Al Maaqal University
College of Engineering
Department of Civil Engineering

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Fluid Mechanics

(Second Stage)

First Semester

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CONTENTS

References:

Books: Any of the books listed below will be adequated.

[1] Engineering Fluid Mechanics by Clayton T, Donald F, Barbara C, and John A

[2] Fluid Mechanics, by Douglas J F, Gasiorek J M, and Swaffield J A, Longman.

[3] Elementary Fluid Mechanics by John K. Vennard.

[4] Mechanics of Fluids, Massey B S., Van Nostrand Reinhold.

[5] Hydraulics in Civil And Environmental Engineering, Chadwick A, And Morfett J., E & Fn Spon - Chapman & Hal.

CHAPTER ONE

PROPERTIES OF FLUID

1.1 Introduction

Fluid mechanics is that branch of science which deals with the behavior of the fluids at rest as well as in motion. It deals with the statics, kinematics, and dynamics of fluids. The study of fluids at rest is called statics. The study of fluids in motion, where the pressure forces are not considered is called fluid kinematics, and if the pressure forces are also considered for fluid in motion that branch of science is called dynamics. The main problems encountered in the fields of water supply, irrigation, navigation, and water power, resulted in the development of fluid mechanics. The available methods of analysis stem from the application of the following principles, concepts, and laws:-

- Newton's law of motion.
- The first and second laws of thermodynamics.
- The principle of conservation of mass.
- Newton's law of viscosity.

In the development of the principles of fluid mechanics, some fluid properties play principal roles. In fluid statics, a specific weight (or unit weight) is an important property, whereas, in fluid flow, density and viscosity are predominant properties.

1.2 Definition of a Fluid

A fluid may be defined as a substance that is capable of flowing. It has no definite shape of its own but conforms to the shape of the containing vessel. Fluids can be classified as liquids or gasses. A 'liquid' is a fluid, which possesses a definite volume, which varies only slightly with temperature and pressure. Since under ordinary conditions liquids are difficult to compress, they may be for all practical purposes regarded as incompressible. A 'gas' is a fluid, which is compressible and possesses no definite volume but it always expands until its volume is equal to that

of the container. Even a slight change in the temperature of a gas has a significant effect on its volume and pressure. The fluids are also classified as ideal fluids and real fluids. 'Ideal fluids' are those fluids that have no viscosity and surface tension and they are incompressible. However, in nature, the ideal fluids do not exist and therefore, these are only imaginary fluids. 'Real fluids' 2 are those fluids that are actually available in nature. These fluids possess the properties such as viscosity, surface tension, and compressibility.

1.3 Civil Engineering Fluid Mechanics

Why are we studying fluid mechanics on a Civil Engineering course? The provision of adequate water services such as the supply of potable water, drainage, sewerage is essential for the development of industrial society. It is these services that civil engineers provide. Fluid mechanics is involved in nearly all areas of Civil Engineering either directly or indirectly. Some examples of direct involvement are those where we are concerned with manipulating the fluid:

- Sea and river (flood) defenses;
- Water distribution/sewerage (sanitation) networks;
- Hydraulic design of water/sewage treatment works;
- Dams; o Irrigation;
- Pumps and Turbines;
- Water retaining structures.

And some examples where the primary objective is construction - yet analysis of the fluid mechanics is essential:

- The flow of air in/around buildings;
- Bridge piers in rivers;
- Ground-water flow.

1.4 The SI System of units

The SI system consists of six primary units, from which all quantities may be described. For convenience secondary units are used in general practice which is made from combinations of these primary units.

International System of Units (SI):

Quantity	SI Unit
Mass	kg
Force	N
Pressure	N/m^2 (Pa)
Mass density	kg/m^3
Weight density (Specific weight)	N/m^3
Work	J
Power	Watt
Dynamic viscosity	$N.s/m^2$
Kinematic viscosity	m^2/s

Derived Units:

There are many derived units all obtained from the combination of the above primary units. Those most used are shown in the table below:

Quantity	SI Unit		Dimension
velocity	m/s	ms^{-1}	LT^{-1}
acceleration	m/s^2	ms^{-2}	LT^{-2}
force	N $kg\ m/s^2$	$kg\ ms^{-2}$	$M\ LT^{-2}$
energy (or work)	Joule J N m, $kg\ m^2/s^2$	$kg\ m^2\ s^{-2}$	ML^2T^{-2}
power	Watt W N m/s $kg\ m^2/s^3$	Nms^{-1} $kg\ m^2\ s^{-3}$	ML^2T^{-3}

pressure (or stress)	Pascal P, N/m^2 , $kg/m/s^2$	Nm^{-2} $kg\ m^{-1}\ s^{-2}$	$ML^{-1}T^{-2}$
density	kg/m^3	$kg\ m^{-3}$	ML^{-3}
specific weight	N/m^3 $kg/m^2\ /s^2$	$kg\ m^{-2}\ s^{-2}$	$ML^{-2}T^{-2}$
relative density	Ratio (No units)		1 (No dimension)
viscosity	$N\ s/m^2$ $kg/m\ s$	$N\ sm^{-2}$ $kg\ m^{-1}\ s^{-1}$	$M\ L^{-1}T^{-1}$
Surface tension	N/m $kg\ /s^2$	Nm^{-1} $kg\ s^{-2}$	MT^{-2}