FLUID MECHANICS

INTRODUCTION

Dear Friends. Firstly, hello to all of you. My name is Ibrahim Çayıroğlu (Assist. prof). I am a member of the Department of Mechatronics Engineering. I have never been abroad. So, I withdraw trouble speaking or understanding English. This course language is English. I did not want to give this course. However, appropriate course instructor (know the fluid mechanics and teach as English) could not be found. I'll try to explain the Lessons in English. You can ask questions, or you can reply in Turkish. But I prefer you to ask and answer questions in Turkish.

Let's start with the course

DEFINITIONS AND UNITS

Force:

A force is any influence that causes an object a certain change (movement, direction, or geometrical construction). Formula is as follows;

Force=Mass x Accelaration => F=m . a

Weight is a force at the same time

G=m . g = kg m /s^2 = N (Newton) or gr.cm/s^2 = dyn

Example:

What is the 1 newton as dyn?

1 N= kg m / s^2 = 1000 gr 100 cm / s^2 = 10^5 gr cm /s^2 = 10^5 dyn

Pressure:

Pressure is an expression of force exerted on a surface per unit area. Its unit is Pascal. Usually used in bar. (1 bar = 10^5 Pascal). Formula is as follows;

Pressure = Force / Area, => P = F/A => N/m^2 =Pascal =Pa

Example: psi is pressure per inch square. 1 libre equal to 0.450 kg and 1 inch equal to 25.4 mm. Thus what is the 1 psi in pascal.

1 psi (pressure per inch) = 1 libre / $inch^2$ = 0.450 kg/(25.4x25.4) mm^2 =4.414 N/(0.0254 x 0.0254)m^2=6842.48 Pa.

Work/Energy:

A person doing Work, he has got a Energy. If he has got a Energy, he can do work. Work is closely related to Energy. Their units are the same as (Joule-J). Formula is as follows;

Work=Energy = Force x Distance = N m = Joule (J)

Power:

The work done per unit of time or consumed energy per unit of time. Its unit is Watt (W=J/s)

Power=Work(~Energy) / Time = N m /s = J / s = Watt (W)

Another commonly used automobile power unit is horsepower.

1 horsepower (hp) = 75 kg m / s

Example:

How many kilowatts power of 60 horsepower in a car?

1 hp=75 kg m/s = (75 kg * 9.81 m/s^2) m/s =736 N m / s = 736 Watt

60 hp = 60 * 736 W = 44145 W = 44.145 kW

Thus, we find the following important equality

1 kW = 1.36 hp

Let's give these units in the table briefly

Definition	Unit	Symbol	Explanation
Force	Newton	N	$kg\ m / s^2$
Pressure	Pascal	Pa	N / m^2
Energy (Work)	Joule	J	N m
Power	Watt	W	N m / s

To use the appropriate powers of units is more convenient in very large and very small values. These powers are as follows

Name	Symbol	Value
otto	o	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	µ	10^{-6}
mili	m	10^{-3}
-	-	$10^0=1$
kilo	k	10^3
mega	M	10^6
giga	G	10^9
tera	T	10^{12}
peta	P	10^{15}
exa	E	10^{18}

For example It is appropriate 32 MW instead of 32 million Watt

Fluid: It is called fluid that deformable substances under the least shear stress. This concept also includes gases as well as liquids.

Density: The mass per unit volume of fluid. It is indicated by ϱ . Its unit is [kg / m^3].

For example the density of water ise 1000 kg/m^3. 1 cm^3 water is 1 gr.

Specific Volume: Density invert is called specific volume. So, It is called as the volume of unit mass of fluid. Its unit is [m^3/kg]

For example the specific volume of water is 10^{-3} m^3/kg = 1 lt/kg.

Specific Weight (gravity): It is called the weight of unit volume fluid.

$\gamma = \varrho g = [kg/m^3]\ [m/s^2] = [N/m^3]$

the specific weight of water;

As newton: $\gamma = \varrho g = 1000\ [kg/m^3]\ 9.81\ [m/s^2] = 9810\ [N/m^3]$

As kgf: 1000 kgf/m^3

Relative density: It is called the proportion of a fluid density to water density. There is no unit. For example, the relative density of oil is 0.78 then its density is 780 kg/m^3 .

Specific energy: It is called owned by a unit mass of a fluid energy. Its unit is (Joule/kg). This energy may be fluid pressure, level difference or fluid speed. The total specific energy of a fluid is shown as follows.

$$E=g.z + P/\rho + v^2/2$$

E: specific energy (J/kg)

ρ: density (kg/m^3)

g: acceleration of gravity (m/s^2)

v: speed (m/s)

z: level difference (m)

P: pressure (Pa)

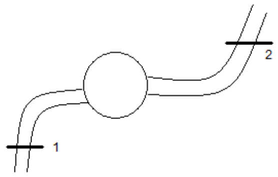
<u>Example</u>: Water flows through a pipe. At a specific point pressure is P = 4.22 Pa. Speed v = 2.1 m / s, According to a point from the reference height z = 3.2 m, What is the sum of the specific energies of the water at this point?

Total Specific Energy = $E= g.z + P/\rho + v^2/2$

$E= 9.81\ m/s^2\ 3.2\ m + 22.4\ (N/m^2) / 1000\ (kg/m^3) + 2.1^2\ (m/s)^2 / 2$

$=33.61\ m^2 / s^2 = 33.61\ J/kg$

Example: Input cross-section of a water pump is $P_1 = 0.2$ bar, speed $v_1 = 3.4$ m/s. Output cross-section pressure is $P_2 = 3.2$ bar, speed v_2=5.1 m/s dir. The difference height between the input and output sections is z=0.46 m. Accordingly, find specific energy of each kg of water passing thrugh the pump gained.



$E_2 – E_1 = [g.z_2 + P_2/ \rho + v_2^2 /2] – [g.z_1 + P_1/ \rho + v_1^2 /2]$

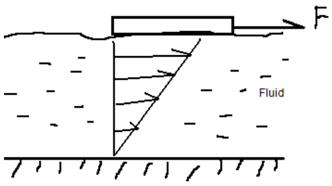
$E_2 – E_1= g(z_2 –z_1) + (P_2 – P_1) /\varrho + (v_2^2- v_1^2)/2$

$E_2 – E_1= 9.81 (0.46) + (3.2 – 0.2) 10^5 /1000 + (5.1^2 – 3.4^2) /2$

$E_2 – E_1= 311.74\ m^2/s^2 =311.74\ J/kg$

Viscosity: It show shear resistance or resistance to shape deformation of fluids.

Dynamic (absolute) viscosity: When we pull a plate on a fluid then the shear stress occurs. Here it is, this is called the coefficient used to calculate the this shear stress.



$\tau = \mu . (u/e)$

u: plate speed

e: openness (opening gap)

μ: dynamic viscosity ($N\ s/m^2$)

Kinematic viscosity: Is called the ratio of absolute viscosity to density.

$\upsilon = \mu / \rho = [(N\ s)/m^2] / [kg/m^3] = m^2 /s$

* Viscosity in a liquid results from cohesion between molecules.

* Fluid viscosity decreases with increasing temperature. It changes very little with pressure. That is usually neglected.

* Does not change the viscosity of pure water mixed. However, increases the viscosity of the sugar add.

* Viscosity in a gas results from random movement of molecules.

* The random movement increases with temperature. So the viscosity increases with the temperature in gases.

We use a lot of Greek and latin letters in formulas. It is useful to get to know them with their readings.

symbol	name			Latin
	antique	Middle Ages	modern	
Α α	alfa (ἄλφα)	alfa (ἄλφα)	alfa (άλφα)	a
Β β	beta (βῆτα)	vita (βῆτα)	vita (βήτα)	b
Γ γ	gamma(γάμμα)	gamma(γάμμα)	gamma (γάμμα / γάμα)	g
Δ δ	delta (δέλτα)	delta (δέλτα)	delta (δέλτα)	d
Ε ε	(εἶ)	e psilon (ἒ ψιλόν)	epsilon (έψιλον)	e
Ζ ζ	zeta (ζῆτα)	zita (ζῆτα)	zita (ζήτα)	z
Η η	eta (ἦτα)	ita (ἦτα)	ita (ήτα)	ē
Θ θ	theta (θῆτα)	theta (θῆτα)	thita (θήτα)	th
Ι ι	iota (ἰῶτα)	iota (ἰῶτα)	iota / yiota (ἰῶτα / γιώτα)	i
Κ κ	kappa (κάππα)	kappa (κάππα)	kapa (κάππα)	k
Λ λ	(λάβδα)	lamda (λάμβδα)	lamda (λάμδα / λάμβδα)	l

Μ μ	mu (μῦ)	mu (μῦ)	mi (μι / μυ)	m
Ν ν	nu (νῦ)	nu ()	ni (νι / νυ)	n
Ξ ξ	ksei (ξεῖ)	ksi (ξῖ)	ksi (ξι)	ks, x
Ο ο	ou (οὖ)	o mikron (ὂ μικρον)	omikron (όμικρον)	o
Π π	pei (πεῖ)	pi (πῖ)	pi (πι)	p
Ρ ρ	ro (ρω)	ro (ρω)	ro (ῥῶ)	r, rh
Σ σ ς	siγma (σῖγμα)	siγma (σῖγμα)	siγma (σίγμα)	s
Τ τ	tau (ταῦ)	tau (ταῦ)	taf (ταυ)	t
Υ υ	u (ὖ)	u psilon (ὔ ψιλον)	ipsilon (ύψιλον)	u, y
Φ φ	phei (φεῖ)	phi (φῖ)	phi (φῖ)	ph
Χ χ	khei (χεῖ)	khi (χῖ)	khi (χῖ)	kh, ch
Ψ ψ	psei (ψεῖ)	psi (ψῖ)	psi (ψι)	ps
Ω ω	o (ὦ)	o mega (ὠ μέγα)	omega (ωμέγα)	ō