ENGG*6790 ST01: TURBULENCE

Winter 2018

UNIVERSITY of GUELPH

School of Engineering

(Revision 0: May 1, 2017)
(Revision 4: November 20, 2017)

1 INSTRUCTIONAL SUPPORT

1.1 Instructor

Instructor:	Amir A. Aliabadi, Ph.D., P.Eng.
Office:	RICH 2515, ext. 54862
Email:	aliabadi@uoguelph.ca
Website:	http://www.aaa-scientists.com
Office hour:	To Be Determined in Class

2 LEARNING RESOURCES

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*6790 ST01 CourseLink site. You are responsible for checking the site regularly.

2.2 Required Resources

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

2.3 Recommended Resources

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

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

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

2.4 Additional Resources

Lecture Information: 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.

Computer Assignments: Computer assignment manuals will be posted on CourseLink.

Paper Presentation Information: Paper presentation requirements will be posted on CourseLink.

Problem Sets: Problems will be posted on CourseLink.

Miscellaneous Information: Other information will be posted on CourseLink.

3 ASSESSMENT

3.1 Marking Schemes and Distribution

Computer Assignments	Short reports	60%	Weekly
Term Test 1	Term Test 1	15%	Thursday, February 15
Term Test 2	Term Test 2	15%	Thursday, March 29
Paper Presentation	Presentation	10%	Last Two Weeks

3.2 Assessment Details

Computer Assignments	Due Date
PythonProgramming	Submit by Term Test 1
OnePointTurbulentStatistics	Submit by Term Test 1
RoundJetSimilarity	Submit by Term Test 1
TwoPointTurbulentStatistics	Submit by Term Test 1
IntegralScales	Submit by Term Test 1
StatisticalPercentiles	Submit by Term Test 1
DiscreteFourierTransform	Submit by Term Test 1
1DMomentumConstantEffectiveViscosity	Submit by Term Test 2
1DMomentumMixingLengthEffectiveViscosity	Submit by Term Test 2
1DMomentumTKEGCI	Submit by Term Test 2
1DMomentumTKETransient	Submit by Term Test 2
1DMomentumTKEHeatTransport	Submit by Term Test 2
1DMomentumTKEPassiveScalarTransport	Submit by Term Test 2
WallModel1 and WallModel2	Submit by Term Test 2
BoxFiltering1DVelocityField	Submit by Term Test 2

Computer assignments: 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%.

Term tests: 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.

Paper Presentation: 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.

3.3 Course Grading Policies

Academic Consideration: When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the instructor in writing, with your name, student ID#, and e-mail contact. See the graduate calendar for information on regulations and procedures for Academic Consideration:
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/sec_d0e2223.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the graduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
https://www.uoguelph.ca/registrar/calendars/graduate/2017-2018/index.shtml

Passing grade: In accordance with the policies of the office of graduate studies, the minimum grade required to pass the course is 65%.

Late Submissions: 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.

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

Missed Tests: 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.

4 AIMS, OBJECTIVES & GRADUATE ATTRIBUTES

4.1 Calendar 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.

4.2 Course Aims

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.

4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability 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.

4.4 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/D2L but these are not intended to be stand-alone course notes. 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 project.

4.5 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and tutorials. 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.

4.5.1 E-mail Communication

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

4.5.2 Recording of Materials

Presentations which are made in relation to course work—including lectures—cannot be recorded in any electronic media without the permission of the presenter, whether the instructor, a classmate or guest lecturer.

4.6 Relationships with other Courses

4.6.1 Previous 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.

4.6.2 Follow-on Courses:

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

5 TEACHING AND LEARNING ACTIVITIES

5.1 Timetable

Lectures:
Two Lectures 1:30 hh:mm Each

5.2 Lecture Schedule (Approximate)

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

5.3 Important Dates (Graduate Calendar)

Friday, December 1: Add period for Winter 2018 begins
Monday, January 8: Classes commence
Friday, January 12: Add period ends, last day to drop two-semester courses
Thursday, January 25: 14th class day; no new student registration permitted after this date
Monday, February 19: Winter break begins - no classes scheduled this week
Monday, February 26: Classes resume
Friday, March 9: 40th class day - last day to drop one semester courses
Friday, March 30: Holiday - no classes scheduled
Friday, April 6: Classes conclude

6 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.

7 ACADEMIC MISCONDUCT

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 discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. The Academic Misconduct Policy is detailed in the Graduate Calendar:

http://www.academicintegrity.uoguelph.ca/

8 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208, email csd@uoguelph.ca or see the following website:
http://www.uoguelph.ca/csd/

Alternatively, contact DHR at 519-824-4120 ext. 53000, email dhrinfo@uoguelph.ca or see the following website:
https://www.uoguelph.ca/diversity-human-rights/accessibility/

9 RECORDING OF MATERIALS

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

10 RESOURCES

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

https://www.uoguelph.ca/registrar/calendars/graduate/current/index.shtml