# *Syllabus*

## *Phys 20054:* The Physics of Climate

Fall Semester 2021

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*TA*: to be assigned

*Prerequisites:* Math 10360 or 10560

The course is offered by the Physics Department to Science and Engineering Majors and provides an introduction to the physics principles dictating the climate conditions on earth. Topics include climate history and development, solar energy transfer and budget, principles of ocean and atmospheric physics, climate models, and climate change.

***Class Content***

The discussion about climate and climate change is a topic that increasingly captures the attention of scientists as well as non scientists. The processes leading to the balance in the earth climate system are fundamental physical processes driven by the laws of thermodynamics, convective hydrodynamics, and radiative transfer. The course will focus on the description and analysis of the underlying physical and chemical processes that define the earth climate. The course will present a short overview of the climate history of our planet as indicated by modern techniques of climate recording. Climate depends critically on the overall energy budget, which is balanced by solar energy and the physical and chemical absorption and reflection processes in our oceans and atmosphere. The physics and chemistry of these processes and the impact on climate balance and weather patterns will be discussed. Global climate predictions require extensive mathematic modeling techniques. The underlying principles will be presented. Finally the course will address questions related to observational evidence and possible consequences for natural and anthropogenic climate change. This part will be discussed in student presentations.

***Course Outline***

1. General concepts of energy transfer and radiation physics
2. Solar radiation and the earth's energy budget
3. Absorption and Irradiation of light and heat (greenhouse effect)
4. Atmosphere and climate
5. Clouds and aerosols
6. Ocean and climate
7. Ocean Currents
8. Climate Proxies
9. History of the earth climate (Paleoclimate)
10. Geoengineering
11. Climate change
12. Consequences of climate change

Each topic will be covered by about two lectures on the underlying principals, followed by one class discussion session. Questions and discussion during the lectures are encouraged!

Unfortunately, there will be two weeks during which the classes will be taught on zoom, August 31 and September 2, because the instructor is attending a scientific conference to present an invited paper in Austria and October 12 and 14, because the instructor will be at the fall meeting of the DNP in Boston to present a couple of scientific papers.

***Course Material***

The detailed class schedule, the lecture notes, and all course material will be provided to the class.

***Textbook and Reading Material***

As official text book I recommend:

F. W. Taylor, *Elementary Climate Physics*, Oxford University Press, 2005, ISBN-0-19-8567340

I preordered this from the book store but did not receive a response yet.
The book unfortunately covers only some of the topics of climate physics which will be discussed in class. Complementary material will be provided and for a more extensive reading I recommend:

David G. Andrews, *An Introduction to Atmospheric Physics*, Cambridge University Press, 2000, ISBN-0-521-62958-6

J. Marshall & R. A. Plumb, *Atmosphere, Ocean, and Climate Dynamics*, Elsevier, 2008, ISBN-13 978-0-12-558691-7

N. Mason & P. Hughes, *Introduction to Environmental Physics*, Taylor & Francis, 2002,

ISBN 0 7484-0765-0
J. P. Peixoto & A.H. Oort, *Physics of Climate*, AIP & Springer Verlag, 1992,
ISBN 0 88318-712-4
K. E. Trenberth, *Climate System Modeling*, Cambridge University Press, reprint 2009,
ISBN 978-0-521-12837-7

***Quizzes and Homework***

Quizzes will be given weekly! The purpose is to test the level of understanding of the course material. On average each quiz will post three questions (no math), reviewing the material covered during the week.

Homework will be given at the end of each of the 12 chapters covered in class. They will test the understanding of the concept and the mathematical treatment of the material. The homework problems will very closely follow the examples giving in class. If students have difficulties with the problems, they should contact the instructor or the TA.

***Class Projects***

Each one of you should pick a project and send me the topic and a couple of sentences on why he/she picked the project and a short abstract on what he/she intends to cover in the essay.

Anthropogenic Climate Changes

1. The economic consequences and opportunities of climate change
2. Agriculture in Mesopotamia
3. Abandonment of Maya Cities
4. The large Midwest Forest clearing
5. Industrial revolution and the impact on global climate
6. Nuclear testing in the 1950-1960ies and the impact on the atmosphere
7. Consequences of tropical deforestation
8. Urban heat islands

Natural Climate Changes

1. Isotope Geology and the mapping of Earth's climate
2. Chicxulub and the death of dinosaurs
3. Volcano eruptions and the consequences for global temperature
4. Sahara in pre-historic times
5. The role of the Amazon jungle for global climate
6. Noah's Flood
7. The little ice age and consequences for medieval life
8. The expansion of the Sahel zone

The final paper on the research project is due at the end of the semester. During the semester you are encouraged to discuss problems and progress with me. The length of the paper should be between 5 and 10 pages (Font Times New Roman, 12pts, line spacing 1.15) The paper should provide a clear introduction to the topic and show how the topic is correlated with the problem of climate or climate change. The student should discuss in more detail the impact on climate and the physics reason for this impact and describe the consequences on climate as observed or anticipated. The paper should present your own conclusions, based on the discussed and presented material and not the opinion of some internet guru. The research should include a thorough literature search, the preference is on scientific material, but also other web-based material and discussion is welcome. In any case, the paper should contain a complete reference list (author, publication, year, pages).

***Exams:***

There will be no mid-term or final exam

***Class Grades:***

Weekly quizzes 25%; Homework 25%; class project 25%; discussion participation 25%

***Honor Code***

All students should familiarize themselves with the Honor Code on the University's website and observe its provisions in all written and oral work, including oral presentations, quizzes and homework, as well as drafts and final versions of essays.