FLUID MECHANICS

Online Class-1 Fluid Properties

by:

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- Fluid Mechanics
- Fluid Statics, Fluid Kinematics and Fluid Dynamics
- Fluid: Substance capable of flowing
- Ideal Fluids and Real Fluids
- Solid and Fluid
- No Slip Condition – Two Parallel Plates

- Mass Density at $4^{o}c$ for water =1000kg (mass)/m^3 or 102 msl / m3 or 1 gm/cc α 1/temp and α pressure
- One msl = (Kg(f) - sec^2) /m
- Specific Weight of water at $4^{o}c$ = 9810N/m^3 or 1000 kg(f) / m^3 or 981dynes/cm^3
- Specific Density = Specific Weight / acceleration due to gravity

- Specific Volume = Reciprocal of Mass Density or specific weight
- Specific Gravity of fluid = Ratio of Specific weight of fluid / Specific weight of water
- Viscosity: by virtue of which fluid offers resistance to deformation
- Shear Stress = Dynamic Viscosity x du/dy – Newtons equation of viscosity

Viscosity

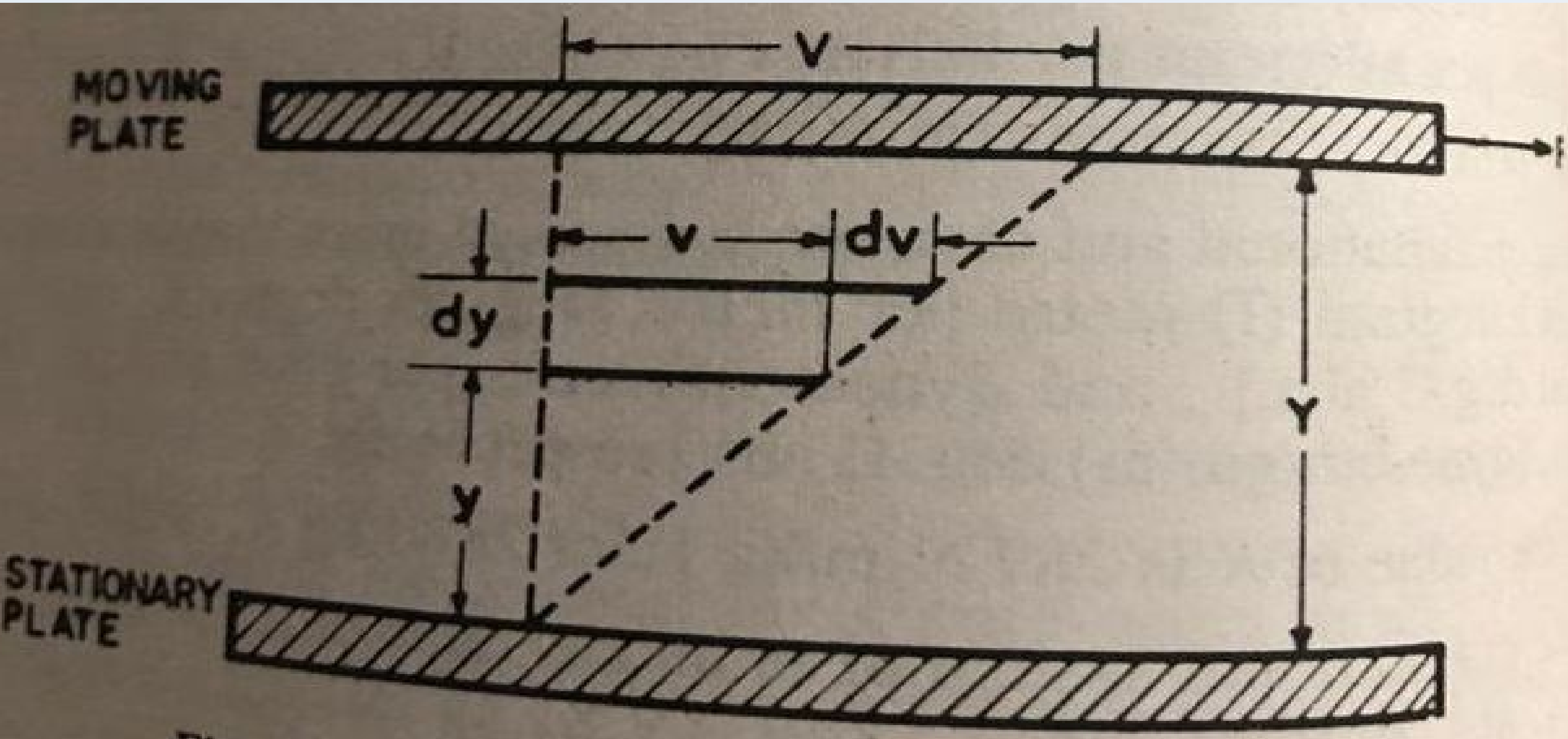


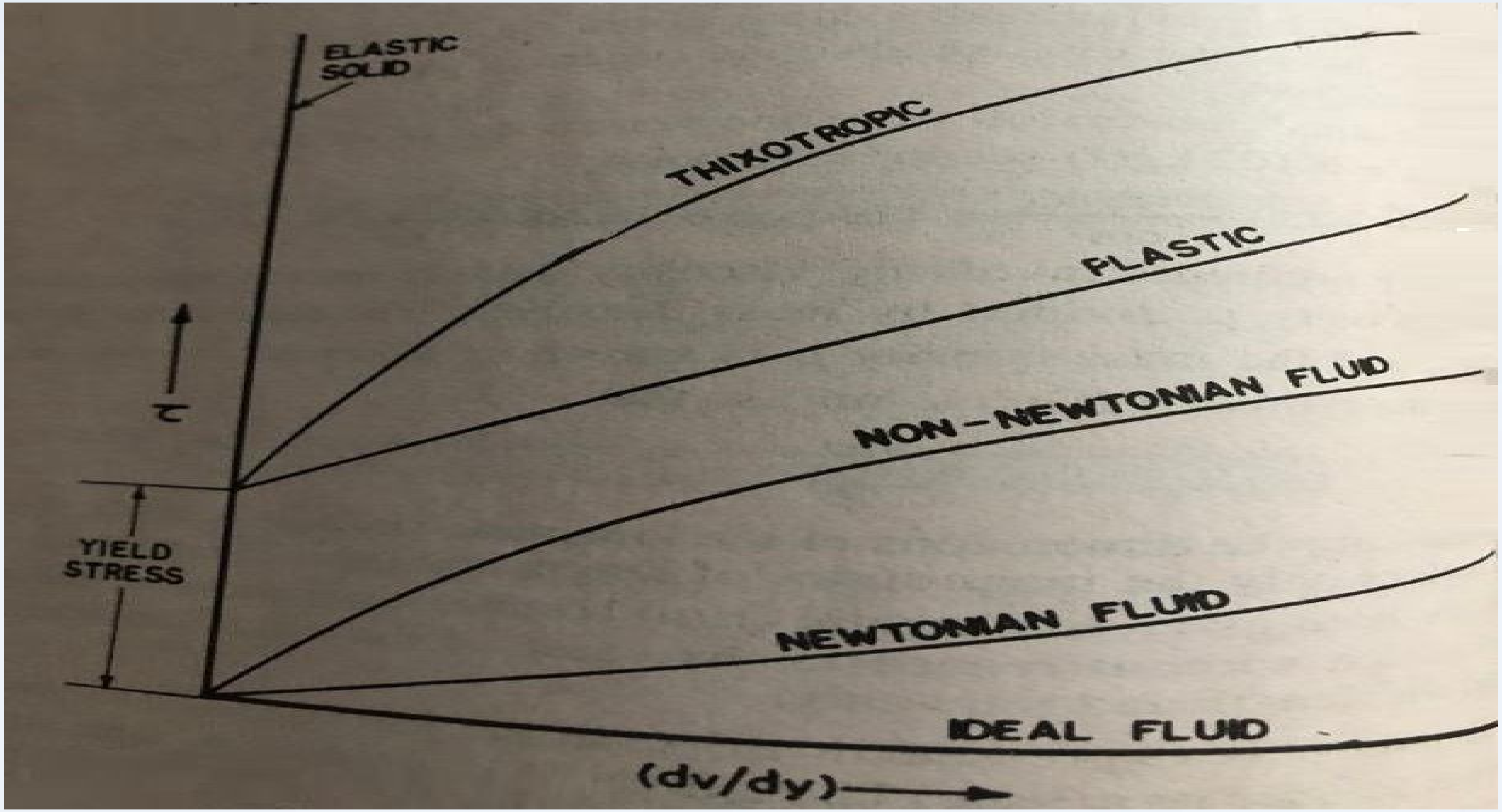
Fig. Fluid motion between two parallel plates

- One (N-Sec)/m^2 = 0.102 (Kg-sec) /m^2 = 10 Poise = 10 (dynes-sec)/cm^2 1Centipoise = 1/100 poise
- Kinematics Viscosity = Dynamic Viscosity/Mass Density, Unit = Stokes = cm^2/sec; m^2/Sec
- Gases: Viscosity α temperature
- Liquids: Viscosity α 1/temperature
- Newtonian Fluid and Non-Newtonian Fluid

- Problem: $u=1.5\ y - y^{3/2}$, Find out shear stress at $y=9cm$, Viscosity=8poise
- Problem: Find out Kinematic Viscosity When Dynamic Viscosity =8 poise
- Problem: One Litre of Crude Oil Weighs 0.96 kgf. Find out specific weight and mass density
- Problem Find out Viscosity when Shear Stress=0.025kgf/m^2; du/dy = 0.3/sec

- Study of non-Newtonian fluids – Rhelogy
- Thixotrophy and Plastic and Ideal Fluid
- Compressible and Incompressible. Fluids
- Proportional to 1/Bulk Modulus, K = -dp/(dv/v)

Types of Fluids



- Measure of change of volume, when a substance subjected to pressure
- Problem: P_1-P_{2-} = 40 Kg/cm^2 volume decrease by 0.2%, Determine K
- Gases $K = \alpha$ temperature α Pressure ; Liquids $K \alpha$Pressure $K \alpha 1/$temperature
- Surface Tension: Droplet p= 4 x surface tension/d; Hollow Bubble p = 8x surface tension/d; Liquid Jet = 2 x surface tension/d
- Capillarity
- Capillary Rise and Fall

Surface Tension

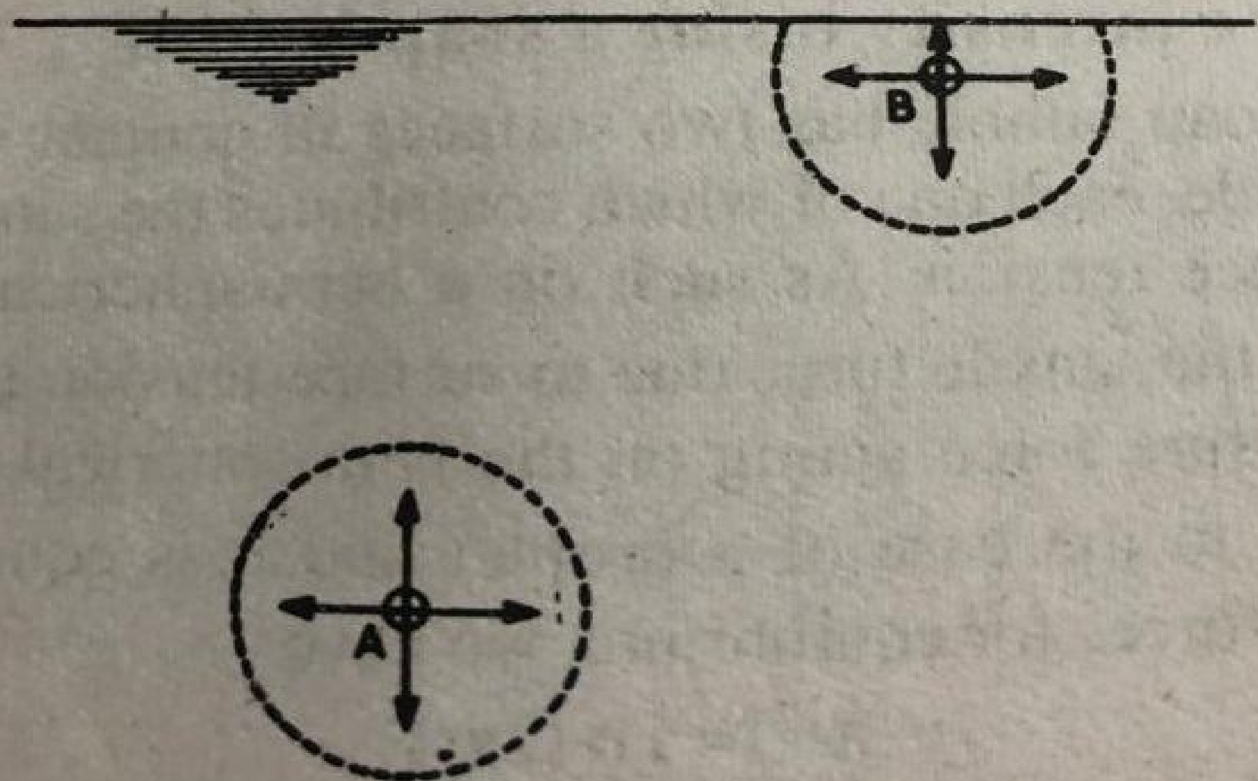


Fig. Inter-molecular forces near a liquid surface

Capillarity

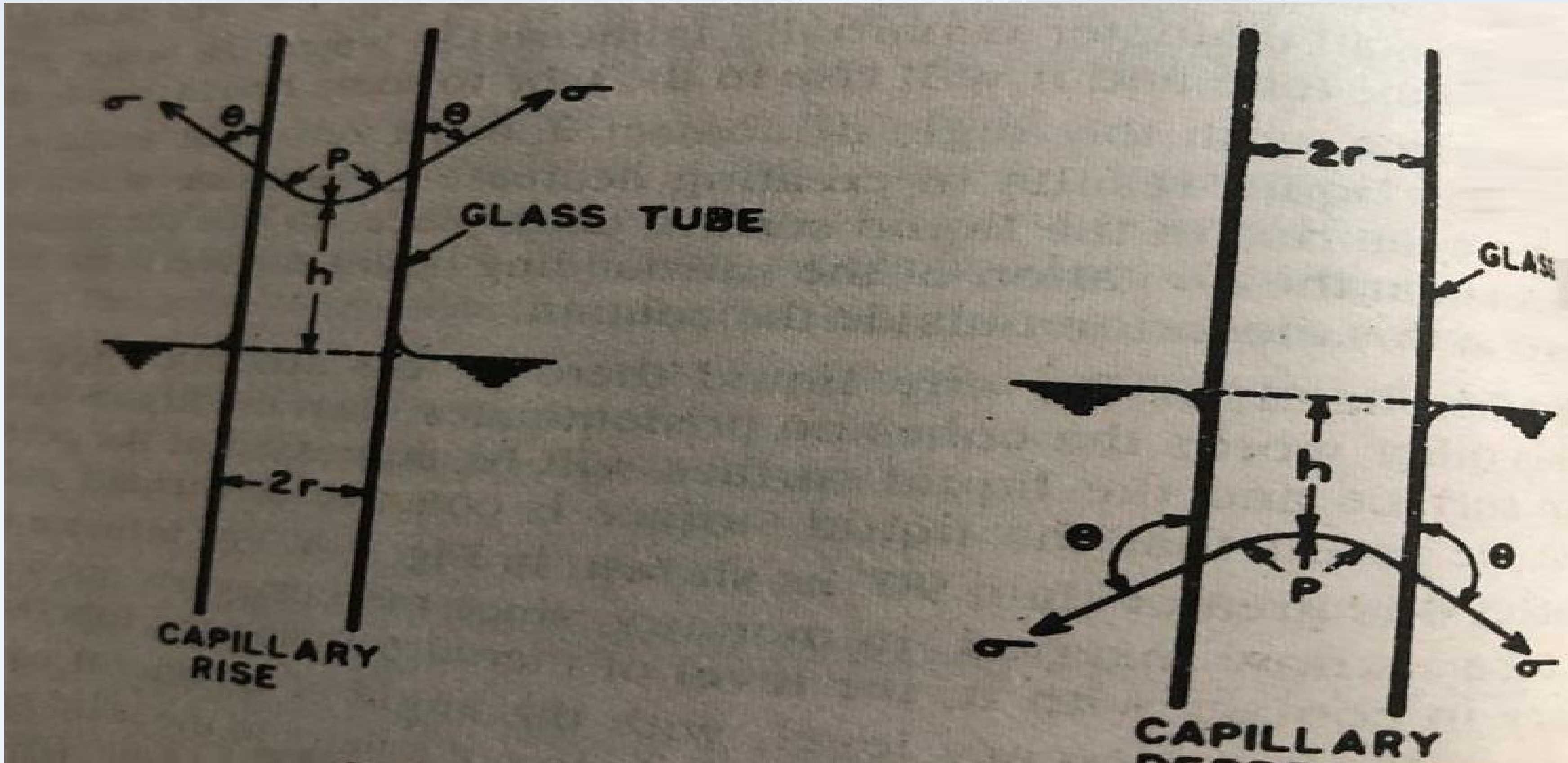


Fig. Capillarity in circular glass tubes

- Cohesion
- Adhesion
- Problem Surface tension at 20^0c = 0.0073 kg(f)/m, p= 0.0015 kg/cm^2, determine diameter
- Water — Adhesive Force > Cohesive force
- Mercury — Cohesive Force > Adhesive Force

- The contact angle θ for glass and water is zero and for mercury is 130^0 $h = \frac{4\sigma Cos\theta}{w_1 D}$

- Problem h=0.5mm; σ = 0.00725kg/m find out the diameter

- Vapour pressure– Vaccum pressure

Objective Questions

1.1 A perfect fluid (also known as an ideal fluid) is

(a) A real fluid

(b) The one which obeys perfect gas laws

(c) Compressive and gaseous

(d) Incompressible and frictionless

1.2 When a shear stress is applied to a substance it is found to resist it by static deformation. The substance is a

(a) Liquid

(b) Solid

(c) Gas

(d) Fluid

1.3 When subjected to shear force, a fluid

(a) Deforms continuously no matter how small the shear stress may be

(b) Deforms continuously only for large shear forces

(c) Undergoes static deformation

(d) Deforms continuously only for small shear stresses

1.4 The conditions of “No Slip” at rigid boundaries is applicable to

(a) Flow of Newtonian fluids only

(b) Flow of ideal fluids only

(c) Flow of all real fluids

(d) Flow of all non-Newtonian fluids

1.5 Newton’s law of viscosity for a fluid states that the shear stress is

(a) Proportional to angular deformation

(b) Proportional to rate of angular deformation

(c) Inversely proportional to angular deformation

(d) Inversely proportional to rate of angular deformation

1.6 The viscosity of

(a) Liquids increases with temperature

(b) Gases increases with temperature

(c) Gases decreases with temperature

(d) None of the Above

1.7 For a fluid, the shear stress was found to be directly proportional to the rate of angular deformation. The fluid is classified as

(a) Newtonian

(b) Non-Newtonian

(c) Dilatant Fluid

(d) Thixotropic

1.8 A real fluid is any fluid which

(a) Has surface tension and is incompressible

(b) Has zero shear stress

(c) Has constant viscosity and density

(d) Has viscosity

1.9 If the shear stress τ and shear rate (du/dy) relationship of a material is plotted with τ on the Y-axis and du/dy on the X-axis, the behavior of an ideal fluid is exhibited by

(a) A straight line passing through the origin and inclined to the X-axis

(b) The positive X-axis

(c) The positive Y-axis

(d) A curved line passing through the origin

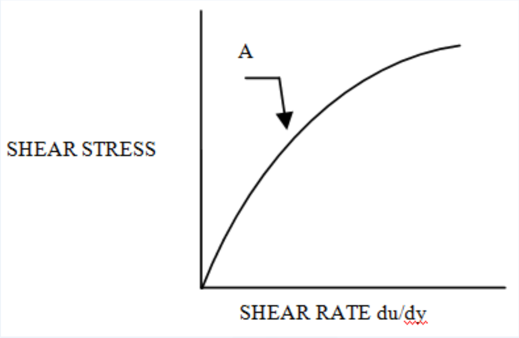
1.10 In the following Figure the line describes the rheological behavior of fluid. The fluid can be classified as

(a) Newtonian

(b) Bingham Plastic

(c) Ideal

(d) Non-Newtonian



1.11 The following shear stress-shear rate relationship was obtained for a fluid:

du/dy (units)	0	1	3	5
τ (units)	0	6	18	20

The fluid is classified as

(a) Bingham Plastic

(b) Dilatant

(c) Newtonian

(d) Ideal

1.12 The dimensions of the coefficient of dynamic viscosity in [M, L, T] notation system are

(a) $M\,L^{-1}\,T$

(b) $M\,L^{-1}\,T^{-1}$

(c) $M^{-1}\,L\,T$

(d) $M\,L\,T^{-1}$

1.13 The dimensions of the coefficient of dynamic viscosity in [F, L, T] notation system are

(a) $F\ T\ L^{-2}$

(b) $F\ L^{-1}\ T^{-1}$

(c) $F\ L^{2}\ T^{-1}$

(d) $F\ T^{-2}\ L$

1.14 Typical example of a non-Newtonian fluid of pseudoplastic variety is

(a) Water

(b) Air

(c) Blood

(d) Printing Ink

1.15 The kinematic viscosity ν is related to the dynamic viscosity μ and density ρ as ν =

(a) μ/ρ

(b) $\mu\rho$

(c) ρ/μ

(d) $\mu/\rho g$

1.16 A flow of a viscous fluid with μ = 1.0 Ns/m^2 has a velocity distribution given by u = 0.90 y-y^2. The shear stress at y = 0.45 m is

(a) 0.90N/m^{-2}

(b) $\propto$

(c) Zero

(d) -0.90 N/m^2

1.17 A perfect gas

(a) Is a perfect fluid

(b) Does not have viscosity

(c) Is incompressible

(d) Does not really exist

1.18 The bulk modulus of elasticity for a liquid, K

(a) Is a function of both temperature and pressure

(b) At any given temperature decreases continuously with pressure

(c) At any pressure increases continuously with temperature

(d) Is a constant

1.19 In a sample of water an increase of pressure by 18MN/m^2 caused 1% reduction in the volume. The bulk modulus of elasticity of this sample, in MN/m^2, is

(a) 1.80

(b) 180

(c) 1800

(d) 0.18

1.20 Broadly speaking, water is

(a) 10 times more compressible than steel

(b) 80 times more compressible than steel

(c) 80 times less compressible than steel

(d) 800 times less compressible than steel

1.21 If the capillary rise of water in a 2 mm diameter tube is 1.5 cm, the height of capillary rise in a 0.5 mm diameter tube in cm, will be

(a) 10.0

(b) 1.5

(c) 6.0

(d) 24.0

1.22 If the surface tension of water-air interface is 0.073 N/m, the gauge pressure inside a rain drop of 1 mm diameter is

(a) 146.0 N/m^2

(b) 0.146 N/m^2

(c) 73.0 N/m^2

(d) 292.0 N/m^2

1.23 The excess pressure (above atmospheric) inside a soap bubble of diameter 1cm, by assuming the surface tension of soap solution to be 0.04 N/m is,

(a) 32.0 N/m^2

(b) 16.0 N/m^2

(c) 160.0 N/m^2

(d) 0.32 N/m^2

1.24 The capillary rise in a 3 mm tube immersed in a liquid is 15 mm. If another tube of diameter 4 mm is immersed in the same liquid the capillary rise would be

(a) 11.25 mm

(b) 20.00 mm

(c) 8.44 mm

(d) 26.67 mm

Gate Questions

The SI unit of kinematic viscosity (υ) is:

(a) m^2/s (b) kg/m-s (c) m/s^2 (d) m^3/s^2

Kinematic viscosity of air at 20°C is given to be $1.6 \times 10^{-5} m^2/s$. Its kinematic viscosity at 70°C will be vary approximately

(a) $2.2\times10^{-5} m^2/s$ (b) $1.6\times10^{-5} m^2/s$ (c) $1.2\times10^{-5} m^2/s$ (d) $3.2\times10^{-5} m^2/s$

Gate Questions

For a Newtonian fluid
(a) Shear stress is proportional to shear strain
(b) Rate of shear stress is proportional to shear strain
(c) Shear stress is proportional to rate of shear strain
(d) Rate of shear stress is proportional to rate of shear strain

The dimension of surface tension is:
(a) ML^{-1} (b) L^2T^{-1} (c) $ML^{-1}T^1$ (d) MT^{-2}

The dimensions of surface tension is:
(a) N/m^2 (b) J/m (c) J/m^2 (d) W/m

Gate Questions

01. Surface tension is due to

(a) Cohesion and Adhesion
(b) Cohesion only
(c) Adhesion only
(d) None of the above

02. Continuum approach in fluid mechanics is valid when

(a) The compressibility is very high
(b) The viscosity is low
(c) The mean free path of the molecule is much smaller compared to the characteristic dimension
(d) M >> 1, where M is the Mach number

03. A fluid is one which can be defined as a substance that

(a) Has same shear stress at all points
(b) Can deform indefinitely under the action of the smallest shear force
(c) Has the small shear stress in all directions
(d) Is practically incompressible

04. With increase of temperature, viscosity of a fluid

(a) Does not change
(b) Always increases
(c) Always decreases
(d) Increases, if the fluid is a gas and decreases, if it is a liquid

05. The unit of dynamic viscosity of a fluid is

(a) m^2/s

(b) $\frac{N-s}{m^2}$

(c) $\frac{Pa-s}{m^2}$

(d) $\frac{kg-s^2}{m^2}$

06. Cavitation is caused by

(a) High velocity

(b) Low pressure

(c) High pressure

(d) High temperature

07. The dimension for kinematic viscosity is

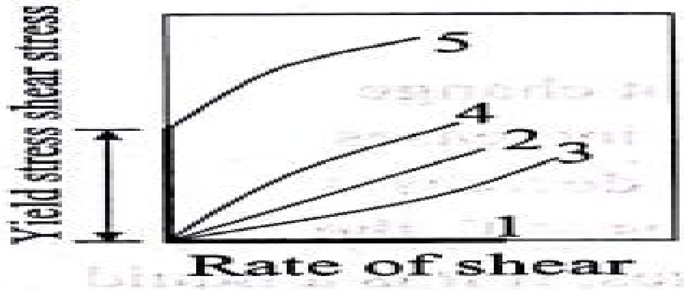
(a) $\frac{L}{MT}$

(b) $\frac{L}{T^2}$

(c) $\frac{L^2}{T}$

(d) $\frac{ML}{T}$

08. Group I contains the types of fluids while Group II contains the shear stress-rate of shear relationship of different types of fluids, as shown in the figure



Group-I	Group-II	
P. Newtonian fluid	1.	Curve 1
Q. Pseudo plastic fluid	2.	Curve 2
R. Plastic fluid	3.	Curve 3
S. Dilatant fluid	4.	Curve 4
	5.	Curve 5

The correct match between Group I and Group II is

(a) P-2, Q-4, R-1, S-5

(b) P-2, Q-5, R-4, S-1

(c) P-2, Q-4, R-5, S-3

(d) P-2, Q-1, R-3, S-4

Two Marks Questions

01. Shear stress in the Newtonian fluid is proportional to
(a) pressure
(b) strain
(c) strain rate
(d) the inverse of the viscosity

02. A liquid of density ρ and dynamic viscosity μ flows steadily down an inclined plane in a thin sheet of constant thickness t. Neglecting air friction the shear stress on the bottom surface due to the liquid flow is (where θ is the angle, the plane makes with horizontal).
(a) $\rho\ g\ t \sin\theta$ (b) $\rho\ g\ t \cos\theta$
(c) $\mu \sqrt{g/t}$ (d) $\rho\ g$

$\Rightarrow$ Dynamic Viscosity , $\mu = \dfrac{\tau}{du/dy}$

$$= \frac{F/L^2}{1/T} = \frac{N.s}{m^2}$$

06. **Ans: (b)**

Sol: Cavitation is phenomenon of low pressure and cause formation of bubbles. If a fluid passes through low pressure region (less than Vapour pressure of the fluid) bubbles form and they collapse on the surfaces causing pitting and there by erosion of surface material.

07. **Ans: (c)**

Sol: Kinematic viscosity, $\nu = \dfrac{\mu}{\rho} = \dfrac{M/LT}{M/L^3}$

$$= L^2/T$$

08. **Ans: (c)**

Hints:

- Newtonian fluids will have linear variation of shear stress and rate of shear strain. Also the relation passes through the origin.
- Pseudo plastic fluid will have nonlinear variation. Towards top of curve from origin, the magnitude of shear stress decreases for a given strain rate. Also called Shear Thinning Fluids.
- Dilatent fluids will have nonlinear variation. Towards top of curve from origin, the magnitude of shear stress increases for a given strain rate. Also called Shear Thickening Fluids.

Two Marks Solutions

01. **Ans: (c)**

Sol: According to Newton's Law of viscosity

$$\tau \alpha \frac{dv}{dy}$$

$$\frac{dv}{dy} = \frac{L/T}{L} = \frac{1}{T} = s^{-1}$$

Strain has no unit.

Rate of strain or Strain rate $= \dfrac{1}{T}$

$\therefore$ Shear stress is proportional to strain rate.

02. **Ans: (a)**

Sol: Self weight acts vertically down word

w = (ρg)(volume)= ρg (A)(t)

Where,

w = self weight of oil

A = Area of contact

t = thickness of liquid film

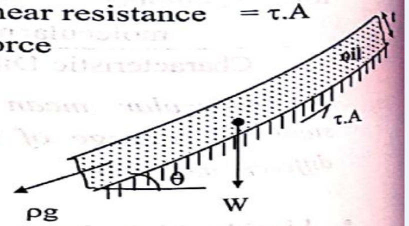
Resolving along the inclined plane,

i.e., weight component along inclined plane

= ρg At sinθ (downward force)

Upward force = shear resistance = τ.A

d/w force = u/w force



ρg At sinθ = τ.A

Cancel out A both sides

$\therefore$ Shear stress, $\tau = \rho g\, t \sin\theta$


THANK YOU
VERY MUCH