IYPT 2021 Crowdsourced Reference Archive

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Problem 1: Invent Yourself

Design a boat that moves only due to the periodical mechanical movements of its internal parts and which only interacts with the environment (air, water) through its stiff hull. Optimise the parameters of your boat for maximum speed.

I. Phenomenon Demonstration

- IYPT 2021 №1 Invent Yourself by ЭйНШтейн https://youtu.be/4HL0pNsh9NY
- IYPT 2021 №1 Invent Yourself (4 engines) by ЭйНШтейн https://youtu.be/Ef_i5Rkg6Aw
- Пьяные физики на озере без вёсел (Drunken Physicists on a Lake Without Oars)
- https://youtu.be/jlvmQzoossI

II. Books, Encyclopedia, Discussion and Forum Posts

- Basic Physics of Rowing http://eodg.atm.ox.ac.uk/user/dudhia/rowing/physics/basics.html#:~:text=For%20boats%2C%20there%20are%20various,energy%20lost%20in%20creating%20waves.
- How Does A Rudder Help In Turning A Ship? By Soumya Chakraborty https://www.marineinsight.com/naval-architecture/rudder-ship-turning/#:~:text=And%20the%20lift%20generated%20
- HYDROFOILS by Tina Rosado https://web.mit.edu/2.972/www/reports/hydrofoil/hydrofoil.html

III. Research Papers

- Boucher, J.-P., Labbé, R., Clanet, C., & Benzaquen, M. (2018). Thin or bulky: Optimal aspect ratios for ship hulls. Physical Review Fluids, 3(7). https://doi.org/10.1103/physrevfluids.3.074802
- Casas-Yrurzum, Sergio & Rueda, Silvia & Riera, JoseVicente & Fernández, Marcos. (2012). On the Real-time Physics Simulation of a Speed-boat Motion.. 121-128.

Problem 2: Circling Magnets

Button magnets with different diameters are attached to each end of a cylindrical battery. When placed on an aluminium foil the object starts to circle. Investigate how the motion depends on relevant parameters.

I. Phenomenon Demonstration

- SIMPLEST HOMOPOLAR MOTOR Simple magnet car by Magnetic Games https://youtu.be/oPzJr1jjHnQ
- Racing Magnet Car, Homopolar party by Magnetic Games https://youtu.be/eYtMDHZG8AY
- Magnetic Motor Homopolar , Magnet Car V2 by Magnetic Games https://youtu.be/STbaw47InfQ
- Homopolar Motor Insane Discovery | Magnetic Games by Magnetic Games
- https://youtu.be/rOQr4SAdRxk

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Homopolar Motor, https://en.wikipedia.org/wiki/Homopolar_motor

III. Research Papers

- Brauer, H., Ziolkowski, M., Porzig, K., & Toepfer, H. (2011). Modelling and simulation of a simple homopolar motor of Faraday's type. Facta Universitatis – Series: Electronics and Energetics, 24(2), 221–242. https://doi.org/10.2298/fuee1102221b
- Stewart, Seán M.. (2007). Some simple demonstration experiments involving homopolar motors. Revista Brasileira de Ensino de Física, 29(2), 275-281. Retrieved September 10, 2020, from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-11172007000200012&lng=en&tlng=en.
- Eagleton, R. D., & Kaplan, M. N. (1988). The radial magnetic field homopolar motor. American Journal of Physics, 56(9), 858–859. https://doi.org/10.1119/1.15448
- Hide, R., Skeldon, A., & Acheson, D. (1996). A Study of Two Novel Self-Exciting Single-Disk Homopolar Dynamos: Theory. Proceedings: Mathematical, Physical and Engineering Sciences, 452(1949), 1369-1395. Retrieved September 10, 2020, from http://www.jstor.org.myaccess.library.utoronto.ca/stable/52921
- Goldbrum, P., Moroz, I. M., & Hide, R. (2000). On The Biasing Effect Of A Battery On A Self-Exciting Faraday Disk Homopolar Dynamo Loaded With A Linear Series Motor. International Journal of Bifurcation and Chaos, 10(08), 1875–1885. https://doi.org/10.1142/s0218127400001146
- Moroz, I. M. (2002). On The Behavior Of A Self-Exciting Faraday Disk Homopolar Dynamo With A Variable Nonlinear Series Motor. International Journal of Bifurcation and Chaos, 12(10), 2123–2135. https://doi.org/10.1142/s0218127402005728
- T. G. Engel and E. A. Kontras, "Analysis and design of homopolar motors and generators," 2014 17th International Symposium on Electromagnetic Launch Technology, La Jolla, CA, 2014, pp. 1-6, doi: 10.1109/EML.2014.6920662
- Stewart, Seán M.. (2007). Some simple demonstration experiments involving homopolar motors. Revista Brasileira de Ensino de Física, 29(2), 275-281. Retrieved December 22, 2020, from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-11172007000200012&lng=en&tlng=en.

Problem 3: Proximity Sensor

A simple passive inductive sensor can detect ferromagnetic objects moving through its magnetic field. Construct such a passive sensor and investigate its characteristics such as sensing range.

I. Phenomenon Demonstration

II. Books, Encyclopedia, Discussion and Forum Posts

- Proximity Sensors by Omron https://www.ia.omron.com/support/guide/41/introduction.html
- Wikipedia: Inductive Sensor https://en.wikipedia.org/wiki/Inductive_sensor#Inductive_proximity_sensor_(proximity_switch)
- Proximity Sensors Compared: Inductive, Capacitive, Photoelectric, and Ultrasonic by Thomas A. Kinney https://www.machinedesign.com/automation-iiot/sensors/article/21831577/proximity-sensors-compared-inductive-capacitive-photoelectric-and-ultrasonic
- INDUCTIVE PROXIMITY SENSOR FOR DETECTING FERROMAGNETIC NON-PERMEABLE OR MAGNET TARGETS by Woolsey et al. https://patentimages.storage.googleapis.com/5e/be/9b/f8184126904597/US6507189.pdf

III. Research Paper

- Passeraub, P. A., Besse, P.-A., & Popovic, R. S. (1996). Scaling down an inductive proximity sensor. Sensors and Actuators A: Physical, 52(1-3), 114–118. doi:10.1016/0924-4247(96)80135-x
- Kejík, P., Kluser, C., Bischofberger, R., & Popovic, R. S. (2004). A low-cost inductive proximity sensor for industrial applications. Sensors and Actuators A: Physical, 110(1-3), 93–97. doi:10.1016/j.sna.2003.07.007
- Passeraub, P. ., Rey-Mennet, G., Besse, P. ., Lorenz, H., & Popovic, R. . (1997). Inductive proximity sensor with a flat coil and a new differential relaxation oscillator. Sensors and Actuators A: Physical, 60(1-3), 122–126. doi:10.1016/s0924-4247(97)01385-x
- Passeraub, P. A., Besse, P. A., Hediger, S., de Raad, C., & Popovic, R. S. (1998). High-resolution miniaturized inductive proximity sensor: characterization and application for step-motor control. Sensors and Actuators A: Physical, 68(1-3), 257–262. doi:10.1016/s0924-4247(98)00014-4
- Passeraub, P. A., Besse, P.-A., de Raad, C., Dezuari, O., Quinet, F., & Popovic, R. S. (1998). Metallic profile and coin imaging using an inductive proximity sensor microsystem. Sensors and Actuators A: Physical, 66(1-3), 225–230. doi:10.1016/s0924-4247(98)00047-8
- George, B., Zangl, H., Bretterklieber, T., & Brasseur, G. (2010). A Combined Inductive–Capacitive Proximity Sensor for Seat Occupancy Detection. IEEE Transactions on Instrumentation and Measurement, 59(5), 1463–1470. doi:10.1109/tim.2010.2040910
- Mizuno, T., Mizuguchi, T., Isono, Y., Fujii, T., Kishi, Y., Nakaya, K., … Shimizu, A. (2009). Extending the Operating Distance of Inductive Proximity Sensor Using Magnetoplated Wire. IEEE Transactions on Magnetics, 45(10), 4463–4466. doi:10.1109/tmag.2009.2021855
- Passeraub, P. A., Besse, P.-A., de Raad, C., Dezuari, O., Quinet, F., & Popovic, R. S. (n.d.). Coin recognition using an inductive proximity sensor microsystem. Proceedings of International Solid State Sensors and Actuators Conference (Transducers ’97). doi:10.1109/sensor.1997.613666
- Bartoletti, C., Buonanni, R., Fantasia, L. G., Frulla, R., Gaggioli, W., & Sacerdoti, G. (1998). The design of a proximity inductive sensor. Measurement Science and Technology, 9(8), 1180–1190. doi:10.1088/0957-0233/9/8/007

Problem 4: Wind Speed

Let an electric current flow through a coil. When cold air flows over the coil, the coil’s temperature will decrease. Investigate how the temperature drop depends on the wind speed. What is the accuracy of this method of measuring the wind speed?

I. Phenomenon Demonstration

- IYPT2020 Problem 1——电流的热效应（实验有危险、谨慎模仿）by IYPT青年物理豪
  https://www.bilibili.com/video/BV18A411Y7DK?from=search&seid=4192481987912084299

II. Books, Encyclopedia, Discussion and Forum Posts

- The Measurement of Fluctuations of Air Speed by the Hot Wire Anemometer by H. L. Dryden and A. M. Kuethe.
  https://books.google.ca/books?hl=en&lr=&id=e7FQU37LXVAC&oi=fnd&pg=PA357&dq=hot+wire+anemometer&ots=yfi1pIHFAl&sig=tz60cynusRY8ySfUhLf6XSbtYsI&redir_esc=y#v=onepage&q=hot%20wire%20anemometer&f=false
- Understanding Hot-Wire Anemometry
  https://www.mouser.com/catalog/additional/ATS_Qpedia_Dec07_Understanding%20hot%20wire%20amemometry9.pdf
- The hot wire anemometer, Part 1: Principles by BILL SCHWEBER
  https://www.eeworldonline.com/the-hot-wire-anemometer-part-1-principles-faq/
- Hot Wire Anemometer ScienceDirect Topics
  https://www.sciencedirect.com/topics/engineering/hot-wire-anemometer

III. Research Papers

- Andrews, G. ., Bradley, D., & Hundy, G. . (1972). Hot wire anemometer calibration for measurements of small gas velocities. International Journal of Heat and Mass Transfer, 15(10), 1765–1786. doi:10.1016/0017-9310(72)90053-1

- McQuaid, J., & Wright, W. (1973). The response of a hot-wire anemometer in flows of gas mixtures. International Journal of Heat and Mass Transfer, 16(4), 819–828. doi:10.1016/0017-9310(73)90093-8
- Bullock, K. J., Ledwich, M. A., & Lai, J. C. S. (1985). Numerical simulation of transient response of heat transfer from a hot-wire anemometer transducer. International Journal of Heat and Fluid Flow, 6(1), 57–65. doi:10.1016/0142-727x(85)90034-7
- Davies, T. W. (1986). Modelling the response of a hot-wire anemometer. Applied Mathematical Modelling, 10(4), 256–261. doi:10.1016/0307-904x(86)90055-7
- Perry, A. & Morrison, Graham. (1971). A study of the constant-temperature hot-wire anemometer. Journal of Fluid Mechanics. 47. 577 – 599. 10.1017/S0022112071001241.
- Corrsin, S. (1947). Extended Applications of the Hot-Wire Anemometer. Review of Scientific Instruments, 18(7), 469-471. doi:10.1063/1.1740981

Problem 5: Synchronised Candles

Oscillatory flames can be observed when several candles burn next to each other. Two such oscillators can couple with each other, resulting in in-phase or anti-phase synchronisation (depending on the distance between the sets of candles). Explain and investigate this phenomenon.

I. Phenomenon Demonstration

- IYPT 2021 №5 Synchronised Candles by ЭйНШтейн https://youtu.be/8fw2mcMeH4o
- Ten flames as synchronized oscillators by Michael Forrester https://youtu.be/qWGhlisVDik
- Candles synchronized oscillations by Attila Gergely https://youtu.be/WtJ9kGxV8F8
- Candles synchronized oscillations by Attila Gergely https://youtu.be/udufeNy1bBM
- Anti-phase Synchronization of Oscillating Candle Flame (speed x0.15) by Hiroyuki KITAHATA https://youtu.be/ld9KHCQ22-4

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Papers

- Okamoto, K., Kijima, A., Umeno, Y. et al. Synchronization in flickering of three-coupled candle flames. Sci Rep 6, 36145 (2016). https://doi.org/10.1038/srep36145
- Forrester, D. M. (2015). Arrays of coupled chemical oscillators. Scientific Reports, 5(1). https://doi.org/10.1038/srep16994
- Chen, T., Guo, X., Jia, J., & Xiao, J. (2019). Frequency and Phase Characteristics of Candle Flame Oscillation. Scientific Reports, 9(1). https://doi.org/10.1038/s41598-018-36754-w
- Kitahata, H., Taguchi, J., Nagayama, M., Sakurai, T., Ikura, Y., Osa, A., … Miike, H. (2009). Oscillation and Synchronization in the Combustion of Candles. The Journal of Physical Chemistry A, 113(29), 8164–8168. https://doi.org/10.1021/jp901487e
- Manoj, K., Pawar, S.A. & Sujith, R.I. Experimental Evidence of Amplitude Death and Phase-Flip Bifurcation between In-Phase and Anti-Phase Synchronization. Sci Rep 8, 11626 (2018). https://doi.org/10.1038/s41598-018-30026-3
- Dange, S., Pawar, S. A., Manoj, K., & Sujith, R. I. (2019). Role of buoyancy-driven vortices in inducing different modes of coupled behaviour in candle-flame oscillators. AIP Advances, 9(1), 015119. doi:10.1063/1.5078674
- Fujisawa, N., Imaizumi, K., & Yamagata, T. (2019). Synchronization of Dual Diffusion Flame in Co-flow. Experimental Thermal and Fluid Science, 109924. doi:10.1016/j.expthermflusci.2019.109924
- Manoj, K., Pawar, S. A., Dange, S., Mondal, S., Sujith, R. I., Surovyatkina, E., & Kurths, J. (2019). Synchronization route to weak chimera in four candle-flame oscillators. Physical Review E, 100(6). doi:10.1103/physreve.100.062204
- Takagi, K., Gotoda, H., Miyano, T., Murayama, S., & Tokuda, I. T. (2018). Synchronization of two coupled turbulent fires. Chaos: An Interdisciplinary Journal of Nonlinear Science, 28(4), 045116. doi:10.1063/1.5009896

- Yang, T., Xia, X., & Zhang, P. (2018). Anti-phase and in-phase flickering of dual pool flames. arXiv preprint arXiv:1803.10411. https://export.arxiv.org/ftp/arxiv/papers/1803/1803.10411.pdf

Problem 6: Irreversible Cartesian Diver

A simple Cartesian diver (e.g. an inverted test tube partially filled with water) is placed in a long vertical tube filled with water. Increasing the pressure in the tube forces the Cartesian diver to sink. When it reaches a certain depth, it never returns to the surface even if the pressure is changed back to its initial value. Investigate this phenomenon and how it depends on relevant parameters.

I. Phenomenon Demonstration

- Cartesian Diver – Sick Science! #138 by Sick Science! https://youtu.be/s5eIRjmor1w
- Can You Solve The Reverse Cartesian Diver Problem? By The Action Lab https://youtu.be/ob2CC7cTy_Y
- How To Make A Cartesian Diver by D!NG https://youtu.be/i0Goh3u2KhU
- Soda Bottle Diver – Cartesian Diver by Sick Science! https://youtu.be/sNOXFiJ4IDU
- Cartesian Diver-sions by FlinnScientific https://youtu.be/A-xUp3R0OAA
- Cartesian Divers by FlinnScientific https://youtu.be/F5ITsJY8UQQ
- Cartesian Divers by ScienceOnline https://youtu.be/QukS1pxoezY
- Soda Bottle Diver – Cartesian Diver by SpanglerScienceTV https://youtu.be/ljvp-iR18Ko
- Buoyancy & Pressure in Fluids: Soda Bottle Cartesian Diver by TeachEngineering https://youtu.be/soIey3Q2moE
- Cartesian Diver with Steve Spangler on DIY Sci S02E05 by TheSpanglerEffect https://youtu.be/YHnX-L1CFL8
- How To Make a Squidy – Cartesian Diver by S J James https://youtu.be/5LLwTIkRZAU
- Physics of toys-Big Cartesian divers-part 2 // Homemade Science with Bruce Yeany by Bruce Yeany https://youtu.be/TMju6WzDnHI
- Cartesian Diver construction and explanation by Dan MacIsaac https://youtu.be/ngct-ryamDc
- Density and the Cartesian Diver by funsciencedemos https://youtu.be/16Ak30_VukA
- Physics of toys- Cartesian diver ideas-part 1 // Homemade Science with Bruce Yeany by Bruce Yeany https://youtu.be/xFT-n6bdy8Q
- Science at Home – Cartesian Diver by TWOSETV https://youtu.be/u7bxdZJzXvU
- HOW TO MAKE: A Cartesian Diver by Questacon https://youtu.be/x3bM0UOS4kY
- Bottle Diver Experiment – Cartesian Diver by YouLab https://youtu.be/C3YxaRzXt9g
- Cartesian Diver by Physics Lens https://youtu.be/RLA8t-lpiOY
- Cartesian diver by MEL Science https://youtu.be/6Jpue5-x4_8
- Cartesian diver science experiment for kids by RonyesTech https://youtu.be/DU8wONWjIXg

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Cartesian Diver https://en.wikipedia.org/wiki/Cartesian_diver
- UCSB Lecture Demonstration http://web.physics.ucsb.edu/~lecturedemonstrations/Composer/Pages/36.37.html
- Soda Bottle Science https://www.bemidjistate.edu/academics/departments/science/k12-science-units/cartesisan-diver.pdf
- How Does The Cartesian Diver Experiment Work? By WILLIAM OREM Indiana Public Media
- https://indianapublicmedia.org/amomentofscience/cartesian-diver-experiment-work.php

III. Research Papers

- Planinsic, G., Kos, M., & Jerman, R. (2003). Two-liquid Cartesian diver. Physics Education, 39(1), 58–64. https://doi.org/10.1088/0031-9120/39/1/003
- Güémez, J. & Fiolhais, Carlos & Fiolhais, M.. (2002). The Cartesian diver and the fold catastrophe. American Journal of Physics – AMER J PHYS. 70. 710-714. 10.1119/1.1477433.

- Luca, R. D., & Ganci, S. (2011). A lot of good physics in the Cartesian diver. Physics Education, 46(5), 528–532. https://doi.org/10.1088/0031-9120/46/5/001
- Amir, N., & Subramaniam, R. (2007). Making a fun Cartesian diver: a simple project to engage kinaesthetic learners. Physics Education, 42(5), 478–480. https://doi.org/10.1088/0031-9120/42/5/004
- Güémez, J., Fiolhais, C., & Fiolhais, M. (2003). A Demonstration Apparatus for the Cartesian Diver. The Physics Teacher, 41(8), 495–496. https://doi.org/10.1119/1.1625211
- Satterly, J. (1928). A Cartesian Diver Experiment. Nature, 122(3064), 97–97. https://doi.org/10.1038/122097a0
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Problem 7: Bead Dynamics

A circular hoop rotates about a vertical diameter. A small bead is allowed to roll in a groove on the inside of the hoop. Investigate the relevant parameters affecting the dynamics of the bead.

I. Phenomenon Demonstration

- Bead on a Rotating Wire by wolframmathematica https://youtu.be/6i7hDzcFmME
- Bead on a Rotating Hoop https://demonstrations.wolfram.com/BeadOnARotatingHoop/
- IYPT 2021 №7 Bead Dynamics (in the Hoop frame of reference) by ЭйНШтейн https://youtu.be/YIUyTxvole8
- IYPT 2021 №7 Bead Dynamics (Movement of the beads to a constant angle) by ЭйНШтейн https://youtu.be/26hVS2dnrBk

II. Books, Encyclopedia, Discussion and Forum Posts

- Worked Example A Bead on a Rotating Wire Hoop https://www.damtp.cam.ac.uk/user/reh10/lectures/ia-dyn-handout13.pdf
- Bead on Hoop https://sites.google.com/site/kolukulasivasrinivas/mechanics/bead-on-a-rotating
- A Bead on a Rotating Hoop by Ryan Seng and Michael Meeks https://mse.redwoods.edu/darnold/math55/DEproj/sp08/sengmeeks/BeadonaHoop.pdf
- A bead on a spinning wire hoop (Taylor), Physics Stackexchange https://physics.stackexchange.com/questions/314588/a-bead-on-a-spinning-wire-hoop-taylor
- Mod-01 Lec-15 Bead on a rotating hoop by nptelhrd https://youtu.be/8qbR7SsJB9U
- Ex. 7.6 – Bead on a Spinning Wire by Brian Jackson https://youtu.be/Io_7vG1rpDA
- Problem Set 3 Solution, Problem 3 – Bead on Hoop Forced to Rotate http://www.physics.hmc.edu/~saeta/courses/p111/uploads/Y2011/hw03sol.pdf
- INTRODUCTION TO CLASSICAL MECHANICS Prof. N. Harnew University of Oxford Page 66 https://users.physics.ox.ac.uk/~harnew/lectures/mechanics-lectures-20to29.pdf
- Bead on a Spinning Hoop http://107.191.96.171/classes/phys3355_2005_fall/assignments/hw12_Lagrange-ans.pdf
- Over-damped bead on a rotating hoop, dimensional analysis and dimensionless form of equations of motion, introduction to 2-D homogeneous linear systems, uniqueness of solution and phase space trajectories http://www.cs.ioc.ee/~dima/YFX1520/LectureNotes_3.pdf

III. Research Papers

- Raviola, L. A., Véliz, M. E., Salomone, H. D., Olivieri, N. A., & Rodríguez, E. E. (2016). The bead on a rotating hoop revisited: an unexpected resonance. European Journal of Physics, 38(1), 015005. https://doi.org/10.1088/0143-0807/38/1/015005
- Dutta, S., & Ray, S. (2011). Bead on a rotating circular hoop: a simple yet feature-rich dynamical system. arXiv: Classical Physics.
- Johnson, A. K., & Rabchuk, J. A. (2009). A bead on a hoop rotating about a horizontal axis: A one-dimensional ponderomotive trap. American Journal of Physics, 77(11), 1039–1048. https://doi.org/10.1119/1.3167216
- Dutta, S., & Ray, S. (2012). Damped bead on a rotating circular hoop – a bifurcation zoo. arXiv: Classical Physics.

- Balandin, D. V., & Shalimova, E. S. (2015). Bifurcations of the relative equilibria of a heavy bead on a hoop uniformly rotating about an inclined axis with dry friction. Journal of Applied Mathematics and Mechanics, 79(5), 440–445. doi:10.1016/j.jappmathmech.2016.03.004
- Burov, A. A., & Yakushev, I. A. (2014). Bifurcations of the relative equilibria of a heavy bead on a rotating hoop with dry friction. Journal of Applied Mathematics and Mechanics, 78(5), 460–467. doi:10.1016/j.jappmathmech.2015.03.004
- Basquerotto, C. H. C. C., Righetto, E., & Silva, S. da. (2018). Applications of the Lie symmetries to complete solution of a bead on a rotating wire hoop. Journal of the Brazilian Society of Mechanical Sciences and Engineering, 40(2). doi:10.1007/s40430-018-0995-x
- Baker, T. E., & Bill, A. (2012). Jacobi elliptic functions and the complete solution to the bead on the hoop problem. American Journal of Physics, 80(6), 506–514. doi:10.1119/1.3682321
- Basquerotto, C. H. C. C., & Ruiz, A. (2020). On the reduction of nonlinear mechanical systems via moving frames: a bead on a rotating wire hoop and a spinning top. Acta Mechanica. doi:10.1007/s00707-020-02798-1

Problem 8: Fuses

A short length of wire can act as an electrical fuse. Determine how various parameters affect the time taken for the fuse to 'blow'.

I. Phenomenon Demonstration

- Blowing Fuses in Slow Motion by Nick Moore https://youtu.be/qgz1lskyYDU
- Fuse vs Circuit Breaker Which Blows Faster (Slow Motion) by Warped Perception https://youtu.be/ZtD_ZrPfXrw

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Fuses (electrical) https://en.wikipedia.org/wiki/Fuse_(electrical)
- What is an Electric Fuse? | Don't Memorise by Don't Memorise https://youtu.be/BLIYsRwKrkE
- Different Types of Fuses Explained – A Galco TV Tech Tip by GalcoTV https://youtu.be/kuthVyWHwqE
- How Do Fuses Work In Appliances? | Repair and Replace by AMRE Supply https://youtu.be/IlPuioUs5N0
- ALL ABOUT CIRCUITS: FUSES Chapter 12 – Physics Of Conductors And Insulators https://www.allaboutcircuits.com/textbook/direct-current/chpt-12/fuses/#:~:text=REVIEW%3A,event%20of%20an%20overcurrent%20condition.

III. Research Papers

- Voronov, S. A., Voronov, Y. A., Onishchenko, E. M., Simakov, A. B., Sosnovtsev, V. V., Suchkov, S. I., & Sugrobova, T. A. (2004). High-Voltage Safety Fuses for the Transition-Radiation Tracking Detector in the ATLAS Experiment. Instruments and Experimental Techniques, 47(2), 191–193. https://doi.org/10.1023/b:inet.0000025200.74310.60
- Pleşca, A. (2015). Numerical Thermal Analysis of Fuse Mounted on Fuse Holder. Heat Transfer Engineering, 36(18), 1518–1524. https://doi.org/10.1080/01457632.2015.1024990
- Ding, X., Lou, W., & Feng, Y. (2016). A controllable IC-compatible thin-film fuse realized using electro-explosion. AIP Advances, 6(1), 015316. https://doi.org/10.1063/1.4941074
- M. Naidu, T. J. Schoepf and S. Gopalakrishnan, "Arc fault detection scheme for 42-V automotive DC networks using current shunt," in IEEE Transactions on Power Electronics, vol. 21, no. 3, pp. 633-639, May 2006, doi: 10.1109/TPEL.2006.872385.
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Problem 9: Light Whiskers

When a laser beam enters a soap film at a small angle, a rapidly changing pattern of thin, branching light tracks may appear inside the film. Explain and investigate this phenomenon.

I. Phenomenon Demonstration

- IYPT2021 P9-Light Whiskers 光须 by IYPT青年物理学家
- https://www.bilibili.com/video/av968965422/
- The laser show in a soap bubble by nature video
- https://youtu.be/UNCNp1tBqKY
- Observation of Branched Flow of Light in a Soap Bubble from Technion by Technion https://youtu.be/StGRtGa1J8A
- kypt_team https://www.instagram.com/p/CEMk9w7gSy_/?igshid=1ia1ca07a90pk

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Paper

- Startsev, A. V., & Stoilov, Y. Y. (2003). A miracle happening to a laser beam in a soap film. Quantum Electronics, 33(5), 380–382. doi:10.1070/qe2003v033n05abeh002422
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- Andre Brandstötter, Adrian Girschik, Philipp Ambichl, Stefan Rotter
- Proceedings of the National Academy of Sciences Jul 2019, 116 (27) 13260-13265; DOI: 10.1073/pnas.1905217116

Problem 10: Spin Drift

When a ring is set to roll in a parabolic bowl, interesting motion patterns may arise. Investigate this phenomenon.

I. Phenomenon Demonstration

- Video by physicsfun https://www.instagram.com/p/B8cGD6tBoFU/
- Spin Drift by Shawn Lani by Shawn Lani https://youtu.be/4vD9tR9vQ20
- Spindrift by Shawn Lani https://youtu.be/S8MX2Y1NW80
- Spindrift by Spindrift https://youtu.be/ktDf2xZ1cQ8
- May 28, 2019 by Shawn Lani https://youtu.be/Eb-9w2AMvpw

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Euler's Disk https://en.wikipedia.org/wiki/Euler%27s_Disk

III. Research Papers

- Leine, Remco. (2009). Experimental and theoretical investigation of the energy dissipation of a rolling disk during its final stage of motion. Archive of Applied Mechanics. 79. 1063-1082. 10.1007/s00419-008-0278-6.
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Problem 11: Guitar String

A periodic force is applied to a steel guitar string using an electromagnet. Investigate the motion of the guitar string around its resonance frequency.

I. Phenomenon Demonstration

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Paper

- Perov, P., Johnson, W., & Perova-Mello, N. (2016). The physics of guitar string vibrations. American Journal of Physics, 84(1), 38–43. doi:10.1119/1.4935088
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Problem 12: Wilberforce Pendulum

A Wilberforce pendulum consists of a mass hanging from a vertically oriented helical spring. The mass can both move up and down on the spring and rotate about its vertical axis. Investigate the behaviour of such a pendulum and how it depends on relevant parameters.

I. Phenomenon Demonstration

- WF Pendulum by WSU Physics Videos https://youtu.be/JRZG26VWOFw
- PH ME CE DEMO 70041A V0241 Wilberforce Pendulum by UniServeScienceVIDEO https://youtu.be/9yVew0–jzw
- The Wilberforce Pendulum by Ben Scott https://youtu.be/CAQt7H2Gjqg
- Wilberforce Pendulum 1.0 at PHELMA (2017) by Alexis Nuttin https://youtu.be/adbEdh-p3_k
- Wilberforce Pendulum by BerkeleyLectureDemos https://youtu.be/S42lLTlnfZc
- Wilberforce Pendulum by Iftikhar Azam https://youtu.be/C1aSBeCFPzk
- Beat in free vibration (Wilberforce Pendulum) / Schwebungen by Mechanik Uni Kassel https://youtu.be/OWjap-1iQbU
- IYPT 2021 №12 Wilberforce Pendulum – Model by ЭйНШтейн https://youtu.be/c0YShREnsWs
- IYPT 2021 №12 Wilberforce Pendulum and cat Esenia by ЭйНШтейн https://youtu.be/-beiNF-Z5Os
- Wilberforce Pendulum by SMUPhysics https://youtu.be/9EnGmhvRVh4
- Wilberforce pendulum: Oscillates between rotation and up-down by James Little https://youtu.be/y4YaGs1HB1M
- Wilberforce pendulum by xofunkox-scientific experiments https://youtu.be/UDXcYJldOYc
- Wilberforce Pendulum by NekoTonberry https://youtu.be/dPeaoT_jn1M
- IOLab crude Wilberforce Pendulum by phys142media https://youtu.be/5MBf8uZU0Ng
- Ealing Film-Loops 80-215 – Wilberforce Pendulum by amt253 https://youtu.be/3K3aYyoIL5M
- Wilberforce pendulum by Thomas Carl Pion https://youtu.be/ms7gf7RH55g
- Wilberforce pendulum Top # 6 Facts by Dorethea https://youtu.be/YAFfCxiCfLE
- IYPT 2021 №12 Wilberforce Pendulum by ЭйНШтейн https://youtu.be/u-irUb83SXw
- Rocking Wilberforce Pendulum by Aniceto Arispe-Moreno https://youtu.be/t8hq1s08oOE
- Wilberforce Pendulum_Experiment phenomenon by Jiaying Zhang https://youtu.be/pgN87Vg6Jug
- Wilberforce Pendulum – H by M. Umar Hasan https://youtu.be/90EJRUwkYoQ
- Wilberforce Pendulum – D by M. Umar Hasan https://youtu.be/TgdKSOmYjZY
- Wilberforce Pendulum (3a70.10) by Christopher Ertl https://youtu.be/qmOEAG3jVek
- Wilberforce Pendulum by nopvelthuizen https://youtu.be/jJ7Hopu7NlQ
- Wilberforce Pendulum by Science Fun https://youtu.be/xJDcLSVGTLo
- 3A70.10 Wilberforce Pendulum by wesphysdemo https://youtu.be/aFMtthr1BDs
- 3A70.10 – Wilberforce Pendulum by UMDemoLab https://youtu.be/BaGeI_mlunQ
- Wilberforce Pendulum by
- StepLab – prototyiping robotica elettronica software apps
- https://youtu.be/Rcd9Hn81MJM
- Wilbur Force Pendulum by bcitphysics https://youtu.be/pNwZ-XUuqZg

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Wilberforce Pendulum https://en.wikipedia.org/wiki/Wilberforce_pendulum
- THE WILBERFORCE PENDULUM by University of Toronto https://faraday.physics.utoronto.ca/PHY182S/WilberforcePendulum.pdf
- A Smart Wilberforce Pendulum by Keith Clay, Green River College https://www.vernier.com/vernier-ideas/a-smart-wilberforce-pendulum/
- The Wilberforce Pendulum by Misay A. Partnof and Steven C. Richards https://mse.redwoods.edu/darnold/math55/DEProj/sp04/stevemisay/presentation.pdf
- The Wilberforce Pendulum https://scipython.com/blog/the-wilberforce-pendulum/

- The Wilberforce Pendulum WOLFRAM Demonstration Project https://demonstrations.wolfram.com/TheWilberforcePendulum/
- Wilberforce Pendulum by Physlab
- https://physlab.org/experiment/wilberforce-pendulum/
- Wilberforce Pendulum Instruction Manual https://www1.phys.vt.edu/~demo/references/equipment_manuals/wilburforce_ME-8091.pdf
- Dynamics of a Wilberforce pendulum by Muhammad Umar Hassan, Azeem Iqbal,
- Amrozia Shaheen and Muhammad Sabieh Anwar https://www.physlab.org/wp-content/uploads/2018/09/Wilberforce_3.pdf
- Quantitative Analysis of the Wilberforce Pendulum by Dan Kriz
- https://phas.ubc.ca/~berciu/TEACHING/PHYS349/Wilberforce.pdf
- Investigation of a Wilberforce Pendulum by Jimmy Miller
- https://cdn.shopify.com/s/files/1/0281/5288/9404/files/WilberforcePendulumPresentation.pdf
- http://www.motiongenesis.com/MGWebSite/MGTextbooks/MGTextbookControlVibrationDesignOfDynamicSystems/WorksheetWilburForcePendulumModesInstructor.pdf
- Wilberforce Pendulum (One or two weights) by University of Toronto
- https://faraday.physics.utoronto.ca/IYearLab/Wilberforce%20Pendulum.pdf
- Vibrations: Two Degrees of Freedom Systems – Wilberforce Pendulum and Bode Plots by Professor Peacock
- https://ocw.mit.edu/courses/mechanical-engineering/2-003j-dynamics-and-control-i-spring-2007/lecture-notes/lec23.pdf
- Second part: Background on Fourier analysis byBCAM – Basque Center for Applied Mathematics http://www.bcamath.org/documentos_public/courses/1_Course2012Chapter2FourierAnalysis.pdf
- Principles of Symmetry, Dynamics and Spectroscopy by W.G,Wiley
- https://modphys.hosted.uark.edu/pdfs/PSDS_Pdfs/PSDS_Ch.2_(4.22.10).pdf
- Il pendolo di Wilberforce studiato con RTL Prototipo di apparato sviluppato nell'ambito del progetto IRDIS Giacomo Torzo e Michele D'Anna http://www.fisica.uniud.it/irdis/Meccanica/Wilberforce/WilberforceRTL.pdf

III. Research Papers

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- The Wilberforce pendulum: a complete analysis through RTL and modelling https://www.labtrek.it/WilberLABTREK.pdf
- Köpf, U. (1990). Wilberforce's pendulum revisited. American Journal of Physics, 58(9), 833–837. doi:10.1119/1.16376
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Problem 13: Sponge

A sponge will soak up water at a rate and in a quantity determined by various parameters. Investigate how effective a sponge is at drying a wet surface.

I. Phenomenon Demonstration

- A more satisfying dried sponge absorbs water. By Adam Clarkson https://youtu.be/v4xNkADJHag
- Which quantity of water can absorb a Sponge?! | drc16 by Experiment Discoverer https://youtu.be/cBfZVbBEXSc

II. Books, Encyclopedia, Discussion and Forum Posts

- How does a sponge "suck" up water against gravity? Physics StackExchange https://physics.stackexchange.com/questions/66625/how-does-a-sponge-suck-up-water-against-gravity
- What Type Of Sponge Is Most Absorbent?
- https://tips.simplygoodstuff.com/most-absorbent-sponge/

III. Research Papers

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Problem 14 Dynamic Hydrophobicity

When a drop of liquid impacts on a horizontally moving surface, the droplet may be reflected or not, depending on the speed of the surface. Investigate the interaction between a moving surface and a liquid drop.

I. Phenomenon Demonstration

- Steady drop levitation (Gallery of Fluid Motion 2014) by Yoshiyuki Tagawa https://youtu.be/Btr4kLmqNaw

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Hydrophobe https://en.wikipedia.org/wiki/Hydrophobe#:~:text=In%20chemistry%2C%20hydrophobicity%20is%20the,is%20an%20absence%20of%20attraction.)

III. Research Paper

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Problem 15: Rebounding Capsule

A spherical ball dropped onto a hard surface will never rebound to the release height, even if it has an initial spin. A capsule-shaped object (i.e. Tic Tac mint) on the other hand may exceed the initial height. Investigate this phenomenon.

I. Phenomenon Demonstration

- Crazy tic tac bounce!? | EVERYDAY MYSTERIES by Physics Girl https://youtu.be/x4ySPDvebes
- Football Science: Bouncing Tic Tac by Kitchen Pantry Scientist https://youtu.be/DeW09x2fQtY
- Tic Tac Bounce: Rotational Kinetic Energy by David Uhrich https://youtu.be/HauPui0vIGo
- Tic Tac Bounce SloMo by Kelly O'Shea https://youtu.be/rKf4o1wScgE
- 2021-15 Rebounding Capsule (Obs) by 建中物理辯論社 https://www.facebook.com/watch/?v=596175371260250
- IYPT 2021 №15 Rebounding Capsule (Отскок капсулы) by ЭйНШтейн https://youtu.be/FsAFYhUvTt4

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Papers

- Bharadwaj, R., Smith, C., & Hancock, B. C. (2010). The coefficient of restitution of some pharmaceutical tablets/compacts. International Journal of Pharmaceutics, 402(1-2), 50–56. doi:10.1016/j.ijpharm.2010.09.018
- Hastie, D. B. (2013). Experimental measurement of the coefficient of restitution of irregular shaped particles impacting on horizontal surfaces. Chemical Engineering Science, 101, 828–836. doi:10.1016/j.ces.2013.07.010
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Problem 16: ULtrasonic Pump

A capillary immersed in an ultrasonic bath works like a pump that can lift water to a considerable height. Explain and investigate this phenomenon.

I. Phenomenon Demonstration

- СВЕРХТЕКУЧАЯ ВОДА – уникальный водяной насос на основе ультразвуковой ванны Игорь Белецкий by Igor Beletskiy https://youtu.be/vp2Ez3sgm-Q
- Water pump by Ultrasonic Air Blower by microwavemont https://youtu.be/opj7XEs_LOk

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Paper

- Hasegawa, Takeshi & Koyama, Daisuke & Nakamura, Kentaro & Ueha, Sadayuki. (2008). Modeling and Performance Evaluation of an Ultrasonic Suction Pump. Japanese Journal of Applied Physics. 47. 4248-4252. 10.1143/JJAP.47.4248.
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- Hasegawa, T., Koyama, D., Nakamura, K., & Ueha, S. (2007). Improvement in the Flow Rate of a Miniature Ultrasonic Suction Pump. Japanese Journal of Applied Physics, 46(7B), 4931–4935. doi:10.1143/jjap.46.4931
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Problem 17: Hand Helicopter

A simple hand helicopter can be made by attaching rotor blades to one end of a vertical stick. The helicopter moves upwards when the stick is twisted at a high enough speed and then let go. Investigate how the relevant parameters affect the lift-off and the maximum height.

I. Phenomenon Demonstration

- How To Make a Helicopter – Hand Helicopter by Andry Scholar https://youtu.be/eaZGsbQZts8
- How To make a mini hand Helicopter by LUCKY CREATION https://youtu.be/A9t0OJSNFk4
- Flying Stick Helicopter by Spark Something https://youtu.be/8jrTQZBqi8o

II. Books, Encyclopedia, Discussion and Forum Posts

- Rotor Motor Aeronautics: An Educator's Guide https://www.nasa.gov/pdf/205711main_Rotor_Motor.pdf
- Structure and Stress Analysis Chapter 11 Torsion of Beams http://freeit.free.fr/Knovel/Structural%20and%20Stress%20Analysis/31961_11.pdf
- The Lift Equation by Nancy Hall NASA https://www.grc.nasa.gov/www/k-12/airplane/lifteq.html#:~:text=The%20lift%20equation%20states%20that,times%20the%20wing%20area%20A.
- Experiment 7 – AERO/HYDRODYNAMIC TESTING by Dr. A. Borgoltz with contribution from Dr. W. H. Mason http://www.dept.aoe.vt.edu/~aborgolt/aoe3054/manual/expt7/index.html
- CFD Analysis on the Main-Rotor Blade of a Scale Helicopter Model using Overset Meshing by

- CHRISTIAN RODRIGUEZ (Masters' Degree Project) http://www.diva-portal.org/smash/get/diva2:608435/FULLTEXT01
- An Analysis on the Helicopter Rotor Aerodynamics in Hover and Forward Flight Using CFD/Time-Marching-Free-Wake Coupling Method by Seong Yong WieDong Kyun ImEugene KimJang Hyuk KwonDuck Joo Lee https://link.springer.com/chapter/10.1007/978-3-642-01273-0_88
- Some Rototcraft Applications of Computational Fluid Dynamics by W. J. McCroskey https://apps.dtic.mil/dtic/tr/fulltext/u2/a197977.pdf
- CFD Laboratory University of Liverpool School of Engineering
- http://www.cerfacs.fr/musaf/PDF_MUSAF_DAY2/BARAKOS/Barakos.pdf

III. Research Papers

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