GIAN 191010G01: Interfacial Instability with Industrial Applications

Course outline and tentative schedule

Total of 28 hours of Lectures and 8 hours of Tutorials.

Tutorials will comprise of problem sessions and will be held from Tuesday through Friday in the first week and Monday through Thursday in the second week

Week 1

1 July 11 2022:- Monday

Lecture 1. 90 minutes

- Introduction to stability and instability, Rayleigh's work principle (RWP) [1]
- Examples of the RWP-The liquid jet
- Examples of the RWP-The liquid bridge-free ends
- Application of liquid bridge instability to materials processing. What other complications can occur.

Lecture 2. 60 minutes

- The heavy over light configuration, i.e., Rayleigh-Taylor instability-free ends
- More examples on the work principle- now using pinned ends

2 July 12 2022:- Tuesday

Lecture 3 90 minutes

- The idea behind linear stability and why we need domain perturbations [1]
- Domain and Surface perturbations
- Examples of domain perturbations. Time constants or eigenvalues for distorted circles. Explanation of the meaning of eigenvalues)

Lecture 4 90 minutes

- Introduction to surface normal, surface speed, and surface curvature

3 July 13 2022:- Wednesday

Lecture 5-90 minutes

- The liquid bridge stability by perturbation- the principle of linear stability in use [2]
- Linear stability applied to the Rayleigh Taylor problem
- Energy method showing why the Pendent Drop instability is only a hydrostatic instability
- Application of the pendent drop instability to tensiometer measurements. Complications that can arise.

Lecture 6-90 minutes

- More on the Pendent Drop- Getting the instability limits from the base problem

4 July 14 2022:- Thursday

Lecture 7- 90 minutes

- Linear stability for the Rayleigh Taylor problem in a porous medium- the Darcy equation
- Translation of the above to the Saffman-Taylor Problem
- Application of Saffman-Taylor to industry.

Lecture 8- 60 minutes

- Linear stability of rotating liquid jets

5 July 15- Friday

Lecture 9- 90 minutes

- The meaning of natural frequency for an inviscid fluid system.
- The Faraday instability for an inviscid fluid [3]
- Applications of the Faraday instability.

Lecture 10-90 minutes

- Review of the week's lectures

Week 2

6 July 18- Monday

Lecture 11- 90 minutes

- Recap of linear methods
- Weak non-linear methods
- Application of nonlinear methods to the Rayleigh Taylor instability

Lecture 12-90 minutes

- Application of weak nonlinear methods to Saffman Taylor Instability

7 July 19- Tuesday

Lecture 13- 90 minutes

- Long wave methods and why they are useful. Evolution equations
- Application to the Rayleigh Taylor problem
- Application of long wave methods to thin film processing

Lecture 14- 90 minutes

- Introduction to "Wolfram Mathematica" ®software.
- Using "Mathematica" ®software to derive the long-wave evolution equations.

8 July 20- Wednesday

Lecture 15- 90 minutes

- The classical convection problem
- Properties of the convection problem

Lecture 16-90 minutes

- The Marangoni problem by Long Wave methods
- The linear stability of Marangoni convection
- Application of the Marangoni instability to engineering processes.

9 July 21- Thursday

Lecture 17- 90 minutes

- solidification instability

Lecture 18-60 minutes

More on the solidification instability

10 July 22- Friday

Lecture 19- 90 minutes

- Introduction to other phase change instabilities- evaporation and electrodeposition
- Applications of phase-change instabilities to materials processing.

Lecture 20- 60 minutes

- Review of the second week lectures and conclusion of the course

References

[1] L. E. Johns and R. Narayanan, *Interfacial Instability.* Springer Science & Business Media, 2002.

[2] P. Lin, X. Lin, L. E. Johns, and R. Narayanan, "Stability of a static liquid bridge knowing only its shape," *Physical Review Fluids*, vol. 4, no. 12, p. 123904, 2019.

[3] T. B. Benjamin and F. J. Ursell, "The stability of the plane free surface of a liquid in vertical periodic motion," *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences*, vol. 225, no. 1163, pp. 505–515, 1954.