

Inhomogeneous Turbulence (Turbulence Modeling)

A Spring 2024 Class for Students Who Want to Predict Chaotic Flows
EGM6934 - Special Topics in Engineering Mechanics: Inhomogeneous Turbulence, Class# 25196

M, W, F / Period 4 (10:40 AM - 11:30 AM)

Location: MAEB 0229 Academic Term: Spring 2024

“Big whorls have little whorls
which feed on their velocity
and little whorls have lesser whorls
and so on to viscosity”

~Lewis Fry Richardson, 1922

Professor

Associate Professor S. A. E. Miller, Ph.D.
University of Florida Department of Mechanical and Aerospace Engineering
Theoretical Fluid Dynamics and Turbulence Group (<https://faculty.eng.ufl.edu/fluids>)
MAE-A 220, Gainesville, FL 32611, PO Box 116250
Contact preference - <https://ufl.instructure.com> message via Canvas

Office Hours

M W, 9:30AM - 10:20 AM, Office MAE-A 220 (or new office in NEB 4th floor, TBD), or via confirmed written appointment. Students are expected to come with pre-prepared technical questions regarding course content.

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

N/A

Course Description

Aerospace Engineering / Special Topics in Engineering Mechanics (Credits 3)

Course Pre-Requisites / Co-Requisites

Graduate class in fluid dynamics and/or turbulence, or permission of the instructor. Some programming knowledge.

Course Objectives

A class that covers in depth concepts of the science and mathematics of turbulence modeling with a historical perspective. Examples are given as much as possible involving contemporary approaches. Statistical quantities, averages, correlations, coherence, the Russian school, law of the wall, chaos, compressible NSE, averaging relations, mean kinetic energy, Re stress transport eqn., boundary layer equations, two-dimensional in laminar and turbulent flows, mixing length concepts, Baldwin-Lomax, Cebeci-Smith, 1/2-equations, one-equation models, Prandtl's model, Spalart-Allmarus, $k-\omega$ and $k-\epsilon$, Boussinesq, nonlinear relations, stress transport models, closure, applications and examples, physical considerations, Morkovin hypothesis, studies in particular flows. These topics will be related to turbulent flows that are observed in our daily lives and within various fields of engineering.

Materials and Supply Fees

None

Required Textbooks and Software

Various handout material provided digitally by professor. A scientific calculator is highly recommended. An open source compiler such as C (gcc) or Fortran (gfortran) are required and freely available online.

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Recommended Materials

N/A – see required Textbooks and software.

Course Schedule

Approximate Estimate

- Classes 1 through 5 - Introduction
- Class 6 - Solver discussion
- Classes 7 - 11 - Equations of motion
- Class 12 - Solver discussion
- Classes 13 - 15 - Physics of canonical flows
- Classes 16 - 19 - Algebraic models
- Classes 20 - Solver discussion
- Classes 21 - 26 - One equation models
- Classes 27 - Solver
- Classes 28 - 31 - Two equation models
- Classes 32 - 33 - Reynolds stress models
- Classes 34 - 36 - Compressibility of turbulence
- Classes 38 - LES / DNS
- Classes 39 - Presentations

Important Dates

- All deadlines and important dates are introduced in class, through the class website, or via Canvas message.

Attendance

- Attendance is required and lack of attendance on a regular basis as judged by the professor will result in failure.
- Required statement by the University of Florida: Excused absences are consistent with university policies in the undergraduate catalog and require appropriate documentation. (<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies>)

Policy on Deadlines

- Late submission of class material is not accepted. Students are responsible for turning in assignments on time.
- Do not email or contact the professor with explanations for missed deadlines, late work, etc.
- If a tragedy has occurred, then instructor notifications are required. See <https://care.dso.ufl.edu/instructor-notifications> for details. Note that, “Professors have the right to accept or reject the notification.”

Ethics

- Any kind of cheating, lying, dishonesty, or any other honor code violation results in a failing grade for the entire course. Violations are reported without student notification per university policy.

Evaluation of Grades and Grading Policy

Course Grade Evaluation Criteria

- A four-part computer programming project will result in a stand-alone marching boundary layer solver. Submissions consist of a short description, results, and source code for each part. The computer projects must be completed or a failing grade will be assigned.
- A short-term paper on the order of five pages and on a subject of the students choosing will be written. It will consist of three parts: abstract, outline, and final paper. The details

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of the assignment, format, and deadline(s) are posted on the class website. The paper must be of AIAA Journal submission quality. The term paper must be submitted or a failing grade will be assigned.

- At the end of the semester each student will present their term paper in the form of a presentation that lasts approximately ten to the class. The presentation must be presented or a failing grade will be assigned.
- Students are expected to attend class and actively participate.
- Weighting of grades (total 1.00)
 - Attendance 0.15
 - Class Participation 0.05
 - Computer Project 0.40
 - Presentation 0.15
 - Term paper 0.25
- The final grade will be assigned via the straight scale:
 - 4.00 (A) → [93.33, 100.00],
 - 3.67 (A-) → [90.00 to 93.33),
 - 3.33 (B+) → [86.67 to 90.00),
 - 3.00 (B) → [83.33 to 86.67),
 - 2.67 (B-) → [80.00 to 83.33),
 - 2.33 (C+) → [76.67 to 80.00),
 - 2.00 (C) → [73.33 to 76.67),
 - 1.67 (C-) → [70.00 to 73.33),
 - 1.33 (D+) → [66.67 to 70.00),
 - 1.00 (D) → [63.33 to 66.67),
 - 0.67 (D-) → [60.00 to 63.33), and
 - 0.00 (E) → [00.00 to 60.00).
- Final grades are rounded to the nearest hundredths place before assignment.
- The final course grades may be curved at the discretion of the professor.
- Students who are active throughout the course, interact regularly, continually ask excellent questions, turn their work in on time, may receive significant letter grade increases at the end of the course at the discretion of the professor.

Grade Corrections

Corrections of grades must be submitted promptly within 3 business days after grade posting. A statement in writing on why there has been an error must be submitted through Canvas. The message should be directed towards the TA / Graders for homework and to the professor for other assignments.

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Required Information by the University, College, and Department

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period

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opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- HWCHE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu

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- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

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Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

On-Line Students Complaints: <https://distance.ufl.edu/getting-help/>;
<https://distance.ufl.edu/state-authorization-status/#student-complaint>.