AE 718 – Hydrodynamic Stability Theory

Instructor: Aniruddha Sinha; Email: *as@aero.iitb.ac.in*

Office hours: By appointment made at least 2 hours prior by email

Course Outline

1. Introduction and motivation: relevance of hydrodynamic stability theory in transition to turbulence, coherent structures in turbulence, flow control, acoustics, etc.
2. Review of equations of fluid mechanics, numerical differentiation, complex analysis and Fourier-Laplace theory
3. Introduction to dynamical systems theory, phase space, bifurcations, and their relevance to transition
4. Linear stability and normal modes; temporal, spatial and spatio-temporal problems
5. Kelvin Helmholtz instability of inviscid and viscous shear flows such as jets, wakes and boundary layers
6. Other canonical fluid instabilities – Rayleigh-Benard, Rayleigh-Taylor, etc.
7. Weakly non-linear stability theory
8. Weakly non-parallel theory (parabolized stability equations) and global stability analysis
9. Introduction to absolute instability theory
10. Introduction to non-normal (non-modal) stability theory

Text books

- P. G. Drazin, Introduction to Hydrodynamic Stability, Cambridge University Press, 2002
- P. J. Schmid and D. S. Henningson, Stability and Transition in Shear Flows, Springer, 2001
- P. G. Drazin and W. H. Reid, Hydrodynamic Stability, Cambridge University Press, 2004

References

- S. H. Strogatz, Nonlinear dynamics and chaos, Addison-Wesley, 1994
- S. Chandrasekhar, Hydrodynamic and hydromagnetic stability, Cambridge University Press, 1961
- F. Charru, Hydrodynamic Instabilities, Cambridge University Press, 2011
- "Video resources" as listed at the beginning of Charru's textbook

Scheme of Assessment

- Quizzes (unannounced): 10%
- Assignments: 30%
- Mid-semester exam: 20%
- Class presentations and report writing based on literature study: 10%
- End-semester exam: 25%
- Class participation (attendance): 5%

Policies

- Although the lectures will generally follow the textbooks and reference books, they will not adhere to any one in particular; students must take detailed notes in class; lecture notes will NOT be uploaded on moodle

- There will be one UNANNOUNCED quiz in each half of the semester; these will be in the last half hour of a regular class, and will be based on topics covered till the previous class
- Assignments must be completed strictly on an individual basis without any discussion or consultations; any hint of similarity between two or more submissions will attract 100% penalty for all parties involved
- A 50% penalty will apply if assignments/reports are submitted after the assigned class but within the next scheduled class; further delay incurs 100% penalty
- Individual mini-research topics will be assigned to students after mid-sem exams; students are expected to conduct a detailed literature survey on the respective topic, write a brief report and make a small presentation to the class on the same
- The score for class participation is binary – full for > 80% attendance, zero otherwise
- Attendance will be recorded manually within the first 3 minutes of class; students entering later than this will not get attendance for the class
- Grades will be assigned by normalizing the score of every student with the highest score. Subsequently, the letter grades are assigned based on the score range given below:

  AA: 100 – 90; AB: 90 – 80; BB: 80 – 70; BC: 70 – 60
  CC: 60 – 50; CD: 50 – 40; DD: 40 – 35; FR: Below 35

  Note: The above system is based on the assumption that the overall score of at least one student is greater than or equal to 85. If this is not true, then no one will be given an AA grade. In such a circumstance, the scores of all the students will be normalized according to the formula: score = (your_actual_score) x 90/85. Letter grades then will be assigned based on the split given above.

Audit policy: Attendance policy as above