

## Physics Department, new and revised subjects, Spring 2021

### NEW SUBJECTS:

#### **8.S227 Special Subject: Technical Communication, Scientific Judgment, and Professional Preparation**

TR 2:30-4:00; virtual

*NOTE: CI-M credit is available to Course 8 majors who take this course*

This course addresses two student needs simultaneously. First, it offers intense practice in technical communication (both written and oral). Second, it uses communication practice in the study of the elements of a scientific or technical career that are typically not encountered in an academic program: the details of scientific publishing; how scientific decisions and errors are made; how legal issues affect scientific/technical work; ethics in and outside of academics. Additional elements (scientific management, language and scientific thinking, scientific/technical creativity-what does it mean?) may be added depending on class interests.

Students will be required to produce several written assignments, both short- and longer-form, including a capstone project; oral presentations will also be required. CIM-8 credit available.

Lecturer: Dr. Richard Price

#### **8.872 Special Topics in Nuclear and Particle Physics: “The Black Hole Information Problem”**

MW 9:30-11:00; virtual

The quantum properties of black holes have been a source of confusion since the work of Bekenstein and Hawking in the early 1970s, but in the last ten years a sequence of developments relating quantum information theory and the AdS/CFT correspondence have led to major advances in our understanding of this problem. These advances have also led to new discoveries in a variety of related fields, including quantum chaos, quantum field theory, quantum error correction, and classical gravity. One of the hallmarks of these developments has been the combination of tools from many different branches of physics, resulting in a high barrier of entry.

The goal of this class is to give a systematic presentation of many of these recent results, starting at a relatively low level that should accommodate a broad audience. Students should certainly be familiar with quantum mechanics, and acquaintance with general relativity and basic quantum field theory would also be helpful but not strictly necessary. NOTE: 8.872 is a standard Physics subject number, which we are using this spring to pilot this new subject; it is possible the topic will become a stand-alone permanent subject in the future.

Lecturer: Prof. Daniel Harlow

## RECENTLY REVISED DESCRIPTIONS OF EXISTING SUBJECTS:

### **8.282 Introduction to Astronomy** **TR 1:00-2:30, virtual**

Quantitative introduction to the physics of planets, stars, galaxies and our universe, from origin to ultimate fate, with emphasis on the physics tools and observational techniques that enable our understanding.

Topics: our solar system, extrasolar planets; our Sun and other "normal" stars, star formation, evolution and death, supernovae, compact objects (white dwarfs, neutron stars, pulsars, stellar-mass black holes); galactic structure, star clusters, interstellar medium, dark matter; other galaxies, quasars, supermassive black holes, gravitational waves; cosmic large-scale structure, origin, evolution and fate of our universe, inflation, dark energy, cosmic microwave background radiation, gravitational lensing, 21cm tomography.

No prior knowledge of astronomy necessary. Not usable as a restricted elective by Physics majors.

Instructor: Prof. Max Tegmark

### **8.284 Modern Astrophysics** **TR 2:00-3:30, virtual**

Application of physics (Newtonian, statistical, and quantum mechanics; special and general relativity) to fundamental processes that occur in celestial objects. Includes main-sequence stars, collapsed stars (white dwarfs, neutron stars, and black holes), pulsars, galaxies, active galaxies, quasars, and cosmology. Electromagnetic and gravitational radiation signatures of astrophysical phenomena will be explored through examination of observational data. No *a priori* knowledge of astronomy is required.

Instructor: Prof. Jacqueline Hewitt

### **8.962 General Relativity** **TR 2:30-4:00, recitations M 4:00, F 11:00, virtual**

Introduction to General Relativity with an emphasis on formal aspects. Topics covered include differential geometry and spacetime curvature, conserved charges and symmetries, causal structure, singularities, and gravitational collapse.

Lecturer: Prof. Netta Engelhardt

## **CROSS-LISTED SUBJECTS OF INTEREST:**

### **6.645/8.582 Physics and Engineering of Superconducting Qubits**

**TR 2:30-4:00, virtual**

**Graduate level, 3-0-9**

**Prerequisites: 6.728 or 8.06 or equivalent**

This course introduces the physics and engineering of superconducting qubits for quantum information processing for graduate and upper-level undergraduate students. Topics will include (1) an introduction to superconductivity and Hamiltonian engineering; (2) superconducting qubits, cavities, and microwave cavity quantum electrodynamics; (3) the theory and microwave engineering of qubit control and measurement; (4) noise, decoherence, dynamical error mitigation; (5) microwave photons, squeezing, and quantum-limited amplification; (6) survey of other solid-state qubit modalities, including semiconductor quantum dots and majorana zero modes; and (7) experimental fault tolerance and quantum error detection. The course will include both classroom lectures, tutorials, homework sets, and hands-on lab practicum with superconducting qubits.

Lecturer: Prof. William Oliver

### **HST.439J/8.245J Viruses, Pandemics, and Immunity (NEW SUBJECT)**

**TR 1:00; recitation R 2:30, virtual**

**Undergraduate level (no first-year students), 2-0-1**

Covers the history of infectious diseases, basics of virology, immunology, and epidemiology, and ways in which diagnostic tests, vaccines, and antiviral therapies are currently designed and manufactured. Examines the origins of inequities in infection rates in society, and issues pertinent to vaccine safety. Final project explores how to create a more pandemic-resilient world.

Lecturer: Arup Chakraborty

## **RECENTLY ADDED SUBJECTS:**

### **8.398 Special Topics in Graduate Physics** **Fridays 12:00, 6-120**

This seminar for first-year grad students, organized in spring 2021 by Prof. Jesse Thaler, will introduce new students to research being conducted in the department and to faculty and scientists who may be adding students to their research groups.

Sessions are held in person to accommodate international students whose F-1 visas require them to take a percentage of their classes in person rather than remotely. US citizens on or near campus who enroll in this subject may also choose to attend in person.

### **Two half-term courses on leadership and professional strategies and skills for grad students,**

#### **8.S396 Developing Your Best Professional Strategies and Skills** **February 16 to April 2, 2021** **TR 9.30-11; virtual**

For many students, academia's many unspoken rules and expectations remain somewhat of a mystery for too long. This prevents students' from reaching their full potential. It also hampers future success in academia by causing frustration and misunderstandings. This course will address many strategies for professional success by focusing on the unspoken expectations of all the skills required for a successful and competitive research career. Participants will learn and hone skills related to giving effective and engaging presentations, writing goal-oriented documents/proposals, gaining confidence in networking, practicing group leadership and associate responsibilities, addressing conflict as it arises, and creating positive work environments. The job application package, process and interviews will also be discussed.

Lecturer and Course director: Prof. Anna Frebel

#### **8.S397 Developing Your Leadership Potential** **April 5 to May 20, 2021** **TR 9.30-11; virtual**

Both leadership and management skills are critical to the success of an MIT PhD after he/she leaves the Institute. Although there is some overlap between these two sets of skills, this course will focus on developing the leadership skills that will make it possible for you to have a greater impact and success in your future work, whether in academia, industry or other area. Each of us has to find their own way in the leadership labyrinth and develop their emotional intelligence, a critical component of leadership, which complements IQ and technical skills. We will investigate self-awareness, self-regulation, empathy, motivation and managing relationships. On the practical side, we will discuss team building, negotiation, managing and resolving conflict, bias, diversity and inclusion. This course is specifically for doctoral candidates in the School of Science.

Lecturer: Dr. Diane Rigos, Associate Director, MITEI Education  
Course Director: Prof. Anna Frebel