DS Terms 2-3, Fall 2022

Course: *From Galileo to Newton: The Emergence of Modern Physical Science*

Discipline(s): Physics

Instructor: Brian Hill

NB: I make the following mapping when applying the GODSAP template to science and math courses:

- 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

Evaluation of *Newton* with respect to the GODSAP

Critical Thinking Skills

This course working through Newton's *Principia* (and materials that Newton relied on) to understand his synthesis of mechanics into three laws of motion, and to understand the Universal Theory of Gravitation.

Newton presents in the style of Euclid and Apollonius: definitions, lemmas, propositions, and corollaries. His arguments are dense and beautiful. They made heavy use of geometric reasoning. As we get to Book III, they survey the known phenomena of the solar system, and show how what has gone before in the *Principia* precisely explains the phenomena.

All of the students (although not of course each to the same degree), immersed themselves in Newton's way of thinking and came away with a view of mechanics and calculus that is quite different and complementary to the standard undergraduate treatments.

Following Technical Arguments and Problem Solutions

We steadily and surely came to understand Newton's ways of solving problems, which are somewhat foreign to the modern mind, even one well-versed in mechanics and calculus. Newton rarely calculates something outright. Instead he calculates ratios. (As an example: where we would calculate an acceleration and be more than happy to use the admittedly oddball units of meters/second-squared, Newton prefers to calculate ratios of distances traveled while holding elapsed time fixed). We worked through proofs in class together. Especially by the time of the final exam, most students were both following technical arguments and applying them to create solutions quite successfully.

Working Collectively to Understand Technical Material

I have to be frank and say that two of the five students led a lot of the discussion. They came consistently excellently prepared and enjoyed being leaders of the discussion. Two more of the five participated more than adequately, but did not take a leading role. The other student was a bit of an outlier: he was vocal but often did not have a great command of the material. For my part, I was also learning Newton's methods and results. Sometimes I had a very good idea of where Newton was heading, other times, it took me two to three classes to master what I thought I was going to be master in one. Out of all of this, I'd say we were quite a successful cohort. We covered what we intended to cover, and we have a rich view of Newton and what he created that complements the standard treatment.

Solving Technical Problems

We had nine problem sets and two exams. Most (but not all) students did high-quality work on the problem sets and exams, and their proficiency grew as the course went on. I was particularly pleased that almost everyone mastered the shell theorem at the end of the course, as evidenced on the four-dimensional shell

theorem that the third problem on the final exam led them through.

General Reflections

This was an ambitious and successful course. The places it fell short were precisely where I was concerned we would have difficulty: (1) Newton was creating a *tour de force* level exposition for his colleagues, not a pedagogy, and (2) Newton's style and the style of the supporting material from Euclid and Apollonius is foreign and arcane for the modern reader.

What would I do about these things if I were to offer the course again? Well, the first is mostly unavoidable, but slowly one can build up a relevant problem bank that complements the material. My problem sets and exams were a fair start on that. (2) The second is part of the intellectual fun, but if I were to offer the course again, I would be clearer (with hindsight) about where it is important to go into Newton's mindset, and where it is fine and indeed desirable, to leave arcane notation behind and produce our own, clearer and syntactically-modernized renditions of his proofs.