Preparation to the Young Physicists’ Tournaments’ 2015

Ilya Martchenko, 1* Andrei Klishin, 2 Reza Montazeri Namin, 3 Stanisław Świdwiński, 4 Aliaksandr Mamoika, 5 Stanisłaŭ Piatruša, 6 and Andrei Schetnikov 7

1 University of Fribourg and Lund University; 2 Massachusetts Institute of Technology; 3 Sharif University of Technology; 4 Yale University; 5 Belarusian State University; 6 Moscow Institute of Physics and Technology; 7 Pythagoras School, Novosibirsk
Welcome to the 3rd IYNT in Belgrade!

The International Young Naturalists' Tournament, IYNT, bridges gaps between natural sciences.

The IYNT is focused on participants aged 12 to 16, and helps them look at core science subjects as a whole.

The format of the IYNT has been successfully tested over many years and is based on Evgeny Yunosov's multi-award winning format of the IYPT.

The IYNT wants more teams, and you can compete.

http://iynt.org
Call for cooperation

- If you are interested in the idea behind the Kit — to structure the earlier knowledge about the physics behind the problems and to encourage students to contrast their personal contribution from the existing knowledge — your cooperation is welcome

- If more contributors join the work on the Kit for 2015, or plan bringing together the Kit for 2016, 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
Do you like what the IYPT organizers do?
Watch the promo video: http://youtu.be/O51W8D-qeiA
Follow @iypt and @iyptarchive on Twitter
The IYPT is seeking for sponsors
If you do not donate today, another project of the IYPT will be put on hold
Being a supporter of the IYPT offers unique publicity, powerful rewards, and much more

Discover the exciting opportunities at http://iypt.org/Sponsors
How to tackle the IYPT problems?

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

Look through the historical solutions in the Archive :-)

- an opportunity for goal-oriented critical learning
- examples, not guidelines
- those solutions were good, but yours should be better!
Meet the UK 1991 team

- The IYPT Archive missed the names of the UK team members at the IYPT 1991
- The names are found thanks to Gordon Woods, UK visitor in 1991!
- Two photos show the team on the stairs of Physics building, Moscow State University


Photo by Sergey Romanchuk, taken nearly simultaneously
Is the novel research limited and discouraged by the existing common knowledge and the ongoing work of competing groups? :-(}
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 :-}
Je ne sais pas où je vais mais je suis sur mon chemin.
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 is a must.
- Taking ideas without citing is 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.
- The IYPT is not 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?
Requirements for a successful IYPT report

- Novel research, not a survey or a compilation of known facts
- Balance between experimental investigation and theoretical analysis
- Comprehensible, logical and interesting presentation, not a detailed description of everything-you-have-performed-and-thought-about
- Clear understanding of the validity of your experiments, and how exactly you analyzed the obtained data
- Clear understanding of what physical model is used, and why it is considered appropriate
- 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
- 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
How to give a science talk

- Take care of your listeners
  - if they all don’t get what you say, it’s your problem
  - it’s your job to do science work and make conclusions. It’s their job to listen

- Put yourself in context of existing results
  - your novelty is only visible in contrast with existing knowledge
  - making profound conclusions is harder than measuring and writing formulas and reading papers
  - be proud of your higher-level achievements (if you have such)

- Present a compelling argument
  - you want to say that you solved the required problem
  - saying how much you’ve struggled on it doesn’t help the case

- Cut the non-essential information
  - if your math is thick, show only core assumptions and derived results, we trust algebra and simulations
  - if your data is big, show us trends / slopes / averaging / fits, not all of it
  - very often, less is more
“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)
“Would you tell me, please, which way I ought to walk from here?”

“That depends a good deal on where you want to get to,” said the Cat.

LEWIS CARROLL
The fraction of space occupied by granular particles depends on their shape. Pour nonspherical particles such as rice, matches, or M&M’s candies into a box. How do characteristics like coordination number, orientational order, or the random close packing fraction depend on the relevant parameters?
Background reading


Problem No. 2 “Plume of smoke”

If a burning candle is covered by a transparent glass, the flame extinguishes and a steady upward stream of smoke is produced. Investigate the plume of smoke at various magnifications.
Background reading

- Grover Schrayer: Candle album on Flickr (2009), https://www.flickr.com/photos/14833125@N02/sets/72157625152859983/
- Hollow Flame - looking inside a candle flame (thenakedscientists.com, 2010), http://www.thenakedscientists.com/HTML/content/kitchenscience/exp/-25aeab656d/
Problem No. 3 “Artificial muscle”

Attach a polymer fishing line to an electric drill and apply tension to the line. As it twists, the fibre will form tight coils in a spring-like arrangement. Apply heat to the coils to permanently fix that spring-like shape. When you apply heat again, the coil will contract. Investigate this ‘artificial muscle’.
Background reading

- Fishing Line Artificial Muscles (youtube.com, from ACESElectromaterials, 19.02.1014), http://youtu.be/Tba8Nf02OSI
Problem No. 4 “Liquid film motor”

Form a soap film on a flat frame. Put the film in an electric field parallel to the film surface and pass an electric current through the film. The film rotates in its plane. Investigate and explain the phenomenon.
Background reading

Background reading

- 2009-Water Film Motor (Dept Physics, Sharif Univ. Tech., 2009), http://phys.sharif.edu/web/medphyslab/2009-water
- 2010-Rotation of Polar Liquid Films (Dept Physics, Sharif Univ. Tech., 2010), http://phys.sharif.edu/web/medphyslab/2010-rotation
- 2010-Instability and Rotation of Liquid Crystal Films (Dept Physics, Sharif Univ. Tech., 2010), http://phys.sharif.edu/web/medphyslab/2010-instability
Problem No. 5 “Two balloons”

Two rubber balloons are partially inflated with air and connected together by a hose with a valve. It is found that depending on initial balloon volumes, the air can flow in different directions. Investigate this phenomenon.
Background reading

- Pressure inside a balloon (SCIPP), [http://scipp.ucsc.edu/outreach/balloon/labs/InflationExp.htm](http://scipp.ucsc.edu/outreach/balloon/labs/InflationExp.htm)
- 2A10.51 Rubber Balloons (brown.edu), [https://wiki.brown.edu/confluence/display/physlecdemo/2A10.51+Rubber+Balloons](https://wiki.brown.edu/confluence/display/physlecdemo/2A10.51+Rubber+Balloons)
- Ch.-Sh. Chen. Two interconnected rubber balloons as a demonstration showing the effect of surface tension (circle.ubc.ca, 2009), [https://circle.ubc.ca/bitstream/handle/2429/7914/08WT2ChiehShanChen.pdf](https://circle.ubc.ca/bitstream/handle/2429/7914/08WT2ChiehShanChen.pdf)
Problem No. 6 “Magnus glider”

Glue the bottoms of two light cups together to make a glider. Wind an elastic band around the centre and hold the free end that remains. While holding the glider, stretch the free end of the elastic band and then release the glider. Investigate its motion.
Background reading

- Magnus Glider (youtube.com, from Children’s Museum of Houston, 20.06.2012), http://youtu.be/I1rdHsTtG_w
- В. А. Заворотов. От идеи до модели. М.: Просвещение, 1988
Problem No. 7 “Shaded pole”

Place a non-ferromagnetic metal disk over an electromagnet powered by an AC supply. The disk will be repelled, but not rotated. However, if a non-ferromagnetic metal sheet is partially inserted between the electromagnet and the disk, the disk will rotate. Investigate the phenomenon.
WEEKLY EVENING MEETING,
Friday, March 6, 1891.

William Crookes, Esq. F.R.S. Vice-President, in the Chair.

Professor J. A. Fleming, M.A. D.Sc. M.R.I.

Electro-magnetic Repulsion.

§ 1. On the 2nd day of October, 1820, Ampère presented to the Royal Academy of Sciences in Paris an important memoir, in which he summed up the results of his own and Arago’s previous investigations in the new science of electro-magnetism, and crowned that labour by the announcement of his great discovery of the dynamical action between conductors conveying electric currents.* Respecting that achievement, when developed in its experimental and mathematical completeness, no less a writer than Clerk Maxwell calls it “one of the most brilliant in the history of physical science.” Our wonder at what was then accomplished is increased when we remember that
Background reading

- Shaded pole motor experiment (youtube.com, from Thomas Kim, 30.07.2013), [http://youtu.be/2jO0wyzFCj0](http://youtu.be/2jO0wyzFCj0)
- А. А. Евсюков. Электротехnika. М.: Просвещение, 1979
Problem No. 8 “Sugar and salt”

When a container with a layer of sugar water placed above a layer of salt water is illuminated, a distinctive fingering pattern may be seen in the projected shadow. Investigate the phenomenon and its dependence on the relevant parameters.
Background reading

- The initial growth of salt fingers: Fig. 2 (Univ. of Victoria), http://csa.phys.uvic.ca/teaching/multi-physics-projects-with-comsol/fluid-mechanics/the-initial-growth-of-salt-fingers/fig-2/view
- Mixing Physics Science Experiment (youtube.com, from Physics Central, 10.01.2013), http://youtu.be/NI85oC3mj0
Problem No. 9 “Hovercraft”

A simple model hovercraft can be built using a CD and a balloon filled with air attached via a tube. Exiting air can lift the device making it float over a surface with low friction. Investigate how the relevant parameters influence the time of the ‘low-friction’ state.
Background reading

- Cheap toy (cheaperthancupofjoe, 02.01.2010), [http://cheaperthanacupofjoe.tumblr.com/post/365742422/cheap-toy](http://cheaperthanacupofjoe.tumblr.com/post/365742422/cheap-toy)
- Balloon Hovercraft (hometrainingtools.com), [http://www.hometrainingtools.com/a/balloon-hovercraft-science-project](http://www.hometrainingtools.com/a/balloon-hovercraft-science-project)
- C. Kapfer and A. Kraushaar. Hovercraft: The Myth, The Legend, The Science (Tualatin High School), [http://tuhsphysics.ttsd.k12.or.us/Research/ib00/KapfKrau/hoverpage.htm](http://tuhsphysics.ttsd.k12.or.us/Research/ib00/KapfKrau/hoverpage.htm)
- How a Hovercraft Works (James' Hovercraft Site, 2012), [http://www.jameshovercraft.co.uk/hover/hovercraft_concept_theory.php](http://www.jameshovercraft.co.uk/hover/hovercraft_concept_theory.php)
Background reading

- CD Hovercraft (youtube.com, from GrandadIsAnOldMan, 18.02.2013), http://youtu.be/qbAuaN8wlVA
- Make Toy CD Hovercraft (youtube.com, from Spacepainter, 27.04.2008), http://youtu.be/sktjTzRtr7M
- CD balloon hovercraft (youtube.com, from QuestaconNSTC, 06.01.2009), http://youtu.be/Uh2oAlm9P_E
Problem No. 10 “Singing blades of grass”

It is possible to produce a sound by blowing across a blade of grass, a paper strip or similar. Investigate this effect.
Background reading

- How to Whistle with a Blade of Grass (youtube.com, from Howcast, 18.08.2010), http://youtu.be/qc9Zc2g9D94
- How To Blow a Grass Whistle (youtube.com, from Prismistic Inkclicks, 26.06.2009), http://youtu.be/GPwJCeDo8v0
- how to whistle with grass (youtube.com, from minimemario12, 02.12.2009), http://youtu.be/FDvLiJPTXh0
- Tacoma Bridge Collapse (youtube.com, from British Pathé, 18.06.2013), http://youtu.be/XggxeuFDaDU
Problem No. 11 “Cat’s whisker”

The first semiconductor diodes, widely used in crystal radios, consisted of a thin wire that lightly touched a crystal of a semiconducting material (e.g. galena). Build your own ‘cat’s-whisker’ diode and investigate its electrical properties.
Background reading

- Alan E. Flowers. Crystal and Solid Contact Rectifiers, [http://www.crystalradio.net/minerals/GALENA.PDF](http://www.crystalradio.net/minerals/GALENA.PDF)
- Build an antique style crystal radio by Ohm, [http://www.instructables.com/id/Build-an-antique-style-crystal-radio/?ALLSTEPS](http://www.instructables.com/id/Build-an-antique-style-crystal-radio/?ALLSTEPS)
Problem No. 12 “Thick lens”

A bottle filled with a liquid can work as a lens. Arguably, such a bottle is dangerous if left on a table on a sunny day. Can one use such a ‘lens’ to scorch a surface?
Background reading

- 5 Ways to Start a Fire, Using Water (youtube.com, from Grant Thompson - "The king of Random", 27.09.2013), http://youtu.be/HCyHC7InMyQ
- Optics Tutorial - 8 - Cardinal Points (youtube.com, from opticsrealm, 06.12.2012), http://youtu.be/Hm3ZWl6l6pl
- Thick lenses and ABCD formalism (sisu.edu), http://www.sjsu.edu/faculty/beyersdorf/Archive/Phys158F06/10-12%20Thick%20Lenses%20and%20the%20ABCD%20formalism.pdf
Background reading

Problem No. 13 “Magnetic pendulum”

Make a light pendulum with a small magnet at the free end. An adjacent electromagnet connected to an AC power source of a much higher frequency than the natural frequency of the pendulum can lead to undamped oscillations with various amplitudes. Study and explain the phenomenon.
Background reading

- Doubochinski’s Pendulum (youtube.com, from Angelica Plumet, 28.07.2011), http://youtu.be/IWx4eKYd9C8
- Magnet powered pendulum (youtube.com, from RHEAD100, 12.05.2008), http://youtu.be/yrKtY7nWc-o
Background reading

- Perpetual Swinging Pendulum (bowdenshobbycircuits.info), http://www.bowdenshobbycircuits.info/swinger.htm
- Enrique Zeleny. Chaotic Motion of Perturbed Pendulum (Wolfram Demonstrations Project, April 19, 2013), http://demonstrations.wolfram.com/ChaoticMotionOfPerturbedPendulum/
- Thomas Gasenzer. The chaotic physical pendulum (Univ. of Heidelberg), http://www.thphys.uni-heidelberg.de/~gasenzer/index.php?n1=teaching&n2=chaos
Problem No. 14 “Circle of light”

When a laser beam is aimed at a wire, a circle of light can be observed on a screen perpendicular to the wire. Explain this phenomenon and investigate how it depends on the relevant parameters.
Background reading

- :-)
A brush may start moving when placed on a vibrating horizontal surface. Investigate the motion.
Background reading

- A. M. Mitskevich. Motion of a body over tangentially vibrating surface, taking into account of friction. Soviet Physics-Acoustics 13, 348-351 (1968)
- Mini brush robot (youtube.com, from ZEUS MEFISTO, 08.11.2013), http://youtu.be/lIvsOh_2XpY
- ROBOT BRUSH - BUILT and in ACTION - Toy for Kids! (youtube.com, from The General Expert, 24.03.2012), http://youtu.be/-_n_ODRQqWo
- Виброход (youtube.com, from prizolov, 13.02.2014), http://youtu.be/Qyj3VXGse3M
Problem No. 16 “Wet and dark”

Clothes can look darker or change colour when they get wet. Investigate the phenomenon.
Background reading

- J. Lekner and M. C. Dorf. Why some things are darker when wet. Appl. Optics 27, 7, 1278-1280 (1988)
Problems No. 17 “Coffee cup”

Physicists like drinking coffee, however walking between laboratories with a cup of coffee can be problematic. Investigate how the shape of the cup, speed of walking and other parameters affect the likelihood of coffee being spilt while walking.
Background reading

Visit iynt.org!

For general requests about the IYNT, media requests, sponsorship and cooperation, please write to info@iynt.org.

Pre-registration of teams

Join our vibrant and growing community, become our entrant or partner, and feel the spirit of the
Preparation to 28th IYPT’ 2015: references, questions and advices

Ilya Martchenko, 1* Andrei Klishin, 2 Reza Montazeri Namin, 3
Stanisław Świdwiński, 4 Aliaksandr Mamoika, 5
Stanisłaŭ Piatruša, 6 and Andrei Schetnikov 7

1 Univ. of Fribourg and Lund Univ.; 2 Massachusetts Inst. Techn.; 3 Sharif Univ. Techn.; 4 Yale Univ.;
5 Belarusian State Univ.; 6 Moscow Inst. Physics & Techn.; 7 Pythagoras School, Novosibirsk

July 11, 2014...October 10, 2014

* to whom correspondence should be addressed:
ilya.martchenko@iypt.org http://ilyam.org