Syllabus
Advanced Optical Remote Sensing
Geography 5120/6120, Spring 2021

Instructor: Dr. Phil Dennison
Class Time and Location: Tuesday and Thursday, 9:10-10:30am
Office Hours: On Zoom, by appointment
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Course Description
Optical remote sensing uses reflected sunlight and emitted thermal infrared radiation to measure the Earth's surface and atmosphere. This course covers remote sensing theory that determines how light and matter interact. It also investigates applications of visible, near IR, thermal IR, and hyperspectral remotely sensed data. Labs demonstrate remote sensing theory, and also work with state-of-the-art data from aircraft and satellites. Topics include modeling absorption and emission of electromagnetic radiation, directional reflectance, spectroscopy, machine learning, and hyperspectral remote sensing techniques. This class is perfect for students who want to the opportunity to learn advanced remote sensing techniques and who are curious about how remote sensing really works.

Learning Outcomes
- Verbally and mathematically describe interactions between electromagnetic radiation and matter.
- Integrate conceptual and mathematical descriptions of interactions with remote sensing applications.
- Calculate radiometric unit conversions, Lambert's Law, Planck's Equation, and Beer's Law.

Prerequisites
For the undergraduate section (5120), completion of Geography 5110 or equivalent experience is required for this course. For the graduate section (6120), no formal prerequisites are required. For both sections some knowledge of trigonometry is expected. For this reason, a basic trigonometry (MATH 1060) or physics (PHYS 1010) course, or equivalent experience (e.g. high school trigonometry), is required. Since we will be using trigonometry in the class, labs, and exams, I strongly recommend that you have access to a scientific calculator or computer that can calculate cosines, sines, tangents, etc.

While all calculations in the class can be done using a scientific calculator, knowledge of a software program or scripting language capable of doing trigonometric calculations could be useful for the calculation sets.

Course Fee
A course fee of $25 per student is assessed to purchase supplies and software for the labs.

Textbooks
There are no textbooks for this course. Reading materials will be provided on Canvas.

Lectures
Lectures will be held on Zoom from 9:10 am to 10:30 am on Tuesdays and Thursdays. As the success of this class depends on interaction, I request that you attend class as scheduled and actively participate. However, all lectures will be recorded to accommodate absences due to COVID-19.

Labs
There will be five labs in this class. Each lab will consist of two parts: a computer exercise, and several questions on the lab and lecture material. To do the computer exercises, you will need a CSBS computing account. If you do not already have a CSBS account, you can request one at https://support.csbs.utah.edu/new-user.php. Answers to lab questions are due at the beginning of class on the day they are due. All labs should be submitted through Canvas. Students are encouraged to work together on lab questions. Students enrolled in the graduate section (6120) are required to answer additional questions at the end of each lab.

Calculation Sets
There will be four calculation sets due during the semester. Each calculation set requires that you apply equations we discuss in lecture to a given problem. Partial credit will be given on calculations if you show correct reasoning in solving a problem, even if your ultimate answer is incorrect. For me to give this credit, you must show your work in addition to your final answers. If you have questions regarding how much work needs to be shown or how partial credit will be given, please see the instructor. Students are encouraged to work together on calculation sets, but please show your work. Students enrolled in the graduate section (6120) are required to solve additional calculations at the end of each calculation set. Calculation sets are due at the beginning of class on the day they are due. Advice: Do not put off solving calculations until the day before they are due. All calculation sets should be submitted through Canvas.

Final Projects
Each student in the class will work on a project that analyzes imaging spectrometer or thermal infrared remote sensing data. A half page project proposal is due **April 1st**. I will encourage you to think about your final project well in advance of this deadline, because it may take significant time to receive the data and master the methods you need to complete the project. **April 22nd and 27th** class periods are set aside for you to work on your project. In a scheduled session during finals week, you will give a 10 minute presentation on your analysis. Required content for your presentation includes:

- Background information on the phenomenon you are examining
- A theoretical explanation of how the phenomenon is expressed in remotely sensed data
- The methodology you used to analyze the data, including justification of why this approach is appropriate
- Your results

Final projects may be done individually, or you can pair with one other student in the class.

Evaluation
The following weights will be assigned to labs and exams to determine grades for the course:

Calculation Sets: 40%
Lab Questions: 40%
Final Project: 20%

Statement on Accommodations
I am willing to grant extensions for lab and calculation set assignments. I request that you check with me about an extension before the assignment is due.

Academic Misconduct Statement
Academic misconduct will not be tolerated. Penalties may include failure of an assignment, the entire course, and/or the filing of formal charges with appropriate university authorities. Academic misconduct includes, but is not limited to, cheating, misrepresenting one's work, and plagiarism:

- Cheating involves the unauthorized possession or use of information in an academic exercise, including unauthorized communication with another person during an exercise such as an examination.
- Misrepresenting one's work includes, but is not limited to, representing material prepared by another as one's own work or submitting the same work in more than one course without prior permission of all instructors.
- Plagiarism means the intentional unacknowledged use or incorporation of any other person's work in one's own work offered for academic consideration or public presentation.

The Americans with Disabilities Act
The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, (801) 581-5020. CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.

University Safety Statement
The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu.

Addressing Sexual Misconduct
Title IX makes it clear that violence and harassment based on sex and gender (which Includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been

harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

Class Schedule

The following schedule lists the anticipated dates for class topics, assignment due dates, and final project deadlines. Updates to the schedule may be provided in class and/or on Canvas.

Date	Topic	Reader	Due
Tue Jan 19	Introduction		
Thu Jan 21	Electromagnetic radiation	Ch 1	
Tue Jan 26	Radiometric units		
Thu Jan 28	Zenith & azimuth angles, Solar geometry	Ch 2	
Tue Feb 2	Solar geometry		
Thu Feb 4	Lambert's cosine law, reflectance	Ch 3	
Tue Feb 9	BRDF, refraction		
Thu Feb 11	Lab 1 – Real-world examples of BRDF		Calculation Set 1
Tue Feb 16	Refraction, specular reflection		
Thu Feb 18	Absorption processes	Ch 4	
Tue Feb 23	Beer's Law, Imaging spectroscopy		*Lab 1 Questions
Thu Feb 25	Imaging spectroscopy		
Tue Mar 2	Lab and field spectroscopy		Calculation Set 2
Thu Mar 4	Spectral matching methods		
Tue Mar 9	Catch Up Class		
Thu Mar 11	Lab 2 – Spectral matching methods		
Tue Mar 16	Spectral mixing		
Thu Mar 18	Lab 3 – Spectral mixture analysis		Lab 2 Questions
Tue Mar 23	Atmospheric absorption and scattering	Ch 5	
Thu Mar 25	Optical depth and radiative transfer		Lab 3 Questions
Tue Mar 30	Catch Up Class		
Thu Apr 1	Lab 4 – Radiative transfer modeling		Final project proposal
Tue Apr 6	Emission processes	Ch 6	Calculation Set 3
Thu Apr 8	Emissivity, Kirchoff's Law		Lab 4 Questions
Tue Apr 13	Machine learning		
Thu Apr 15	Lab 5 – Machine learning: Random Forests		Calculation Set 4
Tue Apr 20	Lab 5 – Machine learning: Random Forests		
Thu Apr 22	Final project work		
Tue Apr 27	Final project work		Lab 5 Questions
Finals Week	Final project presentations, day/time TBD		

*Due date is weather dependent