ENGG*6790 Special Topics in Environmental Engineering

Theory and Applications of Turbulence

Winter 2019
Section(s): C03

School of Engineering
Credit Weight: 0.50
Version 1.00 - June 12, 2019

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1 Course Details

1.1 Calendar Description

A course of directed study involving selected readings and analyses in developing knowledge areas of environmental engineering.

1.2 Course Description

Theory and applications of turbulence is a graduate course designed for future scientists and engineers to develop the fundamental and applied knowledge needed to understand, analyze, and design turbulent processes. Physical and mathematical properties of turbulence are investigated. Turbulence modelling and simulation approaches are investigated. Applications of turbulence are discussed in mechanical engineering, civil engineering, environmental engineering, atmospheric sciences, oceanography, space, physics, and chemistry.

1.3 Timetable

Timetable is subject to change. Please see WebAdvisor for the latest information.

LEC Tues, Thur

10:00AM - 11:20AM

MCKN, Room 313

1.4 Final Exam

There is no final exam for this course.

2 Instructional Support

2.1 Instructional Support Team

Instructor: Amir Aliabadi Ph.D., P.Eng.
Email: aaliabad@uoguelph.ca
Telephone: +1-519-824-4120 x54862
Office: RICH 2515
Office Hours: To Be Announced In Class (TBAIC)

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3 Learning Resources

3.1 Required Resources

Theory and Applications of Turbulence: A Fundamental Approach for Scientists and Engineers (Textbook)

http://aaa-scientists.com/publications.html

Aliabadi. A. A. 2018. Theory and Applications of Turbulence: A Fundamental Approach for Scientists and Engineers. Amir A. Aliabadi Publications, Guelph, Canada.

3.2 Recommended Resources

Turbulent Flows (Textbook)

Pope, S. B. 2000. Turbulent Flows. Cambridge University Press, Cambridge, U.K.

An Introduction to Boundary Layer Meteorology (Textbook)

Stull, R. B. 1988. An Introduction to Boundary Layer Meteorology. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Turbulence: an Introduction for Scientists and Engineers (Textbook)

Davidson, P. A. 2009. Turbulence: an Introduction for Scientists and Engineers. Oxford University Press, Oxford, U.K.

3.3 Additional Resources

CourseLink (Website)

Course material, news, announcements, and grades will be regularly posted to the ENGG*6790 ST03 CourseLink site. You are responsible for checking the site regularly.

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Understand the fundamental mathematical and physical properties of turbulence.
2. Develop and analyze the equations of fluid motion.
3. Understand free shear and wall flows.
4. Understand and analyze scales of turbulent motion.
5. Understand and analyze spectral properties of turbulent motion.
6. Understand, analyze, design, and apply turbulence models and simulations.
7. Critique the advantages, disadvantages, and applications of various turbulence models and simulations.
8. Evaluate turbulence models and simulations.
9. Understand, analyze, or develop turbulent processes in science and engineering.
10. Develop mathematical tools and concepts required for turbulence research.
11. Understand, develop, and apply engineering tools required for turbulence research.
12. Select and apply appropriate turbulence models and simulations for a practical engineering problem.
13. Communicate learning activities in the form of reports.

4.2 School of Engineering - Graduate Degree Learning Outcomes

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
3	Communication Skills	13
3.1	Oral Communication	13
5	Critical and Creative Thinking	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
5.1	Independent Inquiry and Analysis	2, 7
5.2	Problem Solving	8, 10, 12
5.4	Depth and Breadth of Understanding	1, 3, 4, 5, 6, 9, 11

5 Teaching and Learning Activities

5.1 Lecture

Topics: Lecture notes and supporting material will be posted on CourseLink, generally before the specific lecture. Note that posted notes may be incomplete, prepared with the intention that students will take additional notes during lectures.

Week 1: Introduction
Week 2: Equations of Fluid Motion
Week 3: Statistical Description of Turbulent Flows
Week 4: Mean Flow Equations
Week 5: Wall Flows
Week 6: Free Shear Flows
Week 7: Scales of Turbulent Motion
Week 8: Time and Frequency Domains
Week 9: Introduction to Modelling and Simulations
Week 10: Turbulent Viscosity Models
Week 11: Large Eddy Simulation Model
Week 12: Wall Models
Week 13: Model Evaluation
Week 14: Applications

5.2 Seminar

Topics:

Paper presentation requirements will be posted on CourseLink.

Each student will present a research paper about turbulence from the available literature. The presentation is in the format of a journal club. The student will introduce the paper and provide a critique of the paper. The choice of the topic for the research paper is arbitrary, as long as there is relevance with the course content. Students should verify with the instructor the particular paper they wish to present.

5.3 Lab

Topics:

Computer assignment manuals will be posted on CourseLink.

In these assignments, you should guide yourself by the assignment instructions to complete various tasks. You will complete scripts in the Python programming language to perform data analysis or simulations. The scripts in Python are partially completed, i.e.

incomplete, so you should fill in the missing parts to have a working data analysis or simulation. In the short assignment reports, you should include the completed scripts in Python by copying and pasting the code into your report. You should include results in the form of numbers or graphs from the data analysis or simulations. You should also provide answers to any questions in the assignment. Computer assignments will be submitted using a SINGLE Portable Document Format (PDF) through CourseLink Dropbox. Please avoid submitting multiple files as this will overwhelm the instructor when marking. Begin the submission filename with your last name followed by the specific lab compressed name, e.g. Aliabadi WallModel1WallModel2.pdf. Each assignment is worth 4%.

By Term Test 1 Submit the Following Labs:

1: PythonProgramming
2: OnePointTurbulentStatistics
3: RoundJetSimilarity
4: TwoPointTurbulentStatistics
5: IntegralScales
6: StatisticalPercentiles
7: DiscreteFourierTransform

By Term Test 2 Submit the Following Labs:

8: 1DMomentumConstantEffectiveViscosity
9: 1DMomentumMixingLengthEffectiveViscosity
10: 1DMomentumTKEGCI
11: 1DMomentumTKETransient
12: 1DMomentumTKEHeatTransport
13: 1DMomentumTKEPassiveScalarTransport
14: WallModel1 and WallModel2
15: BoxFiltering1DVelocityField

6 Assessments

6.1 Marking Schemes & Distributions

15 Computer Assignments with short reports each 4%, 60%, Weekly
Term Test 1, 15%, Thursday, February 14
Term Test 2, 15%, Thursday, March 28
Paper Presentation, 10%, Last Two Weeks

Two term tests will be administered in class during lecture hours. You primary opportunity to practice for the term tests is to attempt the problems provided in the text.

Assignments will be due at specified dates and times. Late submissions will be assessed but with a 20% mark penalty if submitted within 48 hours of the due date and time. Assignments and project deliverables will not be accepted more than 48 hours after the date and time they are due.

Student submissions may be analyzed using TurnItIn software, or other tools to identify non-original work. All students must submit their own, original writing.

If you miss a test due to grounds for granting academic consideration or religious accommodation, the instructor will determine a mark based on your performance in the entire course. No makeup tests will be administered.

6.2 Assessment Details

PythonProgramming (4%)
Learning Outcome: 1

OnePointTurbulenceStatistics (4%)
Learning Outcome: 1

RoundJetSimilarity (4%)
Learning Outcome: 2

TwoPointTurbulentStatistics (4%)
Learning Outcome: 11

IntegralScales (4%)
Learning Outcome: 4

StatisticalPercentiles (4%)
Learning Outcome: 11

DiscreteFourierTransform (4%)

Learning Outcome: 5

1DMomentumConstantEffectiveViscosity (4%)
Learning Outcome: 8

1DMomentumMixingLengthEffectiveViscosity (4%)
Learning Outcome: 8

1DMomentumTKEGCI (4%)
Learning Outcome: 8

1DMomentumTKETransient (4%)
Learning Outcome: 8

1DMomentumTKEHeatTransport (4%)
Learning Outcome: 8

1DMomentumTKEPassiveScalarTransport (4%)
Learning Outcome: 8

WallModel1 and WallModel2 (4%)
Learning Outcome: 8

BoxFiltering1DVelocityField (4%)
Learning Outcome: 10

Test 1 (15%)
Learning Outcome: 2

Test 2 (15%)
Learning Outcome: 12

Paper Presentation (10%)
Learning Outcome: 13

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7 Course Statements

7.1 Relationship with Other Courses

This course builds on fundamental engineering concepts in mechanics, energy, fluid mechanics, heat and mass transfer, calculus and numerical methods. Students will be expected to have undergraduate preparation in these areas.

Students interested in fluid mechanics and related fields may wish to consider the following courses:

ENGG*4440: Computational Fluid Dynamics (senior undergraduate course)
ENGG*4810: Control of Atmospheric Particulates (senior undergraduate course)
ENGG*6000: Advanced Heat and Mass Transfer
ENGG*6020: Advanced Fluid Mechanics
ENGG*6050: Finite Element Methods

ENGG*6090 ST: Flow-induced Vibrations
ENGG*6090 ST: Heat Transfer in Porous Media
ENGG*6090 ST: Multiphase Flow
ENGG*6740: Groundwater Modelling
ENGG*6840 Open Channel Hydraulics

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for course registration are available in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance and not later than the 40th Class Day.

More information can be found on the SAS website
https://www.uoguelph.ca/sas

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff,

and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars
