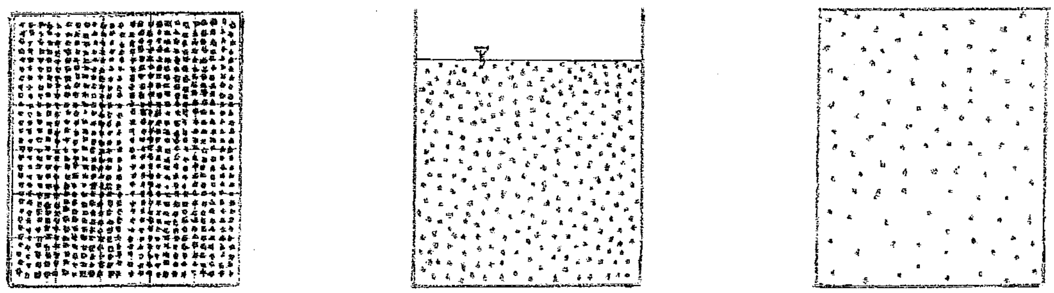
Fluids

States of Matter

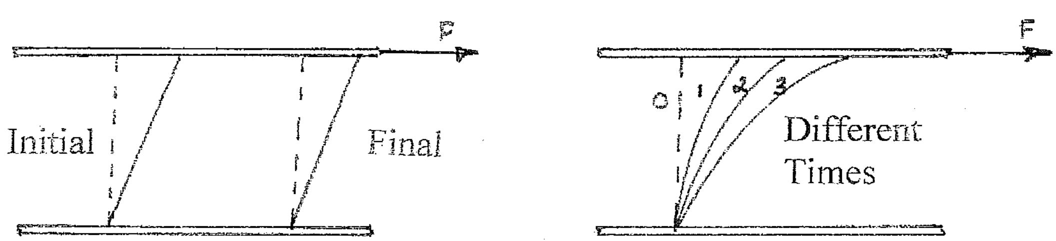


Solid Liquid Gas

Fluid: Liquid, Gas or Mixture

A fluid is a substance which can move and flow and in which there can be relative motions or distortions.

A fluid is a substance which continually deforms under the action of a shear force. Deformations are permanent.



Solid Fluid

Fluid Mechanics

The study of motion and forces in a fluid.

Fluid flows involve:

Fluid properties:

- Density
- Pressure
- Temperature
- Composition

Geometry:

- Objects in the flow
- Domain of the flow field

Kinematics:

- Displacements
- Particle Trajectories
- Velocity
- Acceleration

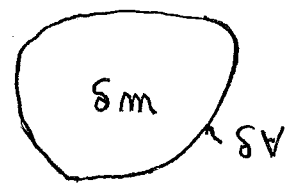
Forces:

- Inertia
- Pressure
- Gravity
- Friction

Density

Density = mass per unit volume = $\rho = \frac{\delta m}{\delta \forall}$

Units = kg/m^3



Specific Weight = weight per unit volume = $\gamma = \frac{\delta w}{\delta \forall}$

Units = N/m^3 $\quad N = kg \cdot m/s^2$

w=mg and $\gamma = \rho g$ where $g = 9.82 m/s^2$

Air at standard sea level conditions: $\rho = 1.22 kg/m^3$ $\quad \gamma = 12.0 N/m^3$

Water at $20^0 C$: $\rho = 998 kg/m^3$ $\quad \gamma = 9800 N/m^2$

Specific Gravity = weight of a fluid relative to that of water

$$s.g. = \frac{\gamma_{fluid}}{\gamma_{water}}$$

For gasoline $\gamma = 6680 N/m^3$ **and s.g. = 0.682**

Continuum

For $\rho = \rho(x, y, z)$ $\qquad \rho = \lim_{\Delta\forall \to 0} \frac{\Delta m}{\Delta\forall}$

For $\Delta\forall < \Delta\forall^*$ in a real fluid there is not sufficient number of molecules in $\Delta\forall$ to obtain a stable value of density.

Continuum Model: For $\Delta\forall < \Delta\forall^*$ the volume is filled with material, there are no holes or voids. The molecular makeup is ignored and the material is continuous.

Valid if a small volume $\Delta\forall^*$

- -contains enough molecules to define the density
- -the volume size $\sqrt[3]{\Delta\forall^*} << L$, where L is a dimension in the flow field.

Instead of $\sqrt[3]{\Delta\forall^*}$ we use λ, the mean free path.

Knudsen number $= \frac{\lambda}{L} < 0.001$ for a continuum

Continuum model is ok for liquids and for gases if the pressure in not too low or the dimension not too small. Not valid in the upper reaches of the atmosphere, or in vacuum equipment and micro–channels.

ENGINEERING APPLICATIONS

Power & Thrust

- Reciprocating Engines
- Jet Engine
- Rocket Engine

Fluid Machinery

- Pumps
- Turbines
- Compressors

Heating, Ventilation, & Air Conditioning

- Fans
- Blowers
- Heat Exchangers

Aerodynamics

- Airplanes
- Automobiles

Flow/Fluid Measuring Devices

WHY STUDY

FLUID MECHANICS

SCIENCE: Study the fundamentals and the phenomena of fluids and fluid motions.

Examples: Chaos, Turbulence, Microgravity, etc.

Engineering: Apply the principles of fluid mechanics to practical problems.

Examples: Lift and drag on a wing, power from a turbine, thrust from a rocket, etc.

AREAS OF FLUID MECHANICS

MAE 422	GAS DYNAMICS
MAE 423	INTRODUCTION TO PROPULSION
MAE 424	AERODYNAMICS
MAE 433	WIND POWER ENGINEERING
MAE 469	ENVIRONMENTAL TRANSPORT PROCESSES
MAE 471	AERODYNAMICS LABORATORY
MAE 515	FLUID MECHANICS 1
MAE 518	MAGNETOHYDRODYNAMICS
MAE 519	TURBULENT FLOW
MAE 534	COMBUSTION
MAE 540	COMPUTATIONAL FLUID MECHANICS
MAE 545	HEAT TRANSFER 1
MAE 607	INVISCID HYPERSONIC FLOW
MAE 608	VISCOUS HYPERSONIC FLOW
MAE 611	CONVECTIVE HEAT TRANSFER
MAE 617	INVISCID INCOMPRESSIBLE FLOW
MAE 618	VISCOUS FLOW
MAE 631	COMPRESSIBLE FLOW