Syllabus
Tides and Planetary Waves
(Physics 8280)
Spring Semester 2025

Instructor Information:

Instructor:	Prof. Jens Oberheide http://globaldynamics.sites.clemson.edu/index.html
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Office Hours:	Wednesday 10:00 – 11:00; I have an open door policy. Students are encouraged to come to my office on an as needed basis any time.
Class Hours:	MWF 9:05 – 9:55, Kinard 223; you may leave class if Prof. Oberheide has not arrived after 15 minutes

Course Mode of Delivery

This is a traditional physics class. I will use powerpoint and work out details on the board as appropriate.

Doing problems is critically important to understand the material. As such, ***regular homework*** will be assigned. You will get feedback on your assignments and (most) solutions will be made available. The use of AI systems is expressly forbidden.

This is an in-person class and in-person attendance is expected.

There will be one midterm exam *(tentatively the March 10-14 week before spring break)* ***and one final exam*** *(tentatively the December 8-12 week before the fall AGU meeting).*

Course Information

Course Rationale: Atmospheric tides and planetary waves are fundamental to all planetary atmospheres and essential for understanding the energy and momentum transfer between different regions of an atmosphere, the energy and momentum budget of planetary thermospheres, dynamo processes, and the distribution of minor constituents and charged particles. The course will provide the student with an advanced graduate level understanding of the theory, observation and impact of tides and planetary waves in Earth's middle atmosphere and in the ionosphere-thermosphere system. The course will also address tides on Venus and Mars, their relevance and future challenges and directions of the field.

Outline, Objectives and Learning Outcomes:

1. Theory (about 5 weeks) Develop the classical tidal and planetary wave theory from first principles; Laplace's Tidal Equation, Hough modes and vertical structure equation; external energy sources: solar radiative and gravitational forcing; internal energy sources and sinks: latent heat, diffusion, radiative damping, gravity wave and ion drag, critical layers; tidal and planetary wave equations with dissipation but without mean winds; tidal equations with mean winds: interaction with mean flow, seasonal and inter-annual variations; mode coupling; nonlinear processes: secondary waves and resonances; Rossby Normal modes; Kelvin waves
2. Observation (about 4 weeks): what parameters to measure; ground-based versus space-based measurements; satellite sampling of tides and planetary waves; satellite data analysis of tides (solar and lunar) and planetary waves; diagnostics of tidal and planetary wave "weather": diagnosing and interpreting short-term tidal variability; lunar tide amplification during sudden stratospheric warmings; recent results
3. Impacts and Hot Topics (about 5 weeks): observation and empirical modeling of thermospheric tides and planetary waves, tidal and planetary wave impact on mean structure of the thermosphere: energy and momentum deposition, constituents, energy budget; plasma density variations imposed by waves due to dynamo action; short-term tidal and planetary wave variability for space weather predictability; new data analysis concepts for the GOLD, ICON, GDC, DYNAMIC satellite missions; tides on Venus and Mars: MGS, MRO, Maven, Venus Express, etc. and their relevance for superrotation, constituent distributions, aerobraking, etc.

Method of Teaching: This is a lecture course based on my own notes. The textbooks are for digging deeper into the theory.

Grading: Assignments in this course are divided into these general categories, which carry the following weight in your final grade calculations:

Category	Weight
Project	30%
Written Homework	30%
Midterm exam	15%
Final exam	25%

There will be ***one midterm exam*** (tentatively in the 10-14 March week) and one ***final exam*** (tentatively in the 8-12 December week, because of AGU).

Students will be assigned an advanced topic not covered in class to demonstrate their mastery of the concepts taught. This will require an extensive literature study of fundamental and contemporary peer-reviewed papers and to overview the assigned topic in a 10-15 page written summary and present the key points to the class in a 20 min short lecture. The grade for the **project** will be 75% written part and 25% lecture part.

Late homework won't be accepted if you do not give me a very good reason.

You are treated as a professional in the course. Accordingly, the grading is strict, but fair. Reading the directions and grading criteria provided for each assignment is the key to understanding how you will be graded.

Letter grade: A: 85-100%; B: 70-85%; C: 55-70%; F:<55%; no D grade and no +- grades.

Recommended Textbooks:

- *Atmospheric Tides* by Chapman and Lindzen
- *Atmospheric Tidal and Planetary Waves* by Hans Volland

Web Sites: The course web site is on Canvas, accessible at https://clemson.instructure.com/courses/255104 It will be used to post homework solutions and some needed material such as the syllabus – so, essentially a file repository.

Course Policies

The following policies are the standard syllabus material. Please read completely.

Prerequisites: PHYS 8210 & 8150 or PHYS 8250, or consent of instructor.

Attendance Policy: This course is designed for active in-person learning and engagement. Attendance and active participation in this course will provide the most benefit for learning. Since you are treated as professionals in the course, ***attendance is not required but highly recommended. I reserve the right to drop any student from the course who stops attending/participating for extended periods of time***

Any exam that was scheduled at the time of a class cancellation due to inclement weather will be given at the next class meeting unless contacted by the instructor. Any assignments due at the time of a class cancellation due to inclement weather will be due at the next class meeting unless contacted by the instructor. Any extension or postponement of assignments or exams must be granted by the instructor via email or other means of communication within 24 hours of the weather-related cancellation.

University Policies

Academic Integrity: The Clemson University statement on academic integrity reads: "As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating or stealing in any form."

Plagiarism is prohibited by Clemson University. Plagiarism includes the intentional or unintentional copying of language, structure, or ideas of another and attributing the work to one's own efforts. Graded works generated by artificial intelligence or ghostwritten (either paid or free) are expressly forbidden in this course.

Student Accessibility Statement: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, Students who experience a barrier to full access to this class should let the instructor know and are encouraged to request accommodations through SAS (Student Accessibility Services) as soon as possible. To request accommodations through SAS, please see this link: www.clemson.edu/academics/student-accessibility-services/how-to-register/requesting-accommodations. You can also reach out to SAS with questions by calling 864-656-6848, email CUSAS@clemson.edu or visiting SAS at the ASC Suite 239. Contact the office for the most updated drop-in schedule if you would prefer not to schedule an appointment.

Clemson University Title IX Statement: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Ms. Alesia Smith is the Clemson University Title IX Coordinator. She is also the Assistant Vice President of Equity Compliance. Her office is located at 223 Brackett Hall, 864.656.3181. Remember, email is not a fully secured method of communication and should not be used to discuss Title IX issues.

Emergency Preparedness Statement: Emergency & Safety Procedures have been posted in all buildings and on elevators. Students should be reminded to review these procedures for their own safety. All students and employees should be familiar with guidelines from Clemson University Public Safety. Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency: 1. Ensure you are signed up for emergency alerts (CU Alerts). Alerts are only sent whenthere is a potential threat to safety, a major disruption to campus services, and for once-monthly tests. 2. Familiarize yourself with all possible exits, safer locations, and other key information onthe emergency evacuation maps in this building and those that you visit regularly. 3. Make a plan for how you would Run, Hide, and Fight in case of an active threat in thisbuilding and those that you visit regularly. Run – What are all the possible exits in this building, and the routes to them? Hide – What are the potential hiding locations in this room and building that are outof sight of doors and windows, how do you lock the door(s), how would youbarricade the door(s) and windows, and where do you turn off the lights? Fight – What tools are available in this room and building, should you have

to fight? 4. Learn what you can do to prepare yourself for the hazards that affect our locations(https://www.clemson.edu/cusafety/emergency-management/emergency-procedures/index.html). 5. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/).