



Syllabus
Applied Mathematics & Statistics 553.793
Turbulence Theory
Spring, 2022
(4 credits, EQ)

Description An advanced introduction to turbulence theory for graduate students in the physical sciences, engineering and mathematics. Both intuitive understanding and exact analysis of the fluid equations will be stressed. Previous familiarity with fluid mechanics is not required, although it could be helpful.

Instructor

Professor Gregory Eyink, eyink@jhu.edu, <http://www.ams.jhu.edu/~eyink>
Office: Wyman Park N449, 410-516-7201, <https://wse.zoom.us/j/7633492271>
Office hours: ??? and by appointment

Teaching Assistant

Jiahao Hou, jhou20@jhu.edu
Office: <https://jhubluejays.zoom.us/j/????>
Office hours: ???

Meetings

Lectures: Monday, Wednesday, 4:30–5:45pm, Hodson 216 and <https://wse.zoom.us/j/91941544232>

Textbook

Recommended:

H. Tennekes & J. L. Lumley, *A First Course in Turbulence* (MIT Press, 1972)
U. Frisch, *Turbulence: The Legacy of A. N. Kolmogorov* (Cambridge University Press, 1995)
The lectures will be based upon the online course notes at:
<https://www.ams.jhu.edu/~eyink/Turbulence/notes.html>

Online Resources

Webpage: Please point your browser to <http://www.ams.jhu.edu/~eyink/Turbulence> for all assignments, solutions, and lecture handouts. Occasionally, the website will also be used to provide reminders and additional information. (Typically this info will also be transmitted to the class via email.) Please check the website frequently for updates.

Piazza: This term we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, the TA, and myself. Rather than emailing questions to the teaching staff, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com.

Find our class signup link at: <https://piazza.com/jhu/spring2022/553793>

Blackboard: We shall not use Blackboard a great deal, but Panopto recordings of all lectures will be available there for asynchronous viewing. Go to <https://blackboard.jhu.edu/webapps/login>.

Course Topics

- Critical Experiments & Simulations (wind tunnels, wakes, channel flow; Earth Simulator).
- Navier-Stokes Equation (physical foundations, symmetries, conservation laws).
- Effective “Large-Scale” Equations (derivation & physical interpretation, orders of magnitude).
- Turbulent Energy Cascade (energy flux; Onsager Theorem; scale-locality; helicity cascade).
- Universal Statistics at Small-Scales (scaling, 4/5th law, multifractal model, return to isotropy).
- Vortex Dynamics (cascade & vortex-stretching, Betchov relations, vortex-line motion).
- Lagrangian Particle Dynamics (Taylor & Richardson diffusion, Kraichnan model).
- Wall-Bounded Turbulence (channel-flow, pipe-flow).
- Other Turbulent Systems (two-dimensional & geostrophic, compressible, MHD, etc.)

Course Expectations & Grading

Grading & Homework The student’s final grade will be based upon weekly homework assignments. Homework will consist of problems covering material up to 2 days before the due date. Please review the Homework Submission Guidelines below. Homework cannot be accepted for credit after solutions have been posted on-line. If a homework is missed and there is a valid excuse, then it will be removed from the student’s total grade for the course, and the remainder of the homework assignments re-weighted.

Attendance: Students are not formally penalized for missing lectures/sections. However, it is the student’s responsibility to turn in any homework due on the date of the missed class. Although participation in online discussion at Piazza will not be graded, statistics of participation by each student will be monitored and may play a role deciding grades in borderline cases.

Homework Submission Guidelines

Please make sure your name is on your homework submission. Please write neatly. The unreadable is ungradeable. Please submit your problems in the order they appear on the assignment sheet. Please make sure to show all work and document any assumptions you are making. If you use special computer software (e.g., MATLAB, Python, Excel, etc.) to complete your homework/project, please read, and adhere to, the Software Usage Guidelines (see below). Homework is due by 5pm Eastern US time on the posted date unless otherwise instructed.

Software Usage Guidelines

You may use any applicable software to do homework assignments, e.g. MATLAB, Python, Excel, etc. Please include not only printouts of results but also all relevant codes. The codes should be sent to the TA or instructor (e.g. in a zipped directory) as specified by them. The answers from the computer must include the requisite amount of explanation. Unless specifically instructed otherwise, you may use symbolic computation software for theoretical problems, but again you must include printouts of relevant code.

Ethics

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In addition, the specific ethics guidelines for this course are:

- (1) If you work in a group you *must* write up your solutions separately. Anything that looks too much like someone else’s work is likely to be considered cheating. Such assignments will receive a grade of zero and you may be subject to other disciplinary action.
- (2) If you work in a group on coding for homework, the group cannot create a joint computer printout and copy it for all group members. Even if you work in a group, you must still do the software work yourself and turn in your own output.
- (3) You are free to use any online material (books, articles, Wikipedia pages, etc.) to assist you in the solutions of homework, but any such material must be cited in your submission with an appropriate

reference (e.g. url). If material is taken without credit from an online (or any other) source, it will be considered plagiarism.

Report any violations you witness to the instructor. You may consult the associate dean of student conduct (or designee) by calling the Office of the Dean of Student Life at 410-516-8208 or via email at studentconduct@jhu.edu.

You can find more information about university misconduct policies on the web at these sites:

- Undergraduates: <https://studentaffairs.jhu.edu/policies-guidelines/undergrad-ethics/>
- Graduate students: <http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/>

Personal Wellbeing

- Because of the ongoing COVID-19 pandemic special requirements will be in effect this term, and these may vary during the term. Please keep updated with these at the following sites:
 - University information: <https://covidinfo.jhu.edu/>
 - WSE information: <https://engineering.jhu.edu/covid-19>
- As of the start of the term all students, instructors and staff must complete health screening daily using the ProDensity app before coming to campus. Masks must be worn properly at all times while in the classroom and other indoor spaces. Vaccination is required unless an exception has been granted by the university for health or religious reasons. Periodic asymptomatic testing may be required. Please follow the university guidance faithfully.
- The Johns Hopkins COVID-19 Call Center (JHCCC), which can be reached at 443-287-8500 seven days a week from 7 a.m. to 7p.m., supports all JHU students, faculty, and staff experiencing COVID-19 symptoms. Primarily intended for those currently within driving distance of Baltimore, the JHCCC will evaluate your symptoms, order testing if needed, and conduct contact investigation for those affiliates who test positive. More information on the JHCCC and testing is on the coronavirus information website.
- If you are sick please notify me by email so that we can make appropriate accommodations should this affect your ability to attend class, complete assignments, or participate in assessments. The Student Health and Wellness Center is open and operational for primary care needs. If you would like to speak with a medical provider, please call 410-516-8270, and staff will determine an appropriate course of action. See also <https://studentaffairs.jhu.edu/student-life/student-outreach-support/absences-from-class/illness-note-policy>
- All students with disabilities who require accommodations for this course should contact me at their earliest convenience to discuss their specific needs. If you have a documented disability, you must be registered with the JHU Office for Student Disability Services (101 Shaffer Hall; 410-516-4720; <http://web.jhu.edu/disabilities>) to receive accommodations.
- Students who are struggling with anxiety, stress, depression or other mental health related concerns, please consider connecting with resources through the JHU Counseling Center. The Counseling Center will be providing services remotely to protect the health of students, staff, and communities. Please reach out to get connected and learn about service options based on where you are living this fall at 410-516-8278, online at <http://studentaffairs.jhu.edu/counselingcenter>
- Student Outreach & Support helps students manage physical and mental health concerns, personal and family emergencies, financial issues, and other obstacles that may arise during their college experience. Students can self-refer or refer a friend who may need extra support or help getting connected to resources. To connect with SOS, please visit this website: <https://studentaffairs.jhu.edu/student-life/student-outreach-support> or email the Dean's office at deanofstudents@jhu.edu, call 410-516-7857, or students can schedule to meet with a Case Manager by visiting the Student Outreach & Support website and filling out a referral form online.

Classroom Climate

As your instructor, I am committed to creating a classroom environment that values the diversity of experiences and perspectives that all students bring. Everyone here has the right to be treated with dignity and respect. I believe fostering an inclusive climate is important because research and my experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. Please join me in creating a welcoming and vibrant classroom climate. Note that you should expect to be challenged intellectually by me, the TAs, and your peers, and at times this may feel uncomfortable. Indeed, it can be helpful to be pushed sometimes in order to learn and grow. But at no time in this learning process should someone be singled out or treated unequally on the basis of any seen or unseen part of their identity.

If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, I invite you to share directly with me or the TAs. I promise that we will take your communication seriously and to seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the department chair (Fadil Santosa, fsantos9@jhu.edu), Director of Undergraduate Studies (Donniell Fishkind, dfishki1@jhu.edu), the Assistant Dean (Darlene Saporu, dsaporu@jhu.edu) for Diversity and Inclusion, or the Office of Institutional Equity (oiie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g. sexual harassment).

Family Accommodations Policy

You are welcome to bring a family member to class on occasional days when your responsibilities require it (for example, if emergency child care is unavailable, or for health needs of a relative). In fact, you may see my children in class on days when their school is closed. Please be sensitive to the classroom environment, and if your family member becomes overly disruptive, you may leave the classroom and return as needed.

University Policy on Incompletes

Students who are confronted with compelling circumstances beyond their control which interfere with the ability to complete their semester's work during the normal course of a term may request an incomplete grade from the instructor. This must be requested by the last day of class. Approval of such a request is neither automatic nor guaranteed, but it is expected that faculty will make every effort to accommodate students dealing with illness in the family and other pandemic-related hardships. The instructor and student must establish a timetable for submitting the unfinished work with a final deadline no later than the end of the third week of the subsequent semester. Exceptions to this deadline require a petition from the instructor to the student's academic advising office before this date. When entering an Incomplete grade in SIS, faculty must include a reversion grade which represents the grade the student will receive if they do not complete the missing work by the agreed-upon deadline.

Deadlines for Adding, Dropping and Withdrawing from Courses

Students may add a course up to **February 4, 2022**. They may drop courses up to **March 6, 2022** provided they remain registered for a minimum of 12 credits. Between **March 6 and April 15, 2022**, a student may withdraw from a course with a W on their academic record. April 15, 2022 is also the last day for students to change their grading system. A record of the course will remain on the academic record with a W appearing in the grade column to indicate that the student registered and then withdrew from the course. For more information on these and other academic policies, follow this [link](#).