KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

POLITEKNIK MALAYSIA
SULTAN SALAHUDDIN ABDUL AZIZ SHAH

POCKET NOTE FLUID CHARACTERISTICS

ARFFAAZILA RAHMAT
ZURENA LEMEN

POCKET NOTE

FLUID CHARACTERISTICS

ARFFAAZILA RAHMAT
ZURENA LEMEN
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

HAK CIPTA TERPELIHARA

GARIS PANDUAN PENYEDIAAN EBOOK

Nama penulis :
Arffaazila Binti Rahmat
Zurena Binti lemen

No eISBN: 978-629-7667-58-4

Terbitan pertama 2025

Diterbitkan oleh:

UNIT PENERBITAN
Politeknik Sultan Salahuddin Abdul Aziz Shah, Persiaran Usahawan, Seksyen U1,
40150 Shah Alam, Selangor.
Telephone No. : +603 5163 4000
Fax No. : +603 5569 1903

e ISBN 978-629-7667-58-4

9 786297 667584

SYNOPSIS

Alhamdulillah, we express our gratitude to the Divine Presence because with HIS permission we were able to complete an ebook titled "Pocket Note Fluid Characteristics".

The production of the eBook "Pocket Note Liquids Characteristics " is an effort and initiative of the building services diploma lecturers to provide notes and training to strengthen students' mastery of this topic. The idea of this effort is a continuation of the ebook courses and workshops that have been implemented by FITAC.

This book is written for first-year engineering students and covers the properties of fluids and solids. It uses clear explanations and simple derivations, and includes illustrative problems to help students understand the theory.

A huge thank you and appreciation to all parties involved in providing assistance and strong support to make this book a success. Hopefully this small effort will benefit readers and encourage ebook writing.

TABLE OF CONTENTS

COURSE SYLLABUS

01 Describe fluid, density, specific weight, specific gravity and specific volume of fluid

02 Describe the relationships between density, specific weight, specific gravity and specific volume and solve problems using these relationships.

03 Describe viscosity of fluid, Newtonian fluid and non-Newtonian fluid

Definition of fluids

Fluids are substances that can flow and take the shape of their container. They are characterized by their ability to deform continuously under the application of a shear stress, no matter how small that stress might be. Fluids encompass two primary states of matter:

Liquids
Have a definite volume but no fixed shape.
Their particles are close together but can move past each other, allowing the liquid to flow.

Examples: Water, oil, and alcohol.

Gases
Have neither a definite shape nor a fixed volume.
Their particles are far apart and move freely, allowing gases to expand and fill any available space.

Examples: Air, oxygen, and carbon dioxide.

Fluids are distinguished from solids, which have a fixed shape and resist deformation. Additionally, fluids can be described in terms of their viscosity (resistance to flow), density, and pressure.

Definition of fluids

- Fluids undergo continuous deformation, i.e. fluids always keep flowing. Fluid is a substance that does not possess a definite shape and easily yields to external pressure.
- Fluid is any liquid or gas or any material that is unable to withstand a shearing or tangential force, when at rest. When the said forces are applied to the fluid, it goes through a continuous change in shape.
- Fluids are substances with zero shear modulus, i.e they cannot resist the shear force applied to them.

In our day-to-today life, we would have heard the dehydrated patient advised to consume more fluids to compensate for the water loss. Fluids help in the digestion of food, hence we need to take more fluids.

For more klik

https://byjus.com/physics/fluid/#:~:text=Fluids%20undergo%20continuous%20deformation%2C%20i.e.,tangential%20force%2C%20when%20at%20rest.

Definition of fluids

A fluid is a substance which deforms (flows) continuously under the application of a shear stress, however small they may be.

A stress is defined as a force per unit area, acting on surface element

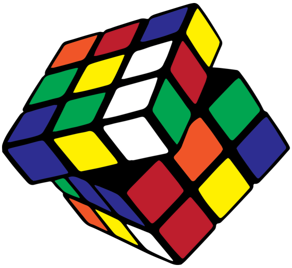
$$P = F/A$$

DEFINITION OF FLUIDS

if a fluid is at rest, there can be no shearing forces.

all forces in the fluid must be perpendicular to the planes upon which they act.

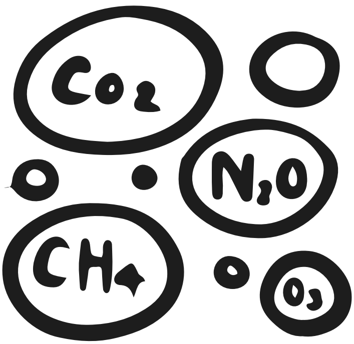
States of matter



SOLID

LIQUID

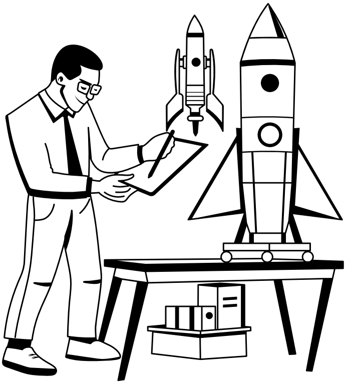
STATES OF MATTER



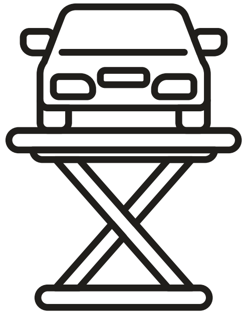
GAS

Notes

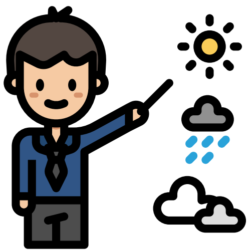
APPLICATIONS OF FLUID MECHANICS



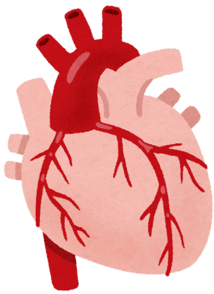
AERODYNAMICS



HYDRAULICS



METEOROLOGY



BIOMEDICAL ENGINEERING

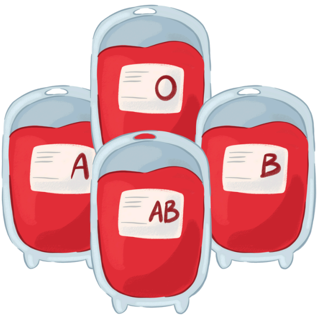
Notes

Content that

CLICKS

FLUIDS - ANY FORM OF MATTER THAT FLOWS

Since liquids and gases do NOT have a definite shape, they are able to flow, making them FLUIDS



BLOOD

HONEY

HELIUM

WATER

TOOTH PASTE

Notes

The three states of matter are solid, liquid, and gas:

Solid: Has a definite shape and volume. Examples of solids include ice, wood, and sand.

Liquid: Has a definite volume but takes the shape of its container.

Gas: Has no definite shape or volume

SCAN HERE

HAPPY WATCHING

NOTES

Frequently Asked Questions - FAQs

What are the three common states of matter?

The three states of matter have one thing in common: they are made up of minuscule particles. They can occupy space and have a certain mass. Each of these three states has a volume. Atoms in these three states are strongly attracted to one another.

NOTES

Frequently Asked Questions - FAQs

Is matter created or destroyed?

In 1785, Antoine Lavoisier discovered a scientific law known as the Mass Conservation Law. In its simplest form, it says that matter cannot be generated or destroyed. The total mass and energy of the cosmos remains constant.

PHYSICAL CHARACTERISTICS

LIQUID

01

Shape

Liquids have a definite volume but no definite shape, liquids take the shape of their container

Compressibility

Liquids are nearly incompressible

02

03

Density

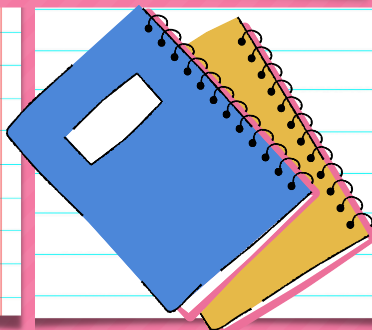
Liquids have lesser densities than solids

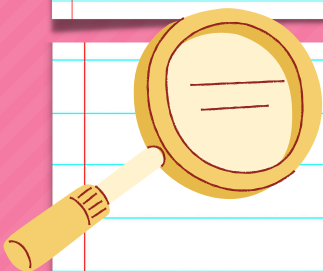
PHYSICAL CHARACTERISTICS

GAS

01 Shape

Gases have neither a fixed shape nor a fixed volume.





Compressibility 02

Gases can be compressed easily.

03 Density

Gases have the least density among solid and liquid

Solid	Liquid	Gas
		
▪ Rigid	▪ Not Rigid	▪ Not Rigid
▪ Fixed Shape	▪ No Fixed Shape	▪ No Fixed Shape
▪ Fixed Volume	▪ Fixed Volume	▪ No Fixed Volume
▪ High Density	▪ Average to High Density	▪ Low Density
▪ Closely tight and organized particles	▪ Closely tight but not disorganized particles	▪ Far apart and disorganized particles
▪ Slightly Compressible	▪ Slightly Compressible	▪ Highly Compressible

VISCOSITY IN FLUID FLOWS

INFO

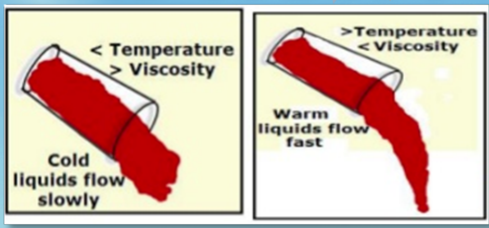
VISCOSITY IS A FLUID'S RESISTANCE TO FLOW, OR ITS INTERNAL FRICTION

A FLUID WITH A HIGH VISCOSITY IS THICK AND FLOWS SLOWLY, WHILE A FLUID WITH A LOW VISCOSITY FLOWS QUICKLY. FOR EXAMPLE, HONEY HAS A HIGH VISCOSITY AND DRAINS SLOWLY FROM A CUP, WHILE WATER HAS A LOW VISCOSITY AND DRAINS QUICKLY.

THANKS
FOR WATCHING

SCAN
ME!

VISCOSITY



RESISTANCE

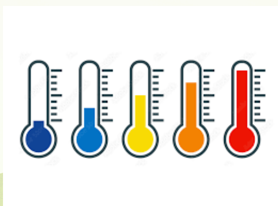
- Fluid friction of liquid to flow
- The physical property of a fluid that limits its ability to flow
- Resistance of a fluid (liquid or gas) to a change in shape, or movement of neighbouring portions relative to one another

FLOWS

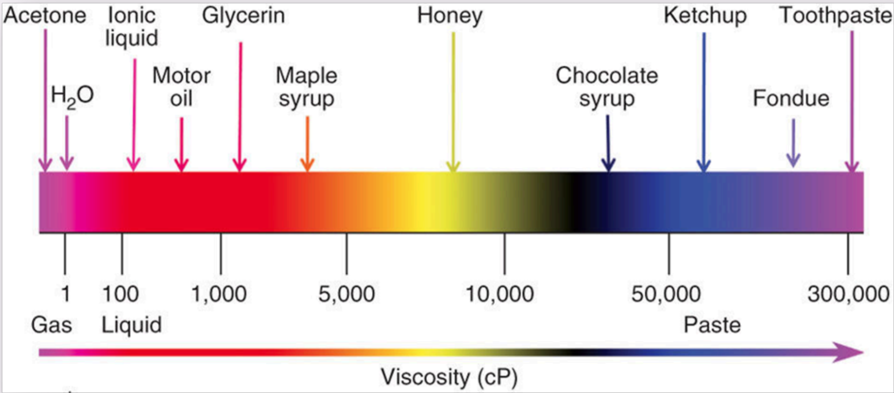
- A liquid with high viscosity is thick and flows slowly
- A liquid with low viscosity is thin and flows quickly

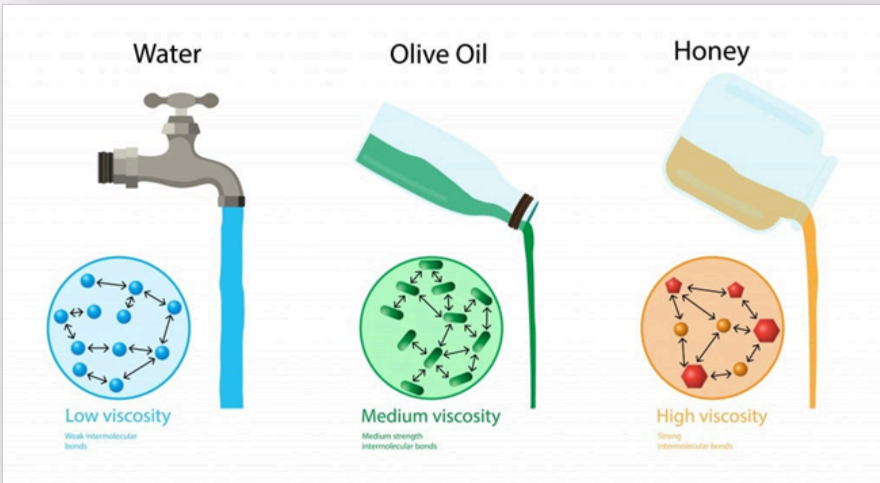
TEMPERATURES

- The viscosity of a liquid decreases with increasing temperatures
- The viscosity of gases increases with increasing temperatures



VISCOSITY OF FLUID





FLUID	VISCOSITY (CPs)
Air	.02
Acetone	.3
Methanol	.6
Water	1.0
Ethanol	1.2
Olive Oil	84.0
Motor Oil	540.0
Maple Syrup	3,200.0
Honey	12,200.0
Molasses	20,000.0

Dynamic Viscosity (μ)

Dynamic viscosity measures a fluid's internal resistance to flow when an external force (shear stress) is applied. It quantifies how "thick" or "sticky" a fluid is.

- **Units:**
  - SI Unit: **Pascal-second (Pa·s)**
  - Common Unit: **Poise (P)**, where $1\,\mathrm{P} = 0.1\,\mathrm{Pa}$\cdotps
  - Millipoise (mP): $1\,\mathrm{Pa}$\cdotps $= 1000\,\mathrm{mP}$
- **Formula:**

  $$\tau = \mu \frac{du}{dy}$$

  Where:

  τ = shear stress (Pa)

  $\frac{du}{dy}$ = velocity gradient (rate of shear deformation)

Example: Honey has a high dynamic viscosity compared to water.

SCAN ME

KINEMATIC VISCOSITY

- Kinematic viscosity is a measure of a fluid's resistance to flow under gravity.
- It's calculated by dividing a fluid's dynamic viscosity by its density

Kinematic viscosity is measured by timing how long it takes a set volume of fluid to flow a known distance through a calibrated viscometer. The temperature at which the test is conducted must also be reported

Kinematic Viscosity (ν):

- **Units:**
  - SI Unit: **Square meter per second (m^2/s)**
  - Common Unit: **Stoke (St)**, where $1\,\mathrm{St} = 10^{-4}\,\mathrm{m}^2/\mathrm{s}$
- **Formula:**

  $\nu = \frac{\mu}{\rho}$

  Where:

  ν = kinematic viscosity (m^2/s)

  μ = dynamic viscosity (Pa·s)

  ρ = density of the fluid (kg/m^3)

click here!

FORMULA OF KINEMATIC VISCOSITY

$$\text{Kinematic viscosity} = \frac{\text{dynamic viscosity}}{\text{density}}$$

*with no force involved

$$\nu = \frac{\mu}{\rho}\ (m^2/s)$$

Typical values:

$$Water = 1.14x10^{-6}m^2/s\ ;\ Air = 1.46x10^{-5}m^2/s$$

Dynamic vs. Kinematic Viscosity:

What's the Difference?

DYNAMIC	VISCOSITY
measures a fluid's resistance to flow when force is applied	measures how fast a fluid moves when a force is applied
Dynamic viscosity is related to external force applied to non-Newtonian fluids	kinematic viscosity is the inherent viscosity of Newtonian fluids
Symbol μ and unit Ns/m^2	Symbol ν and m^2/s
When viscous force is dominant	When inertia, as well as viscous force, is dominant

FLUID PROPERTIES

FLUID TERMS IN ENGINEERING

DENSITY

Density is a measure of how heavy something is for its size, or the mass of an object or substance compared to its volume.

Density can be used to explain why some things sink and others float. For example, if an object is more dense than water, it will sink in water. Ice floats because its density is lower than water.

Density is measured in units such as

g/cm3

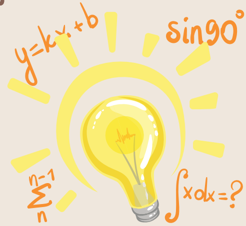
or

$kg/m3$

$$Density = \frac{Mass}{Volume}$$

Density Formula: ρ = m/V, where ρ is the density, m is the mass of the object and V is the volume of the objec

EXAMPLE



A fluid of 5000 kg filled an open cylinder container with volume 5.301 meter cube. Calculate the density of fluid and specific weight.

SOLUTION

DENSITY OF FLUID

$$\rho_{oil} = \frac{m}{v} = \frac{5000kg}{5.301m^3} = 943.14kg/m^3$$

EXAMPLE

If 4.8 m^3 of oil weighs 30 kN, calculate its density and relative density

SOLUTION

Given, $v = 4.8m^3$

$w = 30kN$

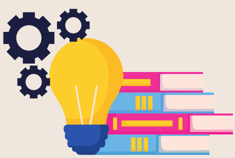
$$w = m \times g \qquad \therefore m = \frac{w}{g}$$

$$\rho = \frac{m}{v} = \frac{w}{g \times v}$$

Density

$$\rho_{oil} = \frac{w}{g \times v} = \frac{30 \times 10^3 N}{9.81 \times 4.8m^3} = 637.10kg/m^3$$

Relative density



$$S._g = \frac{\rho_{oil}}{\rho_{water}} = \frac{637.10}{1000} = 0.637$$

Click here

SPECIFIC WEIGHT

1

Specific weight, also known as unit weight, is the weight of a material per unit volume

2

Specific weight is related to fluid density by the acceleration due to gravity. For example, the specific weight of water on Earth at 4° Celsius is 9.807 kilonewton per meter cube

3

BASIC FORMULA

γ = Weight/ volume

UNIT

N/m^3

4

Weight = m x g

m = mass (kg)

g = gravity (meters per second squared)

5

OTHER FORMULA

$\gamma = \varrho g$

γ = **Density x gravity**

UNIT

N/m^3

EXAMPLE

A drum of 1 meter cube volume contains 8.5 kN an oil when full. Find the specific weight.

SOLUTION

$$w = m \times g \qquad \therefore m = \frac{w}{g}$$

$$\rho = \frac{m}{v} = \frac{w}{g \times v}$$

Specific weight

$$\gamma = \frac{w}{v} = \frac{8.5 \times 10^3 N}{1m^3}$$
$$= 8.5 \times 10^3 N/m^3$$

SPECIFIC GRAVITY

1 WHAT IS SPECIFIC GRAVITY?

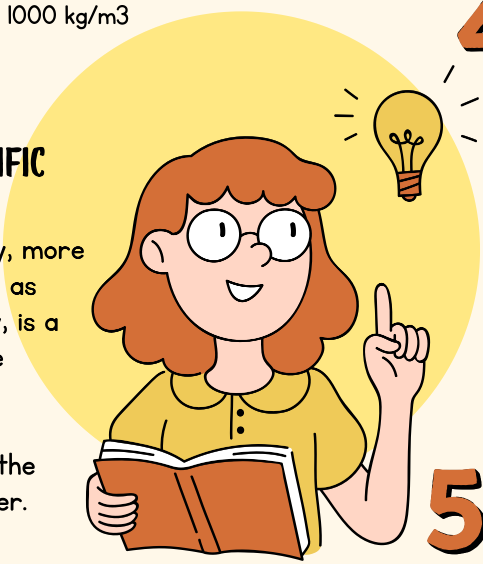
Specific gravity, more formally known as relative density, is a measure of the density of a substance in comparison to the density of water.

2 INFO

It is common to use the density of water at 4 oC as a reference point as water at this point has the highest density of 1000 kg/m3

3 DENSITY OF WATER IN VARIOUS UNITS

- 1000 kilograms per cubic meter
- 1 gram per cubic centimeter
- 62.43 pounds per cubic foot
- 0.036 pounds per cubic inch



4 APPLICATIONS OF SPECIFIC GRAVITY

- The gem purity can be determined by comparing its specific gravity with the already measured high purity level of another gem. This allows the gem's value to be determined very quickly.

5 WHAT IS THE DIFFERENCE BETWEEN SPECIFIC GRAVITY AND SPECIFIC WEIGHT?

Specific weight is the ratio of the weight of an object to the object's volume. In the case of specific gravity, it is the ratio of an object's density to the density of water.

6 FORMULA

$$\text{Specific gravity} = \frac{\text{Density of the object}}{\text{Density of water}} = \frac{\rho_{object}}{\rho_{H_2O}}$$

EXAMPLE

The specific gravity of benzene is 0.876. Calculate its specific weight and its density in SI units.

SOLUTION

Density

$$S_{\cdot g} = \frac{\rho_{benzene}}{\rho_{water}}$$

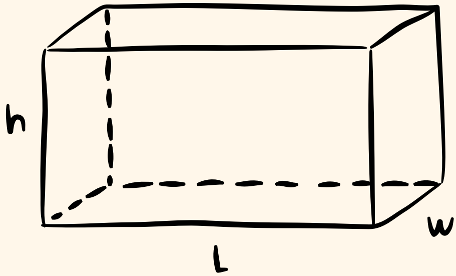
$$\rho_{benzene} = 0.876 \times 1000 = 876 kg/m^3$$

Specific weight

$$\gamma = \frac{w}{v} = \frac{(m \times g)}{v} = \rho \times g$$

$$= 876 \times 9.81 = 8593.6 N/m^3$$

SPECIFIC VOLUME



$$V = Lwh$$

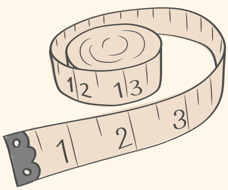
Definition

Specific volume is a thermodynamic property defined as the volume occupied by a unit mass of a substance.

Importance of Specific Volume

Understanding States of Matter: Specific volume helps in describing the physical state of a substance (solid, liquid, or gas). Gases, for instance, have much larger specific volumes compared to liquids and solids due to the greater distance between molecules.

Standard Unit



The standard unit for specific volume is cubic meters per kilogram (m3/kg)

Formula

$$v = \frac{V\ (m^3)}{m\ (kg)}$$

V = Volume (cubic meters)
m = mass (kg)

EXAMPLE

A CYLINDER WITH A HEIGHT OF 600CM AND DIAMETER OF 100CM CONTAINS 6000N OF LIQUID WHEN IT IS FULL. ESTIMATE THE SPECIFIC WEIGHT AND SPECIFIC GRAVITY OF THE LIQUID.

SOLUTION

Specific weight

$$\gamma = \frac{w}{v} = \frac{8.5 \times 10^3 N}{1m^3} = 8.5 \times 10^3 N/m^3$$

Specific gravity

$$\rho_{oil} = \frac{w}{g \times v} = \frac{8.5 \times 10^3 N}{9.81 \times 1m^3} = 866.5kg/m^3$$

$$S._g = \frac{\rho_{oil}}{\rho_{water}} = \frac{866.5}{1000} = 0.8665$$

QUESTION AND ANSWER

During a science experiment, a student pours cooking oil, water, and sand into a transparent beaker. The water and oil form separate layers, while the sand settles at the bottom. When the beaker is tilted, both the water and oil shift position and take the new shape of the beaker, but the sand remains at the bottom. Based on the observation in the experiment, which of the substances can be classified as fluids? Justify your answer using the behavior of the substances in the beaker.

Answer:

Water and oil are classified as fluids because they can flow and take the shape of the container. Sand is not a fluid because it does not flow freely or change shape to fit the container.

QUESTION AND ANSWER

A student is experimenting using a balloon and a plastic bottle filled halfway with colored water. When she squeezes the plastic bottle:

- The water level rises and flows upward through a small tube.
- The balloon, which contains air, expands slightly.

The student observes that the water stays together as a visible stream, while the air in the balloon spreads out to fill the space evenly. Based on the observations from the experiment, describe two physical characteristics of liquids and two physical characteristics of gases. Explain how the experiment shows these characteristics.

Answer:

- Liquids:

1. Have a definite volume – the water stayed the same amount in the bottle.
2. Take the shape of their container – the water flowed and filled the shape of the tube when squeezed.

- Gases:

3. Do not have a definite shape or volume – the air in the balloon expanded to fill the space.
4. Can be compressed – the air in the balloon was squeezed and changed in size.

QUESTION AND ANSWER

An engineer is analyzing the flow of oil through a pipe. The oil has a density of 850 kg/m^3 and a dynamic viscosity of 0.34 Pa·s. She needs to determine the kinematic viscosity of the oil to understand how it will behave under different flow conditions. Using the data given in the stimulus, identify the values of:

a) Dynamic viscosity (μ)

b) Kinematic viscosity (ν)

Then, explain how these properties affect the flow of the oil through the pipe.

Answer:

- a) Dynamic viscosity (μ) = 0.34 Pa·s
- b) Kinematic viscosity (ν) =
- ν=$\mu\rho$=

0.34 Pa\cdotps850 kg/m^3=4.00×10^{-4} m^2

Explanation:

- Dynamic viscosity measures the oil's internal resistance to flow. A higher value means the fluid flows more slowly.
- Kinematic viscosity accounts for both the fluid’s viscosity and its density, helping determine how the fluid moves under gravity and pressure differences.

QUESTION AND ANSWER

Define the term fluid and explain its key characteristics. Then, provide two real-life engineering applications where fluids are used, and describe how their properties are essential to the operation of these systems.

Answer:

Definition of Fluid

A fluid is a substance that can flow and continuously deform under the action of a shear stress, regardless of how small the applied stress is. Fluids include both liquids and gases.

Key Characteristics of Fluids

No fixed shape: Fluids take the shape of their container.

Ability to flow: Fluids can move from one place to another under the influence of pressure or gravity.

Compressibility: Gases are compressible while liquids are relatively incompressible.

Viscosity: A measure of a fluid's resistance to flow.

QUESTION AND ANSWER

Continue....

Density and pressure variation: Fluids exert pressure in all directions and their behavior depends on density.

Real-life Engineering Applications:

Hydraulic Braking System in Vehicles:
Fluids (typically brake fluid) are used to transfer force from the brake pedal to the brake pads. The incompressibility of the fluid ensures that force is transmitted efficiently.

Cooling Systems in Power Plants:
Water or other coolants are circulated to absorb and carry away heat. The high specific heat capacity and fluidity of water allow it to efficiently transfer heat and maintain system temperature.

QUESTION AND ANSWER

Describe the physical characteristics of liquids and gases. Then, compare how these characteristics influence their behavior in engineering applications. Provide at least one example for each.

Answer:

Physical Characteristics of Liquids :

Definite volume but no definite shape – liquids take the shape of their container but maintain a consistent volume.

Incompressibility – liquids are nearly incompressible, meaning their volume does not change significantly under pressure.

Surface tension – liquids have cohesive forces that cause surface tension, allowing them to form droplets.

Flow behavior – liquids can flow and are affected by viscosity, which determines how easily they move.

Physical Characteristics of Gases :

No definite shape or volume – gases expand to fill the shape and volume of their container.

QUESTION AND ANSWER

Continue....

Compressibility – gases are highly compressible and can change volume significantly under pressure.

Low density – compared to liquids, gases have much lower density.

Free movement of molecules – gas molecules move freely and rapidly in all directions.

Comparison and Application:
Liquids in Engineering: Used in hydraulic systems due to their incompressibility, which allows force to be transmitted efficiently (e.g., car brakes).

Gases in Engineering: Used in pneumatic systems where compressibility allows the storage and controlled release of energy (e.g., air compressors in factory automation).

QUESTION AND ANSWER

Identify and define dynamic viscosity (μ) and kinematic viscosity (ν). Explain the difference between them and how each property is applied in engineering systems. Include their units and one practical example for each.

Answer:

Definition of Dynamic Viscosity (μ) :

Dynamic viscosity is a measure of a fluid's internal resistance to flow when an external force is applied. It reflects how "thick" or "sticky" a fluid is.

Unit: Pascal-second (Pa·s) or $N \cdot s/m^2$ or kg/(m·s)

Definition of Kinematic Viscosity (ν):

Kinematic viscosity is the ratio of dynamic viscosity to fluid density. It represents how easily a fluid flows under gravity without considering external force.

Formula: $\nu = \mu / \rho$

Unit: m^2/s

QUESTION AND ANSWER

Continue....

Difference Between μ and ν :

Dynamic viscosity depends only on the fluid's internal resistance to flow, regardless of its density.

Kinematic viscosity considers both internal resistance and density, making it useful in comparing fluids of different densities.

Applications in Engineering :

Dynamic Viscosity Example:
Used in designing lubrication systems for machinery – thicker oils (high μ) are chosen for heavy loads to prevent wear and friction.

Kinematic Viscosity Example:
Used in pipeline design and fluid flow analysis – helps engineers predict flow rate and pressure drop, especially in water treatment or oil transport systems.

QUESTION

When poured into a graduated cylinder, a liquid is found to weigh 8N when occupying a volume of 600 ml. Determine its specific weight, density and specific gravity

ANSWER

Given, v=600ml =0.6l =6 X 10^{-4} m^3

w = 8N

Specific Weight

$\gamma = w/v$

$= 8N / 6 \times 10^{-4}\ m^3$

$= 13333.3 N/m^3$

From Formula Specific weight, we can find the density

$\gamma = \rho \times g$

$\rho = \gamma / g$

$= 13333.3/9.81$

$= 1359.2 kg/m^3$

Specific gravity

$Sg = \rho_{material} / \rho_{water}$

$= 1359.2/1000$

$= 1.36$

QUESTION

A container is filled with oil of specific gravity 0.79, the oil weight is 98 N. Estimate the volume of the oil

ANSWER

Given, Sg=0.79
w = 98N

Specific gravity

$Sg=\rho_{material}/\rho_{water}$
$\rho_{materia} = Sg \times \rho_{water}$
$=0.79 \times 1000$
$= 7900\ kg/m^3$

Specific Weight

$\gamma=\rho\times g$
$\gamma= 7900 \times 9.81$
$=77499 N/m^3$

Find the volume using formula Specific Weight

$\gamma=w/v$
$v = w/\gamma$
$=98N /77499\ N/m^3$
$=0.00126\ m^3$

QUESTION

The kinematic viscosity and the specific weight of a fluid are 3.26×10^{-5} m^2/s and $9.47 kN/m^3$ respectively. Calculate the dynamic viscosity

ANSWER

Given, Sg=0.79
w = 98N

Density

$\gamma = \rho \times g$

$\rho = \gamma / g$

$\rho = 9.47 \times 10^3 / 9.81$

$\rho = 92900.7\ kg/m^3$

Kinematic Viscosity

$v = \mu / \rho$

$3.26 \times 10^{-5} = \mu / 92900.7$

$\mu = 3.26 \times 10^{-5} \times 92900.7$

$\mu = 3.02\ Ns/m^2$

REFERENCE

1. Cengel, Y. A., & Cimbala, J. M. (2013). Fluid Mechanics: Fundamentals and Applications. McGraw-Hill Education.
2. White, F. M. (2011). Fluid Mechanics (7th ed.). McGraw-Hill.
3. Munson, B. R., Young, D. F., & Okiishi, T. H. (2009). Fundamentals of Fluid Mechanics. Wiley.
4. Kundu, P. K., Cohen, I. M., & Dowling, D. R. (2015). Fluid Mechanics. Academic Press.
5. Nizam Mat Ali, Mohd Ali Jasmi, Hamidah Zakaria, Sarah Afzan Karim (2014), A Textbook of Hydraulics. Politeknik Sultan Idris Shah.