Problem 1: Invent Yourself

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

- Heating Effects of Electric Current and Its Applications by toppr
- Conductor Temperature Rise Due to Current Changes in Conductors by The Institute for Interconnecting and Packaging Electronic Circuits https://www.ipc.org/TM/2.5.4.1a.pdf
- Temperature Dependence of Resistivity by toppr
- Electrical Equivalent of Heat (Power Amplifier, Temperature Sensor)
- Ikeda Yoshiro, Yoneta Katsuhiko. Temperature rise of a conductor due to the electric current. 1931 Hokkaido Imperial University Memoirs of the Faculty of Engineering, Hokkaido Imperial University, Volume 2, 107-145. http://hdl.handle.net/2115/37682
- Temperature Coefficient of Resistance Chapter 12 – Physics Of Conductors And Insulators by All About Circuits.
- Heating Effects of an Electric Current by Peda.net
  https://peda.net/kenya/ass/subjects2/physics/form-32/heoaec
Problem 2: Inconspicuous Bottle
Put a lit candle behind a bottle. If you blow on the bottle from the opposite side, the candle may go out, as if the bottle was not there at all. Explain the phenomenon.

- 5 weird ways to put out a candle (YouTube, Physics Girl, Feb 9, 2016), https://youtu.be/WainnKKitGZi?time=61
- How to Blow Out a Candle with a Bottle in the Way ~ Mr. Wizard's Everyday Magic (YouTube, MrWizardStudios, Jan 8, 2014), https://youtu.be/0-Gb1q-g_to
- Blowing Around Corners | Science Experiment for Kids !! (YouTube, HooplaKidzLab, Oct 31, 2014), https://youtu.be/BXe79eO5Ch8
- Blowing Out a Candle Behind a Cylinder (YouTube, JSME FED, Feb 1, 2018), https://youtu.be/JB9BG2KmUzI
- Blowing out candles around corners by The Naked Scientists, https://www.thenakedscientists.com/get-naked/experiments/blowing-out-candles-around-corners
- Blowing Out a Candle Behind a Cylinder by JSME FED
- Turbulence http://labman.phys.utk.edu/phys221core/modules/m8/turbulence.html
  1529-1537.


Problem 3: Swinging Sound Tube

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

- Sound Hose – Whirly Tube (YouTube, Sick Science!, Mar 2, 2009), https://youtu.be/CuGnsW0ysrA
- Twirling sound hose experiment (Sound tubes create low air pressure) (YouTube, Kids Fun Science, May 25, 2017), https://youtu.be/u6uEqszlaZM
- Corrugated sound tube (Youtube, GetAClass – Физика в опытах и экспериментах, Oct. 24, 2019) https://www.youtube.com/watch?v=6r6aPYaHBsA
Problem 4: Singing Ferrite

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

- Magnetostriction, (YouTube, GetAClass – Физика в опытах и экспериментах, Feb. 7, 2019), https://www.youtube.com/watch?v=qAvs6B4Ej1I

Problem 5: Sweet Mirage
Fata Morgana is the name given to a particular form of mirage. A similar effect can be produced by shining a laser through a fluid with a refractive index gradient. Investigate the phenomenon.

- Bending a laser beam. Experiment. (YouTube, Carlos Guirao, April 10, 2011), https://youtu.be/zTx7UoPXvr4
- Gradient Index Optics, (YouTube, University of Rochester, Sep 29, 2014), https://youtu.be/XQj97dva6ss
- Peter W. McCarthy, "Gradient-Index Materials, Design, and Metrology for Broadband Imaging Systems" https://urresearch.rochester.edu/fileDownloadForInstitutionalItem.action?itemId=29594&itemFileId=152209

**Problem 6: Saxon Bowl**

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

**Problem 7: Balls on a String**

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

- Astrojax Orbital Ball Toy from ThinkGeek, (YouTube, ThinkGeek, Oct 8 2013), https://youtu.be/ofywdfGdsNV8

**Problem 8: Soap Membrane Filter**

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

- Self Healing Soap Films, (YouTube, byusplashlab, Oct 16, 2012), https://youtu.be/5ThEyeh6z7g


● The invincible soap bubble! by All Science Fair Projects http://www.all-science-fair-projects.com/project1242_150_2.html

● Surface Tension and Adhesion by Khan Academy https://www.khanacademy.org/science/physics/fluids/fluid-dynamics/v/surface-tension-and-adhesion

● Surface Tension by Georgia Institute of Technology http://www.cns.gatech.edu/~predrag/courses/PHYS-4421-13/Lautrup/surface.pdf


Problem 9: Magnetic Levitation
Under certain circumstances, the ‘flea’ of a magnetic stirrer can rise up and levitate stably in a viscous fluid during stirring. Investigate the origins of the dynamic stabilization of the ‘flea’ and how it depends on the relevant parameters.


Problem 10: Conducting Lines
A line drawn with a pencil on paper can be electrically conducting. Investigate the characteristics of the conducting line.
Problem 11: Drifting Speckles
Shine a laser beam onto a dark surface. A granular pattern can be seen inside the spot. When the pattern is observed by a camera or the eye, that is moving slowly, the pattern seems to drift relative to the surface. Explain the phenomenon and investigate how the drift depends on relevant parameters.

- http://lesnevsky.ilyam.org/etc2/speckles-focus-far.avi
- http://lesnevsky.ilyam.org/etc2/speckles-focus-near.avi
- Topics in Applied Physics Volume 9

Problem 12: Polygon Vortex
A stationary cylindrical vessel containing a rotating plate near the bottom surface is partially filled with liquid. Under certain conditions, the shape of the liquid surface
becomes polygon-like. Explain this phenomenon and investigate the dependence on the relevant parameters

- Nitrogen swirl: creating rotating polygons in a boiling liquid, (YouTube, APS Physics, Jan 28, 2019), https://youtu.be/b6L0vKP1_m4

Problem 13: Friction Oscillator
A massive object is placed onto two identical parallel horizontal cylinders. The two cylinders each rotate with the same angular velocity, but in opposite directions. Investigate how the motion of the object on the cylinders depends on the relevant parameters.

- Friction Oscillator, (YouTube, HayBilt_JLU, Dec 14, 2016), https://youtu.be/-Et_YyjLpCs
- The Friction Oscillator by Enrique Zeleny: http://demonstrations.wolfram.com/TheFrictionOscillator/
- SHM Oscillator (simulations in java) by Chiu-king Ng https://ngsir.netfirms.com/englishhtm/Oscillator.htm
- The Velocity and Temperature Dependence of Rubber Friction https://doi.org/10.1088/0370-1301/66/5/306
- The Velocity and Temperature Dependence of Rubber Friction https://doi.org/10.1088/0370-1301/66/5/306

Problem 14 Falling Tower
Identical discs are stacked one on top of another to form a freestanding tower. The bottom disc can be removed by applying a sudden horizontal force such that the rest of the tower will drop down onto the surface and the tower remains standing. Investigate the phenomenon and determine the conditions that allow the tower to remain standing.

- Tablecloth Trick – Cool Science Experiment, (YouTube, SpanglerScienceTV, Dec 16, 2011), https://youtu.be/PcGtUzZoVc
- Tablecloth Tricks! (Dear Ryan), (YouTube, nigahiga, Mar 29, 2019), https://youtu.be/._0ZvOmsYL8 (Check out 05:42, although the rest of the video is very amusing)
- Inertia Checkers Project, (YouTube, XxemoXxAnimeXx) https://youtu.be/s6O6m3AVuM
- How far can you overhang blocks? By Data Genetics http://datagenetics.com/blog/may32013/index.html
- Solution: ‘Hanging Far Out Over the Edge’ by Quanta Magazine https://www.quantamagazine.org/the-overhang-puzzle-solution-20161202/

Problem 15: Pepper Pot
If you take a salt or pepper pot and just shake it, the contents will pour out relatively slowly. However, if an object is rubbed along the bottom of the pot, then the rate of pouring can increase dramatically. Explain this phenomenon and investigate how the rate depends on the relevant parameters.


Problem 16: Nitinol Engine
Place a nitinol wire loop around two pulleys with their axes located at some distance from each other. If one of the pulleys is immersed into hot water, the wire tends to straighten, causing a rotation of the pulleys. Investigate the properties of such an engine.
Problem 17: Playing Card
A standard playing card can travel a very long distance provided that spin is imparted as it is thrown. Investigate the parameters that affect the distance and the trajectory.

- how to throw playing cards fast and far, (YouTube, Michael Wiseman, Dec 8, 2010), https://youtu.be/nvo3qmDl18I
- Rick Smith Jr. – Throwing Cards, (YouTube, mkarioka, Aug 6, 2010), https://youtu.be/7gK16137k1s


