PEP-575
FUNDAMENTALS OF ATMOSPHERIC RADIATION AND CLIMATE

INSTRUCTOR:	Prof. Knut Stamnes assisted by Prof. Wei Li
SEMESTER:	Spring 2019
COURSE:	PEP575 Fundamentals of Atmospheric Radiation and Climate
TEXT:	Lectures will be based on: Knut Stamnes, Gary Thomas, and Jakob Stamnes, Radiative Transfer in the Atmosphere and Ocean, second edition, published by Cambridge University Press, 2017 (ISBN 978-1-107-09473-4). Lecture notes will be provided.
HOMEWORK:	About one set per week. Solutions will be discussed in class the following week. You will be asked to present your solution to the rest of the class. Assignments will not be graded, but your class participation will be assessed.
EXAMINATIONS:	Midterm. Final.
GRADING:	Class participation: 1/3; Midterm: 1/3; Final: 1/3.

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HOURS: TBA
LOCATION: TBA

INTRODUCTION TO ATMOSPHERIC RADIATION AND CLIMATE

Course Description:

This course treats scattering, absorption and emission of electromagnetic radiation in planetary media. The radiative transfer equation is derived, approximate solutions are found. Important heuristic models (Lorentz atom, two-level atom, vibrating rotator) as well as fundamental concepts are discussed including reflectance, absorptance, emittance, radiative warming/cooling rates, actinic radiation, photolysis and biological dose rates. A unified treatment is provided of radiative transfer within the atmosphere and ocean, and extensive use of two-stream and approximate methods is emphasized. Applications to the climate problem focus on the role of greenhouse gases, aerosols, and clouds in explaining the temperature structure of the atmosphere and the equilibrium temperature of the Earth. The course is suitable for beginning graduate and upper-level undergraduate students. Prerequisites: undergraduate calculus, ordinary differential equations (Ma 221), and basic modern physics (PEP 202 or 242 or equivalent).

INTRODUCTION TO ATMOSPHERIC RADIATION AND CLIMATE

Syllabus:

The following material from the text "Radiative Transfer in the Atmosphere and Ocean" by K. Stamnes, G. E. Thomas, and J. J. Stamnes, Cambridge University Press, 2017 (ISBN 978-1-107-09473-4):

Chapter 1: **Basic Properties of Radiation, Atmospheres, and Oceans**
- Solar and Terrestrial Radiation
- Radiative Interaction with Planetary Media
- Vertical Structure of Planetary Atmospheres
- Density Structure of the Ocean
- Vertical Structure of the Ocean

Chapter 2: **Basic State Variables and the Radiative Transfer Equation**
- Radiative Flux or Irradiance
- Spectral Radiance and Its Angular Moments
- The Extinction Law
- The Differential Equation of Radiative Transfer

Chapter 3: **Basic Scattering Processes**
- Lorentz Theory for Radiation–-Matter Interactions
- Scattering from a Damped Simple Harmonic Oscillator
- The Scattering Phase Function
- Mie-Debye Scattering

Chapter 4: **Absorption by Solids, Aqueous and Gaseous Media**
- Absorption on Surfaces, on Aerosols, and within Aqueous Media
- Molecular Absorption in Gases
- The Two-Level Atom
- Absorption in Molecular Lines and Bands
- Absorption Processes in the UV/Visible
- Transmission in Spectrally Complex Media

Chapter 5: **Principles of Radiative Transfer**
- Boundary Properties of Planetary Media
- Absorption and Scattering in Planetary Media
- Solution of the Radiative Transfer Equation for Zero Scattering
- Formal Solution Including Scattering and Emission
- Radiative Heating Rate, Actinic Radiation, Photolysis Rate and Dose Rate

Chapter 6: **Formulation of Radiative Transfer Problems**
- Separation into Diffuse and Direct (Solar) Radiation Components
- Radiative Transfer in an Atmosphere-Water System
- Examples of Scattering Phase Functions
- Prototype Problems in Radiative Transfer Theory
- Reciprocity, Duality and Inhomogeneous Media

PROPOSED SCHEDULE:

Week 1:	3 hours	Chap 1
Week 2:	3 hours	Chap 2
Week 3:	3 hours	Chap 3
Week 4:	3 hours	Chap 4
Week 5:	3 hours	Chap 4
Week 6:	3 hours	Chap 5
Week 7:	3 hours	Chap 6
Week 8:	3 hours	Chap 7
Week 9:	3 hours	Chap 8
Week 10:	3 hours	Chap 8
Week 11:	3 hours	Chap 9
Week 12:	3 hours	Chap 10
Week 13:	3 hours	Chap 10
Week 14:	3 hours	Review