested phrasing	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 only a small amount of glue, construct a bridge spanning a gap of 290 mm. Introduce parameters to describe the strength of your bridge, and maximize some or all of them.
Source (full citation of any paper, book or webpage used)	One of the suggested effects (see Figure) is a popular physics demonstration at an introductory level. A consistent quantitative description of the mechanical properties of such a bridge, however, is quite difficult and is beyond the level of popular physics books that often cite the effect. In the current wording the problem is left entirely open-ended to test different designs (tubes, paper truss bridges, corrugated sheets etc.) and thus many parameters to optimize.  (Image from http://www.klasika.edu.lv/new/VtorojKlass/Dosug/29b.gif and **not** to be used elsewhere.)
Physical background of the problem	The students are expected to develop good understanding of many concepts from mechanics (**http://en.wikipedia.org/wiki/Strength_of_materials**) and equally show a scientific approach to parametric optimization with various coupled and uncoupled physical parameters. The problem is considered ideal for the IYPT given a combination of visual and simplistic task with a good possibility for the students to acquire broad understanding in theoretical mechanics and material science.
Expected contribution of students (theory / experiment / both)	Both

Commentary (I. M.): the author agreed to a suggestion to switch the title to “Invent yourself” to revive the earlier IYPT tradition to have the most open-ended problem each year titled “Invent yourself”.

Commentary (S. B.): Good problem. Are 3.5 mm overlap on each side enough to support the bridge?

Author’s commentary: True, let it be a gap of 280 mm.

Commentary (J. B.): OK, but gap was too wide for A4 paper. Changed to 280mm as author has already accepted.

ID 2013-16

Received April 17, 2012

3.31

Mechanics, fluid dynamics

Title of the problem	Shaking vessel
Suggested phrasing	Place and fix a vessel partially filled with water on a stiff vertical spring, which is fixed on the floor. Describe the motion of the vessel and its dependence on the amount of water in the vessel.
Source (full citation of any paper, book or webpage used)	Own invention, based on an unsuccessful "experiment" performed during cleaning a vivarium.
Physical background of the problem	Vessel with the spring form a nearly harmonic oscillator. The same holds for small amplitudes for the water in the vessel, however generally with different frequency and always shifted in phase. As such they would form a system of coupled oscillators. The water oscillator however cannot be always driven – it falls down easily into chaotic motion.
Expected contribution of students (theory / experiment / both)	The idea is to perform experiments and to see clear distinction between two kinds of behaviors – coupled oscillators and a spring oscillator strongly damped by the chaotic movement of water. Qualitative theoretical explanation shall be possible on the IYPT level, as well as quantitative for the coupled oscillator movement for all levels of the competition.

Commentary (S. B.): I don't quite understand the "nearly harmonic oscillation" of the water in the container. Is it moving from one side to the other (horizontally)? Is the spring's motion constrained to the vertical direction?

ID 2013-62
Received on April 30, 2012
3.27
Mechanics

Title of the problem	Hoops
Suggested phrasing	Make some hoops from an elastic material (e.g. strips of overhead transparencies). When you drop them vertically onto a hard surface, they rebound to a fraction of the initial height. Investigate how the rebound height depends on the relevant parameters.
Source (full citation of any paper, book or webpage used)	Yang E. Kim H.-Y., "Jumping Hoops", Am. J. Phys. 80, pp 19ff
Physical background of the problem	Conversion of different forms of energy (with dissipation). Elastic forces.
Expected contribution of students (theory / experiment / both)	Students should experimentally investigate the elastic properties ("spring constant") of the hoops and how they depend on various parameters. They might model the hoops motion including the relevant sources of dissipation.
Further explanations or comments	The jump of a hoop is similar to that of a rubber ball with the advantages that the properties can easily be adjusted and that the deformation is clearly visible.

Commentary (S. B.): Interesting problem, works very well. Various parameters to vary.

Commentary (J. B.): OK – I think it is obvious what the intended orientation of the hoops is.

Commentary (I. M., S. B.): Wording changed to make the problem entirely open-ended. Among the reasons was the difficulty to observe a distinct re-bounce after the free-fall impact due to strong air drag and uncontrolled rotation of the hoop.

ID 2013-23
Received on April 27, 2012
3.23
Mechanics, oscillations and waves

Title of the problem	Chain of coupled pendula
Suggested phrasing	Number (around 50) of equal pendula on stiff holds is equidistantly mounted on a horizontal axis in such a way that they can freely swing. Each two neighboring pendula are connected with a weak string. Determine the speed at which a small deflection propagates on such a chain. What is the speed of propagation of full 360° rotation of a pendulum (soliton)?
Source (full citation of any paper, book or webpage used)	Idea taken from the presentation of Thomas Filk, University of Freiburg on Quantum Malta 2012 conference (was used as a toy model for Quantum relativity models).
Physical background of the problem	The group speed of small waves **c** can be derived as a function of spring constant, length of the pendula, mass and gravitation acceleration. This can be also experimentally investigated. Soliton can be evoked by a quick turnaround of the first pendula in the row – it will start to propagate through the chain with a speed depending on the speed of the turnaround, but always smaller than **c**. Theoretical derivation is possible, but more complicated.
Expected contribution of students (theory / experiment / both)	Student should construct their own apparatus and me able to measure and theoretically derive the group speed of small waves. They should also observe the soliton and its propagation speed and the fact that it is smaller than **c**. On a more advanced level they might be able to derive a dependence between the speed of evoking the soliton and the speed (and width) of the soliton.
Further explanations or comments	I am happy to stick only on small waves on the chain if the soliton would seem to be more complicated. On the other hand other different stable solution, like the breathing solution, might be also introduced.

Commentary (I. M.): check with the author if the pendula can oscillate in all possible directions (i.e. along the line, normally to the line etc.)
Commentary (I. M.): suggest a shorter title (“Soliton”? “Oscillations and waves”?) to avoid any confusion with another problem (about the magnetic pendulum)?
Author’s commentary: “As you have mentioned you need to check with the author concerning "soliton": I am fine with changing the title to soliton. The pendula can oscillate only around the axis, so each pendulum has only one degree of freedom.”
Commentary (S. B.): Does "weak string" to "light string" or "loose string"? Same question as Ilya with respect to the direction of oscillation (360° could be circular motion or a full period in any direction). Is the quality of the setup critical for the phenomena to be observed or should a setup made from "simple" materials work as well? (building 50 identical pendula from metal rods is both expensive and time consuming)
Commentary (J. B.): Fine – I have simplified the wording and title.
Commentary (A. K.): The first arising question is whether small or big deflections should be researched.
Small deflections give a system of linear differential equations (linear PDE in limit of infinitely many infinitely small pendula) – ordinary wave equations. This system gives a simple solution for waves which phase velocity depends on frequency. Thus we can split the initial push/pull into fourier harmonics and observe their propagation (not actually a soliton). Due to nonlinearity these waves can be approximately treated as linear for a certain amount of time, which states one of the questions.
Large deflections are governed by the well-studied equation, and Wikipedia gives pretty nice pictures for possible solutions. The initial statement of the problem mentions the 360 degrees swing, which is clearly proved by videos. However, the setup is pretty big and may require careful adjustment. Also the Sine-Gordon equation predicts such interesting solutions as breathers – stable oscillations of a few nearby pendula, which can be resting at some position or travelling across the chain.
Commentary (I. M.): To address this remark, I suggest to consider the following wording: “A chain of similar pendula are 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, i.e. when each pendulum undergoes an entire 360º revolution”
Author’s commentary: I fully agree with the remark, the wording and also with a nice figure, if you find one.

ID 2013-64
Received on April 30, 2012
3.23
Mechanics, electromagnetism

Title of the problem	Rotating disc
Suggested phrasing	A conducting disc (e.g. copper or aluminium) can freely rotate about its axis. When a magnet is rotated about the same axis and close to the disc, the disc starts rotating. Explain and investigate the disc's motion.
Source (full citation of any paper, book or webpage used)	Inspired by a demonstration experiment at our school
Physical background of the problem	Force on induced eddy currents accelerates the disc. An (idealised) stationary situation is reached once the disc's and magnet's speeds match, but because of friction the relative motion might not completely disappear.
Expected contribution of students (theory / experiment / both)	Students should give a correct explanation for the phenomenon. They should experimentally investigate the influence of relevant parameters (different magnets, distance between magnet an disc, speed, mass of disc, …) on the acceleration time, etc. The effect of at least one parameter should be explained with a theoretical model and qualitatively verified.
Further explanations or comments	

Commentary (I. M.): quite similar to a problem from the IYPT 2002: **13. Spinning ball.** A steel ball of diameter 2—3 cm is put on a horizontal plate. Invent and construct a device, which allows you to spin the ball at high angular velocity around a vertical axis. The device should have no mechanical contact with the ball.

Commentary (S. B.): Considering the similarity to a former problem it seems to be reasonable not to include this otherwise interesting problem.

ID 2013-30
Received April 28, 2012
3.15
Fluid dynamics, mechanics

Title of the problem	Fire hose
Suggested phrasing	Look at a fire hose when a water-jet is coming out of its nozzles. In this situation if the fireman drops down the hose you will see the oscillation of hose. Find the effective parameters on the domain and period of this oscillation.
Source (full citation of any paper, book or webpage used)	NON Just looking in hose oscillating.
Physical background of the problem	Water jets and streams, Also Bernoulli Law of continue mechanic
Expected contribution of students (theory / experiment / both)	Both
Further explanations or comments	Water jet Water current Hose oscillation Water cause oscillation

Commentary (I. M.): **consider a more coherent wording?** “A stream of water spurts out of an open end of an elastic hose. If the hose is not fixed, it will oscillate. Investigate the relevant parameters which influence on this motion”?

Commentary (S. B.): Quite challenging to experimentally get reproducible results.

Commentary (S. E.): The fire hose will be very messy!

Commentary (J. B.): Wording tricky, but problem is fine.

Commentary (I. M.): not “oscillation”, but “motion” since it is of chaotic nature.

2.25. Firehose instability. In: Julien C. Sprott. Physics Demonstrations: A Sourcebook for Teachers of Physics (Univ of Wisconsin Press, 2006), Vol. 1, pp. 131-132, http://books.google.se/books?id=9wmgYl49YQ0C

ID 2013-61
Received on April 30, 2012
3.12
Thermodynamics, acoustics

Title of the problem	Hearing Sound
Suggested phrasing	Coat one half of a jar's inside with a layer of soot and drill a hole in its cover. 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.
Source (full citation of any paper, book or webpage used)	Euler M., Niemann K., "Hearing Light", The Physics Teacher, Vol. 38, pp 356ff
Physical background of the problem	Light is absorbed in the soot layer and its energy converted into heat. Since the intensity of light fluctuates, the air near the jar's surface periodically heats up and cools down, leading to pressure variations.
Expected contribution of students (theory / experiment / both)	Students should give a correct qualitative explanation of the phenomenon. They should set up a hypothesis for the relation between the various parameters (intensity and frequency of light, size and shape of jar) and the sound produced in the jar and investigate it experimentally.
Further explanations or comments	

Comment (I. M.) : Consider another title? ("Hearing sound" vs "Hearing light"?) Possibly, "Sound from light" or "Light and Sound" is a good option?
An experimental check performed: the phenomenon easy to produce, well pronounced!
www.uni-landau.de/physik/Hearing%20Light.pdf
Commentary (S. B.): Interesting problem, effect works well.
Author's commentary: Title should be "Hearing Light" (sorry, my mistake).
Commentary (J. B.): Seems very similar to previous problem (4. Cymbal, 2008)
Comment (I. M.): True, they are both on the photoacoustic effects, but not identical. This problem seems very tricky and interesting on it's own. (E.g,: How to build up a sufficient theory for the effect and linking the heat conduction, thermal expansion of the material to the generated acoustic waves.)

ID 2013-49

Received on April 29, 2012

3.12

Mechanics, electromagnetism

Title of the problem	Railgun
Suggested phrasing	A conducting bullet is placed on two conducting rails with potential difference between them. Rails are placed in external magnetic field. Current flows through the system and bullet is accelerated. Investigate the relevant parameters and maximize the efficiency of such a device.
Source (full citation of any paper, book or webpage used)	**http://en.wikipedia.org/wiki/Railgun**
Physical background of the problem	When current flows through a conductor in a magnetic field a Lorentz force acts on it. If conductor (for example a conducting bullet) is free to move it will be accelerated.
Expected contribution of students (theory / experiment / both)	I would expect student to build a device, investigate relevant parameters and determine what is limiting the speed of the bullet. For the theoretical part, one should find equations describing the system. Student may also write a simulation, and use it to optimize the efficiency.
Further explanations or comments	As high current and voltage are dangerous, if task is chosen, a limitation for used voltage should be specified. For example one should use a 100V capacitor too power the device.

Commentary (S. B.): Well known effect, difficult to obtain impressive results with school equipment.

ID 2013-04
Received on January 20, 2012; in revised form on April 29, 2012
3.08
Chaos theory, electromagnetism, mechanics

Title of the problem	Magnetic pendulum
Suggested phrasing	Consider a pendulum with a magnet attached to its end. Place it over base containing magnets, and move it out of its equilibrium position. When is it possible to determine the final position of such pendulum?
Source (full citation of any paper, book or webpage used)	Here is a video well presenting this phenomenon: http://www.youtube.com/watch?v=Qe5Enm96MFQ
Physical background of the problem	Such pendulum exhibits chaotic behavior. Final position of the pendulum depends strongly on initial conditions, and in general one is not able to precisely predict pendulums motion and final position. However for some initial conditions (for example small displacement from equilibrium) one is able to predict final position.
Expected contribution of students (theory / experiment / both)	Solution of the problem would require knowledge of classical mechanics, magnetostatics, and little of electrodynamics. Mayor forces that act on the pendulum are gravitational and once from magnetic interaction. Dumping due to air friction and eddy currents also occurs. Students contribution that I would expects is: **Theoretical:** - Equations describing pendulums motion. - As those equations are hard to solve, a numerical simulation to solve them. - Chaotic systems are often investigated using methods such as: Lyapunov exponent, Poincaré map, Fourier analysis. This also allows comparing theory with experiment. **Experimental:** - Student should build such pendulum - Investigate how it behaves depending on initial conditions, mass of pendulum and its length, strength of the magnets, number of magnets and their position and orientation.
Further explanations or comments	Problem allows students to learn a lot about chaotic systems. Experimental setup is easy to build and no advance apparatus is required to perform measurements.

Commentary (S. B.): Well known and thoroughly studied phenomenon. I doubt that students can come up with interesting new ideas. I recommend not to include this problem because of its lack of originality.

Author's commentary: I agree with the comment that the phenomenon is well studied. However it is common that also well studied phenomena are the tasks for IYPT. In my opinion this still is a great and interesting problem.

(On the other hand If I would have a choice I would rather select problem *Twisted rope*. It seems far more interesting and less trivial. As I look for literature on this topic I find that this phenomenon is important in understanding the behavior of DNA chains. It is interesting that problems of micro-scale can be investigated, and analyzed using macro-scale systems such as rope or elastic rod.)

Commentary (I. M.): Substitute for Chaos theory, electromagnetism, mechanics?

ID 2013-40-82
Received on April 29, 2012
3.08
Heat and mass transfer, fluid dynamics

Title of the problem	Flying chimney
Suggested phrasing	Light paper (e.g. from a tea bag) is formed into a cylinder with open front faces. The cylinder takes off, when one end is lit. Optimize the vertical velocity of the flying chimney.
Source (full citation of any paper, book or webpage used)	Similar problems are investgated in different reports of journals, e.g. "The flight of the humble tea bag" Physics Education, January 2004 pp 22
Expected contribution of students (theory / experiment / both)	Theory and experiments ….

Title of the problem	Teabag Rocket
Suggested phrasing	Cut the teabag's end, throw away contained tea leaves and straighten the material to form a cylinder (see the picture). Put the cylinder vertically to a nonflammable desk (could use an ordinary glass plate) and light the upside end with a lighter. The teabag will fly away vertically when almost burned. Explain the reasons of the phenomena and investigate the critical parameters (like size, density and flammability of the paper) that affect the lift-off occurrence and motion.
Source (full citation of any paper, book or webpage used)	Quite a well-known physics trick (I've seen this on the TV about 10 years ago), I used this video to take the screenshots : http://www.youtube.com/watch?v=TKF3OKxwM8g 
Physical background of the problem	It looks like the air is heated and convection occurs; when the mass of an unburned part and velocity of the convectional flow are in a certain relation the lift-off occurs,
Expected contribution of students (theory / experiment / both)	I expect that the teams prove the qualitative explanation (that is widely spread in the Internet) first and then concentrate on the critical parameters of the teabag (e.g. density/size/flammability of the paper) that influence the process (both lift-off and further motion). I'm pretty sure that these values should be in certain relation (allowed range) for the left-off to occur. I'd be happy to modify the wording to encourage students to study various range of paper and shapes.

Commentary (I. M.): Combined and improved wording coordinated with all authors: "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 on the lift-off and the dynamics of the cylinder."
Commentary (S. B.): Interesting problem. Simple experiment, theoretically challenging.
Commentary (J. B.): Similar to lantern problem from 2012 (and might also be illegal in Australia!!)

ID 2013-03

Received on January 20, 2012; in revised form on April 29, 2012

3.08

Mechanics

Title of the problem	Twisted Rope
Suggested phrasing	Consider a rope hold horizontally on its two ends. Twist one of its ends. At some point rope will form a helix or a loop. Investigate and explain the phenomenon.
Source (full citation of any paper, book or webpage used)	Once I read an interesting article on this topic, but I cannot find it at the time. Here are articles connected with this phenomenon: J. Michael T. Thompson "Single-molecule magnetic tweezer tests on DNA: bounds on topoisomerase relaxation" Proc. R. Soc. Lond. **464** (2008) 2811 A. Goriely M. Tabor "Nonlinear dynamics of filaments. IV Spontaneous looping of twisted elastic rods" Proc. R. Soc. Lond. **454** (1998) 3183
Physical background of the problem	When rope is twisted, energy due to internal strain is building up. At some point it is energetically preferable for rope to form a loop, than remain twisted. Problem involves basic continuum medium physics.
Expected contribution of students (theory / experiment / both)	Student should investigate, why initially straight horizontal twisted rope changes it shape. Student should answer questions: - What shapes can be obtained in this process. - On what parameters dose phenomenon depend: (length of rope, distance between ends of rope angle of twist, diameter of the rope, history of the rope) - Is there hysteretic in the system? It would be greater is student would achieve a phase diagram presenting what shapes can a rope obtain for given distance between ends of a rope and angle of twist. This phenomenon can be analyzed by looking on the total energy of the system. Such analysis, or similar, should be carried out, and conclusions should be carried out.
Further explanations or comments	This is a very common, and easy to observe phenomenon. However it is not easy to explain its cause.

Commentary (I. M.): substitute for Mechanics?

Commentary (S. B.): Sounds promising. Only basic equipment required.

Author's commentary: As I look for literature on this topic I find that this phenomenon is important in understanding the behavior of DNA chains. It is interesting that problems of micro-scale can be investigated, and analyzed using macro-scale systems such as rope or elastic rod.

Here you can find a movie connected with the phenomenon:
http://www.youtube.com/watch?v=k4fbPUGKurI&feature=related

ID 2013-21
Received on April 21, 2012
3.08
Mechanics

Title of the problem	YoYo Physics
Suggested phrasing	The YoYo has been entertaining adults and children for well over two thousand years. The motion of the Yoyo is controlled by gravity, and by applying and manipulating tensile forces in its string. Investigate the motion of a YoYo under various conditions.
Source (full citation of any paper, book or webpage used)	The problem is of my own creation.
Physical background of the problem	The YoYo consists of a fairly heavy spinning cylinder suspended on a length of string that sits in a deep groove around the axis of rotation. The YoYo is set in motion by 'throwing', while control is maintained via the attached string. Simple Yo-Yoing involves the unwinding and subsequent rewinding of the string, but many other tricks are possible. As a spinning system subject to externally applied forces, the YoYo provides many examples of rotational dynamics.
Expected contribution of students (theory / experiment / both)	Students should obtain and analyse the motion of a YoYo under normal play conditions. This means measuring forces in the string, rates of rotation etc. More complex situations may be explored e.g. gyroscopic effects.
Further explanations or comments	Simple YoYos are freely available all around the world, and could even be made. It is not expected that more complex YoYos involving mechanical clutches etc. should be investigated.

Commentary (S. B.): Well studied problem.

Commentary (I. M.): Agreed, the problem is well studied in literature.

ID 2013-47
Received on April 29, 2012
3.08
Mechanics, fluid dynamics

Title of the problem	Water rocket
Suggested phrasing	Fill bottle of water partially with water and compressed air and place it vertically. When bottle is opened water will be pushed out and bottle will fly up. Achieve the highest altitude using a 1 litter bottle.
Source (full citation of any paper, book or webpage used)	Lately, this was an experiment presented during a lecture in physics I attended.
Physical background of the problem	High air pressure in the bottle throws water out giving a thrust to the bottle, and bottle flies into the air. It turns out that there is an optimal ration between amount of air and water in the bottle.
Expected contribution of students (theory / experiment / both)	Student investigating the problem should find optimal ratio between amount of air and water in the bottle. He should also discus other parameters such as shape of the nosle, viscosity of the fluid. For the theoretical part student should explain why bottle flies after all, this can be done from the momentum conservation.

Commentary (A. N.) : May be unsafe because of high pressure applied

Commentary (S. P.): The highest altitude is reached at highest pressure if all other parameters are fixed. The physics behind is not tricky. However, the highest pressure has highest chances to knock out teeth

Commentary (T. H.): it's easy to understand what to do. the experiment is rather simple, e.g. it's easy to achieve good results (meaning something fun to see). all in all it's one of the motivating problems, something even weak teams might immediately want to try. however, as always, once motivated there's enough physics there so that you can make it physically interesting and complex. still the basic idea is fundamental - momentum conservation. on the experimental side also there's lots to excel at - as it's an optimization task too. i love these, as teams can compete also in something easily measurable - highest altitude. finally it's something that makes some noise, involves movement, water, pressure - while still not being too much danger. an iypt with only problems like this one might not be perfect. but an iypt without at least 2 or 3 of these would be worse

Commentary (S. B.): Standard demonstration. If this one were to be selected, we should not include the pressure as a parameter to optimise.

ID 2013-19

Received on April 21, 2012

3.04

Electromagnetism, granular matter

Title of the problem	Carbon Microphone
Suggested phrasing	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.
Source (full citation of any paper, book or webpage used)	The problem is of my own creation.
Physical background of the problem	Carbon granules conduct electricity. The granules are trapped between diaphragms that vibrate when sound waves are received. Greater pressure increases the conductivity of the granules and thus can produce an electrical signal.
Expected contribution of students (theory / experiment / both)	The students would be expected to obtain examples of carbon microphones and break them down into component parts. They should explore the electrical properties of the granules as a function of pressure etc. and the overall acoustic/mechanical/electrical properties of the device.
Further explanations or comments	Such microphones are very cheap and widely available

http://www.gutenberg.org/files/11385/11385-h/11385-h.htm#14

Commentary (S. B.): Nice problem, though a bit outdated. Enough variations with simple setup.

Commentary (J. B.): Fine.

ID 2013-35-52
Received on April 29, 2012
3.04
Thermodynamics, fluid dynamics, heat and mass transfer

Title of the problem	Water rise
Suggested phrasing	Fill a saucer up with water and place a candle in the middle of the water. Light the candle. Cover the candle with a clear beaker. Investigate and explain the phenomenon.
Source (full citation of any paper, book or webpage used)	Many different internet links to the candle experiments one can find (primary school to high school) e.g. http://www.wonderquest.com/candle-out.htm
Physical background of the problem	candle light,
Expected contribution of students (theory / experiment / both)	Theory to the chemical and physical matter and different experiments. At the end the students should give a reasonable explanation.

Title of the problem	Egg in the bottle
Suggested phrasing	Lit a piece of paper and put it inside a bottle. Then place a hard-boiled egg on the vessel and watch the egg being sucked into the bottle. Study the origin of this effect and determine the relevant parameters.
Source (full citation of any paper, book or webpage used)	Presentation of the phenomenon: http://www.youtube.com/watch?v=mpC5zlmtm-g Literature regarding the phenomenon in general: http://www.math.harvard.edu/~knill/pedagogy/waterexperiment/index.html , http://www.math.harvard.edu/~knill/pedagogy/waterexperiment/dhindsa.pdf , http://www.math.harvard.edu/~knill/pedagogy/waterexperiment/vera_rivera_nunez.pdf
Physical background of the problem	A source burning inside a bottle produces a pressure decrease. There seems to be a confusion whether the effect is mainly due to thermodynamic processes (and whether the air escapes the container due to larger temperature), or due to chemical processes occuring during combustion.
Expected contribution of students (theory / experiment / both)	• Theretical discussion of thermodynamics of heating a container (which isn't obvious, see for example http://ajp.aapt.org/resource/1/ajpias/v79/i1/p74_s1?isAuthorized=no) and how it applies to the problem • Theoretical predictions regarding the pressure change in the bottle • Experimental determination of the pressure inside the bottle with connection to other parameters (temperature, way of heating, number of sources etc)

Commentary (I. M.): the author of ID 2013-52 agreed that the “candle” version of the problem is better due to the following reasons. (1) it is difficult to find a bottle with an appropriate diameter of the neck, (2) it is safer to use candle than to throw burning pieces of paper inside a bottle, (3) the “candle” effect seems to be more reproducible, (4) motion of a liquid is itself an interesting phenomenon to address.
Commentary (S. B.): Are students expected to explain the chemical part of the phenomenon? It's a physics tournament after all …
Suggested improved wording: “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.”
Commentary by the author of ID 2013-52: Chemical reactions play the fundamental role in the phenomenon, so some comment will inevitably be expected from students. However, after the main chemical process (i.e. burning of oxygen to carbon dioxide) is identified, the theory behind the problem lies fully inside the field of thermal physics. I believe assigning such role to chemical considerations is acceptable and has been the case on IYPT in the past (e.g. Light Scattering from 2003, Bouncing Flame from 2011).
Commentary (J. B.): May be more interesting than it appears.

ID 2013-34
Received on April 29, 2012
3.04
Fluid dynamics

Title of the problem	Pulsating fountain
Suggested phrasing	Investigate the rising and falling process of a fluid jet, which is vertically upward directed.
Source (full citation of any paper, book or webpage used)	Chr. Clanet, "On large-amplitude pulsating fountains", J. Fluid Mech (1998), vol. 366, pp. 333-350
Physical background of the problem	Surface tension, fluid dynamics
Expected contribution of students (theory / experiment / both)	Theory and experiments especially with water. Experimentally the students have to construct fountains With very constant water flow. May be also other fluids show interesting effects.

Commentary (I. M.): similar to "Fountain" (IYPT 2004): "Construct a fountain with a 1 m 'head of water'. Optimise the other parameters of the fountain to gain the maximum jet height by varying the parameters of the tube and by using different water solutions."

Commentary (I. M.): substitute for Fluid dynamics?

Commentary (S. B.): too close to Fire Hose to be included.

ID 2013-36
Received on April 29, 2012
3.04
Heat and mass transfer, capillary phenomena

Title of the problem	Climbing droplets
Suggested phrasing	Liquid droplets can perform a self-propelled uphill motion when they are placed on a hot ratchetlike surface. Investigate and explain the phenomenon.
Source (full citation of any paper, book or webpage used)	H. Linke et al. "Self-Propelled Leidenfrost Droplets", Physical Review Letters, 96, April 2006
Physical background of the problem	Surface tension, Leidenfrost phenomenon, fluid and vapor
Expected contribution of students (theory / experiment / both)	Theory and experiments.

Commentary (I. M.): as reported by David Quéré (École Polytechnique), the effect is feasible for very small and well-defined teeth of a ratchet (1.5 mm long, 0.2 mm deep.) This makes the effect difficult to reproduce at home from the technical point of view.
http://www.pmmh.espci.fr/fr/gouttes/Publications_files/Dupeux2011b.pdf
http://www.pmmh.espci.fr/fr/gouttes/Publications_files/Dupeux2011a.pdf
http://www.pmmh.espci.fr/fr/gouttes/Publications_files/Lagubeau2011.pdf

Commentary (S. B.): Interesting Effect, but obviously to sensitive to correct ratchet.
Commentary (S. B.): if it's not too difficult to find a working setup
Commentary (I. M.): Could you please justify why do you think it's not too difficult to find a working setup? I agree that the problem is fascinating and very interesting, but as I explained in the first pdf, the requirements for the ratchet seem to be quite tricky. (Very regular structure, 0.2 mm x 1.5 mm teeth of the ratchet, stability at the temperatures up to 200-250°C since the Leidenfrost point for water is ca. 193 °C.) Here I can refer to the opinion of David Quéré and to the references mentioned in the pdf. Could you please suggest how you would see the prototype the students can make in their kitchen / school lab? I can now very promptly send an email to David Quéré and Christophe Clanet and ask for their advise and opinion.
Commentary (S. B.): If the setup for "Climbing Droplets" is as delicate as you describe it, I would rather choose another problem instead.

Commentary from Guillaume Dupeux:
The ratchet experiment is not really difficult to build. The tough part is to machine the ratchet. You need a milling machine and a piece of metal (1x5x10 cm) that can be machined (aluminium, brass...). Then you tilt the head of the milling machine by an angle of 10° and you machine a groove every 1.5mm (the drill should enter into the metal with a depth of 300 microns at least). If you have such equipment available, it is only a matter of time (a few hour to machine a ratchet). The rest of the equipment is a hot plate like the one used for chemistry (large enough according to the size of the ratchet and hot enough, about 350°C for water drops) and a camera if you want to record the motion of a droplet.

About the question of the subject difficulty, it depends I think of what you expect from the students. The physical explanation of the motion has been the subject of at least 4 scientific papers during last months and the only experimental demonstration that has been proposed is really hard to repeat without technical equipment (dry ice, fast camera...). But studying the motion of a propelled drop (acceleration and terminal velocity) can be interesting and experimentally feasible. And the Leidenfrost effect is quite fascinating so I am sure that it will be appreciated by the student.

ID 2013-70
ID 2013-70
Received on April 30, 2012
3.00
Optics

Title of the problem	Spy glass
Suggested phrasing	If you look in a one-way mirror (e.g. in cars or buildings), you just see your reflection. But by taking photos, under certain conditions, you can see the background through the mirror in the picture.
Source (full citation of any paper, book or web page used)	Own observation in venice.
Physical background of the problem	Polarization and Brewster's angle
Expected contribution of students (theory / experiment / both)	The idea is to perform experiments to see the effect and give a theoretical explanation.

Commentary (I. M.): check with the author if the effect is indeed reproducible for a variety of such mirrors.
http://en.wikipedia.org/wiki/One-way_mirror
http://en.wikipedia.org/wiki/Optical_coating
Is the effect only related to the spectral sensitivity of human eye vs CCD matrix?
Is the effect sufficiently reproducible?

Commentary (I. M.): substitute for Optics?

Commentary (S. B.): The effect seems to be restricted to the use of a polarization filter for the camera. If so this should be mentioned in the problem.

ID 2013-85
Received on May 3, 2012
3.00
Capillary phenomena, optics

Title of the problem	Diffraction
Suggested phrasing	Cut a narrow slit on a metal sheet. Immerge the metal sheet into liquid, such as water. When pulling out the metal sheet, you can see a liquid film in the slit. Illuminate the slit with liquid film and study the diffraction pattern of the slit.
Source (full citation of any paper, book or webpage used)	
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	
Further explanations or comments	

Decision: title suggested as "Diffraction"
Commentary (I. M.): illuminate with white light or with monochromatic light?
Commentary (S. B.): Has anyone tried? Is the width of the slit relevant, or the thickness of the liquid film, or both? I would like to have some clarifications before including this problem in the shortlist. The title could be more specific.
Questions to the Author and Author's Commentaries:
Question 1. Is it suggested to illuminate the slit with white light, monochromatic light, or this is left for the students to decide?
Answer: When white light illuminate the slit, we can observe color pattern. According to your question, I think it is better to limit the incident light to be laser.
Question 2. Has anyone tried to reproduce this effect? Is it certain that the effects are really feasible, and what range of diffraction patters we would observe?
Answer: I performed the experiment. It is feasible to observe the pattern. The pattern will change with the distance from the slit to the observation screen, D. If we want to simplify the question, we can also limit D to be 1m, and the incident laser to be 632.8nm or 532nm, i.e. He-Ne laser or second harmonic YAG laser.
Question 3. Do you suggest that the width of the slit is most relevant, or the thickness of the liquid film, or both?
Answer: Both of the width of the slit and the thickness of the liquid film are relevant, because both of the two parameters influence the shape of the liquid film.
Question 4. Could you please suggest a specific title for the problem? (it was not suggested before.)
Answer: In face, I have no idea. For example, wet slit?
Question 5. Is this effect (diffraction on a slit with a water meniscus) an entirely novel idea, or you relied on some references or demonstrations where this effect was reported or used to illustrate a specific phenomenon?
Answer: According to my knowledge, my idea is a new one. There are some reference about the thickness of slit, curve of the slit and so on. Here I limit the slit to be thin one. So we need not to care about the thickness of the slit. My problem just concerns the wavefront change caused by the water meniscus. For sure maybe some students will think about the slit thickness. But I think, in the problem, the word "metal slice" should give the student enough information. When I drafted the problem, I hesitated how to describe the thickness of the metal. If the thickness is too small, water cannot fill the slit to make the meniscus. But if the thickness is to large, the students have to face a complex diffraction theory using Green's function rather than the simple Sinc(theta) function. So in the problem, I give the word "metal slice". I hope the word will not cause confusion.

Commentary (J. B.): Should be OK
Commentary (I. M.): The above suggested title is probably not quite okay. Should we keep "Diffraction"?
Commentary (S. B.): I would change the first sentence of "Diffraction" to "Cut a narrow slit **in/through** a metal sheet." to make it clear that the slit has to go all the way through the plate and is not just a groove on the surface. The problem's title is too general in my opinion. What about "Wet slit diffraction" or "Meniscus diffraction" (the latter of which would also lead the students in the right direction)? I still wonder how significant the effect really is. I trust the author that there is a diffraction pattern, but how different is it from the pattern observed for the empty slit (i.e. is it easy enough to detect with equipment available at a typical school)?

ID 2013-88
Received on May 3, 2012
3.00
Material science, mechanics, heat and mass transfer

Title of the problem	Cracking Ice
Suggested phrasing	When an ice cube is dipped in water, it may crack. Study the origin of this phenomenon and important parameters.
Source (full citation of any paper, book or webpage used)	My freezer
Physical background of the problem	Thermal expansion constraints ? Bubble expansion ?
Expected contribution of students (theory / experiment / both)	Theory : understand mechanical properties and failure of a material, Experiment : different bath temperatures, ice cube geometries, type of ice cubes, etc.
Further explanations or comments	

Commentary (S. B.): I wonder whether a clear relation between parameters (e.g. temperatures) and the cracking can be found. Otherwise interesting idea.

Commentary (S. E.): Agree with S.B. about cracking ice.

ID 2013-10
Received on April 4, 2012
3.00
Mechanics

Title of the problem	Pendulum waves
Suggested phrasing	A determined number of pendulums are put side by side. The sizes of the pendulum's strings increase in the row. With a ruler (or rectangular piece of any material), all the pendulums are inclined together and released at the same time. Investigate the patterns that may be seen during the movement of the system and the relevant parameters for the phenomenon.
Source (full citation of any paper, book or webpage used)	http://www.youtube.com/watch?v=yVkdfJ9PkRQ
Physical background of the problem	The problem is based in the Simple Harmonic Oscillation. The periods of oscillation vary because of the different lengths of the strings, forming different images and patterns of waves that must be studied.
Expected contribution of students (theory / experiment / both)	Students are expected to see the cause of the phenomenon in the periods of oscillation that differ along the row because of the different lengths of the strings as a basic approach to the problem. Mathematical formulations for the patterns seem plausible, as clear waves are formed. For the experiments, a lot of parameters may be altered, including the rate in which the string's lengths change or even the maximum angle of inclination for which a Simple Harmonic Oscillation may be observed for the pendulums, being it a condition for the phenomenon existence. The images and waves formed MUST be evaluated experimentally.
Further explanations or comments	The problem, although based on simple concepts of high school physics, is challenging in the sense that the explored phenomenon may seem chaotic at the first look for some, as a lot of patterns are formed during the movement of the pendulums. Also, it can be solved with accessible material for the experiments.

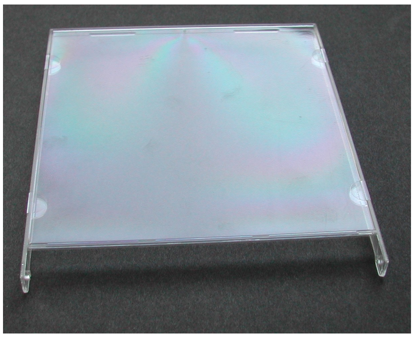
Commentary (I. M.): similar to ID 2013-23 but with a weaker ranking, more trivial physical background.

Commentary (S. B.): Interesting idea, but clearly to similar to Chain of Coupled Pendula.

ID 2013-68
Received on April 30, 2012
2.96
Optics

Title of the problem	Coloured Plastic
Suggested phrasing	Looking at a container or similar things made of plastic in bright sunlight, colours may be seen (see colours.jpg). Study and explain the phenomenon. Ascertain if one also sees the colours using an incandescent lamp as a light source.
Source (full citation of any paper, book or web page used)	Own observation.
Physical background of the problem	Preparing the plastic in a mould usually creates stress birefringence observable under crossed polarizers.
Expected contribution of students (theory / experiment / both)	The idea is to perform experiments to clarify why this colours can be seen without using polarizers and give a theoretical explanation.
Further explanations or comments	Attached find the file colours.jpg.

Commentary (S. B.): I don't see the link between the phrasing of the problem and the notion of stress birefringence. Is the polarization of bright sunlight enough to produce this effect? The figure (colours.jpg) may be misleading since the carrier of a CD already contains the grooves, i.e. it acts as a diffraction grating. Has anyone tried to reproduce this effect with other plastic objects?
Commentary (I. M.): The carrier is seemingly removed from the plastic substrate on this photo.
Author's commentary: enclosed you find another image from a disk-case-cover where you also can see the colors.



The original picture I took was from a clear plastic peace of the form of a disk sometimes covering the CD-ROM's or DVD's on the stacks of 10 or more peaces. So there are for certain no lands or pits in this plastic plate. You may also see this colors in other plastic casings (e.g. boxes of sweets). In particular now to the questions stated.
ad 1) One has to look at a certain angle at the plastic to see the colors at best. So in may opinion this is a hint that Brewsters Angle is of some importance. In sunlight the colors are more pronunced but I was able to see it (but ruther faint) by illumination with an incadescent lamp.
ad 2) As alrady mentioned above the disk used for taking the image I added to my proposal was a normal sheet of plastic in the shape of a CD.
In this context if you look through crossed polaricers encasing the plastic you see the same colors but of course much more prominent.
Commentary (S. B.): Just a short reply to the author's comment on "Coloured Plastic": The plastic disc often found on top of a pack of CD-ROMs does have the same track structure as the CDs themselves. I usually use such an uncoated disc to measure the track pitch of a CD with a HeNe laser, and I get the correct result.
Author: I did'nt try the suggested experiment with a HeNe for my disc, but I think the shape of the colors seen for a CD with pits and lands differ to them on the example picture (see enclosed picture)
Commentary (S. B.): If the author can assure that he has also observed the phenomenon for other plastic objects, this could still be an interesting problem. I just think an uncoated CD isn't a very good example of the claimed effect because of the obvious interference effects.
Author: I assure that this is a rather common phenomenon for pressed plastic objects.
Commentary (I. M.): Could you please suggest if the effect is typical for transparent, industrially stamped plastic plates only? Would it be okay if we edit the text of the problem as suggested below?
"In bright sunlight, a transparent plastic object (e.g. a blank CD case) can sometimes shine in all the rainbow colours. Study and explain the phenomenon. Ascertain if one also sees the colours when various light sources are used."
Author: I agree with the suggested phrasing, in my opinion it might be better not to mention rainbow colors but instead interference colors.I also admit if a picture is added to the problem phrasing it would be better to take the one given for the disc case.
Commentary (J. B.): Well known effect.
Commentary (S. B.): I tried to reproduce "Coloured Plastics" with a CD cover. Due to the lack of bright sunlight I had to use polarised light. I was easily able to observe the expected colours. I'm not sure whether the phrase "in bright sunlight" could be misleading for students, leading them away from the idea of polarisation. The theoretical part of the problem seems to be interesting enough to give it a try.

ID 2013-20

Received on April 21, 2012

2.92

Electricity, solid state physics, thermodynamics

Title of the problem	Peltier Generator
Suggested phrasing	Peltier devices can be used to actively cool the CPU in a computer. The same devices can also be used to generate an electrical output as a result of a temperature difference. Construct and evaluate an electrical generator based on a single Peltier device. Could a scaled up version provide enough electricity to run your home?
Source (full citation of any paper, book or webpage used)	The problem is of my own creation.
Physical background of the problem	Although very inefficient, Peltier devices placed between hot and cold reservoirs can produce a few watts of electrical power output (i.e. the Seebeck effect).
Expected contribution of students (theory / experiment / both)	Students should research and explore the electrical and thermal characteristics of such a device. They should construct an electrical generator consisting of hot and cold reservoirs with a Peltier device sandwiched in between.
Further explanations or comments	Peltier devices are freely available and relatively cheap.

Commentary (A. N.): Highly dependent on materials (best materials are not available)

Commentary (S. B.): Rather a technical challenge than a physical one.

ID 2013-46
Received on April 29, 2012
2.92
Capillary phenomena

Title of the problem	Double bubble
Suggested phrasing	It is a common phenomenon that liquid encloses a gas forming a bubble. Can an opposite situation occur? Can a film of gas enclose a liquid? Explore the phenomenon.
Source (full citation of any paper, book or webpage used)	C.L. Strong, "The Amateur Scientist: Curious Bubbles in Which a Gas Encloses a Liquid Instead of the Other Way Around," Scientific American, vol. 230, no. 4, Apr. 1974, pp. 116-120.
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	Student should explain nature of the phenomenon and determine under what condition it may occur. He should also build an experimental setup that allows creating such bubbles. I would expect student to explain, what is the role of parameters of fluid and gas such as: density, viscosity, surface tension. He should also discuss lifetime of created bubble.
Further explanations or comments	Myself, I first observed this phenomenon while preparing coffee. Droops of coffee, falling into the cup from the filter, floated on the surface (this bubble is called "Globule")

Commentary (S. B.): Interesting phenomenon. Reminds me of "anti-bubbles".

Commentary (I. M.): Anti-bubbles would be interesting, but since the author suggests to consider droplets not coalescing with bulk liquid, this may be too reminiscent of the problem 11. "Water droplets" at the IYPT 2005.

Author's commentary: I was interested in study of those Globules and Anti-bubbles, but as I see this was the second part of the task 11. "Water droplets" at the IYPT 2005. **I would like to withdraw my proposal.** I tried to avoid proposing problems similar to once that were before, but as I see I have overlooked some of them.

ID 2013-79
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2.92
Mechanics

Title of the problem	Friction
Suggested phrasing	The commonly used model of the friction in high-school textbooks results in the friction force independent on the size of the contact area as well as on the velocity. Investigate the limitations of this model.
Source (full citation of any paper, book or webpage used)	Commonly asked question, only qualitative explanations found. See http://hyperphysics.phy-astr.gsu.edu/hbase/frict3.html#nor http://www.newton.dep.anl.gov/newton/askasci/1993/physics/PHY2.HTM as examples.
Physical background of the problem	The model mentioned is very simple (based on the surface roughness) and does not reflect all surface properties (e.g. intermolecular forces).
Expected contribution of students (theory / experiment / both)	Students should construct a device for friction force measurements. They should collect a larger amount of data sets for various materials. After the data collection, the analysis has to be done and suitable physical explanations are expected.
Further explanations or comments	It is commonly known that car stability depends on the size of the contact area between the tyre and the road. The explanation can be partly based on the sticky-tape model (IYPT problem 2010), what is a disadvantage of the proposed problem.

Commentary (S. B.): Difficult to come up with good experimental data without high-level equipment.

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2.88
Fluid dynamics

Title of the problem	Leaky vessel
Suggested phrasing	If there is a hole near the base of the vessel, the liquid will flow out of it. How the flow rate depends on relevant parameters? Is it possible to construct a vessel such that the flow rate is the constant and independent on level of liquid inside the vessel?
Source (full citation of any paper, book or webpage used)	The task it self is my own idea. The part about constant flow rate independent on level of liquid inside the vessel is based on the simple construction I found is a book: Е.И.Бутиков, А.А.Быков, А.С.Кондратьев "ФИЗИКА В ЗАДАЧАХ" Л., Изд-во Ленингр. ун-та, 1974.
Physical background of the problem	In the problem one may find a lot of interesting phenomena know from hydrodynamics and hydrostatics. Such as how size of the hole limits flow rate, role of viscosity, or importance of hole's shape.
Expected contribution of students (theory / experiment / both)	The problem is an engineering task, which requires inventing and investigating device in which flow rate is the independent on level of liquid inside the vessel. This requires building many devices and determining which one is the best. Students should also look for the simplest way to achieve the goal. **Theory:** - Deciding which parameters determining the flow rate of the liquid? (viscosity, density, level of liquid, size and shape of the hole) - Theory can be based on known laws, such as Bernoulli's law, or in a more advanced model, Euler equation or Naviera-Stockes Equation. **Experiment:** - Building different devices and comparison. - Experimental investigation of considered parameters (viscosity, density, level of liquid, size and shape of the hole) - Developing a method for flow rate measurement - Farther improvement of best device.
Further explanations or comments	Problem allows students to learn about hydrodynamics. Students would be able to invent and experiment with the device they build.

Commentary: two very similar problems were suggested by other contributors for the IYPT 2007 and IYPT 2010, but not selected. This may suggest that the effect is of some interest for the community.

Proposed for the IYPT 2010: **Leaky can.** It has been suggested that the depth of liquid in a leaking can decreases exponentially, but this is at best an approximation, and under some circumstances, a very poor approximation. Investigate the problem.-

Proposed for the IYPT 2007: **A4**. How does the depth of fluid in a leaking vessel decrease with time? Investigate the phenomenon for a variety of fluids.

Commentary (S. B.): Simple experiment, theoretical explanation allows for different levels of complexity.

ID 2013-53
Received on April 29, 2012
2.85
Mechanics

Title of the problem	Falling chain
Suggested phrasing	What is the force of interaction between a falling chain and a surfaces it touches. How does it depend on relevant parameters?
Source (full citation of any paper, book or webpage used)	E. Hamm et al, “The weight of a falling chain, revisited”, Am. J. Phys 78(8), 2010 C. Wong et al, “Falling chains”, Am. J. Phys. 74(6), 2006
Physical background of the problem	Although the motion of a falling chain is a standard textbook problem (e.g. weight of a chain falling on a scale, force exerted on a table if we attach one and to it and let the other end fall down), quoted articles (and many other) show that such treatment is seriously oversimplified.
Expected contribution of students (theory / experiment / both)	Build more realistic models of a falling chain and experimentally study its parameters, for example how the force exerted by it changes with time, how it depends on the elastic parameters of the chain etc

ID 2013-78
Received on May 1, 2012
2.85
Fluid dynamics

Title of the problem	Spoon loving water
Suggested phrasing	Take a tea spoon and touch water jet from a faucet. You will feel attraction. Explain the fenomenon and find essential parameters.
Source (full citation of any paper, book or web page used)	
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	
Further explanations or comments	

Commentary (I. M.): similar to problems on Coanda effect and flows due to Bernoulli pressure differences (e.g., “Sticky water”, IYPT 2010.)

ID 2013-71
Received on April 30, 2012
2.81
Acoustics

Title of the problem	the cello and the wolf
Suggested phrasing	Players of stringed instruments, especially those of cello and viola, often have to deal with a most annoying phenomenon: The so called **wolf tone**. It is a fast wobbling very unmusical sound that arises at a sharply defined frequency, characteristic for each single instrument. Investigate the phenomenon and combat the wolf!
Source (full citation of any paper, book or web page used)	Question of my own.
Physical background of the problem	The origin of the phenomenon seems to be an interference resulting in a beat from two overlapping resonances. (The phenomenon arises in cheap models too.) Usually it is dealt with by adding masses to the corpus or the strings or by pressing the instrument - this shifts the sound board resonances. I made two **sound files** of a wolf tone in one of my celli **freely available** too: http://dl.dropbox.com/u/74940793/wolf/audio/WolfGlissando.wav http://dl.dropbox.com/u/74940793/wolf/audio/Wolf.wav
Expected contribution of students (theory / experiment / both)	Investigating the origin of the phenomenon and dealing with interference and beat. If no instruments are available and no model can be built at least the sound files are available for interpretation and path the way for basic calculations and simulations. Nevertheless the author is sure that in nearly every city at least one cello or viola will be available. (Even _some_ violins show this behavior.)
Further explanations or comments	There are several papers on this subject, e.g..: On the mechanical theory of the vibrations of bowed strings and of musical instruments of the violin family, with experimental verification of the results C.V. RAMAN (!!) Indian Association for the Cultivation of Science 15 (1918!!) or The wolf in the cello IAN M. FIRTH AND J. MICHAEL BUCHANAN http://dx.doi.org/10.1121/1.1913343 or Computational modelling of string–body interaction for the violin family and simulation of wolf notes O. Inacioa,_, J. Antunesb, M.C.M. Wright http://dx.doi.org/10.1016/j.jsv.2007.07.079 or On the oscillations of the bowed string, F.G. FRIEDLANDER (!) Proceedings of the Cambridge Philosophical Society 49 (1953) 516–530. etc.

Commentary (A. N.): May be very difficult to get an instrument displaying such an effect

ID 2013-26
Received on April 28, 2012
2.81
Mechanics

Title of the problem	“**Platonic solids”** Compare experimentally the trajectory of the Platonic solids when rolling on a rough inclined surface. Investigate the outcomes for different tilts of the plane. What determines the mean-square perpendicular deviation of the trajectories of the bodies?
Suggested phrasing	
Source (full citation of any paper, book or webpage used)	
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	
Further explanations or comments	

ID 2013-27
Received on April 28, 2012
2.81
Mechanics, heat and mass transfer

Title of the problem	”**Jumper”** It is known that boiled buckwheat “jumps” when it is warmed up on a frying pan. Why? What maximum height can be reached by the jump of a buckwheat seed?
Suggested phrasing	
Source (full citation of any paper, book or webpage used)	
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	
Further explanations or comments	

ID 2013-05

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2.81

Mechanics

Title of the problem	Oscillating disk
Suggested phrasing	A massive horizontal disk is attached to a suspended helical spring. Investigate the motion of the disk after it is subjected to vertical oscillations.
Source (full citation of any paper, book or webpage used)	This device is called a “Wilberforce pendulum”. Movie presenting the phenomenon can be found here: http://www.youtube.com/watch?v=S42lLTlnfZc
Physical background of the problem	When spring is extended, it also rotates a bit. If moment of inertia of suspended body is well selected, vertical oscillations may disappear and rotary oscillations will appear. After some time again rotary oscillations change into vertical oscillations and process repeats.
Expected contribution of students (theory / experiment / both)	Student should build and investigate mentioned device. He should experiment with springs of different parameters and use disks with different moment of inertia. For the theoretical part student is expected to explain why vertical oscillations change into rotary oscillations of the disk and other way.

ID 2013-54
Received on April 29, 2012
2.77
Mechanics

Title of the problem	Newton's cradle
Suggested phrasing	Newton's cradle is very often used to demonstrate the conservation of energy and momentum in a mechanical system. However, many different motions of the balls can exhibit the same momentum and energy. What additional parameters determine the outcome of the collisions of the balls?
Source (full citation of any paper, book or webpage used)	http://www.lhup.edu/~dsimanek/scenario/cradle.htm ; D R Lovett et al, "Collisions between elastic bodies: Newton's Cradle", Eur. J. Phys 9 (1988); F. Hermann et al, "Simple explanation of a well-known collision experiment", Am. J. Phys 49(8), 1981
Physical background of the problem	Collision mechanics, elasticity, dispersion
Expected contribution of students (theory / experiment / both)	There are plenty of experiments that can be performed to study the dependance of the outcome of an elastic collision on various parameters. I believe that the task could be about finding the minimum number of additional factors responsible for the collision and performing clever experiments to show that the suggested list is sufficient, but still every factor on it is relevant.

ID 2013-81
Received on May 2, 2012
2.77
Acoustics, granular matter

Title of the problem	Whistling sand
Suggested phrasing	Walking on dry sand may produce a distinct sound. Investigate the sound produced by a granular medium upon compression, and the role of relevant parameters.
Source (full citation of any paper, book or webpage used)	F. Nori, P. Sholtz, and M. Bretz "Booming Sands". *Scientific American* 277(3), 84 (September 1997). P. Sholtz, M. Bretz, and F. Nori "Sound-producing sand avalanches". *Contemporary Physics* 38(5), 329-342 (October 1997). K. Ridgeway and J. B. Scotton "Whistling sand beaches in the British Isles". *Sedimentology* 20 (2), 263–279 (1973). B. Andreotti "The Song of Dunes as a Wave-Particle Mode Locking". *Phys. Rev. Lett.* 93, 238001 (2004). S. Douady et al. "Song of the Dunes as a Self-Synchronized Instrument". *Phys. Rev. Lett.* 97, 018002 (2006). L. Bonneau, B. Andreotti and E. Clément "Surface elastic waves in granular media under gravity and their relation to booming avalanches". *Phys. Rev. E* 75, 016602 (2006). N.M. Vriend, L. Hunt, R.W. Clayton, C.E. Brennen, K.S. Brantley, and A. Ruiz-Angulo "Solving the mystery of booming sand dunes". *Geophysical Research Letters* 34, 2007GL030276 (2007). B. Andreotti, L. Bonneau and E. Clément "Comment on 'Solving the mystery of booming sand dunes'". *Geophys. Res. Lett.* 35, L08306 (2008).
Physical background of the problem	The phenomenon of singing or whistling sand has been largely investigated in the past, however, remains not entirely understood given the complexity of the interactions between individual grains of the sand. The distinct noise, somewhat similar to the noise of compressed dry snow, can be easily produced and investigated with home-made instrumentation. The problem is suggested as a promising task for the IYPT that can be addressed from various perspectives.
Expected contribution of students (theory / experiment / both)	Both

Commentary (I. M.): substitute for Acoustics?

ID 2013-09

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2.77

Acoustics

Title of the problem	Clapping hands
Suggested phrasing	After a great performance it is nice to gratitude the performer by clapping. Investigate the sound of clapping. Is it possible to synthetically recover the applause of the crowd from a recording of single person clapping?
Source (full citation of any paper, book or webpage used)	My own idea
Physical background of the problem	When one claps, the sound is different from the sound of many people clapping. it is interesting, why and how this sound differs.
Expected contribution of students (theory / experiment / both)	I would expect students to develop a method to turn one persons clapping into a sound of the crowd clapping. This would require investigating what is clapping and its sound. This can be done by looking at spectrum of such sound. Student should answer what is different between one person clapping and a crowd clapping (delay between different person clapping, distances from different people, how important is the way person claps, how shape of room may affect the sound). Recording of crowd clapping and its analysis should be done. I would expect student to explain how sound is produced in general and it this case.
Further explanations or comments	Experiment is easy to perform, one just needs a microphone.

ID 2013-38
Received on April 29, 2012
2.77
Mechanics

Title of the problem	Tumbling stick
Suggested phrasing	A cylindrical wooden stick lies on a horizontal surface. When you flip one end of the stick with your finger it starts to rotate about (or around) its mass centre. Under certain conditions the stick will rise up to a certain angle relative to the surface. Investigate the motion of the stick.
Source (full citation of any paper, book or webpage used)	The problem is of our own creation
Physical background of the problem	….
Expected contribution of students (theory / experiment / both)	Theory and experiments ….
Further explanations or comments	…

ID 2013-89
Received on May 3, 2012
2.77
Acoustics

Title of the problem	Whirly
Suggested phrasing	Study how sound is produced in a "whirly" tube (sound hose).
Source (full citation of any paper, book or webpage used)	A toy my nephew got. http://www.youtube.com/watch?v=CuGnsW0ysrA
Physical background of the problem	Acoustics ; air flow
Expected contribution of students (theory / experiment / both)	Understand various concepts : circular motion, acceleration, air flow, turbulence, resonating modes of a tube Experiments : mainly acoustics and playing around with custom pipes

ID 2013-69
Received on April 30, 2012
2.77
Acoustics, mechanics

Title of the problem	Chirping ribbons
Suggested phrasing	Investigate and compare the sounds produced by tightening rubber bands in contrast to those of e.g. tightened threads. Determine the relevant parameters which are responsible for the differences in the sounds produced.
Source (full citation of any paper, book or web page used)	Based on a problem found in: Jearl Walker, The flying circus of Physics, 2nd ed.; John Wiley & sons, 2007
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	The idea is to make experiments which show the different behaviour of the frequencies produced by stretching the diverse materials and give a theoretical explanation.
Further explanations or comments	

Commentary (S. B.): substitute for Acoustics?

ID 2013-24
Received on April 28, 2012
2.73
Electromagnetism, optics

Title of the problem	”**Edison effect”** The thermo-electron emission was demonstrated by Edison using an electometer and a light bulb. How can the "thermo-emission current" be measured?
Suggested phrasing	
Source (full citation of any paper, book or webpage used)	
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	
Further explanations or comments	

ID 2013-76
Received on May 1, 2012
2.73
Mechanics, fluid dynamics

Title of the problem	Lasso
Suggested phrasing	Lasso is used by various nations to catch animals. Explain mechanics of lasso moving and demonstrate it.
Source (full citation of any paper, book or web page used)	
Physical background of the problem	
Expected contribution of students (theory / experiment / both)	
Further explanations or comments	

ID 2013-52
Received on April 29, 2012
2.69
Thermodynamics, mechanics

Title of the problem	Egg in the bottle
Suggested phrasing	Lit a piece of paper and put it inside a bottle. Then place a hard-boiled egg on the vessel and watch the egg being sucked into the bottle. Study the origin of this effect and determine the relevant parameters.
Source (full citation of any paper, book or webpage used)	Presentation of the phenomenon: http://www.youtube.com/watch?v=mpC5zlmtm-g Literature regarding the phenomenon in general: http://www.math.harvard.edu/~knill/pedagogy/waterexperiment/index.html , http://www.math.harvard.edu/~knill/pedagogy/waterexperiment/dhindsa.pdf , http://www.math.harvard.edu/~knill/pedagogy/waterexperiment/vera_rivera_nunez.pdf
Physical background of the problem	A source burning inside a bottle produces a pressure decrease. There seems to be a confusion whether the effect is mainly due to thermodynamic processes (and whether the air escapes the container due to larger temperature), or due to chemical processes occuring during combustion.
Expected contribution of students (theory / experiment / both)	• Theretical discussion of thermodynamics of heating a container (which isn't obvious, see for example http://ajp.aapt.org/resource/1/ajpias/v79/i1/p74_s1?isAuthorized=no) and how it applies to the problem • Theoretical predictions regarding the pressure change in the bottle • Experimental determination of the pressure inside the bottle with connection to other parameters (temperature, way of heating, number of sources etc)

Commentary (I. M.): merged with "Water rise" (ID 2013-35)

ID 2013-41

Received on April 29, 2012

2.69

Optics

Title of the problem	Green flash
Suggested phrasing	When sun is at the horizon it turns red. Under specific conditions one may observe that very near the horizon sun turns green. Investigate and explain this phenomenon
Source (full citation of any paper, book or webpage used)	http://www.icstars.com/Mad/Astro/GreenFlash.html http://www.webexhibits.org/causesofcolor/13D.html
Physical background of the problem	The phenomenon is observed when sun is actually bellow the horizon. Light path is curved by the earth's atmosphere. Therefore the last ray of sun that one may observe is green.
Expected contribution of students (theory / experiment / both)	Student should explain what determines the color of the sun and how atmosphere curves the path of the light. Determine why last observed ray is green, under what conditions it can be observed and why is it hard to observe it. Several pictures presenting the phenomenon of green sun would be welcome.
Further explanations or comments	This phenomenon was use in the movie "Pirates of the Caribbean". There a green flash indicated that a soul came back from the dead.