Problems for

The 2025 USAYPT Invitational Tournament

Somewhere at sometime?

Sizzler Noise Magnets

A classic inexpensive toy sold at dollar stores is the Sonic Sound Sizzler Magnets. Each pack contains a pair of cigar-shaped magnets, which make a sizzling sound when thrown together up in the air. How these magnets work, however, is a physics puzzle. Just playing with them leads to a bunch of questions, such as: What is the magnetic field surrounding each one, when it is in isolation? What are the forces, and torques on one magnet due to the other when they are close together? And, of course, why do they sizzle at a particular frequency?

Investigate, both experimentally and theoretically how these magnets interact.

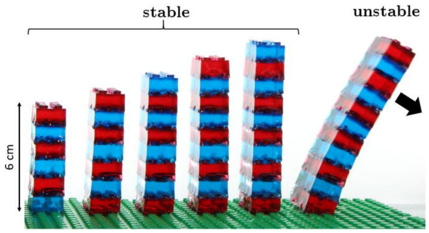
Disc Golf

The fast-growing sport of disc golf employs many flying discs each with quantified flight characteristics. The most common system rates each disc with four numbers called: speed, glide, turn, and fade, which is usually printed on each disc, respectively, as shown.* While there must be physics behind each of these numbers, they are measured simply by disc golfers throwing discs and rating them.

Investigate, both experimentally and theoretically, the physics of the flight of golf discs with different flight characteristics. Go into as much depth as you can, but make sure to experimentally test any theory that you present.

Building with Jell-O™

Tall buildings must be strong enough to hold themselves up, yet elastic enough so that they bend, rather than break, in a natural disaster like a hurricane or an earthquake. Common building materials, such as steel, are both strong and elastic. However, it is difficult to notice the effects of elasticity on toy buildings made of Lego™ bricks, but not if the bricks are made of Jell-O™, as in the photo.†



Use physical experiments with gelatin, and appropriate scaling relations, to model the stability of real skyscrapers. Clearly justify the scaling relations you used to translate the physical conditions in your laboratory to those in the real world.

A Scintillating Conversation

Why do stars twinkle, and planets not so much? How do modern astronomical telescopes "untwinkle" stars to obtain sharper images? These questions relate to the topic of *atmospheric scintillation*, which makes stars appear to jump around and affects what astronomers call *seeing*.

The scintillation or twinkling of starlight can be studied by sweeping the image of a bright star across the field of view of a camera. Even a cell phone has the sensitivity to detect variations in brightness. Characterize scintillation under various viewing conditions. What causes scintillation? Can you model this phenomenon and predict how scintillation varies with atmospheric conditions?

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* The Discmainia™ Genius disc retails for about $10.00, depending on the type of plastic. Note that discs not only come in different plastics, but also with different masses. Discmaina is a Finnish disc design company whose discs are manufactured in Sweden, China, and the USA.

† The figure is from: N. Taberlet, et al., "How tall can gelatin towers be? An introduction to elasticity and buckling," American Journal of Physics 85, 908 (2017).

Note from the Problem Master

About the Problem Writing Process:

Each year I write, but do not solve, a slate of about a dozen problems on a variety of topics, and send them to the USAYPT President, who reads them over for clarity and makes suggestions. After another revision, the President sends them to the Tournament Director, who in turn sends them to the Board of Directors for ranking and comment. Finally, based on the Board's comments, the Tournament Director chooses four problems that work well together as the official problems for the next year. Therefore, like laws, the problems are as written, and it is up to each team to interpret them from then on.

Each *problem* is designed to be primarily a *research question*, rather than a traditional problem. Nobody already knows the answers, but we do have faith that you, the student, will contribute to our understanding of each question. By presenting your work, and debating the questions with colleagues, you demonstrate that you not only understand the physics involved, but are also an active participant in the scientific community.

Clarification of the term *investigate*:

All the problems require both a *theoretical* and an *experimental* investigation. To investigate something *theoretically*, it means that you must start with clearly stated assumptions and derive, or calculate, from those what you expect to measure. This process is called *deductive reasoning*. To investigate something *experimentally*, it means that you must control variables and test hypotheses. This is the process of *inductive reasoning*. Good science combines inductive and deductive reasoning. Good physics is both theoretically derivable and experimentally testable.

In practice, however, real things are complicated, so we usually start with grossly simplistic assumptions, called *hypotheses*, and use deductive reasoning to build a *toy model* that can predict the results of an experiment. Through the process of inductive reasoning, we compare our toy model to experimental measurements, and evaluate our assumptions. By iterating between deductive and inductive reasoning, we learn which assumptions to keep, and which need to be lifted, until the model's predictions match the experiment.

Academic honesty and sources of information:

When you embark on researching a new topic, often you will refer to a source for information, such as a: book, journal article, patent claim, data archive, or any other source of information. In all of these cases, it is important to be clear about where the information came from, which you do by citing each source in context. You never want to confuse your work with work done by others. Whenever possible, it is good practice to find, read, and cite *primary sources*, which were authored by the scientists who did the actual work. If you took the time to read the literature about a topic, and you make that clear, the jurors will reward you for it.

Understanding where data come from is particularly important in science. For example, it is acceptable to use public scientific data, so long as you analyze them yourselves and clearly cite where they came from. Even fundamental constants are measured (or used to define the SI), and need to be appropriately cited.

Additional hints and resources:

I maintain a blog located at: https://jkeohane.wordpress.com/ that contains advice for both the presenter and the opponent. It also contains two important tutorials about: physical modeling and error analysis. These provide more details and examples of what it means to investigate something theoretically and experimentally respectively.

Good luck working through these problems, and I look forward to seeing you at the next USAYPT invitational physics tournament.

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