Korisne stranice i programi

- Repozitoriji knjiga i multimedija materijala koji su u javnom vlasništvu (i mogućnost besplatne posudbe nekih koji nisu):
  archive.org openlibrary.org
- Preprint verzije dobrog dijela članaka iz fizike: https://arxiv.org/
- Kuharice za diferencijalne jednadžbe: kuharica 1, kuharica 2
- Obrada podataka: uvod, ozbiljniji uvod, naprednije: pogotovo slajdovi 47-52
- MIT-ova predavanja: http://ocw.mit.edu/index.htm
- Online grafički kalkulator: wolframalpha.com
- Online simbolički kalkulator (za integrale i slično): Symbolab
- „Wikipedia” za fiziku: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
- Obrada i analiza videa i slika: Tracker, ImageJ, VirtualDub
- Obrada i analiza zvučnih signala: Audacity
- Plotanje grafova: QtiPlot, Kst-visualize your data, Excel (nije dobar za nelinearne fitove, dobar za računanje), za hrabre: Matplotlib za python
- Crtanje matematičkih dijagrama: Geogebra

First Draft of IYPT Reference Kit 2019

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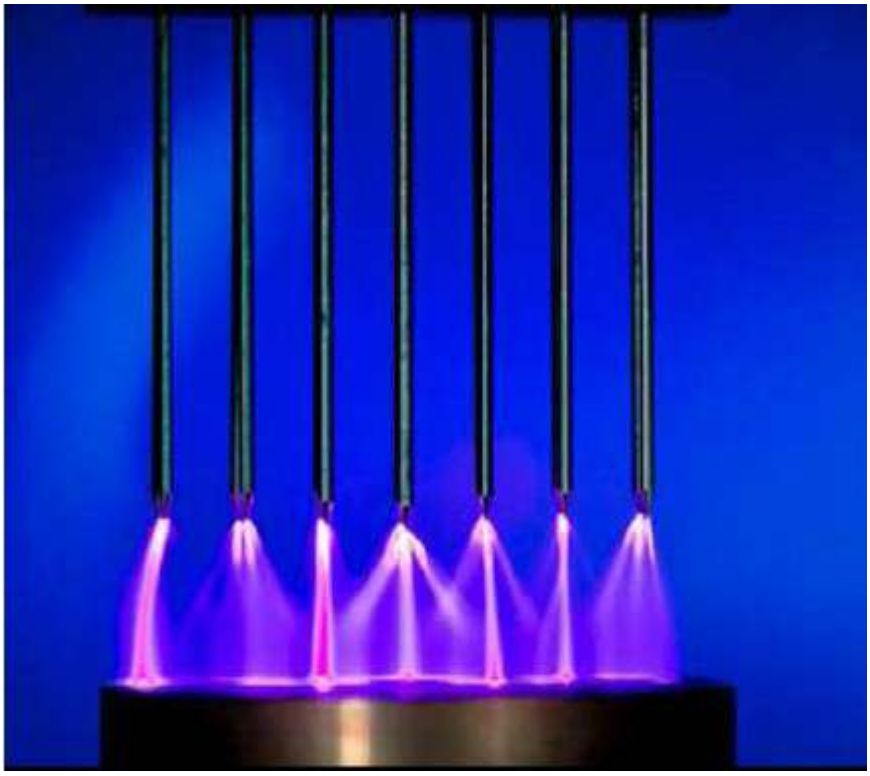
This reference kit is based on my internet searches and knowledge. Here, all the figures are from Google website. Although, it is not a comprehensive and exact solutions for the problems, but it can be considered as a background reading and an initial point for student researches. Please feel free to contact me if you have any comment or question.



1. Invent Yourself

Build a simple motor whose propulsion is based on corona discharge. Investigate how the rotor's motion depends on relevant parameters and optimize your design for maximum speed at a fixed input voltage.

- **https://en.wikipedia.org/wiki/Corona_discharge**
- **https://en.wikipedia.org/wiki/Electrostatic_motor**
- Hattori, M., K. Asano, and Y. Higashiyama. "The fundamental characteristics of a cylindrical corona motor with multi-blade electrodes." *Journal of electrostatics* 27.3 (1992): 223-235.
- Bologa, M. K., et al. "A corona-discharge dipole engine." *Surface Engineering and Applied Electrochemistry* 51.4 (2015): 401-405. **https://link.springer.com/article/10.3103/S106837551504002X**
- **http://www.aun.edu.eg/journal_files/144_J_740.pdf**
- **https://www.researchgate.net/publication/305084128_Analysis_of_Electrostatic_Motors_as_Influenced_by_Corona_Discharge_on_Stator_Periphery**
- **http://www.trupower.net/images/SPECS/CoronaRotatElecMach.pdf**
- Van Wyk, J. D. N., and G. J. Kühn. "A Novel Electrostatic Machine: the Corona Motor." *Nature* 192.4803 (1961): 649.
- **https://www.youtube.com/watch?v=9uEjXsX1F14**
- **https://www.youtube.com/watch?v=9THGyOzMXjo**
- **https://www.youtube.com/watch?v=WkmH2ECctzw**
- **https://www.youtube.com/watch?v=4zKrphJmHnQ**
- **https://www.youtube.com/watch?v=fEQYa7tCujg**
- **https://www.youtube.com/watch?v=Hfj50Jixt0A**
- **https://www.youtube.com/watch?v=RsvnfzmVVr4**
- **https://www.youtube.com/watch?v=f8JguqFxpZ4**

2. Aerosol

When water flows through a small aperture, an aerosol may be formed. Investigate the parameters that determine whether an aerosol is formed rather than a jet for example. What are the properties of the aerosol?

- **https://en.wikipedia.org/wiki/Aerosol**
- **https://en.wikipedia.org/wiki/Spray_nozzle**
- **http://elte.prompt.hu/sites/default/files/tananyagok/AtmosphericChemistry/ch09s02.html**
- **https://en.wikipedia.org/wiki/Deposition_(aerosol_physics)**
- Lin, S. P., and R. D. Reitz. "Drop and spray formation from a liquid jet." Annual Review of Fluid Mechanics 30.1 (1998): 85-105. **https://www.researchgate.net/profile/Rolf_Reitz/publication/234151141_Drop_and_spray_formation_from_a_liquid_jet/links/55d5e71608aeb38e8a821213.pdf**
- Guha, Anirban, Ronald M. Barron, and Ram Balachandar. "An experimental and numerical study of water jet cleaning process." Journal of Materials Processing Technology 211.4 (2011): 610-618. **https://arxiv.org/pdf/1009.0531**
- Mahoney, Lenna A., et al. *Small-Scale Spray Releases: Initial Aerosol Test Results*. No. PNNL-21367 Rev. 1. Pacific Northwest National Lab.(PNNL), Richland, WA (United States), 2013. **https://www.osti.gov/servlets/purl/1133999**
- **https://webspace.clarkson.edu/projects/crcd/public_html/me437/downloads/P_Aerosol_Meas_Suresh.pdf**
- Colbeck, Ian. Physical and chemical properties of aerosols. Blackie Academic and Professional, 1998.
- **https://www.youtube.com/watch?v=fRqqNa5vyPk**

3. Undertone Sound

Allow a tuning fork or another simple oscillator to vibrate against a sheet of paper with a weak contact between them. The frequency of the resulting sound can have a lower frequency than the tuning fork's fundamental frequency. Investigate this phenomenon.

- **https://en.wikipedia.org/wiki/Fundamental_frequency**
- **https://en.wikipedia.org/wiki/Tuning_fork**
- Knapman, Herbert. "An Experiment Illustrating Harmonic Undertones." *Proceedings of the Royal Society of London* 74 (1904): 118-120. **https://www.jstor.org/stable/116664?seq=1#page_scan_tab_contents**
- Irvine, Tom. "THE NATURAL FREQUENCY OF A RECTANGULAR PLATE WITH FIXED-FREE-FIXED-FREE BOUNDARY CONDITIONS." (2011). **http://www.academia.edu/download/44502212/fixed_free_fixed_free_plate.pdf**
- Rossing, Thomas D., Daniel A. Russell, and David E. Brown. "On the acoustics of tuning forks." *American journal of physics*60.7 (1992): 620-626. **https://www.researchgate.net/profile/Daniel_Russell/publication/259017541_On_the_acoustics_of_tuning_forks/links/5435277e0cf2dc341daf936a/On-the-acoustics-of-tuning-forks.pdf**
- **http://moodle.wmchs.net/mod/resource/view.php?id=5392**
- **http://www.answers.com/Q/What_happens_when_you_tuning_fork_touches_paper**
- **https://www.quora.com/What-occurs-when-paper-is-touched-with-a-tuning-fork**

4. Funnel and Ball

A light ball (e.g. ping-pong ball) can be picked up with a funnel by blowing air through it. Explain the phenomenon and investigate the relevant parameters.

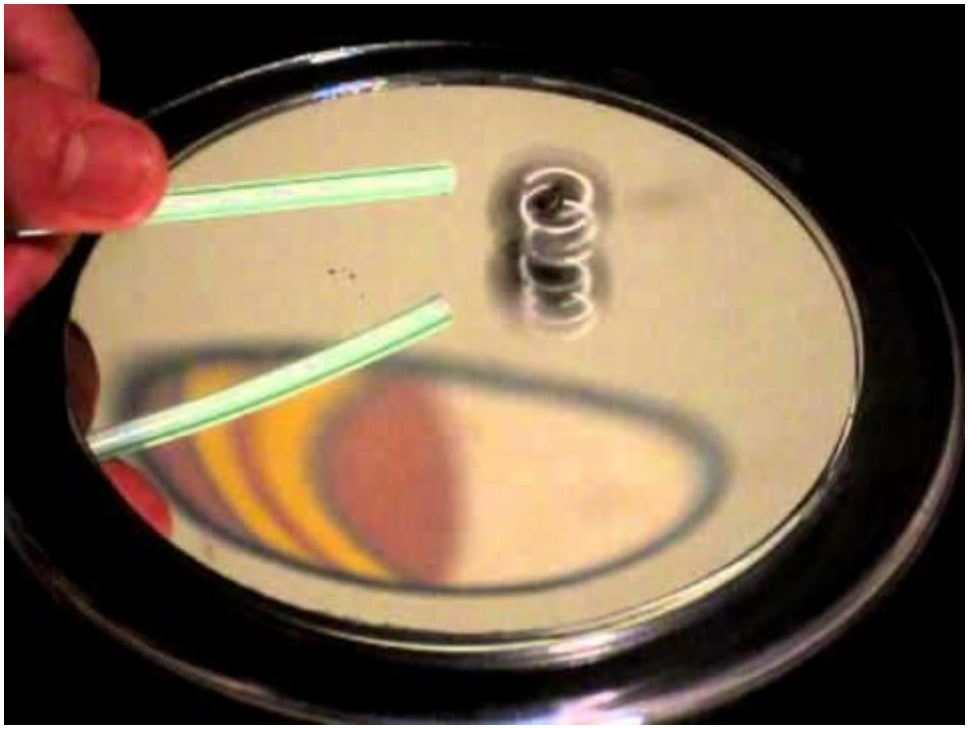
- https://en.wikipedia.org/wiki/Bernoulli%27s_principle
- https://en.wikipedia.org/wiki/Coand%C4%83_effect
- http://www.abc.net.au/science/surfingscientist/pdf/teachdemo_6.pdf
- http://www.csun.edu/scied/4-discrpeant-event/discrep_events/index.htm
- https://teachingfluids.wordpress.com/2013/12/04/levitating-a-ping-pong-ball-in-a-funnel/
- https://airport.unimelb.edu.au/science/physlog/vote.php?entry=2
- http://practicalphysics.org/bernoulli-effect-demonstration.html
- http://spmphysics.onlinetuition.com.my/2013/06/experiments-related-to-bernoullis.html
- https://www.123homeschool4me.com/2016/02/anti-gravity-ping-pong-ball-science_9.html
- http://www.thecrazyscientist.com/looney-lab/experiments-2/amazing-air/superhuman-breath-2/
- http://physicscentral.com/experiment/physicsquest/upload/Turbulent-Times-Extension-Activities.pdf
- http://www.academia.edu/download/36868099/Bernoulli_s_Principle_Disputation_2015g_doc.pdf
- https://www.youtube.com/watch?v=nsnMt8erxH8
- https://www.youtube.com/watch?v=1TQL1ju3RoQ
- https://www.youtube.com/watch?v=K8Oxbb82sMQ
- https://www.youtube.com/watch?v=wuAUJPUupfE
- https://www.youtube.com/watch?v=n7U0H05Kduw

5. Filling Up a Bottle

When a vertical water jet enters a bottle, sound may be produced, and, as the bottle is filled up, the properties of the sound may change. Investigate how relevant parameters of the system such as speed and dimensions of the jet, size and shape of the bottle or water temperature affect the sound.

- **https://en.wikipedia.org/wiki/Acoustic_resonance**
- **https://en.wikipedia.org/wiki/Splash_(fluid_mechanics)**
- Franz, G. J. "Splashes as sources of sound in liquids." *The Journal of the Acoustical Society of America* 31.8 (1959): 1080-1096. **https://asa.scitation.org/doi/10.1121/1.1907831**
- Zheng, Changxi, and Doug L. James. "Harmonic fluids." *ACM Transactions on Graphics (TOG)*. Vol. 28. No. 3. ACM, 2009. **http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.163.5589&rep=rep1&type=pdf**
- Cabe, Patrick A., and John B. Pittenger. "Human sensitivity to acoustic information from vessel filling." *Journal of experimental psychology: human perception and performance*26.1 (2000): 313. **http://www.academia.edu/download/44657745/Cabe___Pittenger_2000_JEPHPP_26_313-324.pdf**
- Frizell, Kenneth Warren, and Roger EA Arndt. "Noise Generation of Air Bubbles in Water: An Experimental Study of Creation and Splitting." (1987). **https://conservancy.umn.edu/bitstream/handle/11299/114029/1/pr269.pdf**
- Velasco, Carlos, et al. "The sound of temperature: What information do pouring sounds convey concerning the temperature of a beverage." *Journal of Sensory Studies* 28.5 (2013): 335-345. **https://onlinelibrary.wiley.com/doi/abs/10.1111/joss.12052**
- Doel, Kees van den. "Physically based models for liquid sounds." *ACM Transactions on Applied Perception (TAP)* 2.4 (2005): 534-546. **https://smartech.gatech.edu/bitstream/handle/1853/50904/vandenDoel2004.pdf**

- https://www.quora.com/Why-does-the-sound-of-water-change-as-a-bucket-is-filling-from-empty-to-full
- https://www.quora.com/When-we-fill-a-vessel-with-water-why-does-the-sound-of-the-pouring-change-as-the-level-increases
- https://intelligentsoundengineering.wordpress.com/2017/05/20/why-can-you-hear-the-difference-between-hot-and-cold-water/
- https://www.audioblocks.com/stock-audio/filling-glass-bottle-with-water.html
- https://physics.stackexchange.com/questions/357512/why-the-sound-of-filling-water-into-a-bottle-rise-in-its-frequency
- https://www.youtube.com/watch?v=pVbaRYoSBYk
- https://www.youtube.com/watch?v=ayNzH0uygFw
- https://www.youtube.com/watch?v=X08NDXMvdz0
- http://www.cs.cornell.edu/projects/HarmonicFluids/



6. Hurricane Balls

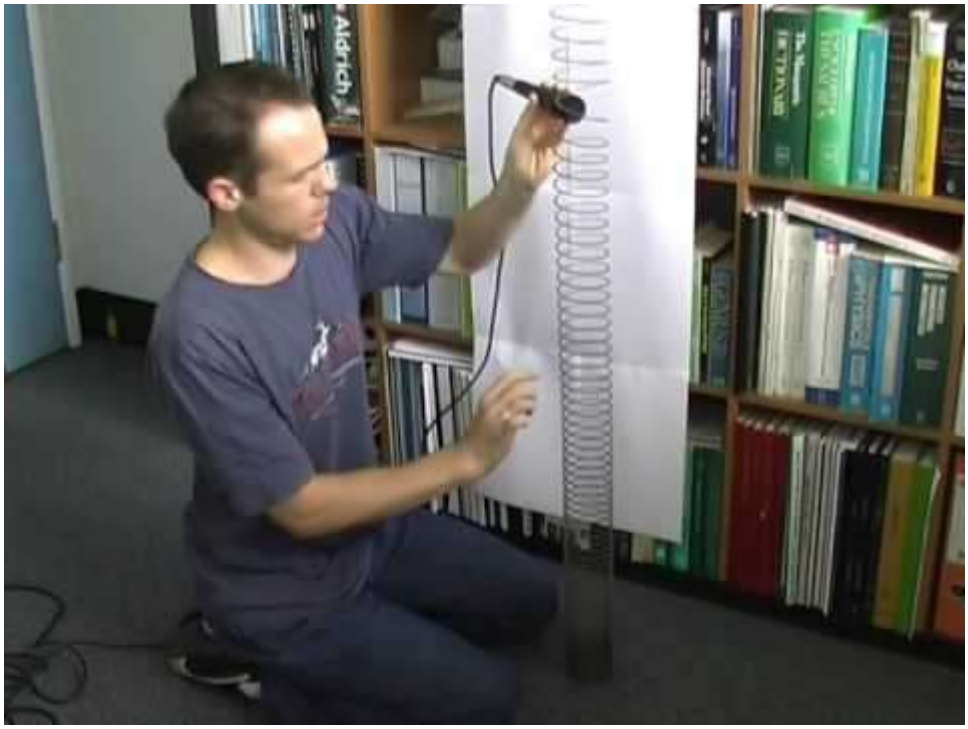
Two steel balls that are joined together can be spun at incredibly high frequency by first spinning them by hand and then blowing on them through a tube, e.g. a drinking straw. Explain and investigate this phenomenon.

- Rolling friction https://en.wikipedia.org/wiki/Rolling_resistance
- https://en.wikipedia.org/wiki/Magnus_effect
- Jackson, David P., David Mertens, and Brett J. Pearson. "Hurricane Balls: A rigid-body-motion project for undergraduates." *American Journal of Physics* 83.11 (2015): 959-968. http://scholar.dickinson.edu/cgi/viewcontent.cgi?article=1443&context=faculty_publications
- Andersen, W. L., and Steven Werner. "The dynamics of hurricane balls." *European Journal of Physics* 36.5 (2015): 055013. https://www.researchgate.net/profile/William_Andersen/publication/279459437_The_dynamics_of_hurricane_balls/links/56b1265f08ae795dd5c4f53b/The-dynamics-of-hurricane-balls.pdf
- Cross, Rod. "The rise and fall of spinning tops." *American Journal of Physics* 81.4 (2013): 280-289. https://www.researchgate.net/profile/Rod_Cross2/publication/258757498_The_rise_and_fall_of_spinning_tops/links/5951a7dba6fdcc218d24c9b4/The-rise-and-fall-of-spinning-tops.pdf
- https://makezine.com/projects/remaking-history-louis-poinsot-and-the-dancing-spheres/
- https://www.youtube.com/watch?v=rFZrwMPNVvk
- https://aapt.scitation.org/doi/full/10.1119/1.4973116
- https://www.youtube.com/watch?v=cvq8laPb498
- https://www.youtube.com/watch?v=0J58SNJWDt4
- https://www.youtube.com/watch?v=CfaZyEmzlhE

7. Loud Voices

A simple cone-shaped or horn-shaped object can be used to optimize the transfer of the human voice to a remote listener. Investigate how the resulting acoustic output depends on relevant parameters such as the shape, size, and material of the cone.

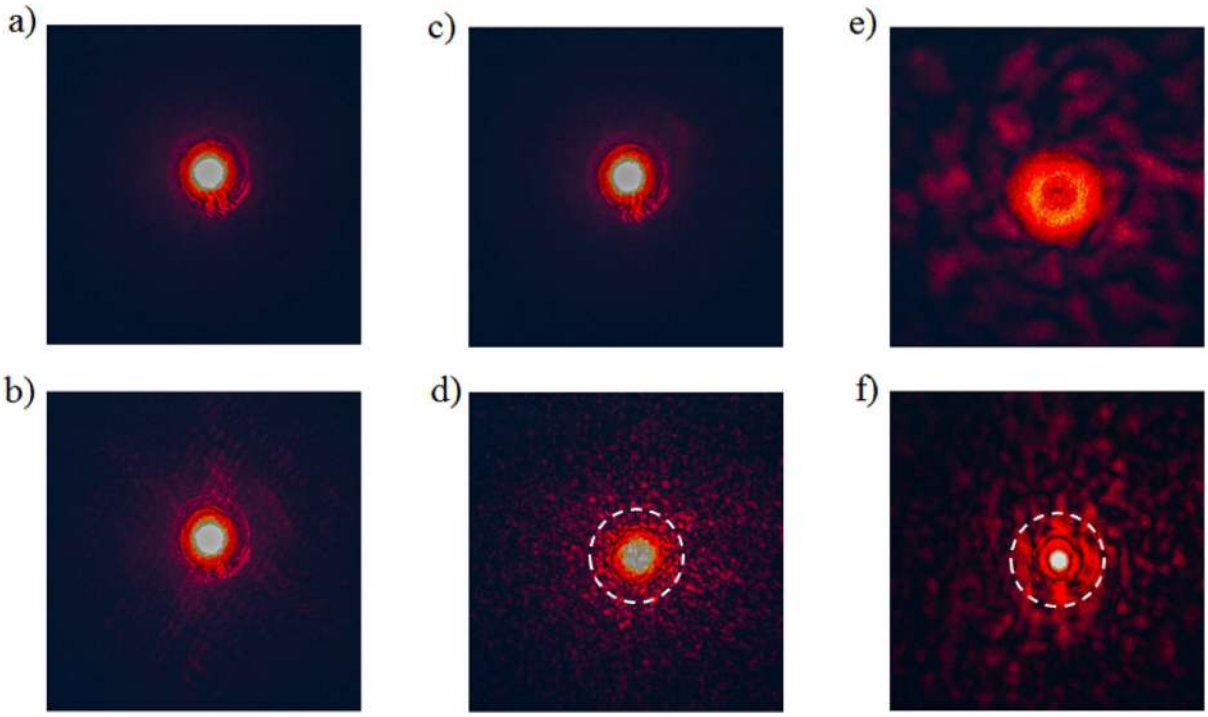
- https://en.wikipedia.org/wiki/Sound
- https://en.wikipedia.org/wiki/Horn_loudspeaker
- https://en.wikipedia.org/wiki/Megaphone
- Kolbrek, Bjørn. "Horn Theory: An Introduction, Part." *Audio Express* 1 (2008): 1-8. https://www.rdacoustic.cz/wp-content/uploads/an-introduction-to-horn-theory.pdf
- Jorge, Rogério. "Nonlinear Acoustics--Perturbation Theory and Webster's Equation." *arXiv preprint arXiv:1311.4238*(2013). https://arxiv.org/pdf/1311.4238
- https://www.radiomuseum.org/forumdata/users/133/PDF/Speaker.pdf
- https://www.quora.com/How-does-a-megaphone-amplify-sound
- http://www.vias.org/crowhurstba/crowhurst_basic_audio_vol1_049.html
- Chaverri, Gloriana, and Erin H. Gillam. "Sound amplification by means of a horn-like roosting structure in Spix's disc-winged bat." *Proceedings of the Royal Society of London B: Biological Sciences* 280.1772 (2013): 20132362. http://rspb.royalsocietypublishing.org/content/280/1772/20132362.short
- https://www.reddit.com/r/explainlikeimfive/comments/las2b/eli5_how_does_a_horn_amplify_sound_without_adding/
- https://www.quora.com/How-does-a-megaphone-amplify-sound
- https://www.youtube.com/watch?v=EfFsDcZxRr4
- https://www.youtube.com/watch?v=TVdrjm1BVP0



8. Sci-Fi Sound

Tapping a helical spring can make a sound like a “laser shot” in a science-fiction movie. Investigate and explain this phenomenon.

- https://en.wikipedia.org/wiki/Slinky
- https://en.wikipedia.org/wiki/Euler%E2%80%93Bernoulli_beam_theory
- Parker, Julian, et al. "Modeling methods for the highly dispersive slinky spring: a novel musical toy." *Proceedings of the 13th International Conference on Digital Audio Effects (DAFx'10)*. 2010. http://dafx10.iem.at/papers/ParkerPenttinenBilbaoAbel_DAFx10_P80.pdf
- Lee, J., and D. J. Thompson. "Dynamic stiffness formulation, free vibration and wave motion of helical springs." *Journal of Sound and Vibration* 239.2 (2001): 297-320. https://www.sciencedirect.com/science/article/pii/S0022460X00931699
- Rutherford, Casey. "A Fresh Look at Longitudinal Standing Waves on a Spring." *The Physics Teacher* 51.1 (2013): 22-24. https://www.researchgate.net/profile/Casey_Rutherford/publication/258810726_A_Fresh_Look_at_Longitudinal_Standing_Waves_on_a_Spring/links/5695160e08ae820ff0749c0f.pdf
- https://www.researchgate.net/post/Why_does_tapping_in_air_not_produce_any_sound_but_tapping_against_a_metal_does_produce_sound
- https://www.youtube.com/watch?v=g2Sa0dRmHgA
- https://www.youtube.com/watch?v=CpZkNWBmKNM
- https://www.youtube.com/watch?v=7VGlBZOywIg
- https://www.youtube.com/watch?v=aqtqiuSMJqM
- https://www.youtube.com/watch?v=rajPbk3CJr4
- https://www.youtube.com/watch?v=SVAd6zxjiow
- https://www.youtube.com/watch?v=XACHZbgcH5M



9. Soy Sauce Optics

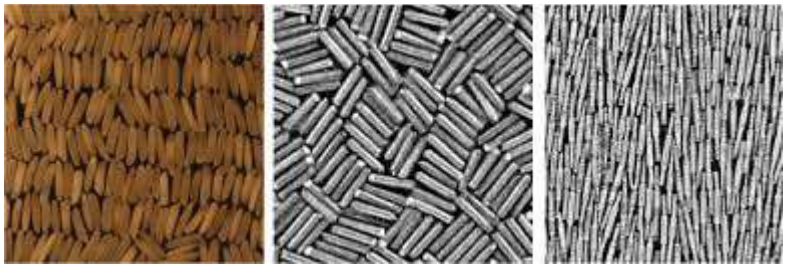
Using a laser beam passing through a thin layer (about 200 μm) of soy sauce the thermal lens effect can be observed. Investigate this phenomenon.

- https://en.wikipedia.org/wiki/Nonlinear_optics
- Turchiello, Rozane de F., Luiz AA Pereira, and Sergio L. Gómez. "Low-cost nonlinear optics experiment for undergraduate instructional laboratory and lecture demonstration." *American Journal of Physics* 85.7 (2017): 522-528. https://aapt.scitation.org/doi/abs/10.1119/1.4984808?journalCode=ajp
- Sheldon, S. J., L. V. Knight, and J. M. Thorne. "Laser-induced thermal lens effect: a new theoretical model." *Applied optics*21.9 (1982): 1663-1669. https://pdfs.semanticscholar.org/ac26/ad507bc2432a136433a53e734bf872e74f42.pdf
- http://photonics.cusat.edu/Research_Thermal%20lens.html
- Sivasubramanian, Dhanuskodi, Rajeswari Ponnusamy, and Vinitha Gandhiraj. "Low power optical limiting and thermal lensing in Mn doped ZnO nanoparticles." *Materials Chemistry and Physics* 159 (2015): 93-100. https://www.sciencedirect.com/science/article/pii/S0254058415002266
- Snook, Richard D., and Roger D. Lowe. "Thermal lens spectrometry. A review." *Analyst* 120.8 (1995): 2051-2068. http://pubs.rsc.org/en/content/articlelanding/1995/an/an9952002051#!divAbstract
- https://www.rp-photonics.com/thermal_lensing.html
- https://www.schott.com/d/advanced_optics/3794eded-edd2-461d-aec5-0a1d2dc9c523/1.0/schott_tie-19_temperature_coefficient_of_refractive_index_eng.pdf

10. Suspended Water Wheel

Carefully place a light object, such as a Styrofoam disk, near the edge of a water jet aiming upwards. Under certain conditions, the object will start to spin while being suspended. Investigate this phenomenon and its stability to external perturbations.

- https://en.wikipedia.org/wiki/Bernoulli%27s_principle
- https://en.wikipedia.org/wiki/Magnus_effect
- https://en.wikipedia.org/wiki/Coand%C4%83_effect
- https://www.researchgate.net/post/Can_you_explain_Veritasiums_Hydrodynamic_levitation_or_Fluid_Juggling
- https://physics.stackexchange.com/questions/356284/any-solutions-to-veritasiums-hydrodynamic-levitation
- https://sploid.gizmodo.com/what-sorcery-keeps-this-giant-ball-floating-on-a-tiny-s-1796416838
- http://forums.xkcd.com/viewtopic.php?t=123045
- https://gizmodo.com/the-physics-of-how-a-water-jet-can-keep-a-ball-floating-1445828275
- https://www.youtube.com/watch?v=mNHp8iyyIjo
- https://www.youtube.com/watch?v=WZrQy7zKM4Y
- https://www.youtube.com/watch?v=p9_aUQDGDbU&hd=1
- https://www.youtube.com/watch?v=_jYoQu3PvIk
- https://www.youtube.com/watch?v=ST6hDiUBSJQ
- https://www.youtube.com/watch?v=gXfSUqiWQZ4
- https://www.youtube.com/watch?v=7lGm3MrjDX0
- https://www.youtube.com/watch?v=WZ1nvvMfdYc
- https://www.youtube.com/watch?v=lHjFx2lp_kw



11. Flat Self-Assembly

Put a number of identical hard regular-shaped particles in a flat layer on top of a vibrating plate. Depending on the number of particles per unit area, they may or may not form an ordered crystal-like structure. Investigate the phenomenon.

- Galanis, Jennifer, et al. "Spontaneous patterning of confined granular rods." *Physical review letters* 96.2 (2006): 028002. https://arxiv.org/pdf/cond-mat/0508202
- Narayan, Vijay, Narayanan Menon, and Sriram Ramaswamy. "Nonequilibrium steady states in a vibrated-rod monolayer: tetratic, nematic, and smectic correlations." *Journal of Statistical Mechanics: Theory and Experiment* 2006.01 (2006): P01005. https://arxiv.org/pdf/cond-mat/0510082
- Windows-Yule, C. R. K. "Do granular systems obey statistical mechanics? A review of recent work assessing the applicability of equilibrium theory to vibrationally excited granular media." *International Journal of Modern Physics B*31.10 (2017): 1742010.
- Daniels, L. J., et al. "Dynamics of gas-fluidized granular rods." *Physical Review E* 79.4 (2009): 041301. https://arxiv.org/pdf/0811.2751
- Olafsen, J. S., and J. S. Urbach. "Clustering, order, and collapse in a driven granular monolayer." *Physical review letters* 81.20 (1998): 4369. https://arxiv.org/pdf/cond-mat/9807148
- Pouliquen, Olivier, Maxime Nicolas, and P. D. Weidman. "Crystallization of non-Brownian spheres under horizontal shaking." *Physical Review Letters* 79.19 (1997): 3640. https://hal.archives-ouvertes.fr/hal-01440072/document
- Dai, Weijing, et al. "Modes of wall induced granular crystallisation in vibrational packing." *arXiv preprint arXiv:1805.07865* (2018). https://arxiv.org/pdf/1805.07865
- Trittel, Torsten, Kirsten Harth, and Ralf Stannarius. "Mechanical excitation of rodlike particles by a vibrating plate." *Physical Review E* 95.6 (2017): 062904.
- Reis, Pedro M., Rohit A. Ingale, and Mark D. Shattuck. "Crystallization of a quasi-two-dimensional granular fluid." *Physical review letters* 96.25 (2006): 258001. https://arxiv.org/pdf/cond-mat/0603408
- Ramaioli, Marco, Lionel Pournin, and Th M. Liebling. "Vertical ordering of rods under vertical vibration." *Physical Review E*76.2 (2007): 021304. https://www.researchgate.net/profile/Marco_Ramaioli/publication/5915242_Vertical_ordering_of_rods_under_vertical_vibration/links/54ed0a660cf28f3e65353561.pdf
- Saadatmand, Sayed Mehrrad. *A Study on Vibration-induced Particle Motion under Microgravity*. Diss. 2012. https://tspace.library.utoronto.ca/bitstream/1807/32879/1/Saadatmand_Mehrrad_201206_PhD_thesis.pdf

12. Gyroscope Teslameter

A spinning gyroscope made from a conducting, but nonferromagnetic material slows down when placed in a magnetic field. Investigate how the deceleration depends on relevant parameters.

- **https://en.wikipedia.org/wiki/Eddy_current**
- **https://en.wikipedia.org/wiki/Eddy_current_brake**
- **https://en.wikipedia.org/wiki/Angular_momentum#Conservation_of_angular_momentum**
- **https://www.youtube.com/watch?v=1ZeCIejT2NY**
- **https://www.youtube.com/watch?v=whoylwf-i0A**
- **https://www.youtube.com/watch?v=SK0EdikjC24**

13. Moiré Thread Counter

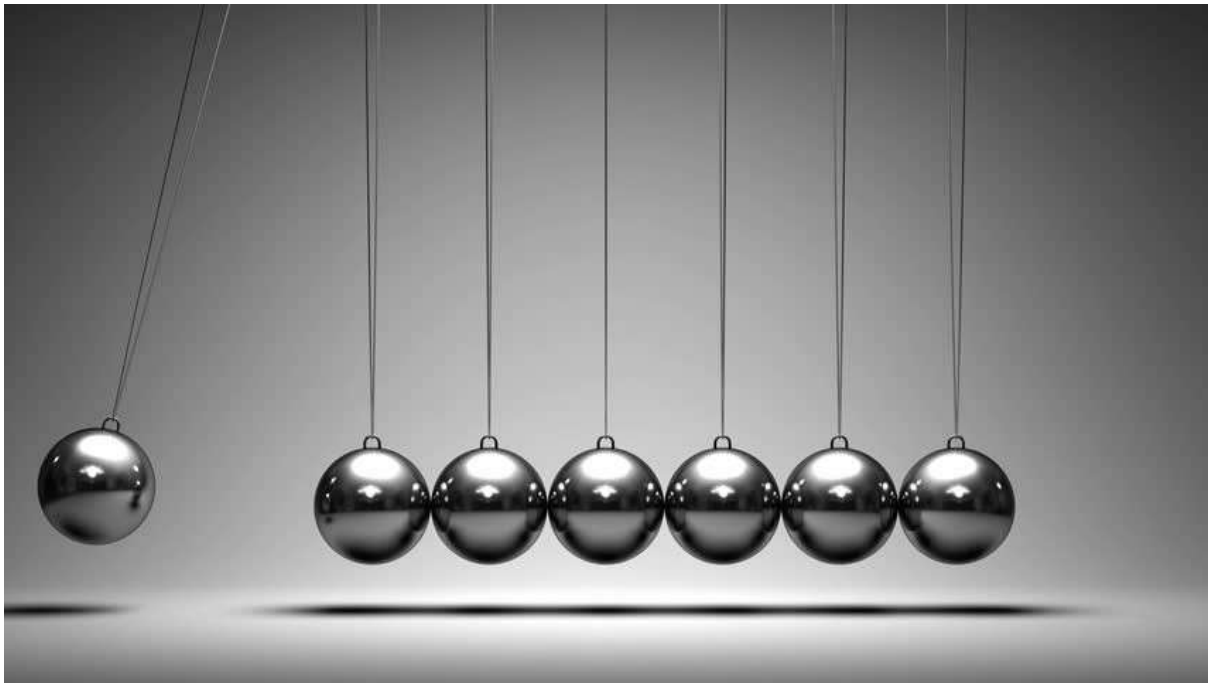
When a pattern of closely spaced non-intersecting lines (with transparent gaps in between) is overlaid on a piece of woven fabric, characteristic moiré fringes may be observed. Design an overlay that allows you to measure the thread count of the fabric. Determine the accuracy for simple fabrics (e.g. linen) and investigate if the method is reliable for more complex fabrics (e.g. denim or Oxford cloth).

- **https://en.wikipedia.org/wiki/Moir%C3%A9_pattern**
- Reich, Gary. "A moiré pattern-based thread counter." *The Physics Teacher* 55.7 (2017): 426-430. **https://aapt.scitation.org/doi/10.1119/1.5003746**
- **https://www.indiamart.com/arhamscientific/textile-testing-instruments.html**
- **http://www.lunometer.com/what.html**
- **http://www.lunometer.de/tech-e.htm**

14. Looping Pendulum

Connect two loads, one heavy and one light, with a string over a horizontal rod and lift up the heavy load by pulling down the light one. Release the light load and it will sweep around the rod, keeping the heavy load from falling to the ground. Investigate this phenomenon.

- https://en.wikipedia.org/wiki/Pendulum
- https://en.wikipedia.org/wiki/Pendulum_(mathematics)
- https://en.wikipedia.org/wiki/Centripetal_force
- https://sciencedemonstrations.fas.harvard.edu/presentations/rope-friction-around-pole
- https://en.wikipedia.org/wiki/Capstan_equation
- https://www.stevespanglerscience.com/lab/experiments/magic-pendulum/
- https://www.istitutotrento5.it/images/test/bre_15_16_looping_pendulum_2_bil.pdf
- https://www.youtube.com/watch?v=SXQ9VaYm3yQ
- https://www.youtube.com/watch?v=ZyhHidThQR8
- https://www.youtube.com/watch?v=XSFXzL4vCPg



15. Newton’s Cradle

The oscillations of a Newton's cradle will gradually decay until the spheres come to rest. Investigate how the rate of decay of a Newton's cradle depends on relevant parameters such as the number, material, and alignment of the spheres.

- https://en.wikipedia.org/wiki/Newton%27s_cradle
- https://en.wikipedia.org/wiki/Inelastic_collision
- Hutzler, Stefan, et al. "Rocking Newton’s cradle." *American Journal of Physics* 72.12 (2004): 1508-1516. https://openresearch-repository.anu.edu.au/bitstream/1885/95080/1/01_Hutzler_Rocking_Newton%E2%80%99s_cradle_2004.pdf
- Donahue, Carly M., et al. "Newton’s cradle undone: experiments and collision models for the normal collision of three solid spheres." *Physics of Fluids* 20.11 (2008): 113301. https://aip.scitation.org/doi/abs/10.1063/1.3020444
- http://scienceblogs.com/principles/2015/11/05/energy-dissipation-in-a-physics-toy/
- http://ffden-2.phys.uaf.edu/212_spring2011.web.dir/Joel_Teune/analysis.html
- James, Guillaume. "Nonlinear waves in Newton's cradle and the discrete p-Schrödinger equation." *Mathematical Models and Methods in Applied Sciences* 21.11 (2011): 2335-2377. https://arxiv.org/pdf/1008.1153

16. Sinking Bubbles

When a container of liquid (e.g. water) oscillates vertically, it is possible that bubbles in the liquid move downwards instead of rising. Investigate this phenomenon.

- https://en.wikipedia.org/wiki/Buoyancy
- https://en.wikipedia.org/wiki/Drag_(physics)
- https://en.wikipedia.org/wiki/Added_mass
- Sorokin, V. S., I. I. Blekhman, and V. B. Vasilkov. "Motion of a gas bubble in fluid under vibration." *Nonlinear Dynamics* 67.1 (2012): 147-158. https://www.researchgate.net/profile/Vladislav_Sorokin2/publication/241045399_Motion_of_a_gas_bubble_in_fluid_under_vibration/links/5625ec4408aeabddac91d707/Motion-of-a-gas-bubble-in-fluid-under-vibration.pdf
- Zoueshtiagh, Farzam, et al. "Air bubbles under vertical vibrations." *The European Physical Journal E* 20.3 (2006): 317-325. https://www.researchgate.net/profile/Philippe_Petitjeans/publication/6912899_Air_bubbles_under_vertical_vibrations/links/58bfd844aca272bd2a3c1e3a/Air-bubbles-under-vertical-vibrations.pdf
- http://math.arizona.edu/~gabitov/teaching/131/math_485_585/Midterm_Reports/Sinking_Bubbles.pdf
- http://math.arizona.edu/~gabitov/teaching/141/math_485/Final_Report/Bubble_Dynamics_Final_Report.pdf

17. Popsicle Chain Reaction

Wooden popsicle sticks can be joined together by slightly bending each of them so that they interlock in a so-called “cobra weave” chain. When such a chain has one of its ends released, the sticks rapidly dislodge, and a wave front travels along the chain. Investigate the phenomenon.

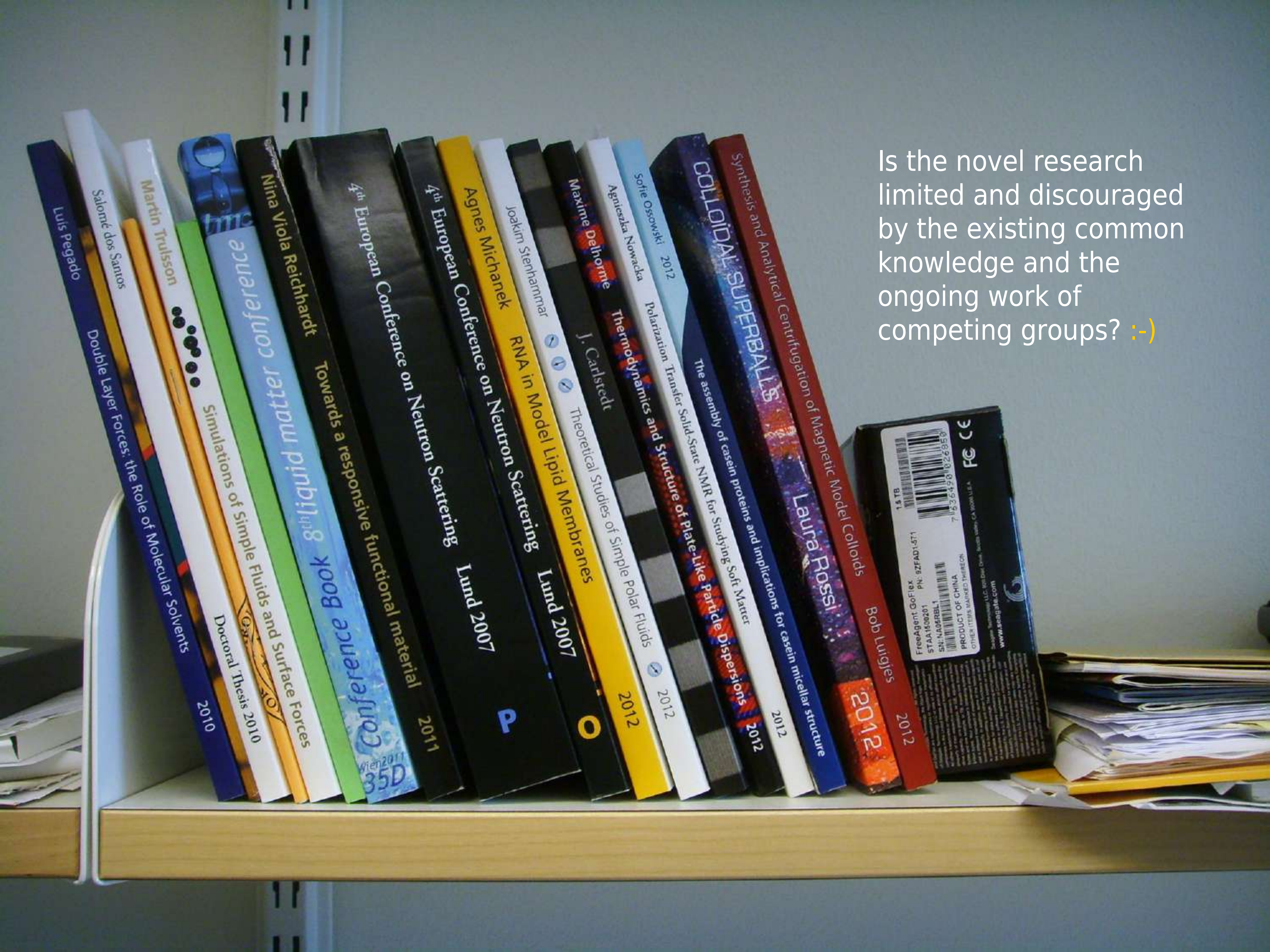
- https://en.wikipedia.org/wiki/Linear_elasticity
- https://en.wikipedia.org/wiki/Euler%E2%80%93Bernoulli_beam_theory
- Sautel, Jérémy, et al. "The physics of a popsicle stick bomb." *American Journal of Physics* 85.10 (2017): 783-790. https://aapt.scitation.org/doi/full/10.1119/1.5000797
- Boucher, Jean-Philippe, et al. "Popsicle-Stick Cobra Wave." *Physical review letters* 119.8 (2017): 084301. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.119.084301
- https://aapt.scitation.org/doi/full/10.1119/1.5000797
- https://www.youtube.com/watch?v=gIwZ9d361A8
- https://www.youtube.com/watch?v=F0jQgGz7GfY
- https://www.instructables.com/id/Cobra-Weave-Exploding-Stick-Bomb/
- http://clubhousebeat.org/wp-content/uploads/2017/08/PopsicleStickReactionGuide.pdf
- https://www.youtube.com/watch?v=T5vYrxC5kmg
- https://www.youtube.com/watch?v=vyFDGczUdQQ
- https://www.youtube.com/watch?v=lX6kkuuMaQw

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!

iypt archive mc^2 hv



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

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
- 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

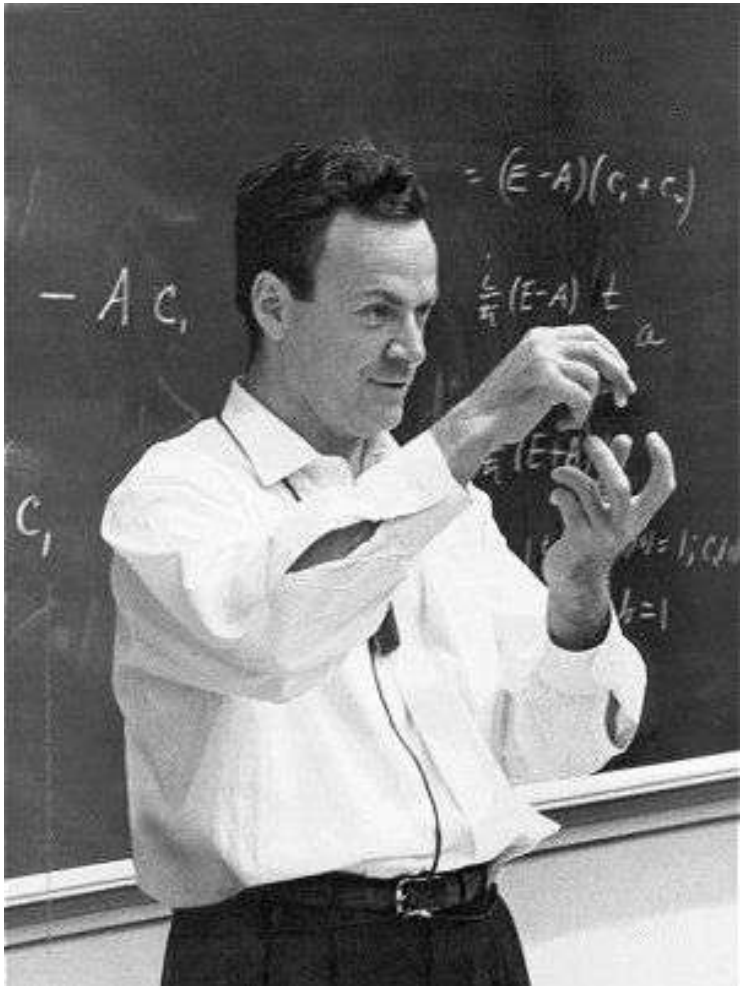
To work towards results?

- 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)