PHY 110 — The Physics of Climate Change
Fall 2025

Meeting Times & Places	**Lecture:**	Tue, 10–10:50am, PAD 168
	Laboratory:	Wed, 9–10:50am, PAD 259
	Discussion:	Thu, 10–10:50am, PAD 168

Instructor: Ben Holder
Email (best method of contact): holderb@gvsu.edu
Office: 152 PAD

Office Hours: Tu 11–12; W 2–3; Th 11-12 (PHC); and by appointment

Course Website and Documents: Blackboard

Course Description: Introduction to the physics of climate change and climate modeling. Introduces the physical processes that determine the Earth's temperature and its variation due to long-time-scale natural effects and contemporary anthropogenic influences. Topics include energy/equilibrium, blackbody radiation, the greenhouse effect, heat transfer by convection, and climate change timescales.

Credits: 4

Prerequisites: MTH 110 (Algebra)

Course Organization: Each week we will consider a different climate-related topic and physical principles related to its analysis. Tuesday's class will generally be in a lecture format, with some assigned reading (from the textbook and/or lecture notes) expected ahead of time. Brief reading quizzes will assess class preparation. This lecture is to prepare students to complete the Laboratory (Wednesday) and Discussion (Thursday) assignments. Lab assignments should be mostly completed within the lab time period, but will be due on Friday. Discussion assignments will be the homework assignment for that week and will be due the following Tuesday.

Textbook: *Introduction to Modern Climate Change*, Andrew Dessler (3rd Ed, Cambridge, 2021)

Evaluation: Grades will be determined from weekly laboratory and discussion/homework assignments, reading quizzes, and a final project/poster, under the following weighting:

Class Preparation/Participation	10%
Discussion/Homework	40%
Laboratory	30%
Final Project	20%

The lowest laboratory assignment will be dropped (allowing for an unexcused absence), other absences must be documented. Assignment grades will be given on a 5-point scale (e.g., with 100 being an "A+", 80 being a "B-", etc). The completion of an assignment will receive at least a "C" (75) and a demonstrated effort toward the correct answers will recieve at least a "B". Final grade boundaries are standard: A 93; A- 90; B+ 88; B 83; B- 80; C+ 78; C 73; C- 70; D+ 68; D 60.

Discussion/Homework: We will spend Thursdays working on the Discussion assignment in small groups. The completion of these assignments after class will the Homework assignment for that week. Students are encouraged to work together on these assignments, but you are expected to turn in your own original and idiosyncratic version of this work (I want to see your thought process in the responses). Late homework will not be accepted, but the lowest homework assignment grade will be dropped.

Laboratory: Each week we will complete a two-hour experimental laboratory related to that week's content. Lab assignments should be mostly completed within the lab period, but will be due at the end of each week (Friday). Printed labs will be available at the beginning of each class and then available electronically on Blackboard. There will be no pre-labs due in F2025. Completed lab reports should include (in a single pdf file, turned in on Blackboard): Your marked up lab with all questions answered completely; work showing any calculation made (or a sample calculation if performed multiple times) with an equation in variables given first, then the numerical calculation; all plots made (with clear and accurate axis labels, units, and titles); any data sets produced; any additional remarks or work done on separate paper.

Final Project: The final week of the class will be devoted to the completion of small project that will be take the form of a poster presentation. These presentations will occur during our final exam period. The final poster will be due at the final exam period, with an earlier deadline to propose and receive approval for your topic (I will help you to narrow its scope).

Final Exam Period: There will be no final exam, but we will meet during the exam period to complete student presentations.

Course Objectives (From the Syllabus of Record): After successful completion of the course, students will be able to...

- Describe the temperature and carbon dioxide time series over geological and contemporary timescales.
- Explain how blackbody radiation of the Sun and albedo of the Earth determine the average incident solar energy flux.
- Explain how physical parameters impact climate model predictions.
- Analyze the effect of carbon dioxide (and other gases) on incident radiation of varying frequencies.
- Experiment with objects and gases, demonstrating transparency/opaqueness to incident radiation of varying frequencies.
- Calculate the equilibrium temperature of the earth with and without an atmosphere, and then including the effects of convection.
- Estimate the uncertainties in measurements, e.g., of temperature and of proxy data, and in climate model output.
- Describe the scientific conclusions presented in technical reports (e.g., by the Intergovernmental Panel on Climate Change (IPCC)) and media articles about climate change.
- Illustrate how evaporation and condensation of water occurs, and its dependence on temperature and humidity.
- Build simple models of atmospheric energy transfer, leading to situations of equilibrium and/or "forcings" from out-of-equilibrium situations.

Academic Honesty: Academic Integrity is discussed in Section 223 of the *Student Code*. You are expected to complete the exams without unauthorized assistance and you should not provide assistance another student. Academic dishonesty will automatically result in an F for the assignment (for all parties involved) and will reported to the appropriate university authorities. Flagrant violations of academic honesty may result in more severe penalties as determined by the appropriate university authorities. Discussing an exam with a student who has not yet taken it is considered academic dishonesty.

Disabilities: Any student who has special needs because of a learning, physical, or other disability should contact *Disability Support Resources* (DSR) at 616-331-2490. If you have a disability and think that you will need assistance evacuating this classroom and/or building in an emergency, please make me aware so that the University can develop a plan with you to assist you.

Inclusion and Equity: The campus of GVSU, including this classroom, is a safe and welcoming space for all students, regardless of age, gender, race, ethnic background, religious affiliation, sexual orientation, and gender identity. Please treat your fellow students with respect and fairness.

General Education: The course satisfies the GVSU General Education requirement for *Physical Sciences* and also the *Laboratory* requirement. The information below details the General Education categories and outcomes that are covered in the course.

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The General Education Program prepares students for informed citizenship, leading to responsible participation in local, national, and global, communities.

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Foundations - Physical Sciences

Knowledge Student Learning Outcomes

1. Explain methodologies physical scientists use to explore and understand the physical universe.
2. Explain ways in which physical scientists use observations and theory to explain and predict the structure and processes of the physical universe.
3. Explain fundamental concepts, principles, and issues of the physical sciences.

Essential Skills Student Learning Outcomes

1. Problem Solving: Design and evaluate an approach to answer an open-ended question or achieve a desired goal.
    - Constructs a clear and insightful problem statement that includes all relevant contextual factors.
    - Identifies multiple approaches for solving the problem that applies to a specific context.
    - Proposes one or more solutions/hypotheses that are sensitive to contextual factors and the ethical, logical, and cultural dimensions of the problem.
2. Quantitative Literacy: Work effectively with numerical data.
    - Calculations are correct, solve the problem, and are presented clearly and concisely.
    - Skillfully converts data into an insightful mathematical portrayal in a way that contributes to a deeper understanding.
    - Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions.

Physics of Climate Change — Fall 2025 — Tentative Course Calendar

Week	Lecture Topic (Tue)	Laboratory (Wed)	Discussion (Thu)
Aug 26–28	Temperatures and CO_2 over Time	Measurement and Uncertainty	Earth's History of Temp
Sep 2–4	Contemporary Climate Change	Global Average Temperature	Weather Indicators of Clim Ch
Sep 9–11	Energy and Equilibrium	Mechanical equilibrium (leaky buckets I)	Energy and Energy Transf
Sep 16–18	EM Radiation (light) and Blackbody	All the light you cannot see (BB rad)	BBody Rad & Earth Temp
Sep 23–25	Atmosphere and Greenhouse Eff I	Heating by radiation	Earth temp: w/Atmosphere
Sep 30 – 2	Atmosphere and Greenhouse Eff II	Absorption of radiation / Blanketing	Atmosph Absorption Spectra
Oct 7–9	Water and Phase Transitions I	Cloud Formation	Evaporation/Condensation
Oct 14–16	Water and Phase Transitions II	Phase Transitions	Earth Temp: Rad-Conv Equil
Oct 21–23	**Fall Break (no class)**	**No Lab (probably)**	Intro to Milankovitch Cycles
Oct 28–30	Paleo Perturbations of Temperature	Milankovich Cycles	More Paleo and Milankovitch
Nov 4–6	Climate Sensitivity	IR absorption by GH gases	CO_2 absorption line
Nov 11–13	Timescales of Climate Change	Equilibration: buckets and radiation	Rates of Change, Timescales
Nov 18–20	Modeling Climate Change	Computational Climate Models	
Nov 25–27	Oceans and Ice	**Thanksgiving (no class)**	
Dec 2–4	**work on project**	Ice and Thermal Exp of H_2O	**work on project**
FINAL EXAM TIMESLOT: Thursday, December 11, 2025, 10am–Noon (Poster Presentations)			