Overview of Brian Hill's Spring 2026 Course Proposals

October 24, 2025

ARRANGED FROM MOST ACCESSIBLE (AP MATH NOT REQUIRED)
TO HARDEST (AP CALCULUS-BASED PHYSICS REQUIRED)

Big-Bang Cosmology

Course Short Name: **Cosmology**

Prereq: Good high school math (AP not required) *Accessible* <=**+**=|===|===> *Hard*

Analog Electronics

Course Short Name: **Electronics**

If another course needs to make significant use of the lab, please do not select this course. It is not feasible to set up and tear down lab stations to accommodate simultaneous lab courses.

Prereq: Very good high school math (AP useful but not required) *Accessible* <===|=**+**=|===> *Hard*

Quantum Mechanics and Quantum Statistical Physics

Course Short Name: **Quantum**

Prereq: One semester of college-level, calculus-based physics *Accessible* <===|===|=**+**=> *Hard*

Big-Bang Cosmology

Course Short Name: **Cosmology**

Prereq: Good high school math (AP not required) *Accessible <=+=|===|===> Hard*

Overview

In 1929, Edwin Hubble used Cepheid variable stars to obtain the distance-redshift relationship that we now know as a Hubble plot. In 1998 Riess *et al*, and independently and one year later Schmidt, Perlmutter, and collaborators, confirmed the essential distance-redshift relationship using supernovae instead of Cepheids. Their research was exciting because it also established a subtle deviation, for which the present explanation is dark energy. Riess, Schmidt, and Perlmutter were awarded the Nobel Prize in 2011.

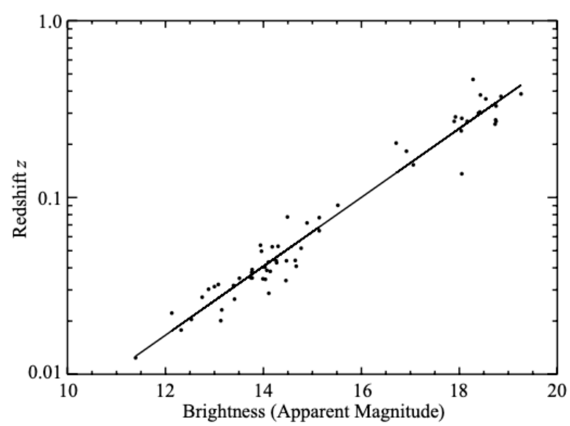
We will study the observational and theoretical developments that are the milestones in more than a century of history, starting somewhat before Hubble's 1929 paper and finishing in the present, as the JWST is now confronting us with further subtle deviations from Big Bang predictions. Do not be misled by clickbait claiming that the Big Bang is being overthrown. To understand these deviations, one first needs to understand the overall framework, and you will see that it can have trouble explaining specific observations while not being under serious threat.

To do justice to the subject of cosmology and to the scientific method, our class will use mathematics, but the mathematics will mostly be limited to algebra and trigonometry. Every physics and cosmological theory that we are confident of, we are confident of precisely because it has been tested quantitatively as well as qualitatively. Similarly, wherever we have doubt in established theories it is because they are having trouble with detailed predictions. We need mathematics and quantitative predictions to appreciation this tension.

The course will first focus on fundamentals such as the properties of light and the black-body spectrum, and the fusion processes in the interior of stars. It will then proceed to the classification of nearby stars and the contents of our galaxy. With these fundamentals, you will be prepared to move farther out into the cosmos. Near the end of the course, we will finally get to the complications of the properties of galaxies and the observed acceleration of the expansion rate that so far can only be explained by dark matter and dark energy, respectively.

Materials

I will be using for our outline the well-regarded 2nd Edition of *Foundations of Modern Cosmology*, John F. Hawley and Katherine A. Holcomb, Oxford, 2005. However, I would digest the material into handouts and provide supplemental readings rather than having you directly read their textbook, which is somewhat too advanced for a course with no prerequisites. At right is a redshift vs. distance diagram from p. 290 of Hawley and Holcomb.



Analog Electronics

Course Short Name: **Electronics**

Prereq: Very good high school math (AP useful but not required) *Accessible <===|=+=|===> Hard*

Overview

Radio Shack was founded in 1921. At its peak in 1999, it had 8,000 stores, but in 2015, it was bankrupt. Radio Shack's arc was the inevitable result of the arc of the electronics industry:

- There was a Frankenstein era going all the way back to the roots of the field where devices were expensive, dangerous, and not very capable. As vacuum tubes became mass produced in the 1920s, the Frankenstein era started to close. By the 1950s, radio and television were consumer items.

- In the 1960s the transistor was invented from fundamentally new materials called semiconductors, and this ushered in a Goldilocks era, where it became far easier to build circuits, and lots and lots of savvy people went to Radio Shack, bought parts, and taught themselves to do it. The synthesizer is among the many creative products of this era.

- The success of the semiconductor era ushered in the HAL 9000 era. The discrete transistor was almost completely replaced by miniature versions of itself replicated *en masse* in integrated circuits and silicon wafers, and even in the most mundane circuitry like that in toasters and thermostats, the componentry became hidden in epoxy-coated boxes that the consumer had no way and little reason to tinker with. Digital circuitry and computers became ubiquitous.

What is the point, today, of tinkering with circuits containing a few discrete components when a general-purpose chip with billions of transistors is already in your pocket? Well, the point is to understand electronics, and be among the few empowered to do new things with electronics.

Materials

In this course, we will return to the Goldilocks era and work through the same materials that countless hobbyists in the 1970s and 1980s used to learn electronics. This is an incredible sweet spot that, like Radio Shack, is well on its way to being forgotten. The materials of the Goldilocks era were hands-on, accessible, and educational. Even though Radio Shack is gone, their kits, some in very good condition, still float around used on eBay. A well-preserved one is pictured at right.

Our course will have some theory, but your time will be dominated by hands-on work with the Radio Shack kits and companion texts authored by Forrest Mims. We will spend about ten weeks of the semester building Mims' introductory circuits, and then in the final few weeks, we'll budget time for each of you to choose a more advanced circuit to build independently.

Quantum Mechanics and Quantum Statistical Physics

Course Short Name: **Quantum**

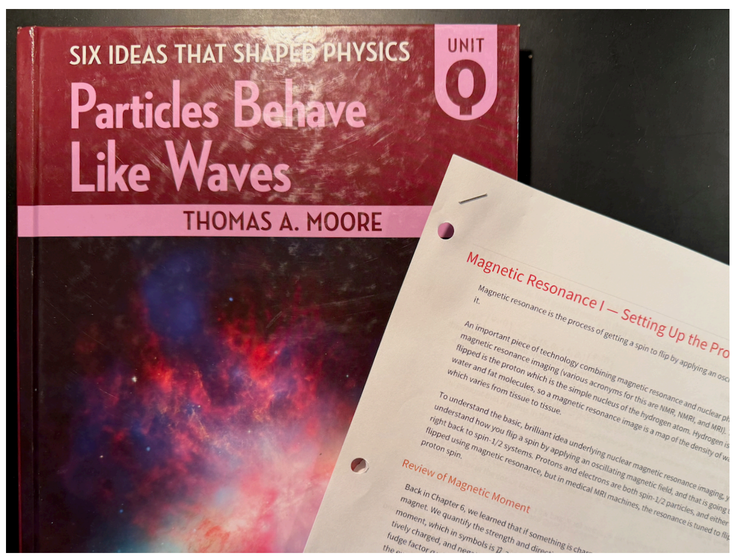
Prereq: One semester of college-level, calculus-based physics *Accessible <===|===|=**+**=> Hard*

Overview

The main goal of a second semester of introductory modern physics would be to understand the 1920s physics created by de Broglie, Bohr, Schrödinger, and Heisenberg. In very roughly the same time period, special and general relativity, which are also advanced and post-Newtonian, were created by Einstein, but they are ultimately comprehensible, and nowadays they are broadly lumped in with classical physics rather than modern physics. Quantum mechanics and quantum statistical physics remain perpetually modern, non-classical, and partially incomprehensible.

The material we will cover in this course is normally encountered only by physics and chemistry majors, typically in their sophomore year after at least two semesters of challenging prerequisites. The curriculum that builds this way is well-crafted and time-honored, but can also feel stale.

In *Six Ideas that Shaped Physics*,Thomas Moore has upended the curriculum so that quantum mechanics and other topics can be encountered sooner. The first two of Moore's six units cover the standard material of the first semester of calculus-based classical mechanics—but even they have a novel organization—and after classical mechanics has been covered, Moore designed the remaining four units to be usable in any order. One of those is Unit Q, "Particles Behave Like Waves."



The idea of this course is to accept Moore's invitation and jump straight from classical mechanics to quantum mechanics, and then from quantum mechanics, we will also be able to introduce the ideas of quantum statistical physics.

Materials

As described above, we will use Unit Q of *Six Ideas that Shaped Physics* by Thomas Moore, and possibly some supplementary materials to round out developments in early 20th century physics. Toward the end of the semester, instead of covering Moore's chapters on nuclear physics, we will delve into quantum statistical physics, which is necessary to understand a variety of exotic phenomena, including magnetic resonance, semiconductors, and supernovae.