FLUID MECHANICS

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Course Details

Subject	Fluid Mechanics
Subject code	Ch.E - 105
Contact hours	3
Credit hours	3

Evaluation procedure

Sessional	30 % (Quizzes + Attendance + Class participation + Assignment)
Mid term	30%
Final term	40%

Course Outline (1)

- **Introduction to Fluid Mechanics**
- **Importance of Fluid Mechanics in chemical Engineering**
- **Description of fluids**
- **Types of fluids**
- **Classification of fluid flows**
- **Compressible vs Incompressible Fluids**
- **Steady and Unsteady fluid flow**
- **Properties of Fluids**

Course Outline (2)

- **Basic equations of fluid flow**
- **Flow of Incompressible fluids in pipes**
- **Laminar and Turbulent flow in closed channel**
- **Processes of compressible fluids flows**
- **Flow through variable area conduits**
- **Boundary layer concept**
- **Prandtl's boundary layer equations**
- **Turbulent boundary layers**
- **Dimensional Analysis**

Recommended Books

Text Book

McCabe Warren L., Smith Julian C., Harriott Peter "**Unit Operations of Chemical Engineering**" 5th Ed. 2001. McGraw Hill Inc.

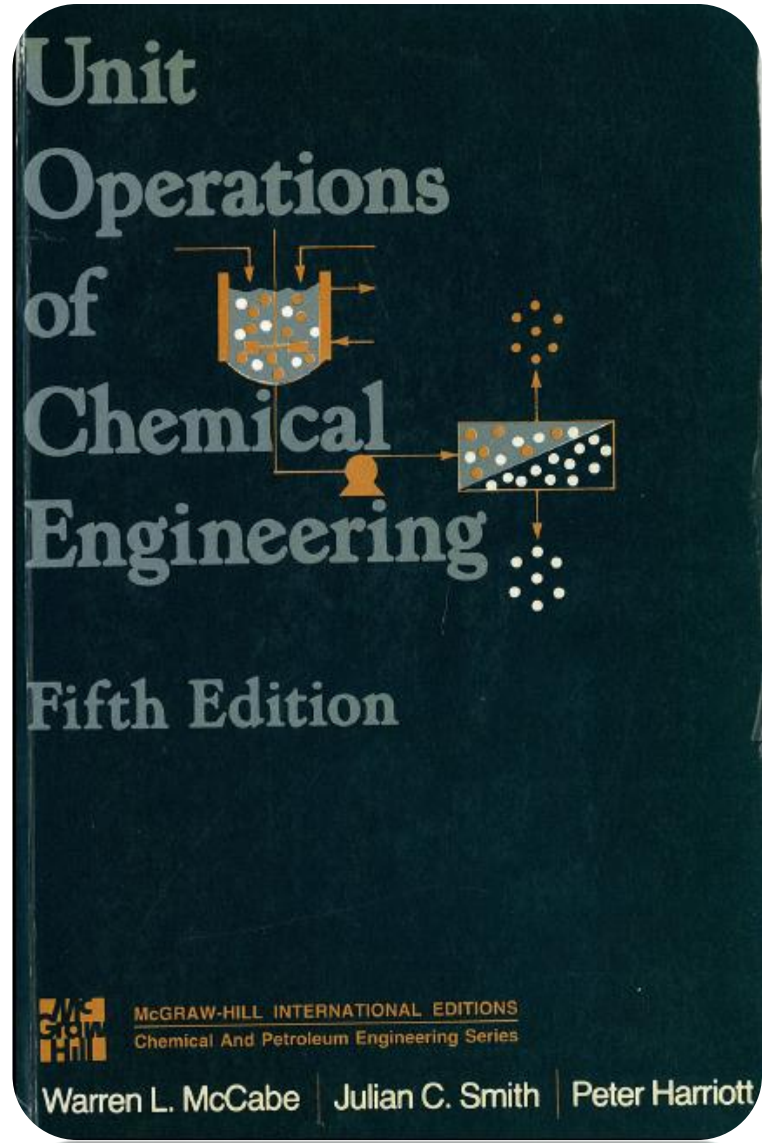
Reference Books

1. Coulson J.M., Richardson J.F., "**Chemical Engineering**" Vol-I,
2. Perry Robert H., Green Don W. "**Perry's Chemical Engineering handbook**" 7th Ed. 1997. McGraw Hill Inc.
3. **"Engineering Fluid Mechanics"** by **Clayton T. Crowe, Donald F. Elger, Barbara C. Williams, John A. Roberson., ed. 9.**
4. **"Fluid Mechanics Fundamentals and Applications" by Yunus A. Cengel, John M. Cimbala**
5. **"Fluid Flow for Practicing Chemical Engineer" by J. Patrick Abulencia, Louis Theodore**

Text book

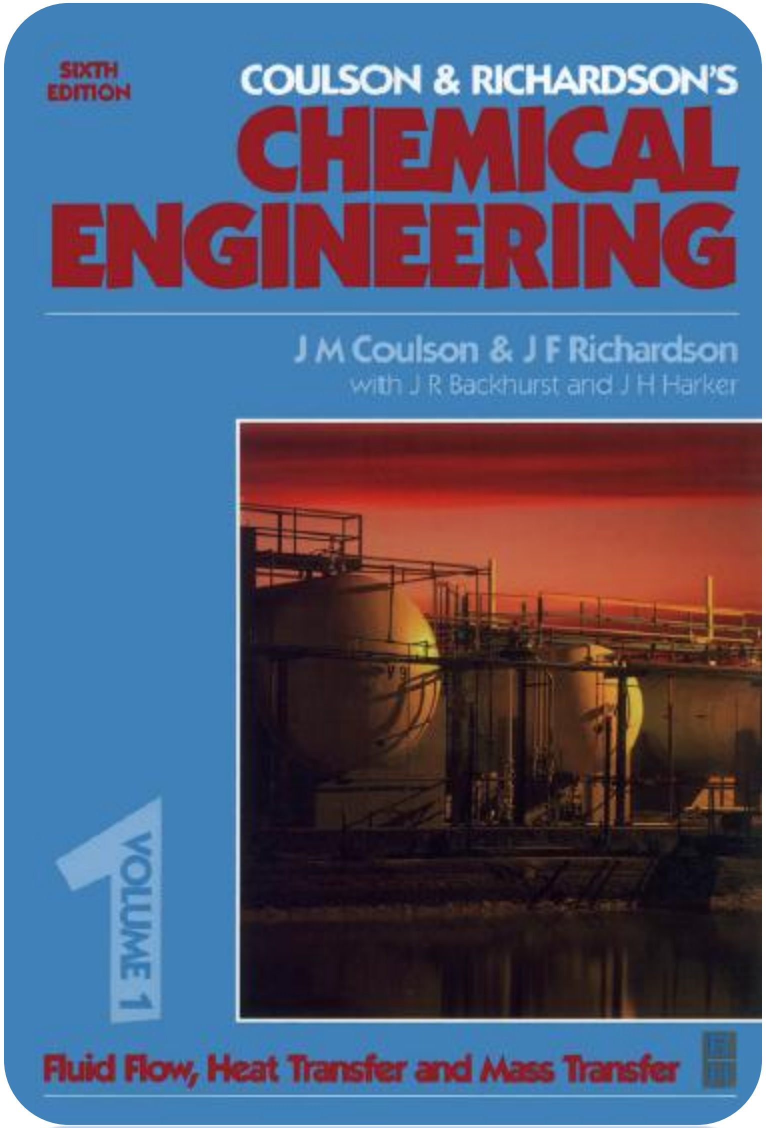
“Unit Operations of Chemical Engineering”
5th Ed.

By Warren L. McCabe, Julian C. Smith & Peter Harriott



"Chemical Engineering" volume 1

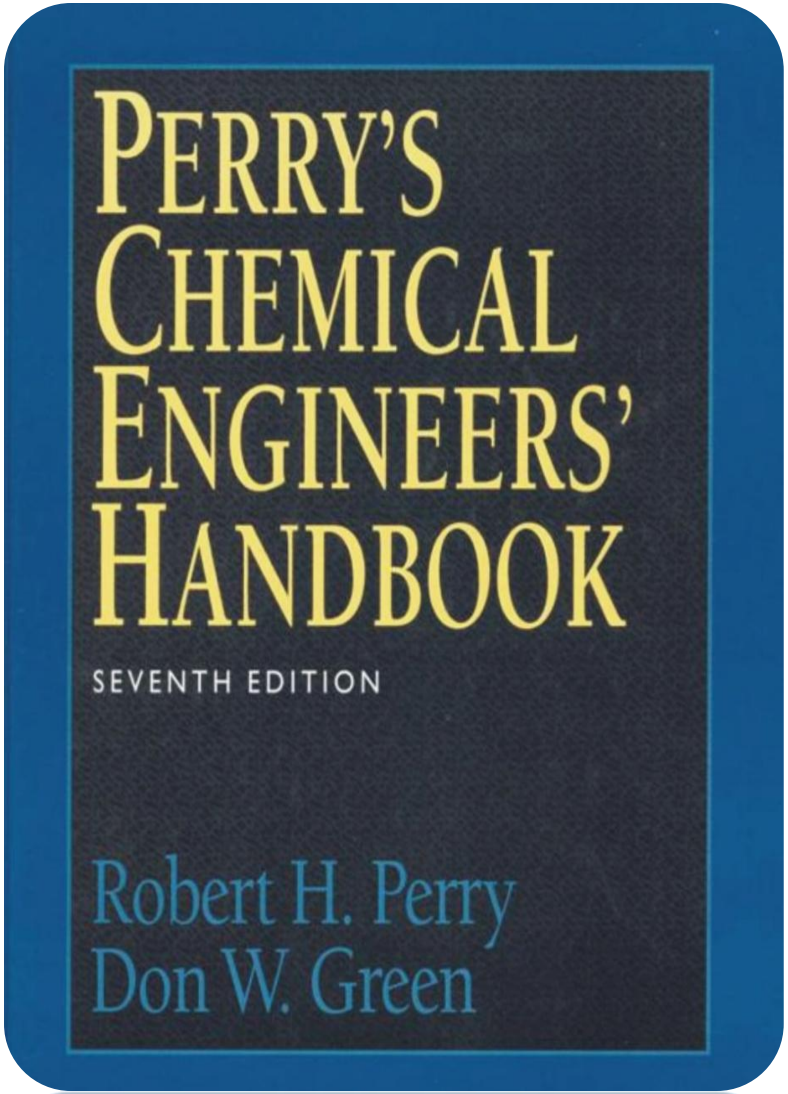
By J. M. Coulson and J. F. Richardson & with J. R. Backhurst and J. H. Harker



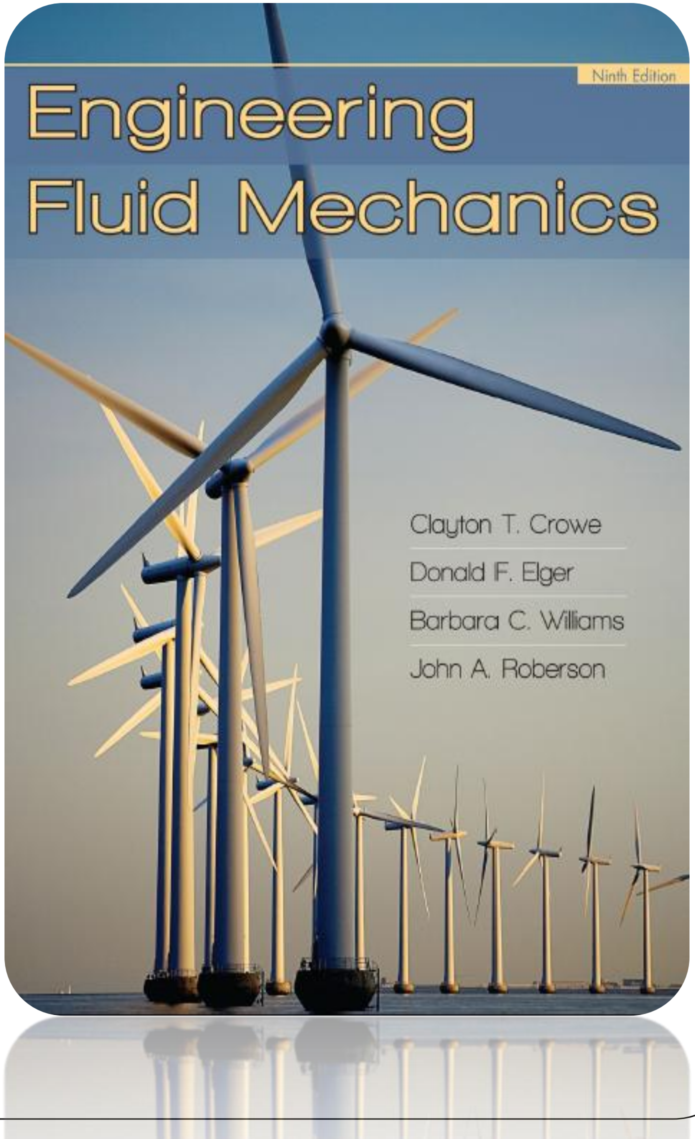
Perry's Chemical Engineering Hand book

Seventh Edition

By Robert H. Perry
Don W. Green

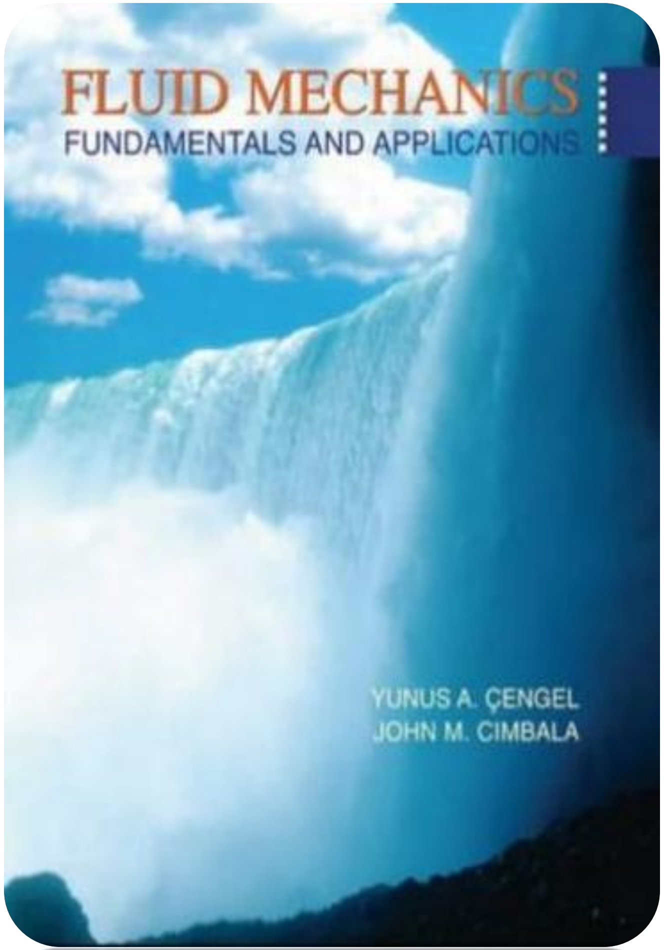


Engineering Fluid Mechanics
Ninth Edition



Fluid Mechanics
Fundamentals and Applications

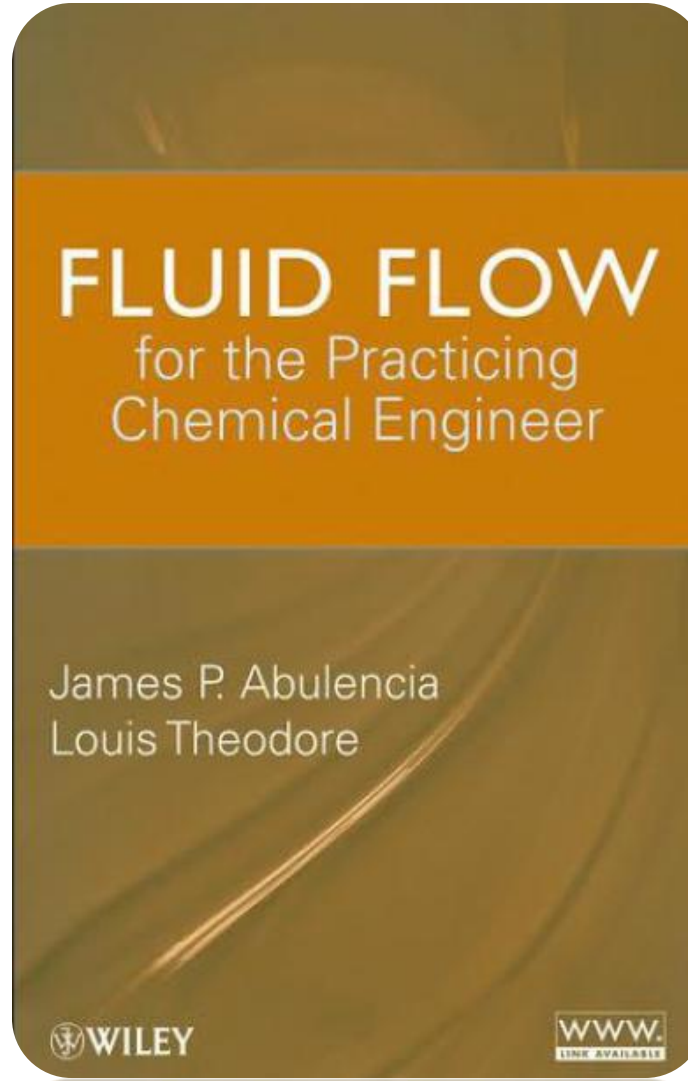
By Yunus A. Cengel, John M. Cimbala



Fluid Flow

For the practicing Chemical Engineer

By James p. Abulencia, Louis Theodore



An Introduction to Fluid Mechanics

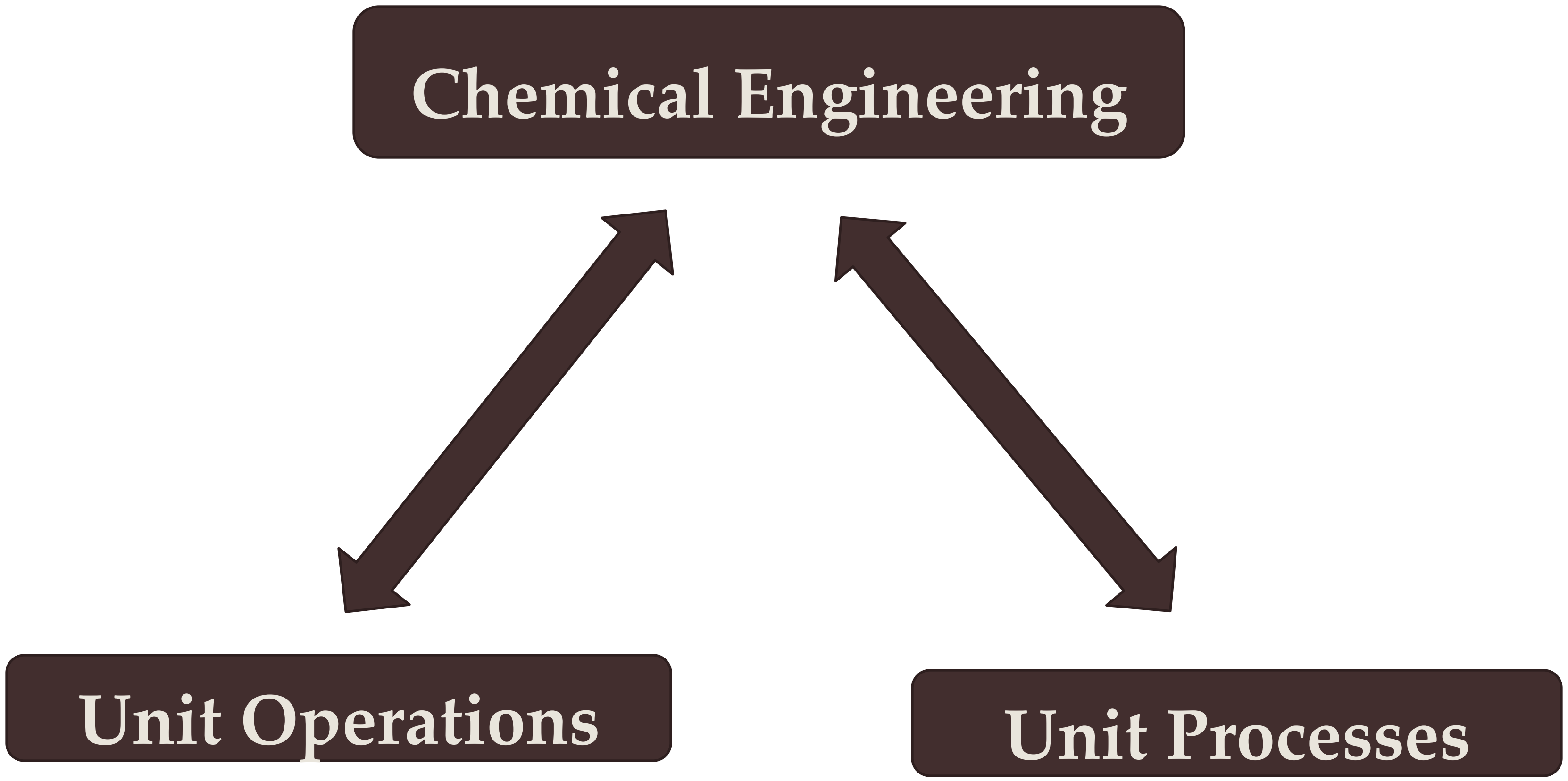
What ………………………………. ???

Why ……………………………….. ???

How ……………………………….. ???

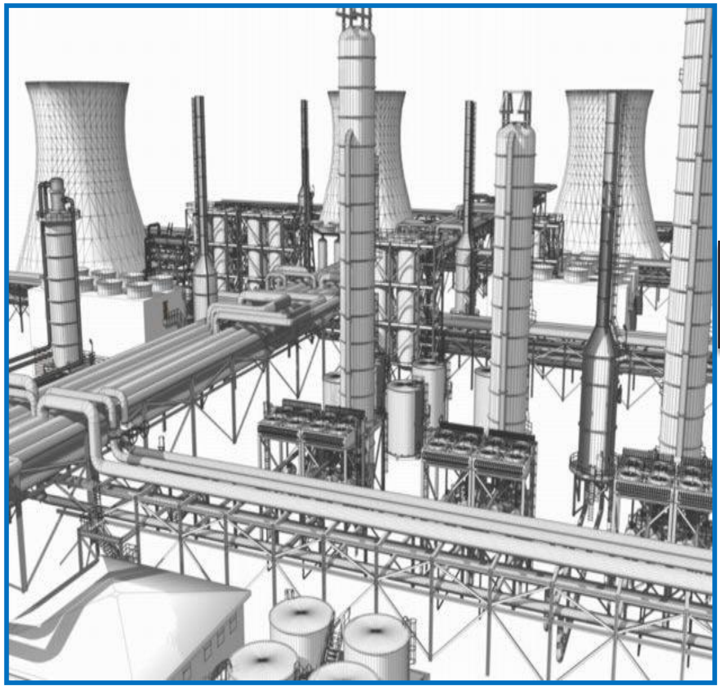
When ………………………………. ???

Who ……………………………………. ???


Chemical Engineering
Unit Operations
Unit Processes

Chemical Process

Raw materials

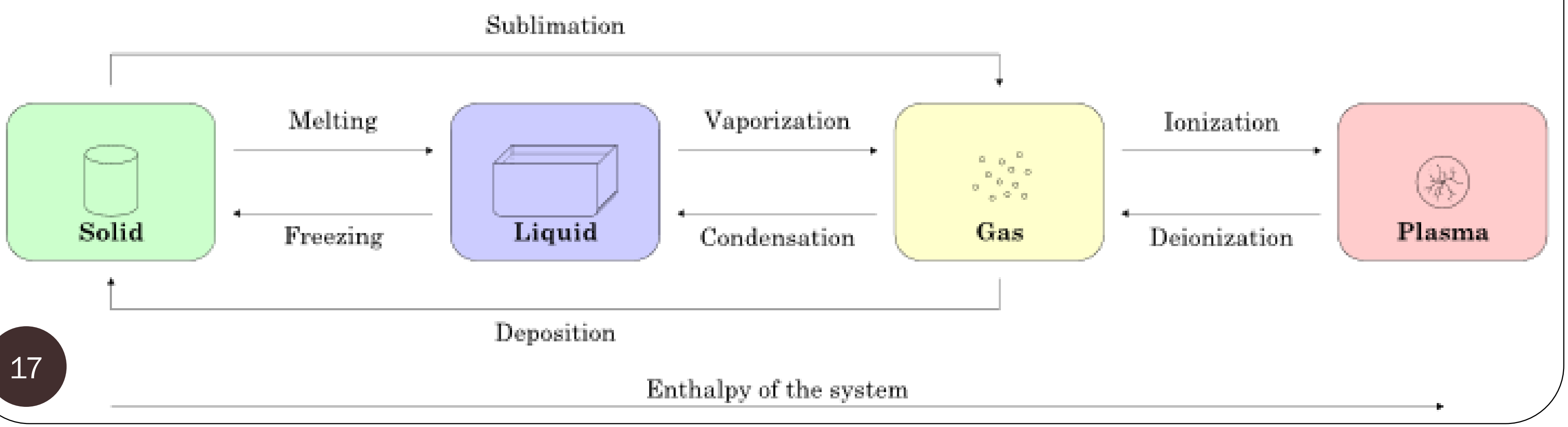


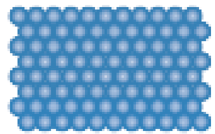
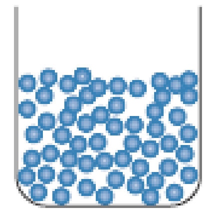
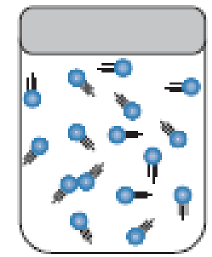
Products

- **Mechanics**
- **Continuum Mechanics**
- **Fluid Mechanics**
  - **Fluid Statics**
  - **Fluid Kinematics**
  - **Fluid Dynamics**

State of Matter

1. **Solid**
2. **Liquid**
3. **Gas**
4. **Plasma**

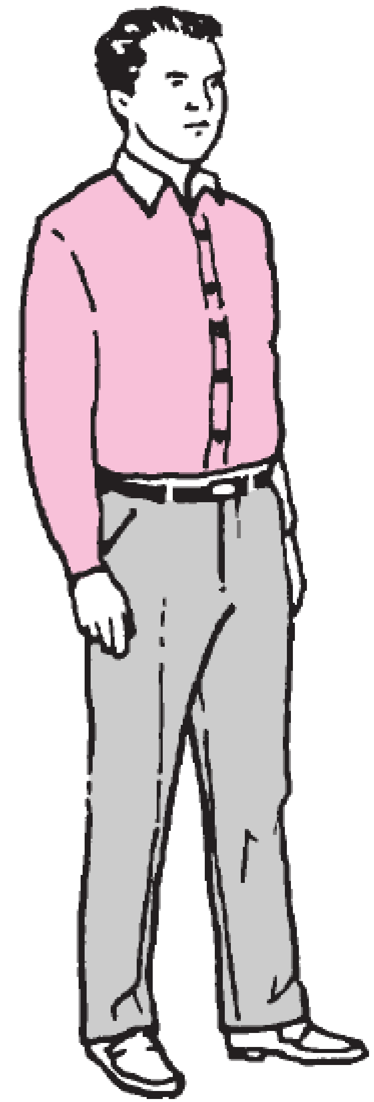


Attribute	Solid	Liquid	Gas
Typical Visualization			
Macroscopic Description	Solids hold their shape; no need for a container	Liquids take the shape of the container and will stay in open container	Gases expand to fill a closed container
Mobility of Molecules	Molecules have low mobility because they are bound in a structure by strong intermolecular forces	Liquids typically flow easily even though there are strong intermolecular forces between molecules	Molecules move around freely with little interaction except during collisions; this is why gases expand to fill their container
Typical Density	Often high; e.g., density of steel is 7700 kg/m^3	Medium; e.g., density of water is 1000 kg/m^3	Small; e.g., density of air at sea level is 1.2 kg/m^3
Molecular Spacing	Small—molecules are close together	Small—molecules are held close together by intermolecular forces	Large—on average, molecules are far apart
Effect of Shear Stress	Produces deformation	Produces flow	Produces flow
Effect of Normal Stress	Produces deformation that may associate with volume change; can cause failure	Produces deformation associated with volume change	Produces deformation associated with volume change
Viscosity	NA	High; decreases as temperature increases	Low; increases as temperature increases
Compressibility	Difficult to compress; bulk modulus of steel is 160×10^9 Pa	Difficult to compress; bulk modulus of liquid water is 2.2×10^9 Pa	Easy to compress; bulk modulus of a gas at room conditions is about 1.0×10^5 Pa

Importance: Applications

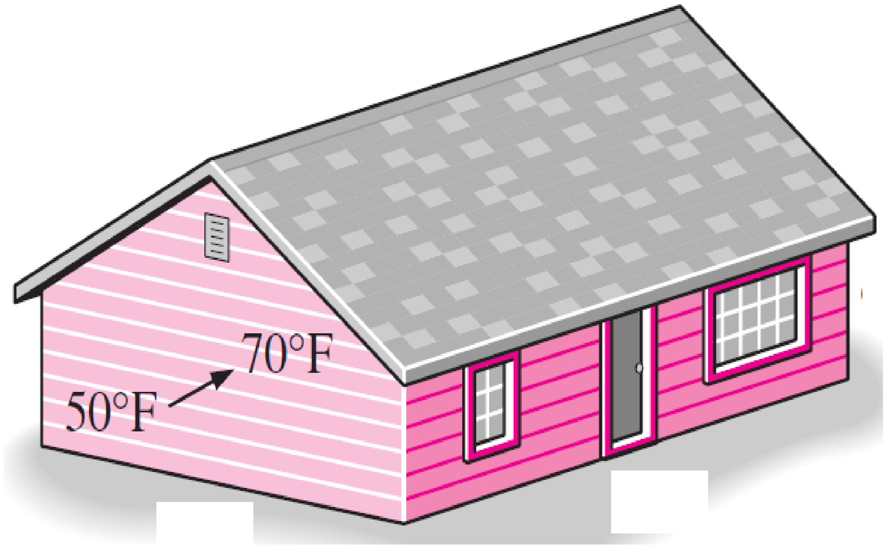
1. Human Body

Bio-fluid mechanics



Domestic systems

Ordinary homes



Water pipelines

Gas pipelines

Sewerage system

air conditioning/heating system

Automobiles

Fuel system

Cooling system

Lubricating system

Exhaust system

Aerodynamics

Aero planes

Aircrafts

Jet

Missiles

Wind turbines

Hydrology

Water flow through open channels

Environmental Distribution

Commercial Applications

Country-wide natural gas transmission system

- **SNGPL**
- **SSGPL**

Industrial Complex piping system

The future looks bright !

Fluid

- **doesn’t permanently resist distortion**
- **Fluid is a substance:**
  - **Capable of flowing.**
  - **Which cannot preserve its shape unless it is restricted into a particular vessel.**
  - **A fluid in equilibrium cannot sustain any shear.**

- **Liquid**
- **Gases**

Dimensions and Units

Dimension	Symbol	Unit (SI)
Length	L	meter (m)
Mass	M	kilogram (kg)
Time	T	second (s)
Temperature	θ	kelvin (K)
Electric current	i	ampere (A)
Amount of light	C	candela (cd)
Amount of matter	N	mole (mol)

Standard prefix

Multiple	Prefix
10^{12}	tera, T
10^{9}	giga, G
10^{6}	mega, M
10^{3}	kilo, k
10^{2}	hecto, h
10^{1}	deka, da
10^{-1}	deci, d
10^{-2}	centi, c
10^{-3}	milli, m
10^{-6}	micro, μ
10^{-9}	nano, n
10^{-12}	pico, p

System of Units

- SI Units
- CGS Units
- FPS Engineering Units

- ❖ Unit conversions
- ❖ Consistency
- ❖ Homogeneity

Concepts

- Density
- Viscosity
- Kinematic Viscosity
  - Viscosity of gases
  - Viscosity of liquids
- Specific Volume
- Specific Gravity

- **Rheology**
- **Types of fluids**
  - **Newtonian fluids**
  - **Non-Newtonian fluids**
- **Classification of Non-Newtonian fluids**
  - **Time Independent**
  - **Time dependent**
- **Viscoelastic fluids**