MECH 4228/5228: Special Topics – Renewable Energy

Mechanical Engineering

College of Engineering, Design and Computing

University of Colorado Denver

COURSE SYLLABUS

Instructor Name: Linyue Gao
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Instructor Website: https://www.gaolinyue.com
Office Hours: Tue/Thu 4:00-5:00 pm or by appointment
Students are welcome to contact Dr. Gao via email to set up meetings even if they are outside office hours.

Term: 2023 Spring
Class Meeting Hours: Tue/Thu 5:00-6:15 pm
Class Location: North Classroom 1402

COURSE OVERVIEW

I. Welcome!

Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. The major types of renewable sources are biomass, hydropower, geothermal, wind, and solar. In this special topic, we will mainly focus on wind energy.

II. University Course Catalog Description

An intermediate-level project-oriented course for renewable energy (wind energy, in particular) covers wind resource assessment, wind turbine aerodynamics, wind turbine wake modeling, wind farm simulation, and wind farm layout optimization. Multiple state-of-the-art tools widely used in academia and industry will be introduced.

III. Course Overview

This course is an introductory/intermediate level for renewable energy and an intermediate/advanced level for wind energy. It covers state-of-the-art information about renewable energy, particularly wind energy, including renewable energy sources, wind resource assessment, wind turbine aerodynamics, wind turbine wake modeling, wind farm simulation and wind farm layout optimization.

IV. Course Goals and Learning Objectives

By the end of the semester, the students will be able to

- Formulate the models to analyze and design wind turbines.

- Conduct real-world wind resource assessment and wind farm planning.
- Model wind turbine wake effects and optimize wind farm layout.
- Estimate the wind farm economics.

V. Course Prerequisites

MECH 3021 (Introduction to Fluid Mechanics) with a grade of C- or higher.

VI. Course Credits

Credits and workload expectations: 3 units (2.5 hours/week lecture). For undergraduate courses, one credit is defined as equivalent to an average of three hours of learning effort per week (over a full semester) necessary for an average student to achieve an average grade in the course. For example, a student taking a three-credit course that meets for 2.5 hours a week, should expect to spend an additional 6.5 hours a week on coursework outside the classroom.

VII. Required Texts and Materials

Textbook (Recommended): Fundamentals of Wind Farm Aerodynamic Layout Design by Torabi (ISSN: 9780128234372).

VIII. Supplementary Texts and Materials

Other reading materials:

- Economics of Renewable Energy: An Assessment of Innovations with Statistical Data by Yoram Krozer (2022).
- Wind Resource Assessment Handbook

Video materials:

- Wind Energy Project Development: Best Practices, Considerations, and Tools https://www.youtube.com/watch?v=bowWGOSwkjs
- Wind Energy Technology Primer: Best Practices, Considerations, and Tools https://www.youtube.com/watch?v=JqiXlU6tneA
- WINDExchange Offshore Wind Webinar: Technology Below the Water https://www.youtube.com/watch?v=V_eGbb_hL8w
- Overview of Floating Offshore Wind
- https://www.youtube.com/watch?v=58EYcYbRKqk

MATLAB materials:

- https://matlabacademy.mathworks.com/

Python materials:

- https://www.python.org/about/gettingstarted/

IX. **Course Schedule** (Could be subject to small modifications – Check Canvas)

Week #	Date	Content	Project (Friday at 5:00 pm on Canvas)
1	01-17 01-19	Introduction to Renewable Energy Introduction to wind energy	Project 1: Resource Assessment
2	01-24 01-26	Atmospheric properties 1 Atmospheric properties 2	
3	01-31 02-02	Wind measurement Wind resource analysis 1	
4	02-07 02-09	Wind resource analysis 2 Wind farm siting	
5	02-14 02-16	Wind farm planning Wind farm resource analysis – case study	
6	02-21 02-23	In-class presentation for Project 1 Wind power	
7	02-28 03-02	Wind turbine aerodynamics – BEM Theory Wind turbine aerodynamics – Blade design	Project 2: Wind Turbine Design
8	03-07 03-09	Wind turbine types: pitch-controlled vs. Stall-regulated WT Wind turbine component efficiency	
9	03-14 03-16	Wind turbine loading Wind turbine design framework	
10	03-21 03-23	Spring break, no class Spring break, no class	
11	03-28 03-30	In-class presentation for Project 2 In-class quiz (open notes/book)	
12	04-04 04-06	Wind turbine wake and its role in wind farm design – conventional wake models Wake model superposition	Final Project: Wind Farm Simulation
13	04-11 04-13	PyWake – Quickstart PyWake – Introduction, and installation	
14	04-18 04-20	PyWake – WindTurbine and Engineering WindFarmModels	
15	04-25 04-27	PyWake – Run wind farm simulation 1 PyWake – Run wind farm simulation 2	
16	05-02 05-04	Experiment – Improve Hornsrev layout In-class presentation for Final Project	
17	Final week	No Final Exam	

EVALUATION

X. Assignments

Project assignments: 3 project assignments will be graded. Assignments are due on Canvas on the dates specified on the homework. No credits for the late homework, unless Dr. Gao is notified in advance, or a medical condition is officially reported.

The regular projects will be done in teams of one to three students that the students can choose. Your team will have the following responsibilities in completing homework:

1. Designate a coordinator, recorder, and one or two checkers for each homework. Rotate these roles for every homework.

2. Agree on meeting times and the individual work to be done before the meetings.

3. Do the required individual preparation.

4. Meet and work. The coordinator keeps everyone on task and makes sure everyone is involved. The recorders prepare the final solution, and the checkers check the solution and ensure that everyone understands the solution and strategy.

5. Submit the assignment and review the returned project report.

XI. Basis for Final Grade

Presentations: In-class presentation about the project deliveries with no makeup.
Projects: Team project. Each team can have 1-3 members.
Final Project: Individual project.
In-class quiz: 1 hour. Tests will be open-book with no makeup.
Pop quiz: If you take all five quizzes (pop quiz 1-5), your final grade will be bumped up to a higher level, e.g., B to B+. Pop quiz 0 (survey) won't be counted toward the final grade.

Final grades are given on an A – F basis with the following weighting:

Final project (individual)	20%
Final project presentation (individual)	5%
In-class quiz	20%
Pop quiz	5% (1%×5)
Projects (team)	40% (20%×2)
Project presentations (team)	10% (5%×2)
Total	100%

Grading Criteria (https://catalog.ucdenver.edu/cu-denver/graduate/records-registration/grading-credits-exams/grading-system/)

Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Lower bound	94	90	87	84	80	77	74	70	67	64	60	NA
Quality points	4	3.7	3.3	3	2.7	2.3	2	1.7	1.3	1	0.7	0

University grading standards will be followed in assigning grades for this course:

- Grade "A": Exemplary achievement of the course objectives. In addition to being clearly and significantly above the requirements, the work exhibited is of an independent, creative, contributory nature.
- Grade "B": Superior achievement of the course objectives. The performance is clearly and significantly above the satisfactory fulfillment of course requirements.
- Grade "C": Satisfactory achievement of the course objectives. The student is now prepared for advanced work or study. Note: The letter grade "C" does not imply satisfactory achievement at the graduate level.
- Grade "D": Unsatisfactory achievement of course objectives, yet achievement of a sufficient proportion of the objectives so that it is not necessary to repeat the course unless required to do so by the academic department.

- Grade “F”: Unsatisfactory achievement of course objectives to an extent that the student must repeat the course to receive credit.

XII. Grade Dissemination

Graded projects in this course will be returned via the Canvas course shell within 1 week of the submission deadline. You can access your scores at any time within the Canvas gradebook. The in-class quiz will be distributed in a class session. I will announce when papers, quizzes, and examinations will be available to be picked up if they are not to be returned during class. To ensure your privacy when papers, projects, quizzes, and examinations are returned in class or made available for pickup, please provide me with a 9x12 envelope.

COURSE PROCEDURES

XIII. Course Policies: Grades

Attendance Policy: You are strongly encouraged to attend the in-person synchronize lectures. Your attendance will be reflected and calculated into the final grade via in-class quizzes and presentations (see section XI) for the course.
Late Work Policy: See section X.
Extra Credit Policy:
There is only one extra credit assignment (optional, detailed information will be available on Canvas/Assignments). If extra credit is granted, the additional points are added to the "In-class quiz" portion of the semester grade. You cannot earn higher than 100% on the "In-class quiz" portion of the grade; any points over 100% are not counted.
Grades of "Incomplete":
The current university policy concerning incomplete grades will be followed in this course. Incomplete grades are given only in situations where unexpected emergencies prevent a student from completing the course; students have up to one year (three semesters) to complete course requirements. Your instructor is the final authority on whether you qualify for an incomplete. Incomplete work must be finished within the time allowed, or the “I” will automatically be recorded as an “F” on your transcript.

XIV. Course Policies: Technology and Media

Email: Students are welcome to contact Dr. Gao and the teaching assistant via the official university email to set up meetings even if they are outside office hours. Dr. Gao will reply to the students’ emails within 48 hours during the weekdays.

Canvas: All the course materials, including but not limited to the syllabus, lecture notes, homework assignments, etc., will be dissemination on Canvas.

- Announcement: The Announcement feature in Canvas, along with the university email system, will be the primary mode of communication for class-related issues. Any messages related to this course that the whole class needs will be sent via Canvas announcements.
- Getting Started with Canvas: The Office of Information Technology (OIT) has a helpful guide for setting up and using Canvas for classes at https://www.ucdenver.edu/offices/office-of-information-technology/get-help/learning-remotely/accessing-course-content.

Laptop and Mobile Device Usage:
You can use laptops and iPad to take notes during the class.

Connecting remotely to CEDC computer labs: Additional computing resources available at the campus labs can be accessed remotely, for example, in performing projects using MATLAB, PyWake or other software. Information on how to connect remotely to computer lab PCs in the College of Engineering, Design, and Computing at CU Denver is available at https://www.cu.edu/docs/computer-help-connect-remote-computer.

XV. Mental Health Resources

CU Denver faculty and staff understand the stress and pressure of college life. Students experiencing symptoms of anxiety, depression, substance use, loneliness, or other issues affecting their mental well-being, have access to campus support services such as the Student and Community Counseling Center, the Wellness Center, and the Office of Case Management. Students also have access to the You@CUDenver online well-being platform available 24/7. More information about mental health education and resources can be found at Lynx Central and CU Denver's Health & Wellness page. Students in imminent crisis can contact Colorado Crisis Services for immediate assistance 24/7 or walk into the counseling center during regular business hours.

UNIVERSITY POLICIES

XVI. Access

Disability Access: The University of Colorado Denver is committed to providing reasonable accommodation and access to programs and services to persons with disabilities. Students with disabilities who want academic accommodations must register with Disability Resources and Services (DRS) in Student Commons Building, #2116, phone 303-315-3510, email disabilityresources@ucdenver.edu. I will be happy to provide approved accommodations once you provide me with a copy of DRS's letter. Note: DRS requires students to provide current and adequate documentation of their disabilities. Once a student has registered with DRS, DRS will review the documentation and assess the student's request for academic accommodations in light of the documentation. DRS will then provide the student with a letter indicating which academic accommodations have been approved.
Extended time (i.e., 1.5 X) for exams can be requested in advance (at least one week ahead) of the Midterms and Final Exam with an accommodation letter from the CU Denver Accommodate system.

XVII. Academic Honesty

Student Code of Conduct: CU Denver defines academic misconduct and sets forth a uniform process for handling allegations of student academic misconduct at CU Denver. As members of the CU Denver community, students are expected to know, understand, and comply with the standards of the University and to accept the responsibility to maintain the highest standards of intellectual honesty and ethical conduct in completing all forms of academic work at the university. In particular, students must refrain from academic misconduct. Detailed information is available at https://catalog.ucdenver.edu/cu-denver/about-cu-denver/university-policies/.

XVIII. Nondiscrimination and Sexual Misconduct

The University of Colorado Denver is committed to maintaining a positive learning, working, and living environment. University policy and Title IX prohibit discrimination on the basis of race, color, national origin, sex, age, disability, pregnancy, creed, religion, sexual orientation, veteran status, gender identity, gender expression, political philosophy or political affiliation in admission and access to, and treatment and employment in, its educational programs and activities. University policy prohibits sexual misconduct, including harassment, domestic and dating violence, sexual

assault, stalking, or related retaliation. If you have experienced some sort of sexual misconduct or discrimination, please visit the Office of Equity/Title IX web site to understand the resources available to you or contact the Office of Equity/Title IX Coordinator at equity@ucdenver.edu or 303-315-2567.

XIX. Important Dates to Remember

Academic Calendar:
The university's current Academic Calendar can be found here.

OTHER: Due to the coronavirus, social unrest, war, or alien invasion it may be necessary to transition to an online format as in previous years.