The Cosmos: A Survey of Modern Astronomy — GODSAP

Evaluation with respect to the Goals of the Deep Springs Academic Program (GODSAP)

It doesn't work ideally that the GODSAP topics do not attempt to encompass the goals of science teaching. Rather than wedge the actual course goals of science courses into these topics, I have made the following mapping:

Critical Thinking Skills → no change
Reading Skills → Following Technical Arguments and Problem Solutions
Speaking and Listening → Working Collectively to Understand Technical Material
Writing Skills → Solving Technical Problems
General Reflections → no change

Critical Thinking Skills

A survey of astronomy is ideal for developing critical thinking skills within a scientific discipline. The arguments for understanding the cosmos as we currently do are — in broad brush strokes — fully accessible to a student with good high school science. The arguments weave together (a) knowledge of terrestrial experiments and physics, (b) observations from a wide variety of instruments, which historically were mostly visible-light telescopes, but which in the present include telescopes observing the full spectrum of electromagnetic signals, neutrino detectors, and most recently, gravitational wave detectors, and (c) crafty, beautiful, and simple deductions about what those instruments are observing.

In the course I have consistently endeavored to explain not just what we know, which is easy story-telling, but how we know it, which is the way a critical understanding of the scientific edifice is developed.

Following Technical Arguments and Problem Solutions

We used a wide variety of problems, in addition to those in the main body of the text, including those from the text, problems that I developed to further

round those out, and problems that are more like activities for exploration, often based on Prather et al's *Lecture Tutorials*, or Hirshfeld's *Astronomy Activity and Laboratory Manual*. The text itself, and all of these sources of problems both develop and assess the students' ability to follow technical arguments and produce problem solutions.

Working Collectively to Understand Technical Material

We worked collectively as a cohort of four people working through both the principal text and supplementary materials (see syllabus). Each student brought questions to class for others to contemplate. We sometimes did in-class activities jointly, and we sometimes did problems at the board. In general, I would like for a course to have more of the latter two things, but our class times was necessarily dominated by collectively digesting the principal text and the supplemental materials.

Solving Technical Problems

The students had 12 problem sets, all of modest difficulty, but in aggregate these problem sets were designed to meet the goals of (a) doing problems that gain familiarity with the concepts introduced in the reading, (b) gaining general facility with the application of formulae to carry out scientific reasoning, and (c) gaining general facility with scientific calculations (units, powers of 10, approximation methods).

General Reflections

I am confident that the principal textbook is a leading — if not the premiere — textbook for a survey of modern astronomy. The authors are well-regarded researchers, the textbook is very current (with results through 2018), and the text is lavishly illustrated and prepared.

Surprisingly for me, I got a fair amount of pushback at the beginning of the term on my basic plan which was to cover most of the textbook. The textbook was alternately considered by some as too dry and hard, and by others as too dry and easy. I adapted to this by choosing various supplementary materials for Term 5. After confidence in the quality and relevance of the textbook had grown,

rather than introducing additional supplementary materials, I stuck to the principal textbook for Term 6, which gives a grand tour of our galaxy, other galaxies, the early evidence for the big bang, black holes, neutron stars and pulsars, quasars, the evidence for dark matter, the use of High-z supernovae to determine that the universe is accelerating, the cosmic microwave background, and modern cosmology with its close ties to particle physics. There would have been no way to introduce additional supplementary material in Term 6 without derailing this grand tour and we did well with that approach.

One way that the course was a little less successful than I had originally hoped is that it took me much longer to get the hardware and software set up for the students special projects. Only in the middle of Term 6 did these really get going, despite many earlier attempts. Thankfully all three special projects turned out remarkably well and the students are happy with them.

Overall, this course was quite successful both for the students and for me, but not without the aforementioned low points. One student who wanted to drop but was not able to warmly told me she was glad she ended up taking the course. Another student who was planning to rent (e.g., return) the textbook at the end of the term, decided it was worth keeping in her personal library.