



Preparation to the Young Physicists' Tournaments' 2024

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

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!





Problem No. 1 "Invent yourself"

Take a box (e.g. a matchbox), filled with identical objects (e.g. matches, balls, ...). Find a method to determine the number of objects in the box solely by the sound produced while shaking the box. How does the accuracy depend on the properties of the objects, the box, and the packing density?

- 1. Invent Yourself (IYPT 2024) (youtube, Fenix Science Club, 05.09.2023), https://youtube.com/shorts/7KVIIgVsa4c
- Maraca History and relation to Physics (youtube, Katt, 30.11.2017), https://youtu.be/SSn0wkAoZRU
- Wikipedia: Rattle (percussion instrument), https://en.wikipedia.org/wiki/Rattle_(percussion_instrument)
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- C. N. J. Stoelinga. A psychomechanical study of rolling sounds (PhD thesis, Technische Universiteit Eindhoven, 2007), https://research.tue.nl/en/publications/a-psychomechanicalstudy-of-rolling-sounds
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- What is the physics of maracas (11-05-06), http://www.sciencemathematics.com/Physics/201105/3771.htm
- Match Counting (Sathya, Ninad, Sriram), https://drive.google.com/file/d/1KLenMUk2V76IYrPt-IFOveL-Ansg74vW/view
- How is sound produced in when playing maracas? (quora.com), https://www.quora.com/How-issound-produced-in-when-playing-maracas
- Physics: DIY Making Maracas (playingscience.co.kr), http://playingscience.co.kr/product? tpf=product/view&category_code=10&code=270
- N. H. Fletcher and T. D. Rossing. The physics of musical instruments (New York, Springer-Verlag, 1991)
- Lord Rayleigh. The Theory of Sound (London, Macmillan, 1877, Courier Dover Publications, 1945), http://books.google.com/books?id=v4NSAlsTwnQC, http://books.google.com/books? id=Frvgu1wSFfU



Problem No. 2 "Droplet microscope"

By looking through a single water droplet placed on a glass surface, one can observe that the droplet acts as an imaging system. Investigate the magnification and resolution of such a lens.

IYPT history

Problem No. 12 "Fluid lens" (IYPT 2007)

Develop a fluid lens system with adjustable focus. Investigate the quality and possible applications of your system.

Reported 5 times, rejected 2 times at IYPT 2007



Contents of the problem :

 Develop a fluid lens system with adjustable focus. Investigate the quality and possible application of your system.



- 2. Droplet Microscope (IYPT 2024) (youtube, Fenix Science Club, 07.09.2023), https://youtube.com/shorts/X01dCcRSQAo
- Water Drop Microscope (youtube, Pueblo Science, 19.11.2022), https://youtu.be/MP2bQuYJBbc
- One drop of water turns an iPhone into a Microscope Day of Curiosity #17 (youtube, Jeremy Pedersen, 30.03.2022), https://youtu.be/aYQsxB2p4Kl
- Laser Microscope Made With a Drop of Water (youtube, The Action Lab, 11.07.2021), https://youtu.be/bYEuo3j2Ly0
- Make a FREE Microscope! (DIY With a Water Drop Lens) (youtube, Squint Science, 28.07.2020), https://youtu.be/cnKCbW75dlk
- Optics Tutorial 8 Cardinal Points (youtube, opticsrealm, 06.12.2012), http://youtu.be/Hm3ZWI6I6pl
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- Wikipedia: Lens, https://en.wikipedia.org/wiki/Lens
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- Y. Yu, C. Lv, L. Wang, and P. Li. The shape of heavy droplets on superhydrophobic surfaces. ACS Omega. 5, 41, 26732-26737 (2020)
- T. E. Agbana, J.-C. Diehl, F. van Pul, S. M. Patlan, M. Verhaegen, and G. Vdovin. Imaging & identification of malaria parasites using cellphone microscope with a ball lens. PLOS ONE 13, 10, e0205020 (2018)
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- The Magnifying Effect of a Water Drop (Science Buddies, scientificamerican.com, July 2, 2015), https://www.scientificamerican.com/article/the-magnifying-effect-of-a-water-drop/
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- Make a Water Drop Microscope (Anthony Joseph, scoutlife.org), https://scoutlife.org/hobbiesprojects/projects/200/make-a-microscope/
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- A. L. Baker. Thick-lens optics: An elementary treatise for the student and the amateur (D. van Nostrand Company, New York, 1912), https://archive.org/details/thicklensopticse00bakerich/



Problem No. 3 "Rigid ramp walker"

Construct a rigid ramp walker with four legs (e.g. in the form of a ladder). The construction may begin to 'walk' down a rough ramp. Investigate how the geometry of the walker and relevant parameters affect its terminal velocity of walking.

IYPT history

Problem No. 6. "Woodpecker toy" (IYPT 2012)

A woodpecker toy (see picture) exhibits an oscillatory motion. Investigate and explain the motion of the toy.

Reported 10 times, rejected 5 times at **IYPT 2012**

- Woodpecker Toy Physics (youtube.com, from DrDaveBilliards, Oct. 8, 2008).
- http://www.youtube.com/watch?v=s3YSnNAIHDg The woodpecker toy dynamics - 4dof model (youtube.com, jankoslavic, Apr. 12, 2008), http://www.youtube.com/watch?v=jYRG8YioOrQ
- F. Pfeiffer. Mechanische Systeme mit unstelligen Übergängen. Ingenieur-Archiv 54, 232-240 (1984) F. Pfeiffer. Dynamic systems with time-varying or unsteady structure. Ztschr. Ang. Math. Mech. 71, 4,
- T6-T22 (1991) Christoph Giocker and Christian Studer. The Woodpecker Toy (ETH Zürich, June 5, 2003), http://www.enm.bris.ac.uk/anm/staft/enmdb/SiCONOS/D61_ETH.pdf
- Remco I. Leine, Christoph Glocker, and Dick H. van Campen. Nonlinear dynamics of the woodpecker toy (Proceedings of DETC'01, 2001), http://www.dct.tue.nl/New/Leine/ASME21608.pdf





- 3. Rigid Ramp Walker (IYPT 2024) (youtube, Fenix Science Club, 10.10.2023), https://youtube.com/shorts/0ro6Ph2tCZk
- Make a Dinosaur Ramp Walker (youtube, OntarioScienceCentre, 27.11.2020), https://youtu.be/aLv9ypg70wk
- Chodiaci papierový panáčik | Experiment | Fyzika | Pokusy pre deti (youtube, FMFI UK, 02.11.2020), https://youtu.be/Lx3PFoMgr8g
- Science Lab: DIY Ramp Walker Toys (youtube, Charlotte County Community Services, 05.10.2020), https://youtu.be/GHG8PLyJv38
- Easy to Make Cardboard Ramp Walker (youtube, Ludic Science, 28.07.2020), https://youtu.be/DjwI-A6S4qs
- Cardboard ramp walkers..... easy build (youtube, Bruce Yeany, 01.06.2020), https://youtu.be/kx-1RuBoSqs
- The Walking Horse | Physics Toy | Gravity Powered Walking Toy (youtube, The Amaze Lab, 16.04.2020), https://youtu.be/GmSa9-Ulyhk
- Walking Horses Made of Paper J Bell (youtube, John Bell, 29.03.2020), https://youtu.be/zxxZXrgUq1c
- How to make a Ramp Walker Toy? | "Ramp Walker Toys DIY" | D'Art of Science (youtube, d'Art of Science, 23.10.2019), https://youtu.be/8lEwmZsjLS0
- Ramp walker (with explanation) (youtube, Physics experiments, 04.08.2019), https://youtu.be/C0Qn5iQW-iA

- Toy Physics--Ramp Walker ///Homemade Science with Bruce Yeany (youtube, Bruce Yeany, 12.06.2014), https://youtu.be/aBq6VArNyQY
- Toy Physics Part 3: Waddling Duck (youtube, DrDaveBilliards, 09.10.2008), https://youtu.be/huOoqu6O-Yo
- R. I. Leine, D. H. van Campen, and C. Glocker. Nonlinear dynamics and modeling of various wooden toys with impact and friction. J. Vib. Control 9, 25-78 (2003), https://www.inm.unistuttgart.de/einzelprojekte/toys/materialien_toys/Leine_x_van_Campen_x_Glocker_-______Nonlinear_Dynamics_and_Modeling_of_Various_Wooden_Toys_with_Impact_and_Friction.pdf
- F. Pfeiffer. Dynamic systems with time-varying or unsteady structure. Ztschr. Ang. Math. Mech.
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- F. Pfeiffer. Mechanische Systeme mit unsteitigen Übergängen. Ingenieur-Archiv 54, 232-240 (1984)
- Ramp walkers lurch into collectors's hearts (Ryan Padgett, antiqueweek.com, 4/9/2018), http://www.antiqueweek.com/ArchiveArticle.asp?newsid=2884
- How to make DIY ramp walker physics toys (thekidshouldseethis.com), https://thekidshouldseethis.com/post/how-to-make-diy-ramp-walker-physics-toys
- R. I. Leine and C. Glocker. Nonlinear dynamics of wooden toys (uni-stuttgart.de), https://www.inm.uni-stuttgart.de/einzelprojekte/toys/woodentoys/, https://web.archive.org/web/20141001211359/http://www.zfm.ethz.ch/~leine/toys.htm



Problem No. 4 "Shooting rubber band"

A rubber band may fly a longer distance if it is non-uniformly stretched when shot, giving it spin. Optimise the distance that a rubber band with spin can reach.

- How to Shoot Rubber Bands (youtube, GIAN MAN SUPER, 16.06.2021), https://youtu.be/N6QCKvqPMYE
- You've Probably Been Shooting Rubber Bands Wrong (youtube, Scam Nation, 10.11.2016), https://youtu.be/fa3vvClBtWg
- Stretching an Elastic band (youtube, QuantumBoffin, 07.11.2009), https://youtu.be/fFtM9JznLh8
- How to shoot a rubber band over 20 feet accurately (youtube, dsohigian, 10.08.2008), https://youtu.be/Ea_39SMCL7E
- Wikipedia: Rubber elasticity, https://en.wikipedia.org/wiki/Rubber_elasticity
- A. T. Oratis and J. C. Bird. Shooting rubber bands: Two self-similar retractions for a stretched elastic wedge. Phys. Rev. Lett. 122, 1, 014102 (2019)
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- Scientists discover the best way to shoot a rubber band (The New Daily, 07 Jan, 2019), https://www.thenewdaily.com.au/life/science/2019/01/07/shooting-rubber-band-research

- How Much Energy Can You Store in a Rubber Band? (Rhett Allain, wired.com, MAR 23, 2018), https://www.wired.com/story/how-much-energy-can-you-store-in-a-rubber-band/
- How to shoot a rubber band twice as fast, twice as far, and much more accurately (Mark Frauenfelder, boingboing.net, Nov 10, 2016), https://boingboing.net/2016/11/10/how-to-shoota-rubber-band-twi.html
- Do Rubber Bands Act Like Springs? (Rhett Allain, wired.com, AUG 8, 2012), https://www.wired.com/2012/08/do-rubber-bands-act-like-springs/
- How to shoot a rubber band and make it roll back to you (guides.brit.co), https://guides.brit.co/guides/shoot-a-rubber-band-and-make-it-roll-back-to-you



Problem No. 5 "Ping pong rocket"

A ping pong ball is placed in a container of water. When the container is dropped, the ping pong ball will get launched to a great height. What maximum height can you reach with up to 2 liters of water?

- Кумулятивные струи (youtube, GetAClass Физика в опытах и экспериментах, 26.12.2023), https://youtu.be/suF5Q2x3-Wk
- Теннисный шарик в падающем сосуде с водой (youtube, Андрей Щетников, 20.12.2023), https://youtu.be/Kwd-PkAzdm0
- ping-pong cumulative cannon (youtube, FlowYe, 22.11.2023), https://youtu.be/gjGas5GYR0M
- 5. Ping Pong Rocket (IYPT 2024) (youtube, Fenix Science Club, 12.09.2023), https://youtube.com/shorts/Uy4_CT4aFts
- Ping Pong Ball Water Rocket! #science #shorts (youtube, JaDropping Science, 07.04.2022), https://www.youtube.com/shorts/98EoAtjflmU
- IPT 2020 Online edition: PF2, Cumulative cannon, Colombia vs Russia (youtube, International Physicists' Tournament, 10.05.2021), https://youtu.be/4hJRDSrC58Q
- IPT 2020 Online edition: PF3, Cumulative Cannon, USA vs India (youtube, International Physicists' Tournament, 09.01.2021), https://youtu.be/sPc8y66KbGE
- Ping Pong Blast Off (youtube, Dr. Pi's STEAM LAB, 14.12.2020), https://youtu.be/74SZjPQ4Dg0
- International Physicists' Tournament 2020 Final Live Stream! (youtube, International Physicists' Tournament, 27.09.2020), https://www.youtube.com/watch?v=5m0uE7veJZ0
- Ping Pong Blast off (Cumulative Cannon) explained in Full detail (youtube, Kids Fun Science, 16.09.2020), https://youtu.be/RugZ2LmmRQI
- Cumulative Cannon (youtube, Projets Scientifiques en Équipe, 30.06.2020), https://youtu.be/mnbN12XtbQE

- TOP 41 amazing tricks and science experiments (youtube, Mr. Hacker, 26.07.2017), https://youtu.be/mPOcFSHyd9o
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 Part 1. Jet formation. J. Fluid Mech. 663, 293-330 (2010)
- A. Antkowiak, N. Bremond, S. Le Dizès, and E. Villermaux. Short-term dynamics of a density interface following an impact. J. Fluid Mech. 577, 241-250 (2007)
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- B. B. Майер. Кумулятивный эффект в простых опытах. М.: Наука, 1989

- G. Hering Scavariello. IPT2020-Problem 1-Cumulative cannon (University of Campinas, Brazil) (Giovanni Hering Scavariello, November 28, 2020), https://zenodo.org/records/4294727
- IPT2020-Problem 1- Cumulative Cannon (MIPT, Russia) (Artem Sukhov, December 5, 2020), https://zenodo.org/records/4307817



Problem No. 6 "Non-contact resistance"

The responses of a LRC circuit driven by an AC source can be changed by inserting either a non-magnetic metal rod or a ferromagnetic rod into the inductor coil. How can we obtain the magnetic and electric properties of the inserted rod from the circuit's responses?

IYPT history

Problems Nos. 9-10 "Gun" (IYPT 1993)

The picture shows an electromagnetic gun circuit. It can launch metal rings.

(S, C, K) is a power supply consisting of

- S, a source of constant voltage in the range 10-300 V,
- C, a capacitor with C=1000 μ F,

K, a switch;

L is an induction coil;

F is a ferromagnetic core;

R is a metal ring projectile with mass from 1 to 100 g.

C_n is a converter (some device that converts the energy passing from the capacitor to inductance L in a way you need.) This element does not contain energy sources. It may be completely absent from your gun. You are to construct, make and demonstrate the electromagnetic gun. It is worth mentioning that the demonstration of your gun will take place with the power supply (elements S, C and K) presented by the Organizing Committee of the YPT. Develop two variants of the gun:

9. A long-range gun is to be constructed to shoot a ring to a maximum altitude. The control parameter is the quantity $H=kh/U^2$, where k=10000 V², h is the height of the projectile, U is the voltage to which the capacitor is charged.

10. A gun-lift is to be constructed to achieve the maximum work of lifting a weight (ring). The control parameter is W=mgh, where *m* is the mass of the ring, $g=10 \text{ m/s}^2$.

Reported 3 (No. 9) and 4 (No. 10) times, rejected 2 (No. 9) and 1 (No. 10) times at IYPT 1993





- Magnetic Permeability (youtube, Bozeman Science, 12.06.2014), https://youtu.be/rWd3WSsWmJQ
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- S. S. Ivković, M. Z. Marković, D. Ž. Ivković, and N. Cvetanović. LCR circuit: new simple methods for measuring the equivalent series resistance of a capacitor and inductance of a coil. Eur. J. Phys. 38, 5, 055705 (2017)
- S. Haidar. Thomson's ring experiment with resonant LC circuit. Phys. Educ. 51, 1, 015013 (2016)
- Lessons In Electric Circuits -- Volume II (ibiblio.org), https://www.ibiblio.org/kuphaldt/electricCircuits/AC/AC_6.html

- V. Matos, L. Silva, and J. Sena Esteves. Induction ring launcher (Selected Papers on Hands-on Science, pp. 347-352), https://core.ac.uk/download/pdf/55609458.pdf
- Project: Electromagnetic Ring Launcher, https://learnltspice.weebly.com/uploads/2/5/5/2/25523252/electromagnetic_ring_launcher.pdf
- Simulation of the Thomson Ring Experiment (Max Bigelmayr), http://www.bigellabs.de/3.Physik/Thomson/web



Problem No. 7 "Giant sounding plate"

When a large, thin and flexible plate (e.g. plastic, metal or plexiglass) is bent, it may produce a loud and unusual howling sound. Explain and investigate this phenomenon.

Problem No. 2 "Singing saw" (IYPT 2001)

Some people can play music on a handsaw. How do they get different pitches? Give a quantitative description of the phenomenon.

Reported 7 times, rejected 2 times at IYPT 2001

2. SINGING SAW

Nona Karalashvili, School Nº42 named after Ilia Vekua Maxim Matosov Georgian Lyceum of Science and Technology, School Nº42 named after Ilia Vekua

In order to receive sound we must have oscillating body. So to play on saw we must make him oscillate. We can do this with bow or mallet



After beating saw with mallet or playing with bow in saw standing will strew sugar or other dust on the surface of saw, and then will play, sugar of other date on point, which don't take will place in oscillations. These points are called nodal points. Oscillations of saw make air oscillate and sound propagates. Londness of sound is defined by amplitude of oscillations.



so we can control on budgess of saw sound by controlling amplitude of oscillations of saw Pitch of sound is defined by frequency of oscillations. Let us define natural frequency of testangle plate

 $\zeta = \zeta_n(x,y)\cos(\alpha t + \alpha)$ $\Delta(\zeta_6 - \zeta) - \chi^4 \zeta_0 = 0, \text{ where } \chi^4 = \omega^4 \frac{12\rho(1 - \sigma^2)}{2}$ or -is Puason's coefficient

E-is Eung's modulus A-is Laplas's operator

By help of Relay-Ritz's method, we can define frequency of oscillations of plate with supported ends:

 $\zeta_0 = A \sin \frac{m\pi x}{b} \sin \frac{n\pi y}{a}$ and ware number of nodes along length and width a-is length of the saw 5 -is width of the saw



- Рептилоиды среди нас (youtube, Андрей Щетников, 20.11.2023), https://youtu.be/02AiCfMC1NQ
- Гигантская звуковая пластина (youtube, GetAClass Физика в опытах и экспериментах, 13.11.2023), https://youtu.be/x5Auq36vTGQ
- 7. Giant Sounding Plate (IYPT 2024) (youtube, Fenix Science Club, 14.09.2023), https://youtube.com/shorts/ljU1HYLUZqs
- Bendy Metal Make Funny Sound (youtube, Dank Energy, 02.03.2021), https://www.youtube.com/shorts/MvYdKq2_d2k
- Поющая пластина(2) Proposal IYPT 2022 (youtube, ЭйНШтейн, 16.09.2020), https://youtu.be/yFvy0T_s9O4
- Поющая пластина Proposal IYPT 2022 (youtube, ЭйНШтейн, 16.09.2020), https://youtu.be/GJBnk5BVhN4
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- Lord Rayleigh. The Theory of Sound (London, Macmillan, 1877, Courier Dover Publications, 1945), http://books.google.com/books?id=v4NSAlsTwnQC, http://books.google.com/books? id=Frvgu1wSFfU



Prob. No. 8 "Another magnetic levitation"

Place a large disk-shaped magnet on a non-magnetic conductive plate. When a smaller magnet is moved under the plate, the magnet on top may levitate under certain conditions. Investigate the levitation and the possible motion of the magnet on top.

IYPT history



"Magnetic suspension" may be used in high speed trains of the future. Design and make an experimental model of such a suspension.

Reported 1 times, rejected 1 times at IYPT 1992

Problem No. 3 "Magnetism" (IYPT 1994)

A cylindrical permanent magnet falling inside a copper tube is found to move at an almost constant velocity, the slower the thicker and the walls of the tube. Use this fact to formulate a problem (See also 14).

Reported 3 times, rejected 3 times at IYPT 1994

Problem No. 16 "Magnetic brakes" (IYPT 2014)

When a strong magnet falls down a nonferromagnetic metal tube, it will experience a retarding force. Investigate the phenomenon.

Reported 15 times, rejected 2 times at IYPT 2014

Problem No. 14 "Magnetic friction" (IYPT 1994)

(a)

To investigate the phenomenon described in the problem 3 we suggest to create the device containing the following elements:

a copper plate (or a set of plates) 0.3 to 15 mm thick. The length and the width of the plate may be chosen according to one's convenience, but they should be large enough to avoid the effect of the boundaries;

a cylindrical electromagnet with a flat butt-end;

a device providing free motion of the flat butt-end of the electric magnet over the horizontal surface of the copper plate. It is very important that the gap between the magnet and the plate is small as possible and constant everywhere;

the push providing the uniform motion of the magnet at a given velocity over the plate surface. Introduce the following notation: T — the push (and the force of magnetic friction), v — the velocity of the magnet, h — the thickness of the plate. Investigate and determine experimentally the dependence of T on h at v=const for several values of v.

Reported 0 times, rejected 0 times at IYPT 1994

- Stable eddy current induction levitation of aluminum disk (youtube, davekni, 18.02.2018), https://youtu.be/AHED5xSnnM8
- Copper's Surprising Reaction to Strong Magnets | Force Field Motion Dampening (youtube, NightHawkInLight, 26.01.2018), https://youtu.be/sENgdSF8ppA
- Eddy Current Levitation (youtube, Chris's Workbench, 28.08.2017), https://youtu.be/A7BScXvM8w0
- (#0126) Lenz's Law Levitation Coil Stable with No Tethers (youtube, High Voltage Hot Dog, 02.01.2014), https://youtu.be/azsqhKg8hX8
- Eddy Currents, Magnetic Braking and Lenz's Law (youtube, Fiona Meade, 21.06.2011), http://youtu.be/otu-KV3iH_I
- Wikipedia: Magnetic levitation, https://en.wikipedia.org/wiki/Magnetic_levitation
- Wikipedia: Eddy current, http://en.wikipedia.org/wiki/Eddy_current
- Wikipedia: Faraday's law of induction, https://en.wikipedia.org/wiki/Faraday %27s_law_of_induction
- Wikipedia: Lenz's law, https://en.wikipedia.org/wiki/Lenz%27s_law
- Wikipedia: Force between magnets, https://en.wikipedia.org/wiki/Force_between_magnets
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- Eddy Current Levitation (Harvard Natural Sciences Lecture Demonstrations), https://sciencedemonstrations.fas.harvard.edu/presentations/eddy-current-levitation
- Force between two magnets (physics.stackexchange.com, May 8, 2019), https://physics.stackexchange.com/questions/478810/force-between-two-magnets


Problem No. 9 "Juicy solar cell"

A functional solar cell can be created using conducting glass slides, iodine, juice (eg. blackberry) and titanium dioxide. This type of cell is called a Grätzel cell. Make such a cell and investigate the necessary parameters to obtain maximum efficiency.

- Make a Transparent Conductive Glass (youtube, Cayrex, 22.02.2021), https://youtu.be/wgKyW025JCQ
- Dye Sensitized Solar Cell (youtube, SKM Edu Channel, 03.11.2017), https://youtu.be/XqNnRDy1R70
- DSSC (youtube, JuiceFromJuice, 02.04.2016), https://youtu.be/fOhKsbhgt1U
- Titanium Dioxide Raspberry Solar Cell (youtube, Wisconsin Mrsec, 31.08.2012), https://youtu.be/Jw3qCLOXmi0
- Juice from Juice Physics of Solar Cells (youtube, JuiceFromJuice, 08.08.2011), https://youtu.be/9bYqVNKbiA0
- Constructing a Dye Sensitized Solar Cell (youtube, Neal Abrams, 09.10.2009), https://youtu.be/17SsOKEN5dE
- Tin Oxide Conductive Glass Stannous Chloride (youtube, Jeri Ellsworth, 06.08.2009), https://youtu.be/dz4YMFbVbyM
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- M. H. Bazargan, M. Malekshahi Byranvand, A. Nemari Kharat, and L. Fatholahi. Natural pomegranate juice as photosensitizers for dye-sensitized solar cell (DSSC). Optoelectron. Adv. Mater. Rapid Commun. 5, 4, 360-362 (2011)

- G. Boschloo and A. Hagfeldt. Characteristics of the iodide/triiodide redox mediator in dyesensitized solar cells. Acc. Chem. Res. 42, 11, 1819-1826 (2009)
- Red Sicilian orange and purple eggplant fruits as natural sensitizers for dye-sensitized solar cells. Sol. Energy Mater. Sol. Cells 92, 11, 1341-1346 (2008)
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- K. O. Nikolaev, E. A. Pecherskaya, and A. A. Shamin. Influence of technological parameters on the energy efficiency of oxide solar cells. Proc. 2018 19th International Conference of Young Specialists on Micro/Nanotechnologies and Electron Devices (EDM) (Erlagol, Russia, 29 June-03 July 2018)
- Titanium Dioxide Raspberry Solar Cell (education.mrsec.wisc.edu), https://education.mrsec.wisc.edu/titanium-dioxide-raspberry-solar-cell/
- Solar Cells: Juice From Juice (ccmr.cornell.edu, 2014), https://www.ccmr.cornell.edu/wpcontent/uploads/sites/2/2015/11/Solar-Cells.pdf
- Make a Grätzel cell (edu.rsc.org), https://edu.rsc.org/resources/make-a-grtaand776zelcell/1290.article
- How to Build & Use a Dye-Sensitized Solar Cell (DSSC) + a Discussion on Energy & Efficiency (instructables.com), https://www.instructables.com/How-to-Build-Use-A-Dye-Sensitized-Solar-Cell-DS/



Problem No. 10 "Magnetic gear"

Take several identical fidget spinners and attach neodymium magnets to their ends. If you place them side by side on a plane and rotate one of them, the remaining ones start to rotate only due to the magnetic field. Investigate and explain the phenomenon.

- 10. Magnetic Gears (IYPT 2024) (youtube, Fenix Science Club, 19.09.2023), https://youtube.com/shorts/7f_4tvNTCb0
- Magnetic Gear Drive Transmission | TURNER TRICKS (youtube, TURNER TRICKS, 28.05.2023), https://www.youtube.com/shorts/afs6lgO_Flc
- Магнитная муфта (youtube, GetAClass Физика в опытах и экспериментах, 08.12.2022), https://youtu.be/rtcMfPz8G3Q
- Demonstration of Magnetic Gear (youtube, Mau Hing CHAN, 20.04.2022), https://youtu.be/INcGbOcSqEg
- Спиннер с научной точки зрения1 #Shorts Игорь Белецкий (youtube, Игорь Белецкий, 20.04.2022), https://youtu.be/x2ZCxkCAoE4
- Magnetic Gears (youtube, K&J Magnetics, 03.08.2021), https://youtu.be/HBgjueoZ58Q
- Магнитный множитель скорости | Magnetic Games (youtube, Magnetic Games, 12.06.2021), https://youtu.be/1w5OI05bILE
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- Force between two magnets (physics.stackexchange.com, May 8, 2019), https://physics.stackexchange.com/questions/478810/force-between-two-magnets
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- E. P. Furlani. Permanent magnet and electromechanical devices (Academic Press, San Diego, 2001)



Problem No. 11 "Pumping straw"

A simple water pump can be made using a straw shaped into a triangle and cut open at the vertices. When such a triangle is partially immersed in water with one of its vertices and rotated around its vertical axis, water may flow up through the straw. Investigate how the geometry and other relevant parameters affect the pumping speed.

- 11. Pumping Straw (IYPT 2024) (youtube, Fenix Science Club, 21.09.2023), https://youtube.com/shorts/p-GyPR_aM5k
- Straw Sprinkler (youtube, Ayushi Verma, 18.10.2021), https://youtu.be/q7dslGdqYL0
- Centrifugal Straw Sprinkler Experiment How to make a sprinkler with a straw (youtube, Kids Fun Science, 22.05.2017), https://youtu.be/lapoJBsIMGo
- How to make a Water pump with a Straw dArtofScience (youtube, d'Art of Science, 12.12.2014), https://youtu.be/yf1tSFXhnjw
- STRAW CENTRIFUGE PUMP ENGLISH 11MB (youtube, Arvind Gupta, 17.06.2009), https://youtu.be/jS-JrWfhEJI
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- K. W. Cheah, T. S. Lee, S. H. Winoto, and Z. M. Zhao. Numerical flow simulation in a centrifugal pump at design and off-design conditions. Int. J. Rotating Mach. 83641 (2007)
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- Centrifugal sprinkler (Sprinkler Straw) experiment (robolab.in), https://www.robolab.in/centrifugal-sprinkler-sprinkler-straw-experiment/
- Spiral pump: Slow pump, high head (survlivel.cultu.be), https://survlivel.cultu.be/spiral-pumphigh-head



Problem No. 12 "The soap spiral"

Lower a compressed slinky into a soap solution, pull it out and straighten it. A soap film is formed between the turns of the slinky. If you break the integrity of the film, the front of the film will begin to move. Explain this phenomenon and investigate the movement of the front of the soap film.

- 12. The Soap Spiral (IYPT 2024) (youtube, Fenix Science Club, 26.09.2023), https://youtube.com/shorts/CBZb3rI78JU
- Playing with bubbles and slinky toy so much fun for kids and adults too! (youtube, Bubbly Heaven, 26.11.2022), https://youtu.be/5o6mIXcOmqs
- Amazing slinky bubble skills..... #kieronthemighty #shorts #shortswithcamilla #slinky #slinkytricks (youtube, Kieron the Mighty, 25.08.2022), https://youtu.be/VBoLo8gBpsg
- Helicoid transformation (youtube, WaveMetrics, Inc., 12.07.2018), https://youtu.be/OGI-NWfxTcg
- Wikipedia: Minimal surface, https://en.wikipedia.org/wiki/Minimal_surface
- Wikipedia: Young-Laplace equation, https://en.wikipedia.org/wiki/Young %E2%80%93Laplace_equation
- Wikipedia: Plateau's problem, https://en.wikipedia.org/wiki/Plateau%27s_problem
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- Blowing bubbles with a slinky toy (Little Party Heaven, Dec 12, 2022), https://www.bubblyheaven.co.uk/2022/12/12/blowing-bubbles-slinky-toy/
- Cover a slinky in dish soap and enjoy (reddit.com), https://www.reddit.com/r/mildlyinteresting/comments/1lccmt/cover_a_slinky_in_dish_soap_and _enjoy/
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- C. V. Boys. Soap bubbles, their colours and the forces which mould them (Dover, New York, 1959)

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Problem No. 13 "Charge meter"

A lightweight ball is suspended from a thread in the area between two charged plates. If the ball is also charged it will be deflected to one side at a certain angle. What is the accuracy of such a device for measuring the amount of charge on the ball? Optimise your device to measure the smallest possible charge on the ball.

IYPT history

Problem No. 3 "Electric pendulum" (IYPT 2004)

Use a thread to suspend a suitable ball between the plates of a capacitor. When the plates are charged the ball will start to oscillate. What does the period of the oscillations depend on?

Reported 7 times, rejected 3 times at IYPT 2004

Ivan Yamshchikov

Motion of the ball · Forces acting on charged ball moving between the plates Electrostatic force $\mathbf{F}_{n} = q^{-1}$ Gravity $\mathbf{F}_g = m\mathbf{g}$

Electrical Force on Ball



Tangential Component: $F_{\rm el,t} = \frac{Uq}{d} \cos \varphi \approx \frac{Uq}{d}$

a - ball charge

g - free fall acceleration

U - voltage

-ê d - distance be



1.2. PROBLEM No 3: ELECTRIC PENDULUM - MPT 2004 SOLUTION OF AUSTRIA

Prablem 35 3: Electric Pendulum Harald Altinger, Bernhard Frena, Eva Hasenhäil, Owisitna Koller, Camill Ladinig

The probles Use a Dread are charged

The cause of the oscillation will be the fact that whenever the ball touch



- Van de Graaff 1 Franklin's Bells (youtube, Robert Bass, 14.02.2023), https://youtu.be/yBNP8uWxVN8
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Problem No. 14 "Ruler trick"

Place a ruler on the edge of a table, and throw a ball at its free end. The ruler will fall. However, if you cover a part of the ruler with a piece of paper and repeat the throw, then the ruler will remain on the table while the ball will bounce off it. Explain this phenomenon, and investigate the relevant parameters.

- 14. Ruler Trick (IYPT 2024) (youtube, Fenix Science Club, 28.09.2023), https://youtube.com/shorts/yXumfSfQRyc
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Problem No. 15 "Wet scroll"

Gently place a piece of tracing paper on the surface of water. It rapidly curls into a scroll and then slowly uncurls. Explain and investigate this phenomenon.

- 15. Wet Scroll (IYPT 2024) (youtube, Fenix Science Club, 03.10.2023), https://youtube.com/shorts/1jp-CeeqkUw
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Problem No. 16 "Cushion catapult"

Place an object on a large air cushion and drop several other objects in such a way that the first object is catapulted away. Investigate how the exit velocity depends on relevant parameters.

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- Human Water Catapult 55 Foot Launch! In 4k (youtube, devinsupertramp, 26.08.2014), https://youtu.be/BopDHDQGud8
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- Launch into Fun with the WaterBlob (The Original Water Blob, 2023), http://thewaterblob.com/
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Problem No. 17 "Quantum light dimmer"

If you put a flame with table salt added in front of a vapour sodium lamp, the flame casts a shadow. The shadow can become lighter, if the flame is put into a strong magnetic field. Investigate and explain the phenomenon.

- Making Black Fire (youtube, Action Lab Shorts, 08.06.2021), https://youtu.be/F0LWtieip9E
- Candle flame is repelled by magnets (and Zeeman follow-up) (youtube, Applied Science, 16.07.2018), https://youtu.be/JV4Fk3VNZqs
- Zeeman Effect Control light with magnetic fields (youtube, Applied Science, 25.06.2018), https://youtu.be/OzkcB1lkgGU
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- The Sodium Doublet (hyperphysics.phy-astr.gsu.edu), https://hyperphysics.phy-astr.gsu.edu/hbase/quantum/sodzee.html
- Zeeman effect (laboratoriofisica.uc3m.es), https://laboratoriofisica.uc3m.es/guiones_ing/aqp/Zeeman_effect.pdf

Find all the differences you can!



IYPT 1989, Team Netherlands IYPT 2016, Team United Kingdom

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

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

Albert Einstein



-Ion Blocher

Important information

- The basic goal of this Kit is not in providing students with a start-to-finish manual or in limiting their creativity, but in encouraging them to
 - regard their work critically,
 - look deeper,
 - have a better background knowledge,
 - be skeptical in embedding their projects into the standards of professional research,
 - and, as of a first priority, be attentive in not "re-inventing the wheel"
- An early exposure to the culture of scientific citations, and developing a responsible attitude toward making own work truly novel and original, is assumed to be a helpful learning experience in developing necessary standards and attitudes
- Good examples are known when the Kit has been used as a concise supporting material for jurors and the external community; the benefits were in having the common knowledge structured and better visible
- Even if linked from iypt.org, this file is not an official, binding release of the IYPT, and should under no circumstances be considered as a collection of authoritative "musts" or "instructions" for whatever competition
- 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 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

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)

Call for cooperation

- If you are interested in the idea behind the Kit to structure the existing 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 2024, or plan bringing together the Kit for 2025, 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 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 may generate original, stateof-the-art research problems, widely used in other activities and at other events
 - and also the authors of the Kit, who could rapidly acquire a competence for the future activities and have a great learning experience



In search for missing results

- Have you attended an IYPT marked in red and preserved Physics Fight results, e.g. by keeping printed rankings?
- Have you attended an IYPT marked in orange or red, and recorded grades from a Fight, e.g. by writing them down?



Green: each and every Juror's grade has been preserved Orange: all Sums of Points (SP) are known, but some Juror's grades are not Red: some Sums of Points (SP) are missing								1988	1989
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Preparation to 37th IYPT' 2024: references, questions and advices

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¹ Foundation for Youth Tournaments ² Novosibirsk State University

August 5, 2023...December 29, 2023

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