Luminary 2022

## Tricking a Rock into Thinking: The Physics of Computing

The invention of the transistor marked a turning point in our computational advancements. Suddenly, the shrinking size of a computing machine made it more accessible to the masses and allowed for electronics to dominate all aspects of life. From the simplest of integrated circuits to the complex lithography that underlies modern processors, this course will examine the physical underpinnings of these systems and how they enable the modern machinery that powers the world. This course will examine content ranging from how silicon is doped to produce nanoscale transistors and the underlying physical models of electrons and the fields they produce via Maxwell's equations to how programming languages are translated to purely physical processes. Additionally, we will look to the future on CPU advancement, including how Machine Learning chips differ from standard computational hardware, the complexities in building 3D NAND, and the rise of quantum computing resulting in the end of many encryption standards. We will also examine the impact of cheap computing on world society and the cultural shifts that have come of that. Students will explore the fundamentals of electricity and magnetism, optics, and circuitry to gain an intuitive understanding of the complex process of designing and constructing computers from first principles.
**PREREQUISITE**: This course requires some advanced mathematics ability. **Geometry is required** and trig is recommended.

## Androids, Aliens, and Atomic Engines: Reading and Writing Science Fiction

What if a planet with two suns protected by solar-powered robots goes dark for only one night a decade? What if an alien race offered to give technology and power to any country that would trade half its citizens? What if the human race discovered a way to travel through wormholes? Questions like these make up the foundation of science fiction, a vast and powerful genre being developed all over the world for over a century. We will analyze the ways sci-fi creators manipulate the details of reality to question, criticize, and explore ideas that could not or cannot be addressed directly due to political or societal pressures. Manipulating reality also allows authors from diverse backgrounds to reimagine futures or pasts when dynamics of power and identity function differently. Students will be reading and writing throughout the entire course, analyzing excerpts and short stories from published science fiction and then exploring parallel ideas and practicing similar techniques in their own craft. Using a survey of pieces in this diverse genre, students will gain an understanding of just some of the possibilities that deliberate alterations of reality can generate in writing science fiction. By the end of the course, students will have produced their own unique works of sci-fi.

## Professional Photography: Before and After the Shutter Clicks

Digital photography is more than just knowing how to handle your camera - there's a lot to consider both before and after the shutter clicks. Together we'll explore how and why cameras have been used over the last couple centuries. We will investigate how we got to this point in photography technology, going all the way from Nicephore Niepce's silver-chloride camera obscura to the first film cameras to devices that start looking like the cameras we're familiar with today. Using these modern image-capturing machines, we'll develop an awareness of the picture plane - how to see the scene before as it will appear as an image rather than as the 3D world before you. At the same time, we'll learn to master skills such as framing, lighting, distance, angling, action lines, implied motion, focal points, visual tension, and shot composition. We won't just be discussing how to take a photo, we also need to know what we're taking photos of and why we're even taking a photo in the first place. What changes when you're taking a photo for your own scrapbook, for a professional event, or for the white walls of a contemporary gallery? Why would you choose photography instead of drawing or painting? What different choices do you make when photographing a place instead of an object or a person? With all these considerations made, we'll take our powerful pictures into the digital darkroom and learn how to correct things like white-balance, lens warp, vignetting, chromatic aberration and more. By the end, you'll have built up both a professional portfolio of individual and collaborative artworks, and develop the skills to expand that portfolio on your own artistic journey.
***MATERIALS****: You must provide your own digital camera and laptop to personally use with Darktable installed (lower-priced cameras can be found for about $50, in lieu of a lab fee for this course).*

## Adventures in Reality: Philosophy and Ethics in Our Tech World

Martin Heidegger thinks we are "chained" to technology, even if we deny it - why does he think that? Nick Bostrom thinks it's very likely that our "reality" is really a simulation - how come? Jason Millar thinks consumers should decide how to program ethics into autonomous vehicles - what do you think? Our modern world of science and technology brings with it many philosophical conundrums and ethical challenges like these. Could we one day build a brain? A person? Would that person think and feel pain? Could we transplant a brain? If we could, should we? Or are mind and matter different substances (Rene Descartes and most Americans think so - do you)? Is reality very different from the way we perceive it (George Berkeley and Donald Hoffman think so - really)? Many of these questions have roots in philosophical problems that have been posed and pondered for centuries. This course will examine such questions, investigate their origins and what answers thinkers have proposed, and look at how they apply to today's technological world. At the same time, we will gather and discuss our own thoughts and opinions and try to discern solutions to these metaphysical and ethical questions and dilemmas. Students will come away with an understanding of philosophical and moral theories that are especially relevant in our technology-driven world, and will devise proposals to advise policy makers and help them come to the best decisions regarding the future of scientific applications.

### Monsters in the Cosmos: Pushing the Boundaries of Modern Astrophysics

What do astrophysicists search for in the night sky? What tools are they using to look? What do they do with the data they find? In this course, we’ll learn how modern astrophysicists work to answer big questions about our universe - what do the origin and future of the universe look like, and what are the limits of our current cosmological models? We will delve into what a universe is made of and how it is structured, and consider why seemingly simple measurements can pose a significant challenge. We’ll start with an exploration of mechanics and astronomical objects, from grains of interstellar dust to galactic structure. We’ll explore electromagnetism and radiative processes to talk about how information from those objects reaches us. We’ll learn about the equations of state and nuclear processes that govern stellar evolution, and how supernovae can be used as measurement tools. Finally, we’ll explore current areas of research - cosmology, the large-scale structure of the universe, dark matter, and dark energy. Students will also learn about optics, photometry, spectrometry, and image analysis, and the course will culminate in students working with an observatory to take their own astronomical images!

**PREREQUISITE**: This course requires some advanced mathematics ability. **Algebra 2 is required** and pre-calc is recommended.

***MATERIALS****: You will need to bring your own laptop with USB capability for sky exploration, image display, and astronomical analysis.*

### Building Believable Physics in 2D Video Games: Simulation and Cohesive Design

One of the core elements of creating a game is believability - making the game "feel right" rather than trying to perfectly simulate our world. A critical element to make things feel "real" is physics, with the ways that objects move and interact contributing significantly to the feel of a game. In this course, we'll dive into the elements of creating physical believability. Although a perfect recreation of our world is not always the right choice, we will learn how we can use physics such as kinematics, forces, and collisions to understand where and how inclusion or exclusion of those behaviors can enhance our physics engine. To create these games, we will learn good programming practices using Python and Pygame, with an emphasis on reuse of code and iterative design to ensure we can tweak parameters effectively. In addition to our focus on physical simulation, we'll also investigate the metaphysics of our games, looking for ways to make them believable when they aren't realistic or perhaps even in spite of their lack of realism. To bring it all together, we will discuss elements of good game design, analyzing the user experience of our and others' games to determine what makes them fun. All of these elements will serve to answer our fundamental question: how do we make our games meaningful?

**PREREQUISITE**: Algebra and experience with programming are recommended.

***MATERIALS****: You will need to bring your own laptop with the ability to install software. Please be sure your computer is not school locked and unusable. If you use a Chromebook, ensure that you can turn on Linux in your settings. Checking that you can install Python 3.7 or later is a good test of suitability.*