# Instabilities


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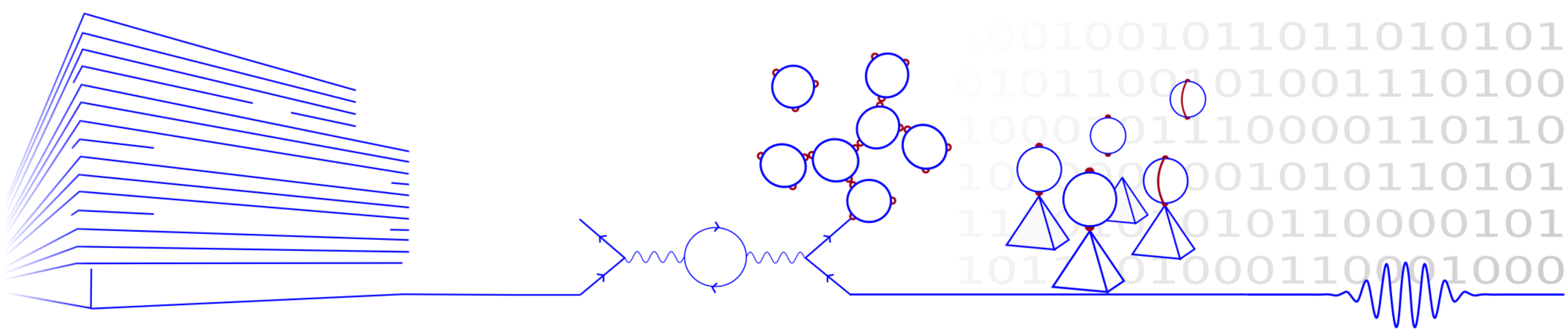
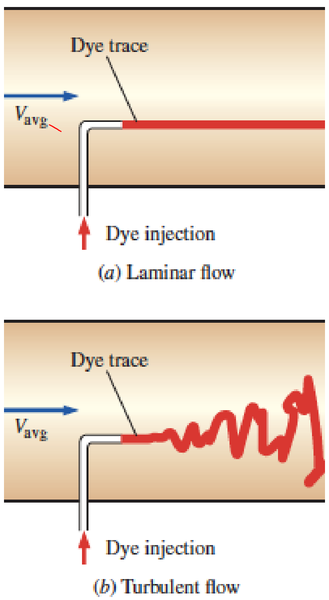
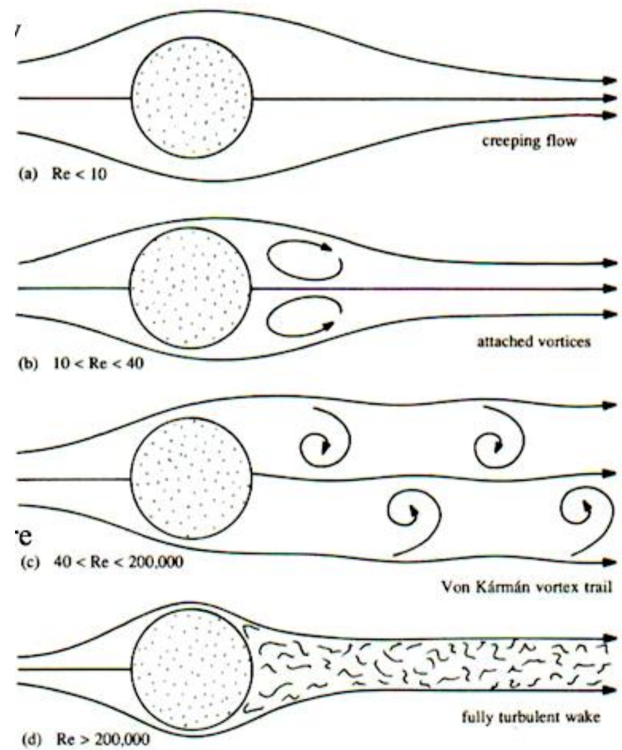


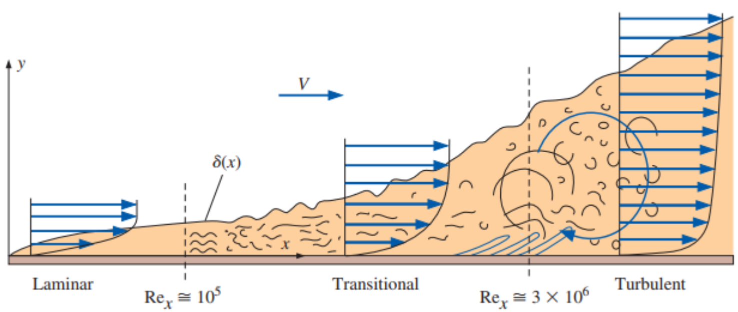
# Overview

- Fluid instabilities show up in everyday life, nature and engineering applications. A seemingly stable system may give rise to the development of an instability, which can cascade into turbulence.
- When the system is exposed to a perturbation, some wavelengths will grow, while others will no, governed by the parameters of the flow. This selectivity of specific structure sizes can be determined using linear stability analysis and then accounting for viscosity.
- Once these unstable wavelengths have grown to a substantial degree, the system becomes nonlinear before turbulence eventually sets in.
- Looking at buoyancy-driven instabilities, one can clearly see how certain wavelengths are selected. This can be extended to shear-driven instabilities and to other systems.
- For some flows, simplifications can be made to analyze the specific fluid structures, while for others, only broad conclusions can be drawn about the stability criteria.

# Previous chapters

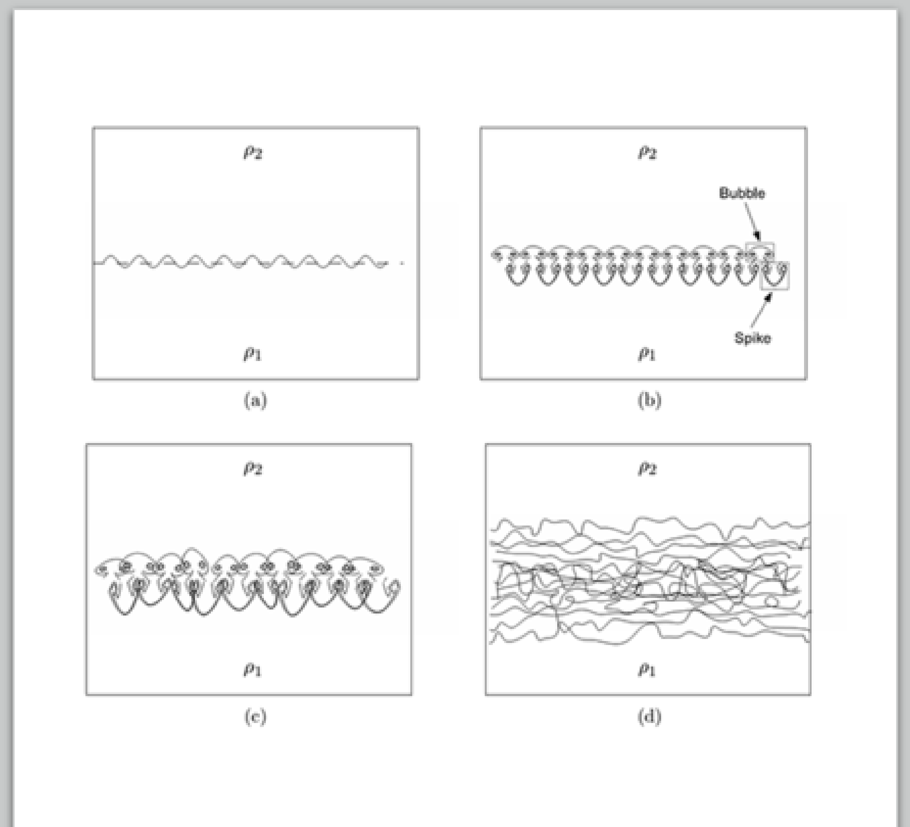


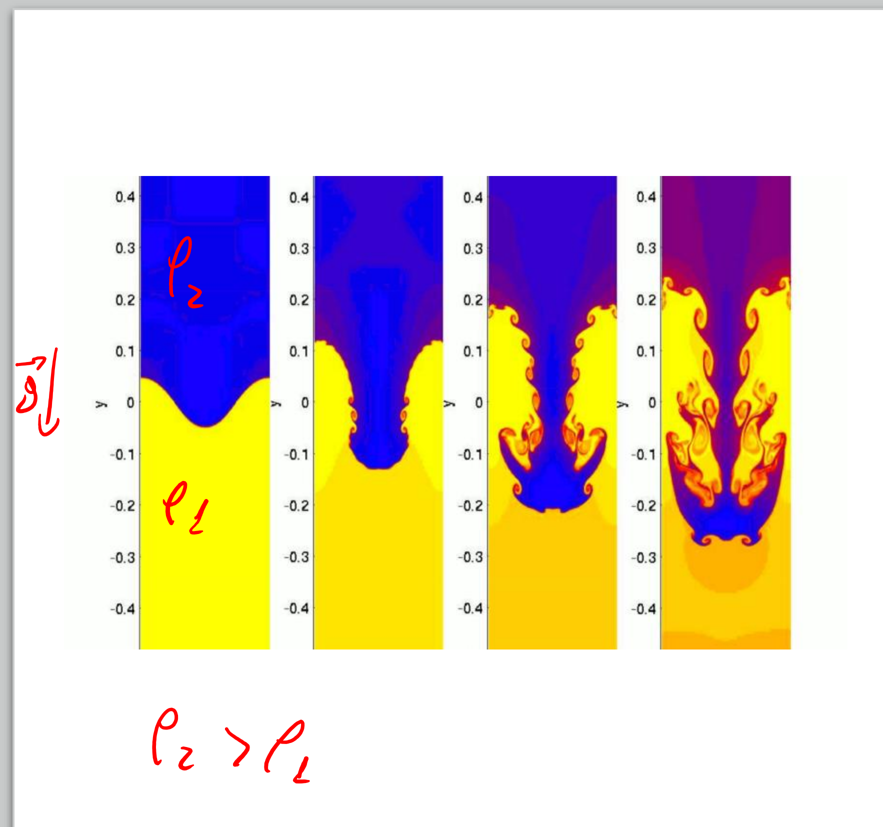



Flow instabilities: https://www.youtube.com/watch?v=8jKZITeUJUQ

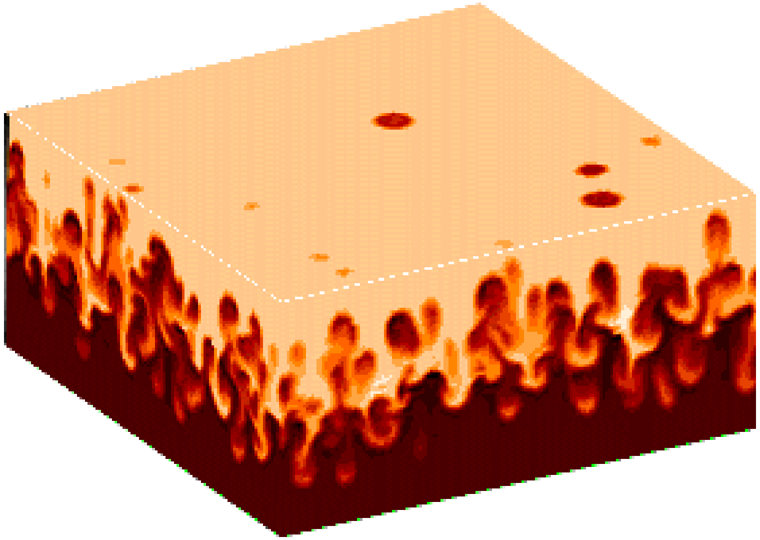

Flow Instabilities | Fluid Mechanics

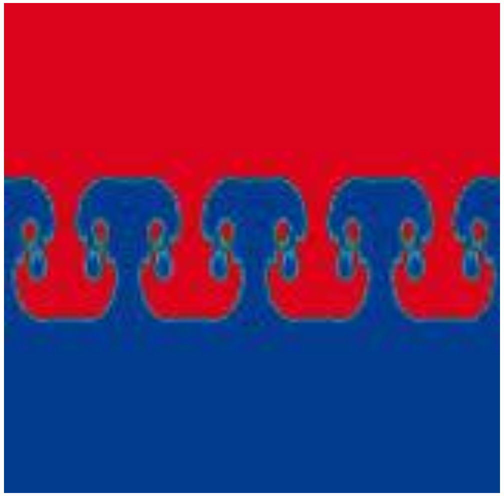


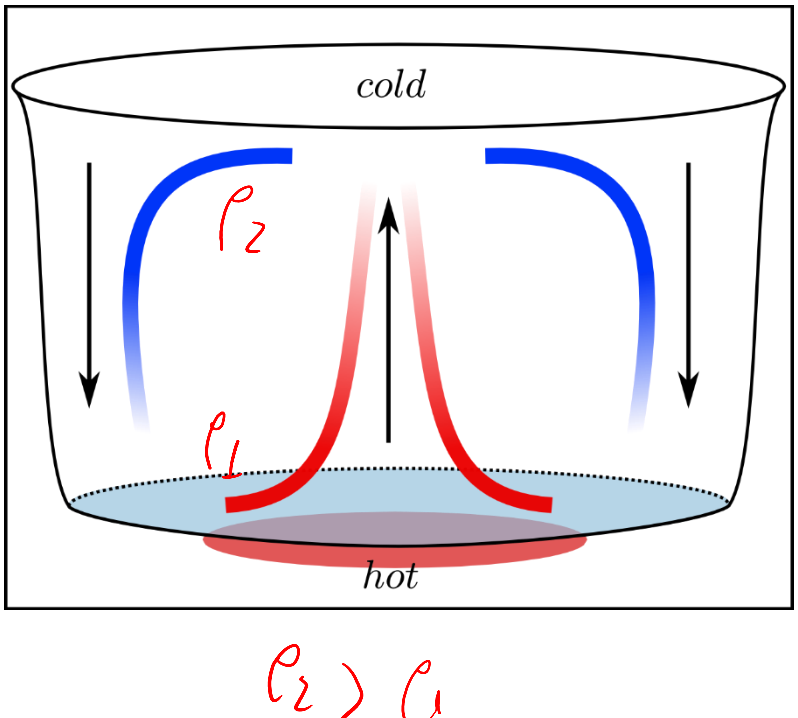




# Rayleigh-Taylor

- Instability of an interface between two fluids of different densities, which occurs when the lighter fluid $\rho_1$ is pushing the heavier fluid $\rho_2$.

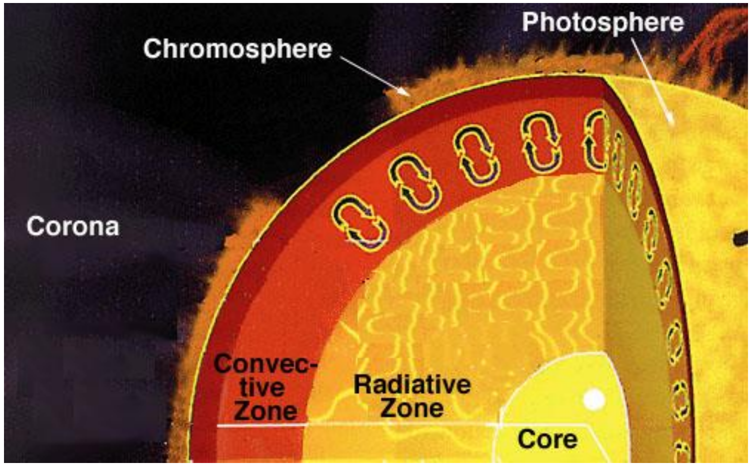







# Rayleigh–Bénard

- Instability of a gradient of density of the same fluid (e.g., due to the temperature) under gravity.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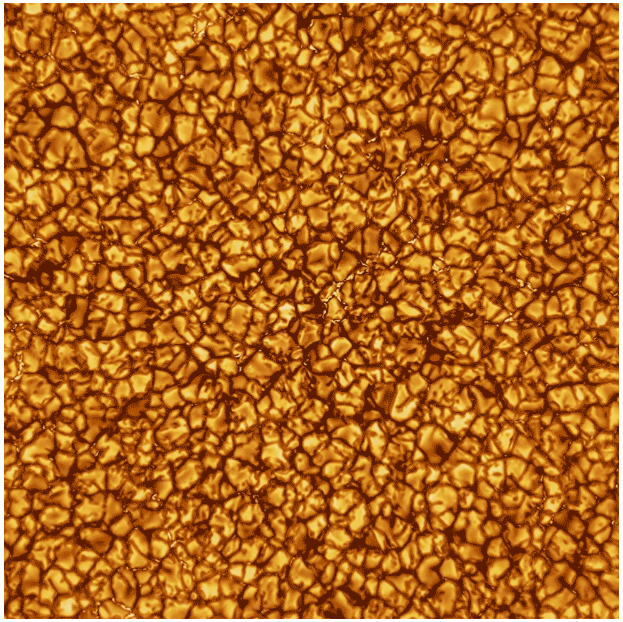
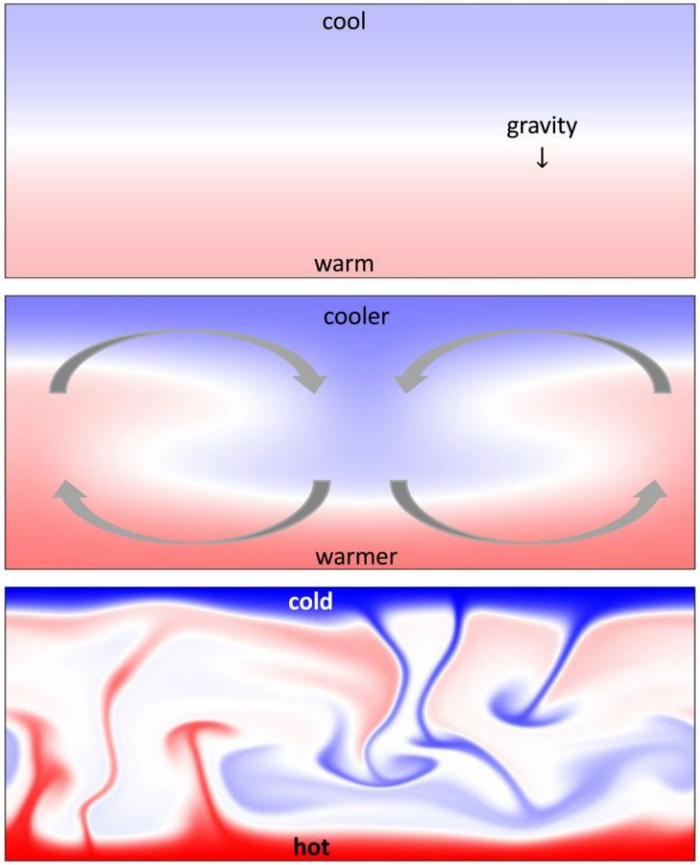
Radiative
Zone
Core

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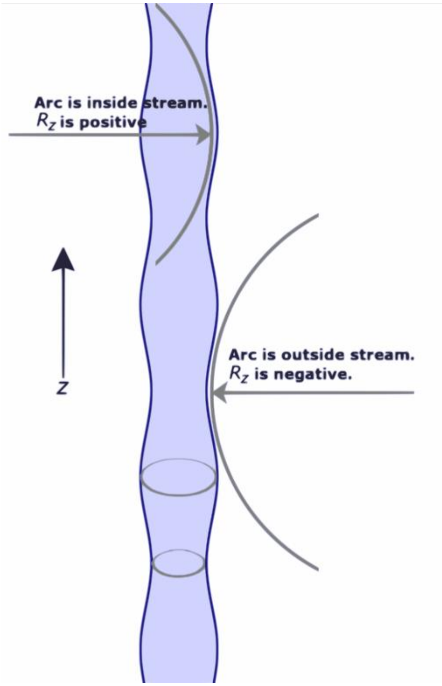
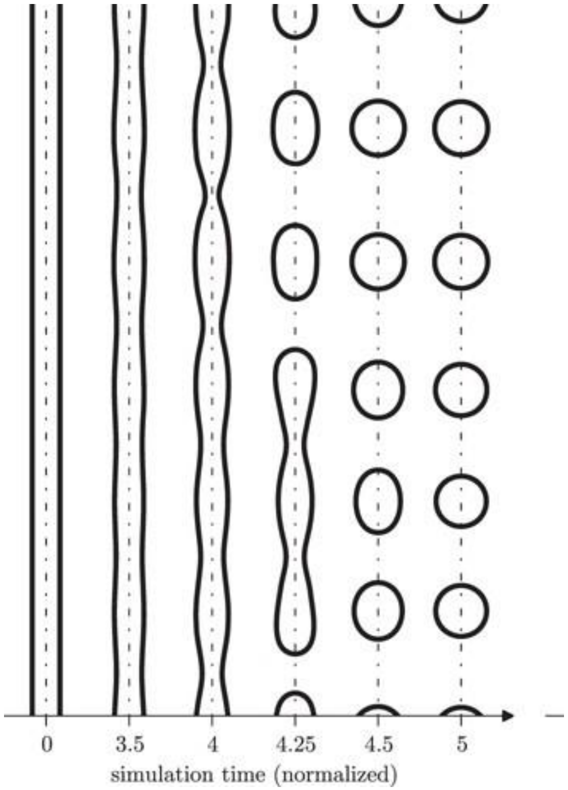
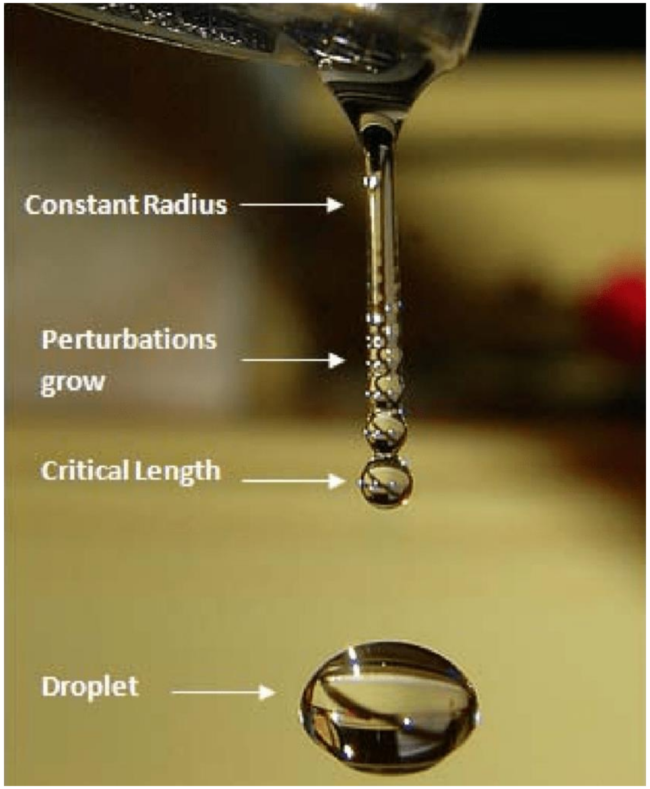
gravity
↓
warm
cooler
warmer
cold
hot




# Rayleigh-Plateau

- Instability of a falling stream of fluid that breaks up into smaller packets with the same volume but less surface area.




The Plateau–Rayleigh instability is named for Joseph Plateau and Lord Rayleigh. In 1873, Plateau found experimentally that a vertically falling stream of water will break up into drops if its wavelength is greater than about 3.13 to 3.18 times its diameter, which he noted is close to π.[3][4] Later, Rayleigh showed theoretically that a vertically falling column of non-viscous liquid with a circular cross-section should break up into drops if its wavelength exceeded its circumference, which is indeed π times its diameter. (https://en.wikipedia.org/wiki/Plateau%E2%80%93Rayleigh_instability)

Application: inkjet printing.