

IYPT 2020 Crowdsourced Reference Archive

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Contributors:

- Francisco Lago Lira Passos from Brazil
- Raymond Lin from Canada
- Rowland Chen from China
- Tianyi Xiao from China
- Zian Lie from China
- Arsha Niksa from Iran (Also a member of STEM Fellowship)
- Jinil Yoo from Korea
- Lydia from New Zealand
- Andrey Schetnikov from Russia
- Artem Sukhov from Russia

Problem 1: Invent Yourself

Design an instrument for measuring current using its heating effect. What are the accuracy, precision, and limits of the method?

- Heating Effects of Electric Current and Its Applications by toppr
<https://www.toppr.com/guides/physics/electricity/heating-effects-of-electric-current-and-its-applications/>
- Conductor Temperature Rise Due to Current Changes in Conductors by The Institute for Interconnecting and Packaging Electronic Circuits <https://www.ipc.org/TM/2.5.4.1a.pdf>
- Temperature Dependence of Resistivity by toppr
<https://www.toppr.com/guides/physics/current-electricity/temperature-dependence-resistivity/>
- Heating Effect of Current | Joule's Law of Electric Heating by Electronics Tutorials
<https://electronicspani.com/heating-effect-of-current-joules-law-of-electric-heating/>
- Electrical Equivalent of Heat (Power Amplifier, Temperature Sensor)
- https://www.unr.edu/Documents/science/physics/labs/181/11_Electrical_Equivalent_of_Heat.pdf
- Ikeda Yoshiro, Yoneta katsuhiko. Temperature rise of a conductor due to the electric current. 1931 Hokkaido Imperial University Memoirs of the Faculty of Engineering, Hokkaido Imperial University, Volume 2, 107-145.
<http://hdl.handle.net/2115/37682>
- Temperature Coefficient of Resistance Chapter 12 – Physics Of Conductors And Insulators by All About Circuits.
<https://www.allaboutcircuits.com/textbook/direct-current/chpt-12/temperature-coefficient-resistance/>
- Heating Effects of an Electric Current by Peda.net
<https://peda.net/kenya/ass/subjects2/physics/form-32/heoae>
- Osman Kahvecia, Emin Çadirlib, Mehmet Aria, Hicran Tecerc, Mehmet Gündüza. Measurement and Prediction of the Thermal and Electrical Conductivity of Al-Zr Overhead Line Conductors at Elevated Temperatures. Mat. Res. vol.22 no.1 São Carlos 2019 Epub Dec 06, 2019 <http://dx.doi.org/10.1590/1980-5373-mr-2018-0513>
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http://www.scielo.br/scielo.php?pid=S1806-11172011000400020&script=sci_abstract
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https://www.researchgate.net/publication/322106952_A_Generalized_Analytical_Model_for_Joule_Heating_of_Segmented_Wires

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Problem 2: Inconspicuous Bottle

Put a lit candle behind a bottle. If you blow on the bottle from the opposite side, the candle may go out, as if the bottle was not there at all. Explain the phenomenon.

- How to Blow out a Candle behind a Bottle | Kids Science (YouTube, TheDadLab, Nov 15, 2018), <https://youtu.be/fxlrwaOzWwo>
- 5 weird ways to put out a candle (YouTube, Physics Girl, Feb 9, 2016), <https://youtu.be/WainnKktGZI?t=61>
- How to Blow Out a Candle with a Bottle in the Way – Mr. Wizard’s Everyday Magic (YouTube, MrWizardStudios, Jan 8, 2014), <https://youtu.be/0-Gb1q-g-to>
- Blowing Around Corners | Science Experiment for Kids !! (YouTube, HooplaKidzLab, Oct 31, 2014), <https://youtu.be/BXe79e05Ch8>
- Blowing Out a Candle Behind a Cylinder (YouTube, JSME FED, Feb 1, 2018), <https://youtu.be/jB9BG2KmUzI>
- Wikipedia: Coandă effect, https://en.wikipedia.org/wiki/Coand%C4%83_effect
- Blowing out candles around corners by The Naked Scientists, <https://www.thenakedscientists.com/get-naked/experiments/blowing-out-candles-around-corners>
- Blowing Out a Candle Behind a Cylinder by JSME FED
- http://www.jsme-fed.org/experiment-e/2014_2/001.html
- http://www.jsme-fed.org/experiment-e/2014_2/002.html
- http://www.jsme-fed.org/experiment-e/2014_6/003.html
- Turbulence <http://labman.phys.utk.edu/phys221core/modules/m8/turbulence.html>
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<http://www.sciencedirect.com/science/article/pii/0167610586900668>

Problem 3: Swinging Sound Tube

A Sound Tube is a toy, consisting of a corrugated plastic tube, that you can spin around to produce sounds. Study the characteristics of the sounds produced by such toys, and how they are affected by the relevant parameters.

- Sound Hose – Whirly Tube (YouTube, Sick Science!, Mar 2, 2009), <https://youtu.be/CuGnsW0ysrA>
- Twirling sound hose experiment (Sound tubes create low air pressure) (YouTube, Kids Fun Science, May 25, 2017), <https://youtu.be/u6uEqsZlaZM>
- Corrugated sound tube (Youtube, GetAClass – Физика в опытах и экспериментах, Oct. 24, 2019) https://www.youtube.com/watch?v=_q6aPYaHBsA
- Wikipedia: Whirly tube, https://en.wikipedia.org/wiki/Whirly_tube
- Frank S. Crawford. Singing Corrugated Pipes. *American Journal of Physics* 42, 278 (1974);<https://doi.org/10.1119/1.1987673>.<http://www.physics.umd.edu/deptinfo/facilities/lecdem/services/refs/refsh/Crawford-SingingPipes.pdf>
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- A Simple Experiment to Explore Standing Waves in a Flexible Corrugated Sound Tube, Maria Eva Amorim, Teresa Delmira Sousa, and P. Simeao Carvalho, *The Physics Teacher*, Vol. 49, September 2011<https://aapt.scitation.org/doi/10.1119/1.3628265>
- Measurements on tones generated in a corrugated flow pipe with special attention to the influence of a low frequency oscillation. Ulf R. Kristiansen, Pierre-Olivier Mattei, Cedric Pinhde, Muriel Amielh. ISBN 978-82-8123-004-0. <https://arxiv.org/abs/1011.6150>

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Problem 4: Singing Ferrite

Insert a ferrite rod into a coil fed from a signal generator. At some frequencies, the rod begins to produce a sound. Investigate the phenomenon.

- How anti-theft tags work – magnetostriction, (YouTube, Applied Science, Nov 30, 2015), <https://youtu.be/KAm7qAKAXwI>
- Magnetostriction effect: production of ultrasonic sound, (YouTube, Cybo Socks, Feb 25, 2018), <https://youtu.be/qwSjq-keP3U>
- Magnetostriction, (YouTube, GetAClass – Физика в опытах и экспериментах, Feb. 7, 2019), <https://www.youtube.com/watch?v=qAvs6B4Ej1I>
- Wikipedia: Ferrite core, https://en.wikipedia.org/wiki/Ferrite_core
- Matthew Jones. Physics 42200 Waves & Oscillations Lecture 15 – French, Chapter 6 (2013), https://www.physics.purdue.edu/~jones105/phys42200_Spring2013/notes/Phys42200_Lecture15.pdf
- Wikipedia: Resonance, <https://en.wikipedia.org/wiki/Resonance>
- Wikipedia: Magnetostriction, <https://en.wikipedia.org/wiki/Magnetostriction>
- Wikipedia: Electromagnetically excited acoustic noise and vibration, https://en.wikipedia.org/wiki/Electromagnetically_excited_acoustic_noise_and_vibration
- Adam Bie ńkowski, Roman Szewczyk. Magnetostrictive Properties of Mn_{0.70}Zn_{0.24}Fe_{2.06}O₄ Ferrite. *Materials* 2018, 11(10), 1894; <https://doi.org/10.3390/ma11101894>. <https://www.mdpi.com/1996-1944/11/10/1894/pdf/1>
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Problem 5: Sweet Mirage

Fata Morgana is the name given to a particular form of mirage. A similar effect can be produced by shining a laser through a fluid with a refractive index gradient. Investigate the phenomenon.

- Bending a laser beam. Experiment. (YouTube, Carlos Guirao, April 10, 2011), <https://youtu.be/zTx7UoPXvr4>
- Bending of light – Laser Science Experiment, (YouTube, Taras Kul, Feb 24, 2016), <https://youtu.be/c6HVWe9tMFA>
- Gradient Index Optics, (YouTube, University of Rochester, Sep 29, 2014), <https://youtu.be/XOj97dva6ss>
- Wikipedia: Mirage, <https://en.wikipedia.org/wiki/Mirage>
- Rabi Ibrahim Rabaday. Simplified Model for Light Propagation in Graded-Index-Medium. Optics and Photonics Journal, 2013, 3, 347-350 Published Online November 2013 (<http://www.scirp.org/journal/opj>) <http://dx.doi.org/10.4236/opj.2013.37054>. <https://pdfs.semanticscholar.org/9f8f/e29d292732c8a7fb1aa82f0ce5df94822077.pdf>
- Robert G. Greenler, "Laboratory simulation of inferior and superior mirages," J. Opt. Soc. Am. A 4, 589-590 (1987) <https://www.osapublishing.org/josaa/abstract.cfm?uri=josaa-4-3-589>
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- [Russian] Light in an Optically Inhomogeneous Medium: Educational Studies М а й е р В. В. С в е т в о п т и ч е с к и н е о д н о р о д н о й с р е д е : у ч е б н ы е и с с л е д о в а н и я . — М.: Ф И З М А Т Л И Т , 2007. — 232 с . — ISBN 978-5-9221-0712-9. (Page number 159 is part about "Fata Morgana" mirage)
- [Russian] Mirage in unevenly heated water М и р а ж в н е р а в н о м е р н о н а г р е т о й в о д е <http://potential.org.ru/pub/Home/FullTextArticles/miraj.pdf>
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- Schricker, A. (2001). Refractive Bending of Light due to Thermal Gradients in Air (No. ATL-MUON-2001-017). ATL-COM-MUON-2001-023. <http://cds.cern.ch/record/684258/files/muon-2001-017.pdf>

Problem 6: Saxon Bowl

A bowl with a hole in its base will sink when placed in water. The Saxons used this device for timing purposes. Investigate the parameters that determine the time of sinking.

- Water flow III – Saxon Bowls, <http://seniorphysics.com/physics/eei.html>
- Lesson 8: Sinking Water Clock, (YouTube, Kimberly Blauvelt, Oct 11, 2014), https://youtu.be/eqqUo_flykM
- Aluminum Foil Timer- Intro To Sinking Water Clock, (YouTube, Kimberly Blauvelt, Oct 11, 2014), <https://youtu.be/gsyMnuGZN9Q>

- What physics equation can be used to describe the saxon bowl experiment?
<https://physics.stackexchange.com/questions/416112/what-physics-equation-can-be-used-to-describe-the-saxon-bowl-experiment>
- How is Bernoulli's equation related to saxon bowls?
<https://www.physicsforums.com/threads/how-is-bernoullis-equation-related-to-saxon-bowls.862660/>
- Saxon Bowl IYPT 2020 – analytical solution from ilinblog by Ivan Ilin http://ilinblog.ru/article.php?id_article=58
- A Descriptive Catalogue of Indian Astronomical Instruments by Sreeramula Rajeswara Sarma (Page 403)
https://srsarma.in/catalogue/docs/A_Descriptive_Catalogue_of_Indian_Astronomical_%20Instruments_Abridged_Version.pdf
- Greer, Allan & Kincanon, Eric. (2000). An experiment with Saxon bowls. *The Physics Teacher*. 38. 112-112. 10.1119/1.880442. https://www.researchgate.net/publication/239045627_An_experiment_with_Saxon_bowls

Problem 7: Balls on a String

Put a string through a ball with a hole in it such that the ball can move freely along the string. Attach another ball to one end of the string. When you move the free end periodically, you can observe complex movements of the two balls. Investigate the phenomenon.

- Astrojax Trick Tutorial: Vertical Orbit, (YouTube, Jim Marielli, Dec 5, 2013), <https://youtu.be/VmGJiiHqn6E>
- Astrojax Orbital Ball Toy from ThinkGeek, (YouTube, ThinkGeek, Oct 8 2013), <https://youtu.be/ofywdGdsNV8>
- How to Make an Amazing Physics Toy With 3 Balls & a String.
<https://www.instructables.com/id/How-To-Make-An-Amazing-Physics-Toy-With-3-Balls-A-/>
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Problem 8: Soap Membrane Filter

A heavy particle may fall through a horizontal soap film without rupturing it. However, a light particle may not penetrate the film and may remain on its surface. Investigate the properties of such a membrane filter.

- Self Healing Soap Films, (YouTube, byusplashlab, Oct 16, 2012), <https://youtu.be/5ThEyeh6z7g>
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- Self-healing reverse filter opens the door for many novel applications by Pennsylvania State University. <https://phys.org/news/2018-08-self-healing-reverse-filter-door-applications.html>
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- Surface Tension and Adhesion by Khan Academy <https://www.khanacademy.org/science/physics/fluids/fluid-dynamics/v/surface-tension-and-adhesion>
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Problem 9: Magnetic Levitation

Under certain circumstances, the ‘flea’ of a magnetic stirrer can rise up and levitate stably in a viscous fluid during stirring. Investigate the origins of the dynamic stabilization of the ‘flea’ and how it depends on the relevant parameters.

- The Flight of the Humble Flea: Levitation and Inefficient Mixing in Magnetic Stirrers, (YouTube, APS Physics, Jan 29, 2019), <https://youtu.be/3ZJQaQazFqw>
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Problem 10: Conducting Lines

A line drawn with a pencil on paper can be electrically conducting. Investigate the characteristics of the conducting line.

- Paper Circuit!, (YouTube, Household Hacker, Sep 21, 2011), <https://youtu.be/BwKQ9Idq9FM>
- How To Make Electricity Conducting Paint at Home Using Pencil | DIY Graphite Paint, (YouTube, jeevan jee, Jun 26, 2019), <https://youtu.be/3u8y8zLKDdU>
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Problem 11: Drifting Speckles

Shine a laser beam onto a dark surface. A granular pattern can be seen inside the spot. When the pattern is observed by a camera or the eye, that is moving slowly, the pattern seems to drift relative to the surface. Explain the phenomenon and investigate how the drift depends on relevant parameters

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<https://iopscience.iop.org/article/10.1088/0031-9120/31/3/012/pdf>

Problem 12: Polygon Vortex

A stationary cylindrical vessel containing a rotating plate near the bottom surface is partially filled with liquid. Under certain conditions, the shape of the liquid surface

becomes polygon-like. Explain this phenomenon and investigate the dependence on the relevant parameters

- Nitrogen swirl: creating rotating polygons in a boiling liquid, (YouTube, APS Physics, Jan 28, 2019), https://youtu.be/b6L0vKP1_m4
- Top view, (YouTube, Kåre Hartvig Jensen, Dec 15, 2012), <https://youtu.be/d3TMO0Um9-4>
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Problem 13: Friction Oscillator

A massive object is placed onto two identical parallel horizontal cylinders. The two cylinders each rotate with the same angular velocity, but in opposite directions. Investigate how the motion of the object on the cylinders depends on the relevant parameters.

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- The Friction Oscillator, (YouTube, wolframmathematica, Dec 2, 2013), <https://youtu.be/TSVcGDSNz9I>
- The Friction Oscillator by Enrique Zeleny: <http://demonstrations.wolfram.com/TheFrictionOscillator/>
- SHM Oscillator (simulations in java) by Chiu-king Ng <https://ngsir.netfirms.com/englishhtm/Oscillator.htm>
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Problem 14 Falling Tower

Identical discs are stacked one on top of another to form a freestanding tower. The bottom disc can be removed by applying a sudden horizontal force such that the rest of the tower will drop down onto the surface and the tower remains standing. Investigate the phenomenon and determine the conditions that allow the tower to remain standing.

- Tablecloth Trick – Cool Science Experiment, (YouTube, SpanglerScienceTV, Dec 16, 2011), <https://youtu.be/PcGIUZZWoVc>
- Tablecloth Tricks! (Dear Ryan), (YouTube, nigahiga, Mar 29, 2019), https://youtu.be/_02ZvOmsYL8 (Check out 05:42, although the rest of the video is very amusing)
- Inertia Checkers Project, (YouTube, XxemoXxAnimeXx) https://youtu.be/s6O6m3A_ViM
- How far can you overhang blocks? By Data Genetics <http://datagenetics.com/blog/may32013/index.html>
- Solution: 'Hanging Far Out Over the Edge' by Quanta Magazine <https://www.quantamagazine.org/the-overhang-puzzle-solution-20161202/>
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Problem 15: Pepper Pot

If you take a salt or pepper pot and just shake it, the contents will pour out relatively slowly. However, if an object is rubbed along the bottom of the pot, then the rate of pouring can increase dramatically. Explain this phenomenon and investigate how the rate depends on the relevant parameters.

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Problem 16: Nitinol Engine

Place a nitinol wire loop around two pulleys with their axes located at some distance from each other. If one of the pulleys is immersed into hot water, the wire tends to straighten, causing a rotation of the pulleys. Investigate the properties of such an engine.

- Cheap Nitinol Engine, (YouTube, Latheman's crazy machines, Apr 8, 2016), <https://youtu.be/g56ZmScZG1s>
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<https://aip.scitation.org/doi/abs/10.1063/1.325013?journalCode=jap>

Problem 17: Playing Card

A standard playing card can travel a very long distance provided that spin is imparted as it is thrown. Investigate the parameters that affect the distance and the trajectory.

- Card Throwing Tutorial | Rick Smith Jr., (YouTube, Rick Smith, Jr., Jul 24, 2017), <https://youtu.be/BIMicGTLQNU>
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- Aerodynamics: Mathematically Modeling the Flight of an Object. <https://www.physicsforums.com/threads/aerodynamics-mathematically-modeling-the-flight-of-an-object.182550/>
- CARD THROWING MACHINES by Jonathan Santos <http://jonathansantos.com/card-throwing-machines>
- Card throwing machine [Lego] <http://forums.stickpage.com/showthread.php?5858-Card-throwing-machine-Lego>
- The Aerodynamics and Stability of Flying Discs by Anthony Scodary <http://large.stanford.edu/courses/2007/ph210/scodary1/>
- Y. Yamakawa, K. Kuno and M. Ishikawa, "Throwing and shooting manipulations of playing cards using a high-speed multifingered hand and a vision system," 2014 IEEE-RAS International Conference on Humanoid Robots, Madrid, 2014, pp. 92-98. doi: 10.1109/HUMANOIDS.2014.7041343. <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7041343&isnumber=7041308>
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