AE 718 – Hydrodynamic Stability Theory

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

Office hours: None

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 (2 nos.): 20%
- Assignments (5 nos.): 50%
- Presentation based on literature study: 10%
- End-semester exam: 20%

Assessment Policies

- 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, no excuses being entertained
- A 50% penalty will apply if assignments/reports are submitted after the deadline but within a week from it; further delay incurs 100% penalty

- Individual seminar topics will be assigned (or students may suggest their own choices); students are expected to conduct a detailed literature survey on the respective topic and make a small presentation on the same
- The score for class participation is binary – full for > 80% attendance, zero otherwise

Grading Policy

This course is NOT graded on a curve. Absolute grading is done, with some allowance for the relative toughness of the course. In particular, prior to awarding the final grade of a student, the actual total (raw) marks ($ActualMarks$) obtained by her will be normalized as follows

$$\text{Normalized marks} = \text{RoundUp}\left(\frac{ActualMarks}{\max(ClassMax, 90)} \times 100\right),$$

where $ClassMax$ is the maximum score achieved across the class. The following is the credit mapping scheme that will be used on the above normalized marks:

AA:	100 – 90;	AB:	89 – 80;	BB:	79 – 70;	BC:	69 – 60
CC:	59 – 50;	CD:	49 – 40;	DD:	39 – 30;	FR:	≤ 29

Note: Note that if the maximum raw score in the course is less than 90%, then 90 will be used in the normalization instead of the class maximum.

Audit policy: Students must secure pass marks in the course per the above grading scheme