UNIT-I FLUID PROPERTIES AND FLOW CHARACTERISTICS

PRE REQUEST DISCUSSION

Unit I broadly deal with units and dimensions, properties of fluids and applications of control volume of continuity equation, energy equation, and momentum equation.

Man's desire for knowledge of fluid phenomena began with his problems of water supply, irrigation, navigation, and waterpower.

Matter exists in two states; the solid and the fluid, the fluid state being commonly divided into the liquid and gaseous states. Solids differ from liquids and liquids from gases in the spacing and latitude of motion of their molecules, these variables being large in a gas, smaller in a liquid, and extremely small in a solid. Thus it follows that intermolecular cohesive forces are large in a solid, smaller in a liquid, and extremely small in a gas.

DIFFERENCES BETWEEN SOLIDS AND FLUIDS

The differences between the behaviors of solids and fluids under an applied force are as follows:

i. For a solid, the strain is a function of the applied stress, providing that the elastic limit is not exceeded. For a fluid, the rate of strain is proportional to the applied stress.
ii. The strain in a solid is independent of the time over which the force is applied and, if the elastic limit is not exceeded, the deformation disappears when the force is removed. A fluid continues to flow as long as the force is applied and will not recover its original form when the force is removed.

FLUID MECHANICS

Fluid mechanics is that branch of science which deals with the behavior of fluids (liquids or gases) at rest as well as in motion. Thus this branch of science deals with the static, kinematics and dynamic aspects of fluids. The study of fluids at rest is called fluid statics. The study of fluids in motion, where pressure forces are not considered, is called fluid kinematics and if the pressure forces are also considered for the fluids in motion, that branch of science is called fluid dynamics.

1.1 UNITS AND DIMENSIONS.

The word dimensions are used to describe basic concepts like mass, length, time, temperature and force.Units are the means of expressing the value of the dimension quantitatively or numerically.

Example - Kilogram, Metre, Second, Kelvin, Celcius.

The four examples are the fundamental units; other derived units are

Density = mass per unit volume = kg/m^3

Force = mass x acceleration = $kg.m/s^2$ = Newton or N
Pressure = force per unit area = N/m^2 =Pascal or Pa
Other unit is ' bar',
where 1 bar =1 X10^5 Pa =100 Kpa = 0.1 Mpa
Work = force x distance = Newton x metre = N.m==J or Joule
Power = work done per unit time= J/s = Watt or W

Term	Dimension	Unit
Area	L*L	m^2
Volume	L*L*L	m^3
Velocity	$L*T^{-1}$	m/s
Acceleration	$L*T^{-2}$	m/s^2
Force	$M*L*T^{-2}$	N
Pressure	$M*L^{-1}*T^{-2}$	N/m^2 = Pa
Work	$M*L^2*T^{-2}$	Nm = J
Power	$M*L^2*T^{-3}$	J/s = W
Density	$M*L^{-3}$	kg/m^3
Viscosity	$M*L^{-1}*T^{-1}$	kg/ms = N s/m^2
Surface Tension	$M*T^{-1}$	N/m

Quantity	*Representative symbol*	*Dimensions*
Angular velocity	ω	t^{-1}
Area	A	L^2
Density	ρ	M/L^3
Force	F	ML/t^2
Kinematic viscosity	ν	L^2/t
Linear velocity	V	L/t
Linear acceleration	A	L/t^2
Mass flow rate	m	M/t

Power	P	ML^2/t^3
Pressure	P	M/Lt^2
Sonic velocity	C	L/t
Shear stress	τ	M/Lt^2
Surface tension	σ	M/t^2
Viscosity	μ	M/Lt
Volume	V	L^3

Dimensions:
Dimensions of the primary quantities:

Fundamental dimension	***Symbol***
Length	L
Mass	M
Time	T
Temperature	T

Dimensions of derived quantities can be expressed in terms of the fundamental dimensions.

1.1.1 SYSTEM OF UNITS

1. CGS Units – Centimeter – Gram – Second
2. FPS Units – Foot – pound – Second
3. MKS Units – Metre – kilogram – Second.
4. SI Units – International System of units

1.2 FLUID PROPERTIES

1 Density or Mass density:

Density or mass density of a fluid is defined as the ratio of the mass of a fluid to its