Physics 131K

Frontiers of 21st Century Physics

Spring 2016

Dates / contact hours: 300 contact minutes / week for 7 weeks (as per Duke requirements)
Academic Credit: 1 course
Areas of Knowledge: NS
Modes of Inquiry: STS
Course format: lecture, lecture + discussion, field trips (can accommodate up to 25 students)

Instructor’s Information

Haiyan Gao, Henry Newson Professor of Physics, Department of Physics (Duke) and Vice Chancellor for Academic Affairs, DKU, Fitzpatrick Family Professor of Photonics (Duke), Stephen Teitsworth, Associate Professor of Physics, Department of Physics (Duke)

Prerequisite(s), if applicable

Pre-calculus and at least one quantitative science course at high school level

Course Description

Introduction to six big questions representing frontiers of 21st century physics, such as what are the ultimate laws of nature, how does complex structure arise, and how can physics benefit society. Classes will involve presentations by the two instructors, possibly guest speakers, and by students, discussions of journal articles, and tours of physics labs involved with related research. Prequisites: Pre-calculus and at least one quantitative science course at the high school level, such as chemistry or physics. Can accommodate up to 25 students.

Course Goals / Objectives
Students will be expected to master the materials at several different levels of the Revised Bloom Taxonomy, from defining and describing information (lower level) to assessing, evaluating, creating, and integrating information (higher level). Assignments will be aligned with course objectives in a logical manner. Because most of the assignments are written essays and class presentations, students will be expected to display skills in the logical development of an argument, proper literature citations, and other aspects of scientific writing. Rubrics for evaluation will be provided for all assignments so that students will understand the expectations for each task.

**Required Text(s)/Resources**

Students will use articles from the primary research literature, popular science magazines, as well as review articles and other bibliographic sources.

**Recommended Text(s)/Resources**

There are no required textbooks. All reading materials will be provided by the instructor(s) and/or available online.

**Additional Materials (optional)**

PowerPoint

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**Course Requirements / Key Evidences**

Class participation (10% of grade)

1 introductory essay (individual work) (15% of grade)

2 midterm essays (individual work) (20% of grade each)

Group presentation (2-3 people, PowerPoint presentation ~45 minutes each (30 minutes for presentation, 15 minutes for Q&A) based on one of the Big Questions listed below (35% of grade):

BQ1: What are the ultimate laws of nature?

BQ2: What are the uses of quantum mechanics?

BQ3: How do strongly coupled systems work?

BQ4: How does organized behavior arise in complex systems?

BQ5: What does physics say about biological phenomena?

BQ6: How can physics benefit society?

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**Technology Considerations, if applicable**
The Duke Sakai system will be used. The lectures and discussions will be conducted mostly through PPT presentations and online resources.

**Assessment Information / Grading Procedures**

Rubrics for written essays will be provided ahead of time and students will be given their evaluation sheets from scored rubrics. ESL students will receive advice and counseling on their English skills if required or will be referred to the English Writing courses offered at DKU by the Thompson Writing Program faculty and/or ESL faculty. A rubric for the PowerPoint group presentation will also be created.

**Diversity and Intercultural Learning (see Principles of DKU Liberal Arts Education)**

One of the instructors has extensive experience in the university systems and cultures of both China and the US. She has hosted delegations of visiting Chinese scholars, both Chinese high school and university students, and Chinese exchange students in the Physics Department at Duke University. The co-instructors of the course also have research and teaching experience in US, China, and Europe. All aspects of the classroom experience, from classroom discussions to group presentations to library work, will be accomplished with attention to intercultural sensitivity and awareness of global cultural diversity.

**Course Policies and Guidelines**

- The group (3-4 students) needs to work on the presentation together and submit ppt slides to the instructor before the class presentations. Each group may select one person to make the presentation to the entire class or choose to divide the time among group members. All members need to participate in the Q&A session.
- While group discussion and collaboration are highly encouraged, students are expected to follow The Duke Kunshan University Community Standard. Its Community Standard states: “Duke Kunshan University is a community composed of individuals of diverse cultures and backgrounds. We are dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Members of this community commit to reflect upon and uphold these principles in all academic and non-academic endeavors, and to protect and promote a culture of integrity.” Violations of the DKU academic honesty standard will not be tolerated. Cheating, lying, falsification, or plagiarism in any practice will be considered as an inexcusable behavior and will result in zero points for the activity.
- Students are required to attend all classes. Absence will be excused for special circumstance such as illness, family emergency upon written request in advance.
- All required work needs to be submitted on or before the published due day. In special cases such as illness and family emergency, extension may be granted following written request.
- Cell phone use is not allowed during classes, laptop use in class is allowed only for searching for information relevant to the class discussion with the permission of the instructor.

**Tentative Course Outline or Schedule**
Syllabus

The class meets 2 times a week and each time 150 minutes.

Week 1: What are the ultimate laws of nature?
   - Lecture 1: Introduction on fundamental forces, Symmetries and Standard Model
   - Lecture 2: Symmetry breakings, and new physics beyond the Standard Model

Week 2: Fundamental physics of information
   - Lecture 1: Entropy, information and measurement
   - Lecture 2: Quantum measurement, communication and computation

Week 3: Applied physics of information
   - Lecture 1: Physics of measurement and memory
   - Lecture 2: Physics of communications and processing

Week 4: How does organized behavior arise in complex systems?
   - Lecture 1: Introduction to complex and nonlinear systems; complex dynamics in small-scale systems; simple electronic circuits
   - Lecture 2: Complex dynamics in large-scale systems with many degrees-of-freedom; the Earth’s climate

Week 5: The physics and technology of energy
   - Lecture 1: Conservation of energy and the laws of thermodynamics; heat engines and motors
   - Lecture 2: Generation and storage of electric power; batteries; fossil fuels, power plants, and the problem of greenhouse gas emissions

Week 6: Emerging sources of renewable energy
   - Lecture 1: Wind energy and wind energy lab experience
   - Lecture 2: Solar energy and new directions in nuclear energy
Week 7: Class presentations

1 April 2016