IYPT 2022 Crowdsourced Reference Archive

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Problem 1: Invent Yourself

Create a non-invasive device that determines the direction of fluid flow inside an opaque pipe. Optimise your device so that you can measure the smallest flow possible.

I. Phenomenon Demonstration

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Flow Measurement, https://en.wikipedia.org/wiki/Flow_measurement
- Wikipedia: Ultrasonic Flow Meter, https://en.wikipedia.org/wiki/Ultrasonic_flow_meter
- What Is an Ultrasonic Flow Meter and How to Use One? https://www.omega.ca/en/resources/ultrasonic-flow-meters
- How an Ultrasonic Flow Meter Works https://www.sierrainstruments.com/blog/?ultrasonic-flow-meter-works
- The Ultrasonic Flow Measuring Principle by Endress+Hauser https://youtu.be/Bx2RnrfLkQg
- Doppler vs Transit Time – Let's talk Ultrasonic Flow Meters by OMEGA Engineering https://youtu.be/NQWNYARWmB8
- Ultrasonic flow measurement principle by Siemens https://youtu.be/DD2bBLu6kLM
- Ultrasonic Flow Sensor by CeramTec – The Ceramic Experts https://youtu.be/_6CQVN3KYz8
- Ultrasonic Acoustic Sensing Brown University http://cs.brown.edu/people/tdean/courses/cs148/02/sonar.html
- How Does An Ultrasonic Flow Meter Work? https://www.openchannelflow.com/blog/how-does-an-ultrasonic-flow-meter-work
- Clamp-on type ultrasonic flow meter and a temperature and pressure compensation method therein https://patents.google.com/patent/US5856622A/en
- Ultrasonic flow metering with laminar to turbulent transition flow control https://patents.google.com/patent/US10012521B2/en
- Beam shaping acoustic signal travel time flow meter https://patents.google.com/patent/US10036763B2/en

III. Research Papers

- Jha, D. K., Ray, A., Mukherjee, K., and Chakraborty, S. (November 7, 2012). "Classification of Two-Phase Flow Patterns by Ultrasonic Sensing." ASME. J. Dyn. Sys., Meas., Control. March 2013; 135(2): 024503. https://doi.org/10.1115/1.4007555
- V. K. Chillara, B. T. Sturtevant, C. Pantea, and D. N. Sinha, in AIP Conference Proceedings (AIP Conference Proceedings, 2017).
- A. Shiozaki, S. Senda, A. Kitabatake, M. Inoue, and H. Matsuo, Ultrasonics 17, 269 (1979).
- R. A. Rahim, M. H. F. Rahiman, K. S. Chan, and S. W. Nawawi, Sensors and Actuators A: Physical 135, 337 (2007).
- N. Munasinghe and G. Paul, IEEE Sensors Journal 20, 6083 (2020).
- L. C. Lynnworth and Y. Liu, Ultrasonics 44, e1371 (2006).
- Nontraumatic aortic blood flow sensing by use of an ultrasonic esophageal probe R. E. Daigle, C. W. Miller, M. B. Histand, F. D. McLeod, and D. E. Hokanson Journal of Applied Physiology 1975 38:6, 1153-1160
- N. Li, K. Xu, and S. Li, EURASIP Journal on Wireless Communications and Networking 2018, (2018).

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- R. A. Rahim, M. H. F. Rahiman, K. S. Chan, and S. W. Nawawi, Sensors and Actuators A: Physical 135, 337 (2007).
- N. Munasinghe and G. Paul, IEEE Sensors Journal 20, 6083 (2020).
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- Nontraumatic aortic blood flow sensing by use of an ultrasonic esophageal probe R. E. Daigle, C. W. Miller, M. B. Histand, F. D. McLeod, and D. E. Hokanson Journal of Applied Physiology 1975 38:6, 1153-1160
- N. Li, K. Xu, and S. Li, EURASIP Journal on Wireless Communications and Networking 2018, (2018).

Problem 2: Rayleigh Disk

A disk suspended vertically by a thin thread is placed in an acoustic field. This device can be used to measure the intensity of sound by turning about the axis of the thread. Investigate the accuracy of such a device.

I. Phenomenon Demonstration

- Rayleigh disc. By GetAClass-Physics in experiments https://www.youtube.com/watch?v=8Kj-rxDbKmM

II. Books, Encyclopedia, Discussion and Forum Posts

- Merriam Webster: Rayleigh disk https://www.merriam-webster.com/dictionary/Rayleigh%20disk

III. Research Papers

- A. Garbin, I. Leibacher, P. Hahn, H. Le Ferrand, A. Studart, and J. Dual, The Journal of the Acoustical Society of America 138, 2759 (2015).
- C. F. Hayes, The Journal of the Acoustical Society of America 60, 1227 (1976).
- J. Awatani, The Journal of the Acoustical Society of America 28, 297 (1956).
- J. Hartmann and T. Mortensen, The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science 39, 377 (1948).
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- M. G. R. Sause and M. A. Hamstad, Sensors and Actuators A: Physical 269, 294 (2018).
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- Wood, A. (2002). A correction to the theory of the rayleigh disc as applied to the measurement of sound-intensity in water. Proceedings of the Physical Society. 47. 779. 10.1088/0959-5309/47/5/301.

Problem 3: Ring on the Rod

A washer on a vertical steel rod may start spinning instead of simply sliding down. Study the motion of the washer and investigate what determines the terminal velocity.

I. Phenomenon Demonstration

- A Washer Falls Down Threaded Rod https://www.reddit.com/r/oddlysatisfying/comments/iwsjh7/a_washer_falls_down_threaded_rod/
- DANCING WASHERS – ENGLISH – 19MB by Arvind Gupta https://youtu.be/hHtkJzOU2bo
- IYPT ring on the rod demonstration by Aradyha Jain. https://www.youtube.com/watch?v=IVJiNpXZI4M
- Washer on a threaded rod by GEORGE ZARIFIS: https://youtu.be/oD6yxsCkkpg
- Кольцо на стержне / Ring on the rod / IYPT 2022 by Андрей Щетников. https://www.youtube.com/watch?v=jce_Jya1lZ8

II. Books, Encyclopedia, Discussion and Forum Posts

- Vibrational Detachment of Threaded Fasteners https://www.boltscience.com/pages/VibrationalDetachmentOfFasteners.htm

III. Research Papers

- Cross, Rod. “Rotating Ring on a Vertical Rod.” Physics Education 56, no. 2 (2021): 023003. https://doi.org/10.1088/1361-6552/abd992. https://iypt.ru/wp-content/uploads/2021/09/Rotating-ring-on-a–vertical.pdf
- Jirandehi, Arash P, and Tajbakhsh N Chakherlou. “A Profound Study on the Effects of Friction Coefficient on …” Research Gate, September 2015. https://www.researchgate.net/publication/294874446_A_profound_study_on_the_effects_of_friction_coefficient_on_torque_tightened_longitudinally_loaded_bolted_connections.

Problem 4: Unsinkable Disk

A metal disk with a hole at its centre sinks in a container filled with water. When a vertical water jet hits the centre of the disc, it may float on the water surface. Explain this phenomenon and investigate the relevant parameters.

I. Phenomenon Demonstration

- Unsinkable Disk IYPT2022 by ЭйНШтейн https://youtu.be/Wi1K2yRbMLo

- Unsinkable disc by GetAClass – Physics in experiments https://youtube.com/watch?v=eP5_9eUjfkI

II. Books, Encyclopedia, Discussion and Forum Posts

- Introduction to Impinging Jets by LearnChemE https://youtube.com/watch?v=rjJciObMiE8
  Impinging jets https://thermopedia.com/content/872/

III. Research Papers

- Michelson, Irving(1969). Fluidic Jet Impingement-Analytical Solution and Novel Physical Characteristic. , 223(5206), 610-611. doi: 10.1038/223610a0
- Bolek, A., & Bayraktar, S. (2019). Flow and heat transfer investigation of a circular jet issuing on different types of surfaces. *Sādhanā*, *44*(12). https://doi.org/10.1007/s12046-019-1226-6

Problem 5: Bimetallic Oscillator

A simple electric oscillator can be made using a bimetallic contact-breaker. Investigate the relevant parameters that affect the frequency of such an oscillator.

I. Phenomenon Demonstration

- Homemade bimetallic strips – Thermostat demonstration // Homemade Science with Bruce Yeany by Bruce Yeany https://youtu.be/5fI-El2kipE

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Bimetallic Strip, https://en.wikipedia.org/wiki/Bimetallic_strip
- Thermal Circuit Breaker, https://reviseomatic.org/help/e-components/Thermal%20Circuit%20Breaker.php
- US Patent: Bimetallic strip for a circuit breaker, https://patents.google.com/patent/US20050134424A1/en#patentCitations

III. Research Papers

- Ravindran, S.K.T., Kroener, M., Woias, P., 2012. A Bimetallic Micro Heat Engine for Pyroelectric Energy Conversion. Procedia Engineering 47, 33–36.. doi:10.1016/j.proeng.2012.09.077
- De Alba, R., Abhilash, T.S., Rand, R.H., Craighead, H.G., Parpia, J.M., 2017. Low-Power Photothermal Self-Oscillation of Bimetallic Nanowires. Nano Letters 17, 3995–4002.. doi:10.1021/acs.nanolett.6b04769
- Arnaud, A., Boisseau, S., Monfray, S., Puscasu, O., Despesse, G., Boughaleb, J., … & Skotnicki, T. (2013, December). Piezoelectric and electrostatic bimetal-based thermal energy harvesters. In Journal of Physics: Conference Series (Vol. 476, No. 1, p. 012062). IOP Publishing.

Problem 6: Tennis Ball Tower

Build a tower by stacking tennis balls using three balls per layer and a single ball on top. Investigate the structural limits and the stability of such a tower. How does the situation change when more than three balls per each layer and a suitable number of balls on the top layer are used?

I. Phenomenon Demonstration

- Physicist creates remarkable tennis-ball towers, including one made from 46 balls, https://physicsworld.com/a/physicist-creates-remarkable-tennis-ball-pyramids-including-one-made-from-46-balls/

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Papers

- Sissler, Lise & Jones, R & Leaney, Paul & Harland, A.R.. (2010). Viscoelastic Modelling of Tennis Ball Properties. IOP Conference Series: Materials Science and Engineering. 10. 012114. 10.1088/1757-899X/10/1/012114.
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- Kazachkov, A., & Kireš, M. (2017). A stack of cards rebuilt with calculus. Physics Education, 52(4), 045019. doi:10.1088/1361-6552/aa6a4e
- Hall, J. F. (2005). Fun with stacking blocks. American Journal of Physics, 73(12), 1107–1116. doi:10.1119/1.2074007
- Thomsen, Kasper Kronborg. “Simulating Object Stacking Using Stack Stability.” Aalborg University . Accessed November 11, 2021. http://projekter.aau.dk/projekter/files/198080087/Full_Report.pdf.
- Winkelmann, J., Mughal, A., Weaire, D., & Hutzler, S. (2019). Equilibrium configurations of hard spheres in a cylindrical harmonic potential. *EPL (Europhysics Letters)*, *127*(4), 44002. https://doi.org/10.1209/0295-5075/127/44002

Problem 7: Three-Sided Dice

To land a coin on its side is often associated with the idea of a rare occurrence. What should be the physical and geometrical characteristics of a cylindrical dice so that it has the same probability to land on its side and one of its faces?

I. Phenomenon Demonstration

- How thick is a three-sided coin? By Stand-up Maths https://youtu.be/-qqPKKOU-yY
- How Thick is a 3 Sided Die? (wrong) by sirrandalot https://youtu.be/VhYgY42SBb0

II. Books, Encyclopedia, Discussion and Forum Posts

- Three-sided Cylindrical Dice by Matthew, Rebekah, Deepu, Brian, Fiona, Miracle, Carsten, https://riverbendmath.org/math_circle/3-sided-dice/3-sided_dice-report
- How thick should a cylindrical coin be for it to act as a fair three-sided die? https://math.stackexchange.com/questions/2029476/how-thick-should-a-cylindrical-coin-be-for-it-to-act-as-a-fair-three-sided-die
- The geometry of weird-shaped dice by skullsinthestars https://skullsinthestars.com/2017/03/09/the-geometry-of-weird-shaped-dice/

III. Research Papers

- Jones, D. L. (2009). Examining Cylindrical Dice, The Mathematics Teacher MT, 102(6), 420-424. Retrieved Aug 20, 2021, from https://pubs.nctm.org/view/journals/mt/102/6/article-p420.xml

Problem 8: Equipotential Lines

Place two electrodes into water, supply a safe voltage and use a voltmeter to determine electric potential at various locations. Investigate how the measured equipotential lines deviate from your expectations for different conditions and liquids.

I. Phenomenon Demonstration

- Electric Field Lines Lab [Teacher's Instructions] by Physics Burns https://youtu.be/oD9amPhBi8k
- ARCO Field Lines & Equipotential Lines by ARCO Let's Learn Science https://youtu.be/KyO1_DZnLgs
- Mapping Electric Fields – Water and Voltage Activity by AP Physics C with Mr. D'Antuono https://youtu.be/NLBz1K_UlN8
- Electric Field Visualised with Semolina and caster oil by David Ferguson https://youtu.be/JO_iqqAYJzY
- lab 1 Equipotential Lines, Electric and Magnetic Field Mapping by https://youtu.be/WcSSWN4Tnoo
- Demo-by-Lewin(8.02-02-2): Display electric fields with grass seeds by Dake Wang https://youtu.be/CoXCb1HHLJQ
- ELECTRIC FIELD Visualized with Crystals by James Lincoln https://youtu.be/63FnT0W-Hxc

II. Books, Encyclopedia, Discussion and Forum Posts

- Chp-10 Electric fields in Matter http://www.physics.mcgill.ca/~gang/PHYS340/Wiseman-Phys340-lecture-notes.update.pdf
- Chapter 4 Electric Fields in Matter http://www.phys.nthu.edu.tw/~thschang/notes/EM04.pdf
- Equipotential Lines and Electric Fields Plotting the Electric Field https://www.nms.org/Portals/0/Docs/FreeLessons/PHYS_Equipotential%20Lines%20and%20Electric%20Fields.pdf
- Electric Fields in Matter https://physics.uwo.ca/~cottam/EMsec4.pdf
- Electric fields in matter https://www.compadre.org/nexusph/course/Electric_fields_in_matter
- Experiment 4: Mapping Electric Equipotentials http://www1.phys.vt.edu/~labs/phys2306/fall08/ph2306_lab4.pd
- Wikipedia: Double layer (surface science) https://en.wikipedia.org/wiki/Double_layer_(surface_science)

III. Research Papers

Problem 9: Water Spiral

If a stream of liquid is launched through a small hole, then under certain conditions it twists into a spiral. Explain this phenomenon and investigate the conditions under which the spiral will twist.

I. Phenomenon Demonstration

II. Books, Encyclopedia, Discussion and Forum Posts

- Jets asymétriques, w B. Jouk, M. Marmonier & N. Aymerich. https://twitter.com/PSE_ESPCI/status/738734718699601921

III. Research Papers

- A.-C. Ruo, M.-H. Chang, and F. Chen, Physics of Fluids 20, 062105 (2008).

- H. Q. Yang, Physics of Fluids A: Fluid Dynamics **4**, 681 (1992)
- Z. Liu and Z. Liu, International Journal of Multiphase Flow 34, 42 (2008).
- S. H. Collicott, S. Zhang, and S. P. Schneider, Experiments in Fluids 16, 345 (1994).
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- X.-T. Wang, Z. Ning, and M. Lü, Journal of Non-newtonian Fluid Mechanics 288, 104466 (2021).
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- H. Parmar, V. Pareek, C. M. Phan, and G. M. Evans, Chemical Engineering Science 123, 247 (2015).
- M.-C. Renoult, G. Brenn, G. Plohl, and I. Mutabazi, Journal of Fluid Mechanics 856, 169 (2018).
- Takao Yoshinaga, Fluid Dynamics Research 52, 045502 (2020).
- Wang, Ning, Z., & Lü, M. AIAA Journal, 56(9), 3515–3523 (2018).
- X.-T. Wang, Z. Ning, and M. Lü, European Journal of Mechanics – B/fluids 77, 118 (2019).

Problem 10: Droplet Explosion

When a drop of a water mixture (e.g. water-alcohol) is deposited on the surface of a hydrophobic liquid (e.g. vegetable oil), the resulting drop may sometimes fragment
into smaller droplets. Investigate the parameters that affect the fragmentation and the size of the final droplets.

I. Phenomenon Demonstration

- Marangoni Bursting: Evaporation-Induced Emulsification of a Two-Component Droplet. By ASP Physics https://www.youtube.com/watch?v=y44rQdiixuw
- Visually stunning display of water & isopropyl alcohol | Marangoni Bursting. By Will Donaldson https://www.youtube.com/watch?v=Ax38VQCRsyk

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Papers

- A. D'Aubeterre, R. Da Silva, and M. E. Aguilera, International Communications in Heat and Mass Transfer 32, 677 (2005).
- A. E. Hosoi and J. W. M. Bush, Journal of Fluid Mechanics 442, 217 (2001).
- D. Bratsun, K. Kostarev, A. Mizev, S. Aland, M. Mokbel, K. Schwarzenberger, and K. Eckert, Micromachines 9, 600 (2018).
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- H. Machrafi, A. Rednikov, P. Colinet, and P. Dauby, Journal of Colloid and Interface Science 349, 331 (2010).
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- R. A. Lopez De La Cruz, C. Diddens, X. Zhang, and D. Lohse, Journal of Fluid Mechanics 923, (2021).
- T. Köllner, K. Schwarzenberger, K. Eckert, and T. Boeck, Journal of Fluid Mechanics 791, (2016).
- N. Kovalchuk, Open Chemistry 10, 1423 (2012).
- W. Batson, Y. Agnon, and A. Oron, Journal of Fluid Mechanics 819, 562 (2017).
- Y. F. Yano, H. Tada, E. Arakawa, W. Voegeli, T. Ina, T. Uruga, and T. Matsushita, The Journal of Physical Chemistry Letters 11, 6330 (2020).
- Y. Li, C. Diddens, A. Prosperetti, and D. Lohse, Physical Review Letters 126, (2021).

Problem 11: Balls on an Elastic Band

Connect two metal balls with an elastic band, then twist the elastic band and put the balls on a table. The balls will begin to spin in one direction, then in the other. Explain this phenomenon and investigate how the behaviour of such a “pendulum” depends on the relevant parameters.

I. Phenomenon Demonstration

- Centripetal Spheres by Physicsfun https://www.facebook.com/physicsfunbyrhall/videos/centripetal-spheres/336416410055646/
- Bolas de Fuerza, caseras/Homemade Centripetal Spheres by Delcopond https://www.youtube.com/watch?v=b6nZVVNmR8o

II. Books, Encyclopedia, Discussion and Forum Posts

- Allain, Rhett. “How Much Energy Can You Store in a Rubber Band?” Wired. Conde Nast, March 23, 2018. https://www.wired.com/story/how-much-energy-can-you-store-in-a-rubber-band/.

III. Research Papers

- J. Liu, J. Huang, T. Su, K. Bertoldi, and D. R. Clarke, PLOS ONE 9, e93183 (2014).
- Li, X.; Sun, B.; Zhang, Y.; Dai, Y. Dynamics of Rubber Band Stretch Ejection. Preprints 2021, 2021030294 (doi: 10.20944/preprints202103.0294.v1)
- Oratis, Alexandros T., and James C. Bird. “Shooting Rubber Bands: Two Self-Similar Retractions for a Stretched Elastic Wedge.” Physical Review Letters 122, no. 1 (2019). https://doi.org/10.1103/physrevlett.122.014102.
- P. Kozić and R. Pavlović, Journal of Sound and Vibration 274, 1103 (2004).
- Roundy, D. (2013). Exploring the thermodynamics of a rubber band. American Journal of Physics 81, 20. https://doi.org/10.1119/1.4757908
- Triana, C A, and F Fajardo. “Dependence of Some Mechanical Properties of Elastic Bands on the Length and Load Time.” European Journal of Physics 33, no. 4 (2012): 771–84. https://doi.org/10.1088/0143-0807/33/4/771.
- Vermorel, R., Vandenberghe,N., Villermaux, E. (2007). Rubber Band Recoil. Proceedings of The Royal Society A Mathematical Physical and Engineering Sciences 463(2079). https://doi.org/10.1098/rspa.2006.1781.
- X. Moya,N. D. Mathur,Caloric materials for cooling and heating, Science, 370, 6518, (797-803), (2021).

Problem 12: Strange Motion

Sprinkle small floating particles on the surface of water in a bowl. Bring a strong magnet above and near to the water surface. Explain any observed motion of the particles.

I. Phenomenon Demonstration

- Magnetic Cereal https://www.kjmagnetics.com/blog.asp?p=cereal-contains-iron

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Papers

- Cenev, Zoran, Alois Würger, and Quan Zhou. “Motion and Trapping of Micro- and Millimeter-Sized Particles on the Air–Paramagnetic-Liquid Interface.” *Physical Review E* 103, no. 1 (2021). https://doi.org/10.1103/physreve.103.l010601.
- J. M. D. Coey, R. Aogaki, F. Byrne, and P. Stamenov, Proceedings of the National Academy of Sciences 106, 8811 (2009).
- J. Vialetto, M. Hayakawa, N. Kavokine, M. Takinoue, S. N. Varanakkottu, S. Rudiuk, M. Anyfantakis, M. Morel, and D. Baigl, Angewandte Chemie International Edition 56, 16565 (2017).
- L. E. Helseth, T. H. Johansen, and T. M. Fischer, Applied Physics Letters 93, 042516 (2008).

Problem 13: Candle Powered Turbine

A paper spiral suspended above a candle starts to rotate. Optimise the setup for maximum torque.

I. Phenomenon Demonstration

- Wind turbine powered by candles by Elaine Yap https://youtu.be/honY6CohgpI
- School Science Projects Spiral Convection by DIY Projects https://youtu.be/sxFp3hchVYw

II. Books, Encyclopedia, Discussion and Forum Posts

- Characterization of Candle Flames by ANTHONY HAMINS* AND MATTHEW BUNDY https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=101159

III. Research Papers

- Cross, Rod. “Rotating Ring on a Vertical Rod.” *Physics Education* 56, no. 2 (2021): 023003. https://doi.org/10.1088/1361-6552/abd992.

- Favrin, S., Nano, G., Rota, R. (2016). Preliminary CFD analysis of a ventilated chamber for candles testing. https://re.public.polimi.it/retrieve/handle/11311/1016147/187157/Extended_Abs-Favrin.pdf
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- S. Ghosh, S. Mondal, T. Mondal, A. Mukhopadhyay, and S. Sen, International Journal of Spray and Combustion Dynamics 2, 267 (2010).

Problem 14: Ball on Membrane

When dropping a metal ball on a rubber membrane stretched over a plastic cup, a sound can be heard. Explain the origin of this sound and explore how its characteristics depend on relevant parameters.

I. Phenomenon Demonstration

- BALL TRAMPOLINE – KANNADA – 13MB by Arvind Gupta https://youtu.be/NQJEt1VZK_E
- The World's Bounciest Surface. by The Action Lab https://youtu.be/mHumpKBD8qE
- The Bounciest Surface in the World! by The Gripsion https://www.youtube.com/watch?v=z0enFzMZi24

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Vibrations of a circular membrane https://en.wikipedia.org/wiki/Vibrations_of_a_circular_membrane
- Wikipedia: Hearing the shape of a drum https://en.wikipedia.org/wiki/Hearing_the_shape_of_a_drum
- Vibrations of Ideal Circular Membranes (e.g. Drums) and Circular Plates https://courses.physics.illinois.edu/phys406/sp2017/Lecture_Notes/P406POM_Lecture_Notes/P406POM_Lect4_Part2.pdf
- Drum Head Modal Vibrations https://courses.physics.illinois.edu/phys406/sp2017/Student_Projects/Spring09/Knud_Sorensen/K_Sorensen_Phys498POM_Spring09_Final_Report.pdf
- Circular Drum Head Simulation https://www.compadre.org/osp/EJSS/4495/280.htm
- Circular Membrane (drum head) Vibration by Dan Russell https://youtu.be/v4ELxKKT5Rw
- Vibrations of a Soap Membrane. Bessel function example by LeoGalP https://youtu.be/fs56Ox86eZM

III. Research Papers

- Russel, D. (2010). Basketballs as spherical acoustic cavities. American Journal of Physics 78, 549. https://doi.org/10.1119/1.3290176
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Problem 15: Boycott Effect

If particles are suspended in a liquid that has a lower density than the particles, the particles will settle to the bottom of the container. The rate of settling can be affected by tilting the container that holds the liquid. Explain this phenomenon and investigate the effect of relevant parameters.

I. Phenomenon Demonstration

- Boycott effect (sedimentation) by Fluid Dynamics https://youtu.be/8zjixDxTEN8
- Boycott Effect by Canadian Young Physicists' Tournament https://youtu.be/i1oA8B83180
- The Boycott Effect by Jadon Pauling. https://www.youtube.com/watch?v=AsUVwHQ831o

II. Books, Encyclopedia, Discussion and Forum Posts

III. Research Papers

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Problem 16: Saving Honey

When rotating a rod coated with a viscous liquid (e.g. honey), under certain conditions the liquid will stop draining. Investigate this phenomenon.

I. Phenomenon Demonstration

- Honey Dipper / Honey spoon by ALLT OM BIODLING https://youtu.be/qN_PMjuZ5vI

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Dilatant https://en.wikipedia.org/wiki/Dilatant
- Wikipedia: Non-Newtonian fluid https://en.wikipedia.org/wiki/Non-Newtonian_fluid
- Concept of Shear Thinning – Definition and Applications https://materials-today.com/shear-thinning-definition-applications/
- Wikipedia: Thixotropy https://en.wikipedia.org/wiki/Thixotropy
- Wikipedia: Rheopecty https://en.wikipedia.org/wiki/Rheopecty
- Honey Analysis https://www.intechopen.com/books/5520

III. Research Papers

- C. Faustino and L. Pinheiro, Foods 10, 1709 (2021).
- G. V. B. Costea, M. Neculau, L. Patrascu, and C. Vizireanu, Journal of Biotechnology 256, S73 (2017).
- J. Gasparoux, D. Laux, J. Y. Ferrandis, J. Attal, and P. Tordjeman, Journal of Non-newtonian Fluid Mechanics 153, 46 (2008).
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Problem 17: Invisibility

Lenticular lenses can be used to distort light and make objects disappear. Investigate how changing the properties of the lens and the geometry of the object affect the extent to which the object can be detected.

I. Phenomenon Demonstration

- A Real Invisibility Shield | How Does It Work? By NightHawkInLight https://youtu.be/CFiPJjrmmtE
- DIY Printed Holographic Display(Lenticular Optics Explained). By bitluni https://www.youtube.com/watch?v=ktgbtoCD58I

II. Books, Encyclopedia, Discussion and Forum Posts

- Wikipedia: Lenticular lens, https://en.wikipedia.org/wiki/Lenticular_lens

III. Research Papers

- Banerjee, D., Ji, C., Iizuka, H., 2016. Invisibility cloak with image projection capability. Scientific Reports 6, 38965.. doi:10.1038/srep38965
- Lee, K.-T., Ji, C., Iizuka, H., Banerjee, D., 2021. Optical cloaking and invisibility: From fiction toward a technological reality. Journal of Applied Physics 129, 231101.. doi:10.1063/5.0048846
- R. Barry Johnson, Gary A. Jacobsen, "Advances in lenticular lens arrays for visual display," Proc. SPIE 5874, Current Developments in Lens Design and Optical Engineering VI, 587406 (25 August 2005); https://doi.org/10.1117/12.618082
- Yia-Chung Chang, Li-Chuan Tang, and Chun-Yi Yin, "Efficient simulation of intensity profile of light through subpixel-matched lenticular lens array for two- and four-view auto-stereoscopic liquid-crystal display," Appl. Opt. 52, A356-A359 (2013)
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