

ENVR 672
Principles of Environmental Physics II
Spring Semester 2018

1 General Information

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2 Grading Bases

The bases for assigning grades are as described in the following tables; additional detail about these components is given in sections that follow. The grading basis for graduate students is

In-Class Participation:	50%
Final Project:	50%

and for undergraduate students

In-Class Participation:	50%
Mid-Term Exam:	25%
Final Exam:	25%

3 Introduction

This course is the continuation of a two-semester sequence in environmental physics. The level is appropriate for an advanced undergraduate or early level graduate student. The name “environmental physics” is somewhat unusual. Books with these words in the title are rare and courses by this name are rarely taught in other graduate programs. This seems somewhat strange. Environmental inorganic and organic chemistry, environmental microbiology, environmental policy, etc courses are quite common. Why not environmental physics? Is it that all the relevant physics needed for the study of the environment has been mastered at the undergraduate level? Or is it that the physics needed is so broad and specialized that it is taught in multiple specialized courses that bear different names, such as fluid mechanics, continuum mechanics, solid mechanics, transport phenomena, and process dynamics? If it is the latter, how many typical graduate students are exposed to the breadth of principles covered in this range of courses compared to what fraction of the students could benefit from graduate-level education in physical principles? Another possibility is that physical principles are so important that they are covered in many courses as a part of specialized study in a wide variety of areas. If this is the case, it would seem that we have an inefficient system of graduate education. One other reason could be the lack of a mathematical background on the part of both students and faculty that makes tackling the elements of environmental physics

difficult. Thus, “environmental” courses are offered that deal with the outcomes of environmental processes without considering the causes or physical mechanisms of those processes.

Our view is that an essential element of graduate education involves mastering a set of fundamental principles. This mastery should provide sufficient skill to apply these principles to a broad range of systems that could be encountered routinely. Additionally, this mastery should provide fundamental understanding that will provide a basis for addressing atypical problems or new issues that may develop throughout one’s career. Most certainly, a set of physical principles exists that has widespread application in environmental systems. These principles involve concepts that allow for analysis of environmental systems in terms of the simplest possible set of important variables as well as analysis in terms of continuum representations of conservation principles that provide mechanistic representations of the important processes. This course, along with its prequel, is focused on:

- i. exposing participants to this broad set of principles;
- ii. educating participants in their development and application;
- iii. paving the way for more advanced and specialized study in a wide range of speciality areas; and
- iv. cutting across and integrating the many areas of study collectively referred to as “environmental sciences and engineering.”

4 Course Objectives

Specific objectives for students in this course are the following:

- to understand the broad scope of problems to which the principles of environmental physics can be applied and to appreciate the commonalities that exist among widely varying systems;
- to derive general microscale conservation and balance equations and be able to simplify them in a manner consistent with the physics of systems of interest;
- to learn principles and applications associated with conservation principles applied to a broad range of environmental systems;
- to be able to formulate descriptions of problems at different scales; and
- to appreciate classes of problems that are not tractable with the principles covered in this course.

5 Background Required

The essential pre- or co-requisites for this course are the following:

- calculus through ordinary differential equations;
- partial differential equations;
- calculus-based physics;
- general chemistry;

- computer literacy (e.g., programming in one or more languages, such as Matlab, Mathematica, or C++); and
- completion of the first course in this sequence, or equivalent.

Students who are deficient in one or more of these areas are not necessarily excluded from participation in this course and may be able to successfully complete the course. However, deficiencies in some areas will require additional commitment and effort to master the material in a way that will provide both intellectual satisfaction and a strong grade.

Because this is an advanced-undergraduate or beginning graduate-level course, it is expected that significant time will be required outside of lecture to master the material covered in the lectures and to complete the problem sets. Also dedication to learning the material is assumed, including seeking additional assistance when needed, helping classmates, and consideration of the context of the material presented in class. Those with an “average” background, should plan to spend about 10 hours per week outside of class. Deficiencies in background will require additional time. However, despite these guidelines, it is important that graduate students understand their classes as an activity designed to encourage intellectual growth. Such growth occurs only through immersion in a subject; it does not occur by compartmentalizing course topics to various hours of the day or using a clock to monitor engagement in a course. Students are encouraged to try to integrate what they see in class to what they observe on the news, in experiences of rain storms, of runoff, of air quality, of water quality, of their environment. Those who become sensitive to their environment and come to understand environmental physics as a context for understanding system behavior will gain the most benefit from the course. In essence, participants are encouraged to make this course a part of their lifestyles!

6 Instructional Approach and Participation

This course uses a flipped-classroom model. Students are provided with course notes, and other suggested readings. They are expected to read the material and digest the contents prior to class. Class time is used for in-depth student discussion to be sure students have mastered the material. A common occurrence will be students working through suggested calculations and derivations in detail on a white board. Topics will be addressed in these session that do not come from the notes or readings, but which are approachable using the concepts covered in the course.

7 Semester Project

All graduate students will prepare and present a semester project, which will involve some significant, independent work using the principles of environmental physics. Topics will be open to negotiation in order to direct the student to an appropriate topic and scope of work. Outstanding students may be able to publish the work performed in the project or use it to otherwise advance their research.

8 Exams

Exams will only be given to undergraduate students. For such students, a mid-term and a final exam will be given in this course. These exams will be in-class exams.

9 Course Text and References

The material covered in this course does not map to any available book, so no book purchase is required. Course notes will be prepared and posted on sakai. References will be suggested in addition to the notes. Books on tensor calculus, fluid mechanics, transport phenomena, continuum mechanics, process dynamics, and a high-level programming language will be of some use. There are many available. Students are asked to notify the instructors of any particularly helpful references they encounter that provide either details or context for this course including journal articles, text books, and popular media.

10 Course Outline

The topics to be covered in this course are summarized as follows:

1. Review of Environmental Physics I
2. Conservation of Angular Momentum
3. Turbulence
4. Mechanical Energy
5. Change of Scale Theorems
6. System with Reduced Dimensionality