Preparation to the Young Physicists’ Tournaments’ 2014

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BIC POFICHBEXXX
The first IYPT-themed book where all articles underwent rigorous peer review
98 reviews from 25 reviewers
32 papers selected
revisions, resubmissions before getting accepted
The IYPT Archive is missing the names of the UK team members at the IYPT 1991. **Please help!**

- all members were from Hills Road Sixth Form College in Cambridge;
- team leader was Stephen Martin, and one member’s first name was Claudia;
- an article might have been published in an HRSFC’s magazine or in the Principal’s report to the governors;
- some members, including Claudia, are seen on Russian participant Sergey Romanchuk’s photos

Is the novel research limited and discouraged by the existing common knowledge and the ongoing work of competing groups? :-}
How to structure a report?  
What level is competitive?  
How to set the goals, fix the priorities, and set the direction of the work?  
How were people resolving particular issues in the past?  

How to tackle the IYPT problems?

- Look through the historical solutions in the Archive :-)
- an opportunity for goal-oriented critical learning
- examples, not guidelines
- those solutions were good, but yours should be better!
The basic goal of this Kit is not in providing students with a start-to-finish manual or in limiting their creativity, but in encouraging them to

- regard their work critically,
- look deeper,
- have a better background knowledge,
- be skeptical in embedding their projects into the standards of professional research,
- and, as of a first priority, be attentive in not “re-inventing the wheel”

An early exposure to the culture of scientific citations, and developing a responsible attitude toward making own work truly novel and original, is assumed to be a helpful learning experience in developing necessary standards and attitudes

Good examples are known when the Kit has been used as a concise supporting material for jurors and the external community; the benefits were in having the common knowledge structured and better visible

Even if linked from iypt.org, this file is not an official, binding release of the IYPT, and should under no circumstances be considered as a collection of authoritative “musts” or “instructions” for whatever competition

Serious conclusions will be drawn, up to discontinuing the project in its current form, if systematic misuse of the Kit is detected, such as explicit failure of citing properly, replacing own research with a compilation, or interpreting the Kit itself as a binding “user guide”

All suggestions, feedback, and criticism about the Kit are warmly appreciated :-}
Habits and customs

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

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

Arkady Strugatsky and Boris Strugatsky

Quote from: Arkady Strugatsky and Boris Strugatsky. Monday Begins on Saturday. Translated from the Russian. (The Young Guard Publishing House, Moscow, 1966)
Requirements for a successful IYPT report

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

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

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

Albert Einstein
When throwing pebbles into water, watch the ripples; otherwise throwing the pebbles becomes a futile pastime.

Kozma Prutkov

* “When throwing pebbles into water, watch the ripples; otherwise throwing the pebbles becomes a futile pastime.”
Kozma Prutkov

// The epigraph for the problems selected by the IYPT Founder Evgeny Yunosov on July 5, 2013
// Translated from the Russian
Problem No. 1 “Invent yourself”

It is known that some electrical circuits exhibit chaotic behaviour. Build a simple circuit with such a property, and investigate its behaviour.
Background reading

- 電子回路 (Chua 回路) で観測される分岐現象 (youtube.com, from IkeguchiLab, 04.11.2010), http://youtu.be/B4ZI1lJ5RA
Background reading

Problem No. 2 “Hologram”

It is argued that a hologram can be hand made by scratching a piece of plastic. Produce such a ‘hologram’ with the letters ‘IYPT’ and investigate how it works.
Background reading

- Hand-drawn holograms (youtube.com, from wbeaty, 06.04.2008), http://youtu.be/XUy8iELWhJg
- Scratch Holograms (youtube.com, from fortworthmuseum, 07.01.2009), http://youtu.be/0uko9oixijg
Problem No. 3 “Twisted rope”

Hold a rope and twist one end of it. At some point the rope will form a helix or a loop. Investigate and explain the phenomenon.


Closely Packed Helix (youtube.com, from pieranski, 20.01.2009), http://youtu.be/7NqhDyzzG7Y


Problem No. 4 “Ball sound”

When two hard steel balls, or similar, are brought gently into contact with each other, an unusual ‘chirping’ sound may be produced. Investigate and explain the nature of the sound.
Background reading

- Поющие магниты. Singing Magnets (youtube.com, from QQQ3118, 06.02.2013), http://youtu.be/XjqJ208Z5GM
- Cool Magnets (youtube.com, from minnesotavikingsnf, 03.05.2010), http://youtu.be/ARmmdjGa1mE
- Eulers Disc (youtube.com, from Hendrik Ball, 05.02.2011), http://youtu.be/rFtYzVJcWyA


L. L. Koss and R. J. Alfredson, Transient sound radiated by spheres undergoing an elastic collision, J. Sound Vibr. 27 (I), 59-75, (1973)


Problem No. 5 “Loaded hoop”

Fasten a small weight to the inside of a hoop and set the hoop in motion by giving it an initial push. Investigate the hoop’s motion.
Background reading

Problem No. 6 “Bubble crystal”

A large number of very small, similar air bubbles float on the surface of a soapy liquid. The bubbles will arrange themselves into a regular pattern similar to a crystalline lattice. Propose a method to obtain bubbles of a consistent size, and investigate the formation of such a bubble crystal.
Background reading

- Bragg Bubble Raft (with vacancy) (youtube.com, from Christie Gilliland, 16.09.2012), [http://youtu.be/AM86z7cTqi0](http://youtu.be/AM86z7cTqi0)
- Bubble raft sintering model .m4v (youtube.com, from Bob Morris, 08.01.2012), [http://youtu.be/ah1Q6yyqTdpA](http://youtu.be/ah1Q6yyqTdpA)
Background reading

- Y. Ishida. Order structures and dislocations in bubble raft grain boundary. J. Mat. Sci. 7, 1, 75-83 (1972)
Background reading

Problem No. 7 “Pot-in-pot refrigerator”

The ‘pot-in-pot refrigerator’ is a device that keeps food cool using the principle of evaporative cooling. It consists of a pot placed inside a bigger pot with the space between them filled with a wet porous material, e.g. sand. How might one achieve the best cooling effect?
Background reading

- Clay Pot Refrigerator Test (youtube.com, from tjar12, 04.07.2012), http://youtu.be/ATWEIKE_nLw
- Evaporative Cooling - The Clay Refrigerator (practicalaction.org), http://practicalaction.org/evaporative-cooling-the-clay-refrigerator
Background reading

Problem No. 8 “Freezing droplets”

Place a water droplet on a plate cooled down to around -20 °C. As it freezes, the shape of the droplet may become cone-like with a sharp top. Investigate this effect.

[Andrei Schetnikov 2013]
Herbert Grove Dorsey. Peculiar ice formations. Phys. Rev. 18, 2, 162-164 (1921)
Background reading

- James R. Carter. Other unusual formations of ice // Ice formations with daily (diurnal) freeze/thaw cycles (Illinois State University), http://my.ilstu.edu/~jrcarter/ice/diurnal/
Problem No. 9 “Water bombs”

Some students are ineffective in water balloon fights as the balloons they throw rebound without bursting. Investigate the motion, deformation, and rebound of a balloon filled with fluid. Under what circumstances does the balloon burst?
Background reading

- Slow Motion: Water Balloons Free Falling (youtube.com, from hackability, 13.08.2012), [http://youtu.be/VIUNevslGgE](http://youtu.be/VIUNevslGgE)
- The Science Behind Bursting Water Balloons (youtube.com, from dj Busby, 02.11.2011), [http://youtu.be/1qYyVPjsb5k](http://youtu.be/1qYyVPjsb5k)
- A water balloon not exploding in high-speed (youtube.com, from LucidMovement, 15.02.2007), [http://youtu.be/XngQjzAmVm8](http://youtu.be/XngQjzAmVm8)
Problem No. 10 “Coefficient of diffusion”

Using a microscope, observe the Brownian motion of a particle of the order of micrometre in size. Investigate how the coefficient of diffusion depends on the size and shape of the particle.
Background reading

- Brownian Motion (youtube.com, from Stephen Curry, 25.09.2012), http://youtu.be/ernnQJwaKTs
- Jean Perrin. Mouvement brownien et réalité moléculaire. Annales de Chimie et de Physique, 8e série 18, 1-114 (1909)
Problem No. 11 “Candle Power Plant”

Design a device that converts the heat of a candle flame into electrical energy. Investigate how different aspects of the device affect its efficiency.
Background reading

- Thermoelectric Lamp, Electric Generator Plans (scraptopower.co.uk), http://www.scraptopower.co.uk/thermoelectric/Thermoelectric-lamp-seebeck-generator
- DIY Peltier Candle Powered Electric Generator (youtube.com, from filear, 17.01.2011), http://youtu.be/SvBeCCjb9ds
Background reading


candles make electricity (youtube.com, from suburbanjeff4x4, 31.05.2010), http://youtu.be/-VDVJy9p83U

Electricity From Candles (youtube.com, from levent sakar, 01.03.2009), http://youtu.be/cAijFoFlz0k

Mike Szczys. Generate electricity with a candle (hackaday.com, 2010), http://hackaday.com/2010/01/05/generate-electricity-with-a-candle/

Pt.3 Candle Powered Peltier Charger / Lamp / Defroster / Warming Plate (youtube.com, from KyleCarrington, 08.03.2012), http://youtu.be/zopX9NH0Gzs

Thermoelectric Peltier Generator passive candle powered. HD (youtube.com, from Elwyn Harris, 19.12.2010), http://youtu.be/lEj1fcrl0tk
Problem No. 12 “Cold balloon”

As air escapes from an inflated rubber balloon, its surface becomes cooler to the touch. Investigate the parameters that affect this cooling. What is the temperature of various parts of the balloon as a function of relevant parameters?
Background reading

Problem No. 13 “Rotating saddle”

A ball is placed in the middle of a rotating saddle. Investigate its dynamics and explain the conditions under which the ball does not fall off the saddle.
Background reading

- Upside-down pendulum (Franz-Josef Elmer, University of Basel, 1998), [http://www.elmer.unibas.ch/pendulum/upside.htm](http://www.elmer.unibas.ch/pendulum/upside.htm)
- Parametric Resonance (Franz-Josef Elmer, University of Basel, 1998), [http://www.elmer.unibas.ch/pendulum/parres.htm](http://www.elmer.unibas.ch/pendulum/parres.htm)
- Rotating Saddle Shape (Harvard Natural Sciences Lecture Demonstrations), [http://www.fas.harvard.edu/~scidemos/OscillationsWaves/SaddleShape/SaddleShape.html](http://www.fas.harvard.edu/~scidemos/OscillationsWaves/SaddleShape/SaddleShape.html)
- Stability and Instability (Alan A. Berryman, Washington State University, 1997), [http://classes.entom.wsu.edu/529/Stability.htm](http://classes.entom.wsu.edu/529/Stability.htm)
- Ion Trap Research Group (Jessie Petricka, Gustavus Adolphus College), [http://physics.gac.edu/~petricka/research.html](http://physics.gac.edu/~petricka/research.html)


Rotating saddle (thekidshouldseethis.com), http://thekidshouldseethis.com/post/41457034607


Problem No. 14 “Rubber motor”

A twisted rubber band stores energy and can be used to power a model aircraft for example. Investigate the properties of such an energy source and how its power output changes with time.
Background reading

- Rubber band airplane (youtube.com, from rmfoco, 08.08.2009), http://youtu.be/-WVrPgG0y9U
- rubber band powered biplane conversion (youtube.com, from MPHORLD, 25.02.2009), http://youtu.be/Y8xhKghukgc
- Elastomers and entropic springs (Aparna Baskaran, Syracuse University), http://physics.syr.edu/~abaskara/rubber_popular.html
- Stretching a Rubber Band (schoolphysics.co.uk), http://www.schoolphysics.co.uk/age14-16/Matter/text/Rubber_band/index.html
Background reading

- L. R. G. Treloar. The physics of rubber elasticity (Oxford University Press, 1975)
- Rubber band car engine (youtube.com, from TheKunsthammer, 06.10.2012), http://youtu.be/gju3SNMnwY4
- NC Science Olympiad: How to Wind and Fly your Helicopter (youtube.com, from kellstuh, 18.10.2010), http://youtu.be/H7HqkcE1o04
Problem No. 15 “Oil stars”

If a thick layer of a viscous fluid (e.g. silicone oil) is vibrated vertically in a circular reservoir, symmetrical standing waves can be observed. How many lines of symmetry are there in such wave patterns? Investigate and explain the shape and behaviour of the patterns.
Background reading

- Michael Faraday. On a peculiar class of acoustical figures; and on certain forms assumed by groups of particles upon vibrating elastic surfaces. Phil. Trans. R. Soc. Lon. 121, 299-340 (1831), http://www.jstor.org/stable/107936
Background reading

Problem No. 16 “Magnetic brakes”

When a strong magnet falls down a non-ferromagnetic metal tube, it will experience a retarding force. Investigate the phenomenon.
Background reading

- Neodymium magnet falling through a copper tube (youtube.com, from Les Garwood, 11.10.2010), http://youtu.be/kCq1u_x07S8
- Gravity Machine (youtube.com, from RayBamBay, 08.08.2011), http://youtu.be/mS0Y5nTfoqc
- Eddy Current Tubes (Extra Large) (youtube.com, from EducateInnovate, 23.03.2010), http://youtu.be/MT16pLWqvXo
Background reading

- Eddy Current Tubes (youtube.com, from ybelfort, 29.05.2008), http://youtu.be/nrw-i5Ku0ml
- Magnet Brakes its own fall (youtube.com, from George Mizzell, 04.09.2007), http://youtu.be/iABmUEH5s0k
- Copper Pipe Magnet (youtube.com, from JamesRB1995, 19.05.2010), http://youtu.be/G7ysnXH53Wo
Problem No. 17 “Chocolate hysteresis”

Chocolate appears to be a solid material at room temperature but melts when heated to around body temperature. When cooled down again, it often stays melted even at room temperature. Investigate the temperature range over which chocolate can exist in both melted and ‘solid’ states and its dependence on relevant parameters.
Background reading

- How to melt and temper chocolate (youtube.com, from Howdinguru, 24.02.2009), http://youtu.be/bDcF7nJbF04
Background reading

Don't Drink and Derive

\[ \frac{\partial^2 u}{\partial t^2} - \frac{1}{c^2} \frac{\partial^4 u}{\partial x^4} = 0 \]

\[ F = G \frac{m_1 m_2}{r^2} \]

\[ J(x) = \int a(x) e^{i \omega t} \]

\[ \nabla \cdot F = \frac{1}{\rho} \]

\[ E = mc^2 \]

\[ F = \sqrt{E^2 - m^2 c^4} \]

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

\[ \frac{1}{2} \rho = \frac{1}{2} m v^2 \]
To work towards results?

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

- If you cannot solve the entire problem, decide **what is really necessary** and solve a partial problem.

- If you can solve the entire problem, nevertheless decide **what partial case is sufficient**, and your solution will be much better.

- Be brave in what you do, but always reserve a great degree of scientific skepticism!

- **Procrastination is definitely a risk :-)**
Feynman: to be self-confident?

- “I’ve very often made mistakes in my physics by thinking the theory isn’t as good as it really is, thinking that there are lots of complications that are going to spoil it

- an attitude that anything can happen, in spite of what you’re pretty sure should happen.”

R. P. Feynman. Surely You’re Joking, Mr. Feynman (Norton, New York, NY, 1985)
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Preparation to 27th IYPT’ 2014: references, questions and advices

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Call for cooperation

- If you are interested in the idea behind the Kit — to structure some earlier knowledge about the physics behind the problems and to encourage students to contrast their personal contribution from this knowledge — your cooperation is welcome.
- If more contributors join the work on the Kit for 2014, or plan bringing together the Kit for 2015, good editions may be completed earlier.
- It would be of benefit for everybody,
  - students and team leaders, who would have an early reference (providing a first impetus to the work) and a strong warning that IYPT is all about appropriate, novel research, and not about “re-inventing the wheel”
  - jurors, who would have a brief, informal supporting material, possibly making them more skeptical and objective about the presentations
  - the audience outside the IYPT, who benefits from the structured references in e.g. physics popularization activities and physics teaching
  - the IYPT, as a community and a center of competence, that generates vibrant, state-of-the-art research problems, widely used in other activities and at other events
  - and also the author (-s) of the Kit, who could rapidly acquire a competence for the future activities and have a great learning experience
