Web info

On-line material:

Potential Flow: MIT:
http://web.mit.edu/2.016/www/handouts/2005Reading4.pdf

Efluids for general stuff and examples and images and videos:

http://www.efluids.com

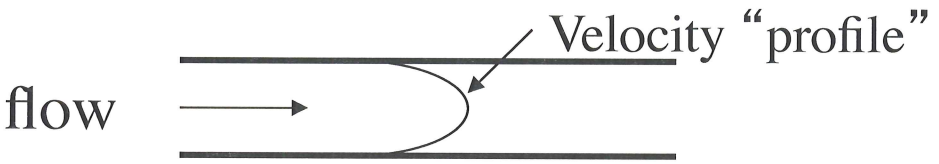
APS gallery of motion

http://gfm.aps.org

What is a Fluid?

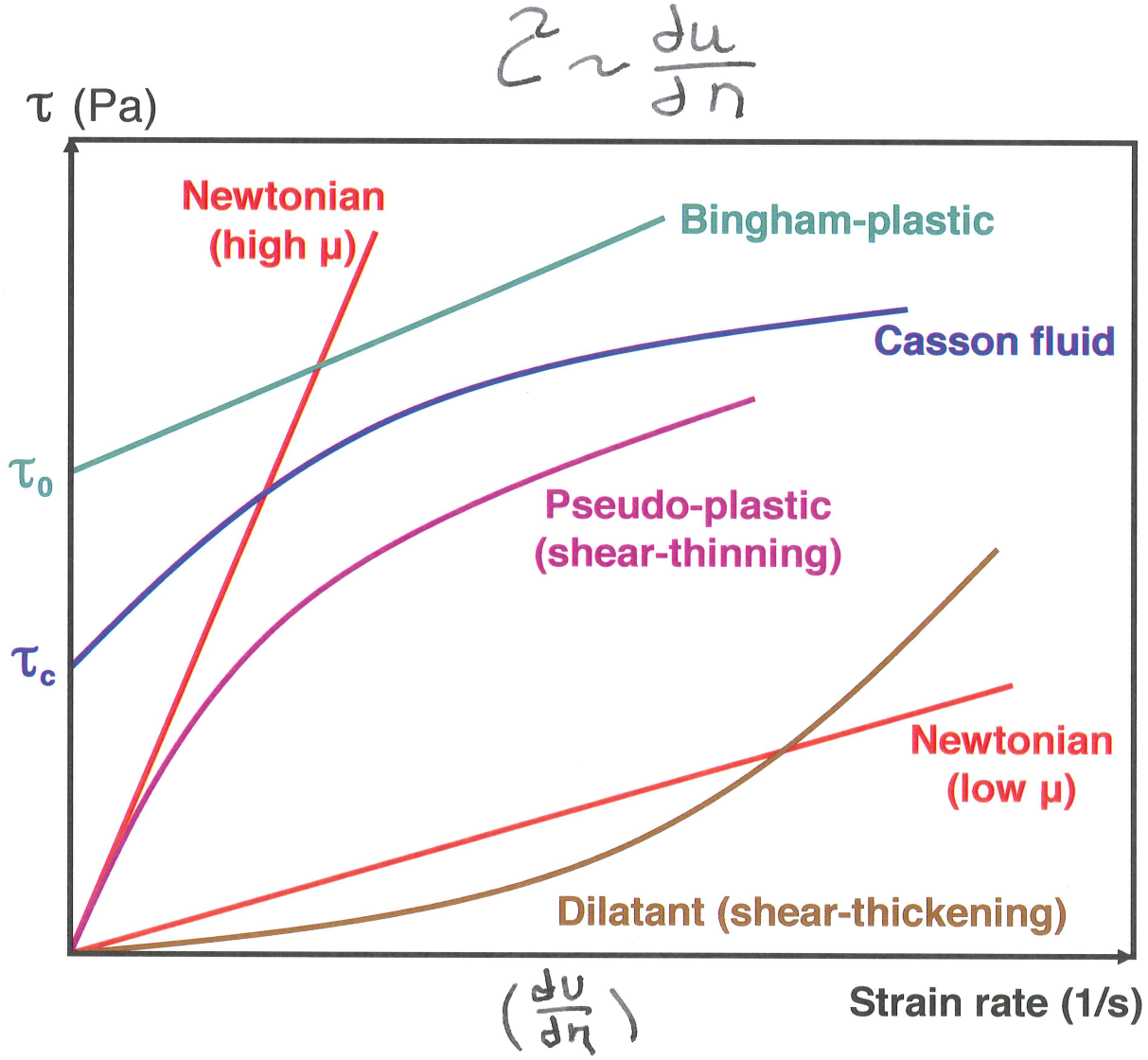
- Gas vs Liquid
- Single vs multiphase flows (boiling)
- Incompressible/compressible:
  - Mach No. = V/a > 0.3
- Newtonian/Non-Newtonian:

$\tau = \mu dU/dy$



Newtonian vs. non-Newtonian

- Newtonian fluids: water, air.
- Pseudoplastic fluids: paint, printing ink.
- Dilatant fluids: dense slurries, wet cement.
- Bingham fluids: toothpaste, clay.
- Casson fluids: blood, yogurt.
- Visco-elastic fluids: polymers (not shown in graph because viscosity is not isotropic).



Summary

- Fluid flows can be classified in a variety of ways:
  - Internal vs. external.
  - Laminar vs. turbulent.
  - Compressible vs. incompressible.
  - Steady vs. unsteady.
  - Supersonic vs. transonic vs. subsonic.
  - Single-phase vs. multiphase.
  - Elliptic vs. parabolic vs. hyperbolic.

Flow classifications

- Laminar vs. turbulent flow.
  - Laminar flow: fluid particles move in smooth, layered fashion (no substantial mixing of fluid occurs).
  - Turbulent flow: fluid particles move in a chaotic, "tangled" fashion (significant mixing of fluid occurs).
- Steady vs. unsteady flow.
  - Steady flow: flow properties at any given point in space are constant in time, e.g. $p = p(x,y,z)$.
  - Unsteady flow: flow properties at any given point in space change with time, e.g. $p = p(x,y,z,t)$.

Flow classifications

- Incompressible vs. compressible flow.
  - Incompressible flow: volume of a given fluid particle does not change.
    - Implies that density is constant everywhere.
    - Essentially valid for all liquid flows.
  - Compressible flow: volume of a given fluid particle can change with position.
    - Implies that density will vary throughout the flow field.
    - Compressible flows are further classified according to the value of the Mach number (M), where.

$$M = \frac{V}{c}$$

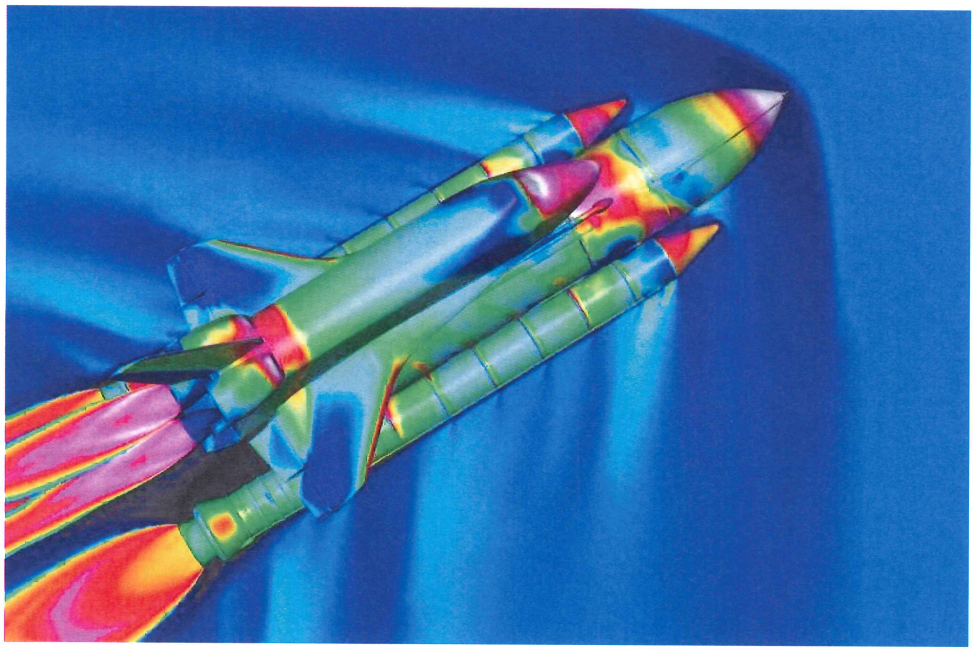
    - M < 1 - Subsonic.
    - M > 1 - Supersonic.

Flow classifications

- Single phase vs. multiphase flow.
  - Single phase flow: fluid flows without phase change (either liquid or gas).
  - Multiphase flow: multiple phases are present in the flow field (e.g. liquid-gas, liquid-solid, gas-solid).
- Homogeneous vs. heterogeneous flow.
  - Homogeneous flow: only one fluid material exists in the flow field.
  - Heterogeneous flow: multiple fluid/solid materials are present in the flow field (multi-species flows).

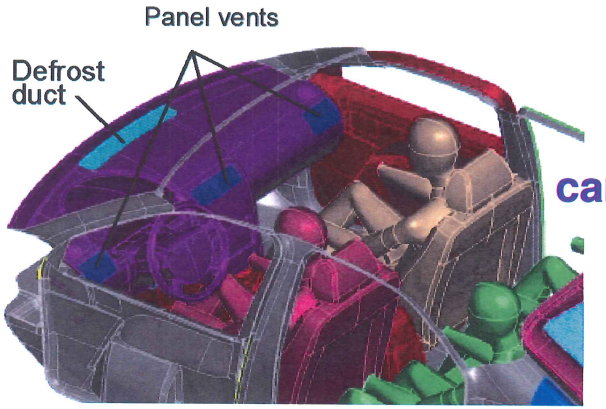
Flow configurations - external flow

- Fluid flows over an object in an unconfined domain.
- Viscous effects are important only in the vicinity of the object.
- Away from the object, the flow is essentially inviscid.
- Examples: flows over aircraft, projectiles, ground vehicles.

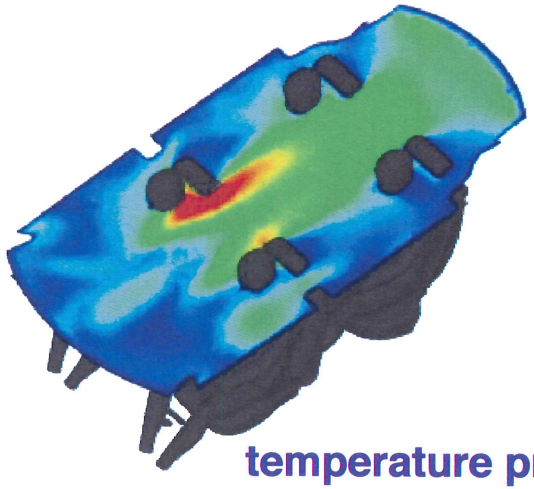


Flow configurations - internal flow

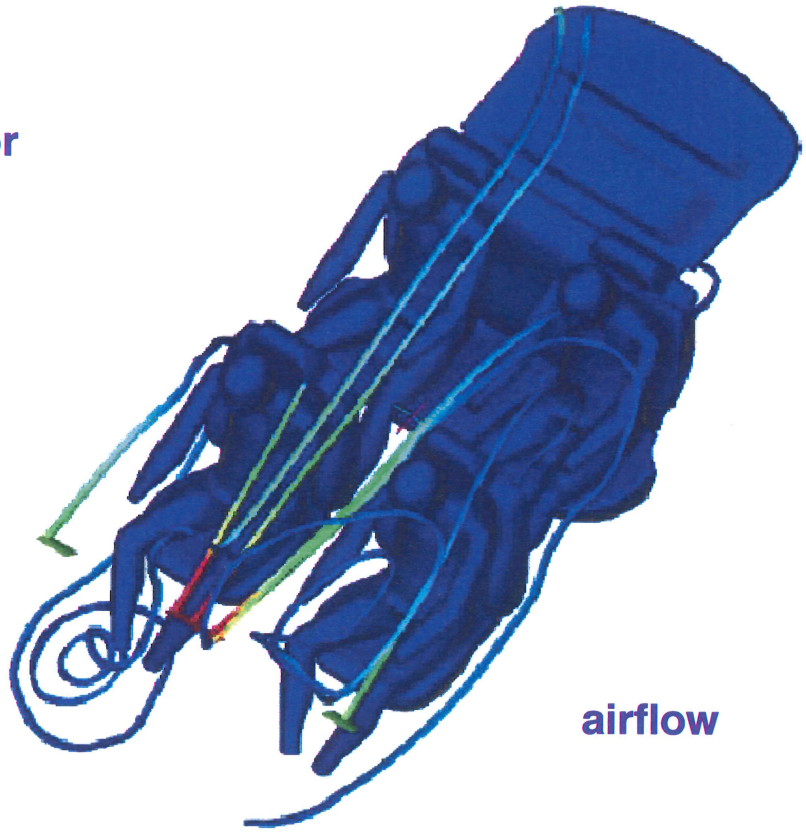
- Fluid flow is confined by walls, partitions, and other boundaries.
- Viscous effects extend across the entire domain.
- Examples: flows in pipes, ducts, diffusers, enclosures, nozzles.



car interior



temperature profile



airflow

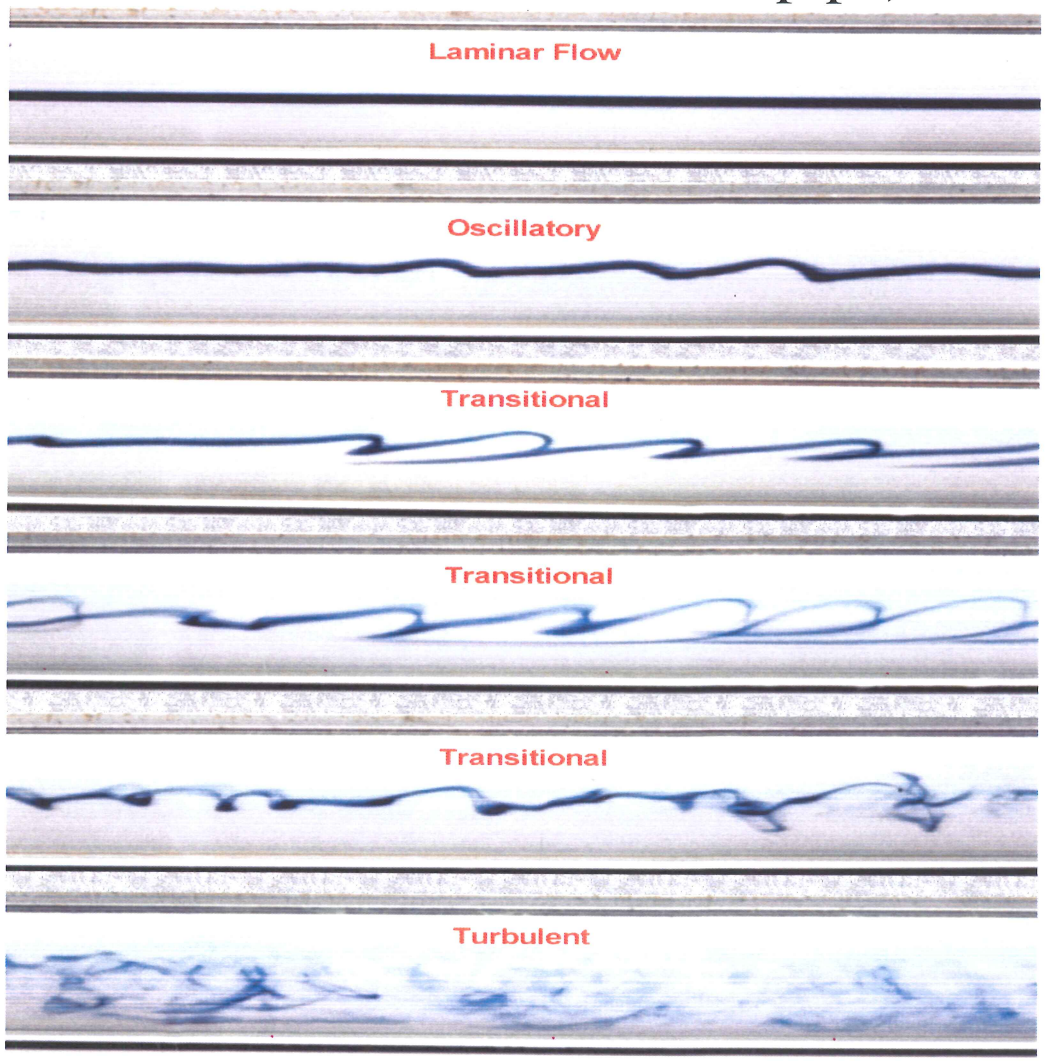
Reynolds number

- The Reynolds number Re is defined as: $Re = \rho V L / \mu$.
- Here L is a characteristic length, and V is the velocity.
- It is a measure of the ratio between inertial forces and viscous forces.
- If $Re >> 1$ the flow is dominated by inertia.
- If $Re << 1$ the flow is dominated by viscous effects.

Effect of Reynolds number : Guess Re ?

Nondimensional Flow Parameters

(flow visualization in a pipe)



Increasing Velocity or Re

Increasing pressure drop

Re>2300