Fluid mechanics(1)
Syllabus

Basics:

• Definition of a fluid: concept of ideal and real fluids, both compressible

• Properties of fluids and the dimensions of these properties.

Hydrostatics:

• The variation of pressure with depth of liquid.

• The measurement of pressure and forces on immersed surfaces.

Hydrodynamics:

• Description of various types of fluid flow; laminar and turbulent flow;
Reynolds's number, critical Reynolds's number for pipe flow.

• Conservation of energy and Bernoulli's theorem. Simple applications of the continuity and momentum equations.

• Flow measurement e.g. Venturi meter, orifice plate, Pitot tube, notches and weirs.

• Concept of major and minor losses in pipe flow, shear stress, friction factor, and friction head loss in pipe flow.

• Darcy-Weisbach equation, hydraulic gradient and total energy lines. Series and parallel pipe flow.

• Flow under varying head.

• Chezy equation (theoretical and empirical) for flow in an open channel.

• Practical application of fluid mechanics in civil engineering.

Programme
Lectures

There are 4 hours of lectures per week. One of these will be considered as a tutorial class – to be confirmed. And one to be experimental work at lab.

Assessment

The marks awarded for this subject are assigned as follows:

• 40% for end-of-semester examination;

• 10% for laboratory work and reports.

50% for final examination.

References:

any of these books should help you understand fluid mechanics:

• Douglas, J.F., Swaffield, J.A., Gasiorek, J.M. and Jack, L.B. (2005), *Fluid Mechanics*, 5th Edn., Prentice Hall.

• Massey, B. and Ward-Smith, J. (2005), *Mechanics of Fluids*, 8th Edn.,
Routledge.

• Chadwick, A., Morfett, J. and Borthwick, M. (2004), *Hydraulics in Civil and Environmental Engineering*, 4th Edn., E & FN Spon.

• Douglas, J.F. and Mathews, R.D. (1996), *Solving Problems in Fluid Mechanics, Vols. I and II*, 3rd Edn., Longman

1. Introduction to Fluids

Background and Definition

Background

• There are three states of matter: solids, liquids and gases.

• Both liquids and gases are classified as fluids.

• Fluids do not resist a change in shape. Therefore fluids assume the shape of the container they occupy.

• Liquids may be considered to have a fixed volume and therefore can have a free surface. Liquids are almost incompressible.

• Conversely, gases are easily compressed and will expand to fill a container they occupy.

• We will usually be interested in liquids, either at rest or in motion.

Definition

The strict definition of a fluid is:
A fluid is a substance which conforms continuously under the action of shearing forces.
According to this definition, if we apply a shear force to a fluid it will deform and take up a state in which no shear force exists. Therefore, we can say:
If a fluid is at rest there can be no shearing forces acting and therefore all forces in the fluid must be perpendicular to the planes in which they act.

Units

Main units are: Length (L), Mass (M), and Time (T). Most of the other quantities like force, pressure, power, and more can be derived from the main three quantities: LMT

• The U.S. customary system (sometimes called the ***English Gravitational Unit System***, or the ***Pound-foot-second*** system:

Dimension	Unit
Length (L)	foot (ft)
Mass (M)	*slug $= \frac{lb.\sec^2}{ft}$
Time (T)	second (s)
Force (F)	F = mass × acceleration = pound (lb)
Temperature (θ)	Rankin °R Fahrenheit °F

*Force = Mass * Acceleration

$F = m.a$

Where:

a acceleration expressed in units of (ft/s^2)

$$m = \frac{F}{a} = \frac{lb}{ft/s^2} = \frac{lb.s^2}{ft} = slug$$

Note: Acceleration due to gravity (g) in BG units = **32.20 ft/s^2**

(For more precision, g = 32.17405 ft/s^2)

- The International System of Units (SI)

Dimension	Unit
Length (L)	meter (ft)
Mass (M)	kilogram (kg)
Time (T)	second (s)
Force (F)	Newton (N) = $kg.m/s^2$) = MLT^{-2}
Temperature (θ)	Kelvin °K Celsius °C

Acceleration due to gravity, g in SI units = **9.81 m/s^2**.

Temperature conversion

$$^\circ C = \frac{(^\circ F - 32^\circ)}{1.8} \rightarrow {}^\circ F = 1.8 \times {}^\circ C + 32^\circ$$

$$\cdot K = \frac{(^\circ R - 0.6^\circ)}{1.8} \rightarrow {}^\circ R = 1.8 \times \cdot K + 0.6^\circ$$

$$^\circ R = {}^\circ F + 460^\circ$$

$$\cdot K = {}^\circ C + 273^\circ$$

Some useful conversions:

Length:

	cm	ft	in	yard	mile	meter	km
cm	1.0	0.0328084	0.3937008	0.01093613	6.213712E-6	0.01	1E-5
ft	30.48	1.0	12.0	0.3333333	0.0001893939	0.3048	0.0003048
in	2.54	0.08333333	1.0	0.02777778	1.578283E-5	0.0254	2.54E-5
yard	91.44	3.0	36.0	1.0	0.0005681818	0.9144	0.0009144
mile	160934.4	5280	63360	1760	1.0	1609.344	1.609344
meter	100.0	3.28084	39.37008	1.093613	0.0006213712	1.0	0.001
Km	100000	3280.84	39370.08	1093.613	0.6213712	1000	1.0

Volume:

	cm^3	ft^3	in^3	U.S Gallon	U.K Gallon	m^3	Liter
cm^3	1.0	3.531467e-5	0.061024	0.0002641721	0.0002199692	1e-6	0.001
ft^3	28316.85	1.0	1728	7.480519	6.228833	0.02831685	28.31685
in^3	16.38706	0.0005787037	1.0	0.004329004	0.003604649	1.6387e-5	0.016387
U.S Gallon	3785.412	0.1336806	231	1.0	0.8326738	0.00378541	3.785412
U.K Gallon	4546.092	0.1605437	277.4196	1.20095	1.0	4.5461e-3	4.5461
m^3	1000000	35.31467	61023.74	264.1721	219.9692	1.0	1000
Liter	1000	0.03531467	0.001	0.2641721	0.2199692	0.001	1.0

Commonly used prefixes for SI units:

Factor by which unit is multiplied	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n