USAYPT Problems 2026
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Photometry of Flash Bulbs

Textbooks presenting Planck blackbody radiation show idealized spectra from which it appears straightforward to determine a temperature. But physicists and astronomers must often contend with broadband photometric data in which the wavelength selectivity is coarse, and sometimes overlapping. The spectral response of the cone cells in the human retina provides an example of broad-band photometry.

Use quantitative broad-band photometric data to study the behavior of flash bulbs, those vintage devices that produce a burst of light by igniting a tangle of wire in an oxygen atmosphere [1]. How does the total intensity and/or color of the light vary with time? Is the emission determined by the type of bulb, or can it be affected by ignition conditions? Construct a physical model of the light-emitting material that is consistent with your experimental results (temperature, surface area, etc. as a function of time).

Your photometers should be constructed from standard equipment [2].

Eddy Currents and Braking Forces

When a permanent magnet moves relative to a nonmagnetic conductor, Eddy currents are induced and a force pair arises that tends to oppose the relative motion. Explore this phenomenon theoretically and experimentally, with particular attention to the magnitude of the force and its dependence on speed. Consider at least an azimuthally symmetric magnet moving through a cylindrical tube, but feel free to include other geometries, and the effect of parameters other than speed.

Euler-Eytelwein Equation

In a classic statics problem, students must demonstrate that under simplified assumptions, when a rope is wrapped around a post, the tension required to initiate slippage grows exponentially with the length of the wrap. Explore how this idealized result plays out in the real world from both a theoretical and experimental viewpoint. What combinations of materials most closely follow the idealized result? Why / how do deviations arise, and how can they be modeled? Consider exploring both static and dynamic conditions. Photo courtesy Kindel Media.

Multi-Bounce Kinematics

The internet is rife with "trick shot" videos showing improbable outcomes of kinematic experiments, often involving a ball striking or landing in a target following multiple bounces. One of countless examples is provided below. Of course, such videos may have been doctored, and/or selected from a large multiplicity of trials to achieve the demonstrated outcome.

Construct an apparatus in which a ball is dropped or launched in air, bounces from several surfaces, then intersects a defined target plane. At least one bounce-surface should be non-planar. You must be able to measure the coordinates at which the ball intersects your target plane.

Conduct multiple trials as consistently as you can. The target-plane intersection point will nonetheless move about as a result of various effects. These might include variation in the behavior of the ball(s), differences between the actual and theoretical normal vector(s) of each surface, time-variable wind, creep or other changes in the structure, and other effects. Your work should focus on quantifying whatever effects are most important and exploring the statistical variation in the intersection point both experimentally and theoretically using propagation-of-error techniques. Can you use your work to identify characteristics of "trick shot" videos that make them more or less credible? For one example, see https://www.youtube.com/shorts/248ILXyzowc

Footnotes and General Notes from the Problem Master

[1] Although some bulbs are evidently still being manufactured, old stock is inexpensive and widely available on auction sites. Use appropriate precautions with these devices. To a generation accustomed to cell-phone flash units, bulbs can be surprisingly bright. Additionally, although the bulbs are usually coated in a plastic layer for safety, a shield should be placed between the bulb and human observers whenever a bulb is ignited.

[2] Standard equipment here means the “light sensors” available from high school laboratory suppliers, or their equivalent, and colored transparent films that might be found at an office or theatrical supply store. Spectrometers may be used to characterize the instrumental response, but not to take direct measurement of the flash bulbs. You will need to calibrate your photometers using sources having a variety of spectral shapes. Nature provides a well-studied source that appears each morning, and you may be able to think of others.

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.

Real things are often complicated, so we usually start with simplified assumptions, and use deductive reasoning to build a model that can predict the results of an experiment. Through the process of inductive reasoning, we compare our 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 modified. Ideally, the model’s predictions match the experimental results within quantifiable uncertainties. In practice, do not be dismayed if there remains some distance between model predictions and experimental data. You should however strive to explain why.

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 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. Never present work done by others as your own. 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.

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

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