Fluid Mechanics

References

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Asst. Lec. Safa Ali Hussein

1.1 Scope of fluid mechanics:

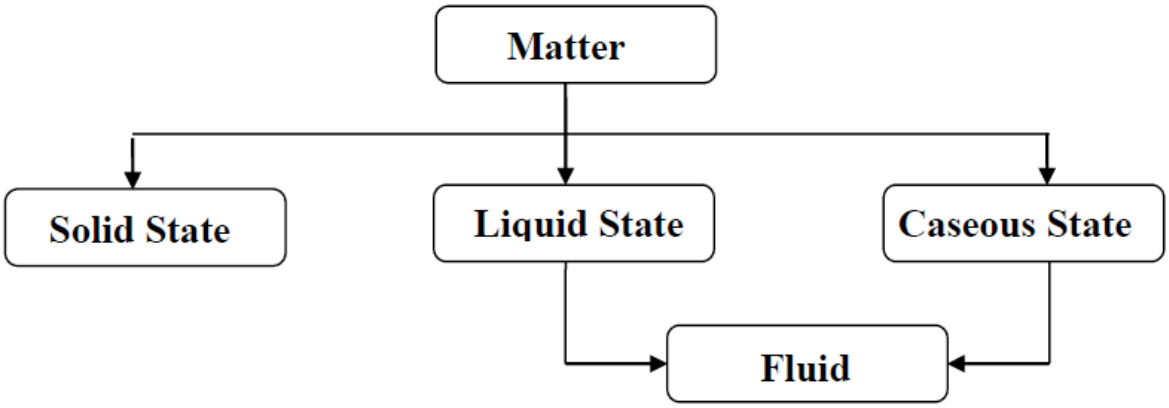
Hydraulics: is that branch of Engineering–science, which deals with water at rest or in motion and based on experimental observation of water flow.

❖ **Hydraulics** a Greek word 'Hudour' which means water.

Hydrodynamics: is a branch of physics that deals with the motion of fluids and the forces acting on solid bodies immersed in fluids and in motion relative to them (study of the forces exerted by fluids in motion).

Mechnics: it is a physical science that deals with state of rest and motion of bodies under the influence of forces.

Fluid: is a substance that deforms continuously when subjected to a shear stress and is capable of flowing.



Basic difference: molecules distance; activities; structures
المسافة بين الجزيئات , نشاط الجزيئات , بنية الجزيئات

Fluid Mechanics: is that branch of Engineering–science which deals with the behaviour of a fluid when subject to a system of forces under the conditions of rest and motion, it is a composion of both hydrodynamics and hydraulics.

Characteristics of fluid: A fluid has the following characteristics:

1) It has no definite shape of its own, but conforms to the shape of the containing vessel.
2) Even a small amount of shear force exerted on a liquid/fluid will cause it to undergo a deformation which continues as long as the force continues to be applied.

Classifications of fluid: A fluid may classified as follows:

A) → i)Liquid, ii) Gas, iii) Vapour
B) → (i) Ideal fluids , (ii)Real Fluids

Liquid:

- A liquid is a fluid which possesses a *definite volume* (which varies only slightly with temperature and pressure).

Gas: it possesses *no definite volume* and is *compressible*.

Vapour: it is a gas whose temperature and pressure are such that it is very near the liquid state (e.g., steam)

Ideal fluids: an ideal fluid is one which has *no viscosity* and *surface tension* and is *incompressible*.

Real fluids: A real practical fluid is one which has *viscosity*, *surface tension* and *compressibility* in addition to the *density*. The real fluids are actually available in nature.

1.2 Parts of fluid Mechanics:

fluid mechanics may be divided into three parts:

Statics: fluid at rest →incompressible fluids under static conditions is called ***hydrostatics*** & → compressible static gases is termed as ***aerostatics***.

Kinematics: fluid in motion→ it is deals with velocities, accelerations and the patterns of flow only. Force or energy causing these patterns flow are not considered.(Forces are not considered).

Dynamics: fluid in motion→it is deals with the relations between velocities, accelerations of fluid with forces or energy causing them. (Force are considered).

1.3 Fields of Engineering depending on fluid mechanics:

1- Hydraulics **2- Hydraulics Machinery** **3- Lubrication(التزييت)**
4- Biomedicine **5- Chemical Engineering** **6- Aeronautics(علم الطيران)**
7-Plasma Physics **8- Oceanography(علم البحار)** **9- Meteorology(علم الأنواء الجوية)**

1.4 Units & Dimensions:

The term dimension is used to denote a formula which is derived from the definition of the quantity.

- Basic Dimensions: Force, Length, Time (F, L , T)
Mass , Length, Time (M , L , T)

Table of the dimensions of some quantities in fluid mechanics

Quantity	Symbol	Dimensions(F,L,T)
Length	l	L
Time	t	T
Mass	m	M
Force	F	$MLT^{-2}=ML/T^2$
Velocity	V	$LT^{-1}=L/T$
Acceleration	a	$LT^{-2}=L/T^2$
Area	A	L^2
Discharge	Q	$L^3T^{-1}=L^3/T$
Pressure	ΔP	$ML^{-1}T^{-2}=M/LT^2$
Gravity	g	$LT^{-2}=L/T^2$
Density	ρ	$ML^{-3}=M/L^3$
Unit gravity force	γ	$ML^{-2}T^{-2}=M/L^2T^2$

Dynamic viscosity	μ	$ML^{-1}T^{-1}=M/LT$
Kinematic viscosity	υ	$L^2T^{-1}=L^2/T$
Surface tension	σ	$MT^{-2}=M/T^2$
Bulk modulus of elasticity	K	$ML^{-1}T^{-2}=M/LT^2$

- **Units:** SI Units; English Units

Quant. / system	Mass	Force	Length	Time
SI Units	gr	dyne	cm	Sec
	Kg	Newton	m	Sec
English Units	slugs	pounds	ft	Sec

Table of basic units for some basic quantities in fluid mechanics

Quantities	SI Unit
Length	Meter (m)
Time	Second(sec)
Mass	Kilogram(Kg)
Temperature	
a- Absolute degree	Kelvin (K)
b- Customary degree	Degree Celsius (C^o)
Derived units include	
Force	Newton($N=kg.m/s^2$)
Energy (work and quantity of heat)	Joule ($j=N\ .\ m$)
Power	Watt ($W=j.s^{-1}$)
Pressure, stress	Pascal ($Pa=N/m^2$)

For example, the dimension of velocity are [L/T], but the units may in (m/sec) or (cm/minute)...ect.

Example:1// **A body moves a distance ($l = 10Mm$) through a time ($t = 5\sec$).Calculate its velocity (V) in (m/s) and ($\mu m/s$).**

Solution:

$$V = \frac{l}{t} = \frac{10*10^6}{5} = 2*10^6 \ m/s \qquad Ans.$$

$$V = 2*10^6 *10^6 = 2*10^{12} \ \mu m/s \qquad Ans.$$

Examples: 2//

1 km = 1000 m = 100 000 cm = 10^6 mm

1 m^3 = 1000 liters

Hours (hr) = 60 minutes (min) = 3600 s

Acceleration gravity (g) = 9.81 m/s²

kN = 1000 N

Mpa = 10^6 Pa = 10^6 N/m²

$$W = m\,g = \frac{kg\,.m}{s^2} = N$$