MADE EASY PUBLICATIONS

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CIVIL ENGINEERING

Objective Practice Sets

Fluid Mechanics

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CHAPTER

Fluid Mechanics

Fluid Properties

Q.1 A fluid is said to be Newtonian fluid when the shear stress is
(a) directly proportional to the velocity gradient
(b) inversely proportional to the velocity gradient
(c) independent of the velocity gradient
(d) none of these

Q.2 Which one of the following is the bulk modulus *K* of a fluid? (Symbols have the usual meaning)

(a) $\rho \frac{dp}{d\rho}$ (b) $\frac{dp}{\rho d\rho}$

(c) $\rho \frac{d\rho}{dp}$ (d) $\frac{d\rho}{\rho dp}$

Q.3 **Statement (I):** In fluid, the rate of deformation is far more important than the total deformation itself.
Statement (II): A fluid continues to deform so long as the external forces are applied.
(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but Statement (II) is false
(d) Statement (I) is false; but Statement (II) is true

Q.4 In a quiescent sea, density of water at free surface is ρ_0 and at a point much below the surface density is ρ. Neglecting variation in gravitational acceleration *g* and assuming a constant value of bulk modulus *K*, the depth *h* of the point from the free surface is

(a) $\frac{K}{g}\left(\frac{1}{\rho_0}+\frac{1}{\rho}\right)$ (b) $\frac{K}{g}\frac{(\rho-\rho_0)}{(\rho+\rho_0)^2}$

(c) $\frac{K}{g}\left(\frac{1}{\rho_0}-\frac{1}{\rho}\right)$ (d) $\frac{K}{g}\left(\frac{\rho\rho_0}{\rho+\rho_0}\right)$

Q.5 A thin plane lamina of area A and weight *W*, slides down a fixed plane inclined to the vertical at an angle α and maintains a uniform gap ε from the surface of the plane, the gap being filled with oil of constant viscosity μ. The terminal velocity of plane lamina is

(a) $\frac{\varepsilon \cos\alpha}{\mu WA}$ (b) $\frac{\varepsilon\mu W}{A\sin\alpha}$

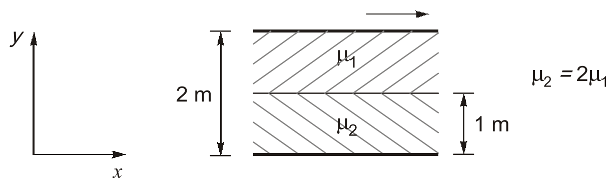
(c) $\frac{\varepsilon W\cos\alpha}{A\mu}$ (d) $\frac{\mu W\sin\alpha}{\varepsilon A}$

Q.6 A 50 mm diameter and 0.1 m long cylindrical body slides vertically down in a 52 mm diameter cylindrical tube. The space between the cylindrical body and tube wall is filled with oil of dynamic viscosity 1.9 Ns/m^2. The velocity of fall if its weight is 16 N will be
(a) 0.536 m/s (b) 0.268 m/s
(c) 0.804 m/s (d) 0.638 m/s

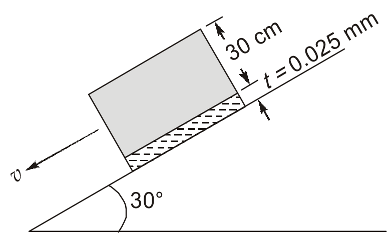
Q.7 Two immiscible, incompressible, viscous fluids having same densities but different viscosities are contained between two infinite horizontal parallel plates, 2 m apart as shown below. The bottom plate is fixed and the upper plate moves to the right with a constant velocity of 3 m/s. With the assumptions of Newtonian fluid, steady, and fully developed laminar flow with zero pressure gradient in all directions, the momentum equations simplify to

$$\frac{d^2u}{dy^2} = 0$$

If the dynamic viscosity of the lower fluid, μ_2, is twice that of the upper fluid, μ_1, then the velocity at the interface (round off to two decimal places) is _______ m/s.



Q.8 As shown in the figure, a cubical block of 30 cm side and of 30 kg weight is allowed to slide down along a plane inclined at 30° to the horizontal on which there is a film of oil having viscosity of 2×10^{-3} N-s/m^2. The film thickness is 0.025 mm. The terminal velocity of the block is



(a) 12.44 m/s (b) 16.89 m/s
(c) 20.44 m/s (d) 22.22 m/s

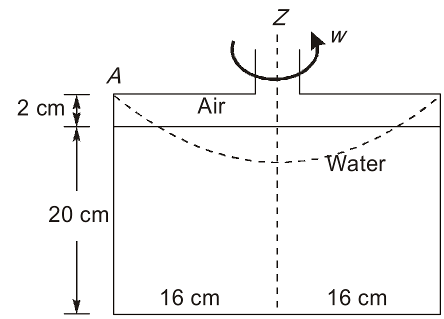
Q.9 The 4 m^3 of a certain oil weighs 30 kN. The relative density of oil is
(a) 0.765 (b) 0.813
(c) 0.872 (d) 0.965

Q.10 A plate 0.03 mm distant from a fixed plate, moves at 80 cm/s and requires a force of 4 N per unit area to maintain this speed. The fluid viscosity between the plates is
(a) 1.5×10^{-4} poise (b) 2.5×10^{-3} poise
(c) 1.5×10^{-3} poise (d) 2.5×10^{-4} poise

Q.11 The equation of a velocity profile over a plate is $V = 7y^2 + y$ (where V is the velocity in m/s). The viscosity of the liquid is 8.35 poise. The shear stress at y = 7.5 cm is
(a) 1.71 N/m^2 (b) 3.42 N/m^2
(c) 4.62 N/m^2 (d) 4.78 N/m^2

Q.12 The gap between a horizontal shaft and concentric sleeve is filled with viscous oil. The sleeve moves with a constant velocity of 2 m/s when a force of 1500 N is applied parallel to the axis of the shaft. If it is required to move the sleeve at a velocity of 3 m/s, then calculate the force required. The temperature can be assumed to be constant throughout.
(a) 1150 N (b) 1560 N
(c) 1875 N (d) 2250 N

Q.13 A cylinder is rotated about the central axis as shown in figure. The force (in N) on the bottom of the cylinder, when the rotation speed is such that the water just touches the point A will be



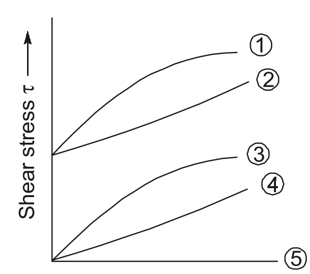
(a) 157.8 (b) 187.5
(c) 142.1 (d) 117.5

Q.14 The shear stress in a fluid may be expressed as:

$$\tau \propto \left(\frac{dv}{dy}\right)^n$$

where $\frac{dv}{dy}$ is the velocity gradient and n is constant. The n value for Newtonian and Non-newtonian fluids will be respectively
(a) $n = 1$ and $n > 1$ (b) $n < 1$ and $n > 1$
(c) $n = 1$ and $n < 1$ (d) $n = 1$ and $n \neq 1$

Q.15 Which of the curves labelled as ①, ②, ③, ④, & ⑤ in the given figure represent the Newtonian and the ideal fluid respectively?



(a) 1 and 5 (b) 2 and 4
(c) 3 and 4 (d) 4 and 5

Q.16 Classify the fluid based upon the following results of a test on their rheological behaviour

Shear rate, $\frac{\partial u}{\partial y}$	0	0.50	1.0	1.5	2.0
Shear stress, τ	1	2	3	4	5

(a) Ideal fluid (b) Newtonion fluid
(c) Bingham plastic (d) Pseudo plastic

Q.17 The dynamic viscosity of fluid is 0.5 poise and its specific gravity is 0.5. The kinematic viscosity of this fluid (in stokes) is:
(a) 0.25 (b) 0.5
(c) 1.0 (d) 1.5

Q.18 Kinematic viscosity of air at 20°C is given to be 1.6×10^{-5} m²/s. Its kinematic viscosity at 70°C will be varying approximately
(a) 2.2×10^{-5} m²/s (b) 1.6×10^{-5} m²/s
(c) 1.2×10^{-5} m²/s (d) 3.2×10^{-5} m²/s

Q.19 The equation of a velocity distribution over a plate is given by $u = 2y - y^2$ where u is the velocity in m/s at a point y meter from the plate measured perpendicularly. Assuming μ = 8.60 poise, the shear stress at a point 15 cm from the boundary is
(a) 1.72 N/m² (b) 1.46 N/m²
(c) 14.62 N/m² (d) 17.20 N/m²

Directions : Each of the next items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:
(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but Statement (II) is false
(d) Statement (I) is false; but Statement (II) is true

Q.20 **Statement (I):** In general, viscosity in liquids increases and in gases it decreases with rise in temperature.
Statement (II): Viscosity is caused by intermolecular forces of cohesion and due to transfer of molecular momentum between fluid layers; of which in liquids the former and in gases the later contribute the major part towards viscosity.

Q.21 **Statement (I):** The kinematic viscosity of both air and water decreases as the temperature increases.
Statement (II): The kinematic viscosity of liquids and gases at a given pressure is a function of temperature.

Q.22 Consider the following statements related to the fluid properties:
1. Vapour pressure of water at 373 K is 101.5×10^3 N/m².
2. Capillary height in cm for water in contact with glass tube and air is (tube diameter)/0.268.
3. Blood is a Newtonian fluid.

Which of these statements is/are correct?
(a) 1 only (b) 1 and 3
(c) 1 and 2 (d) 2 only

Q.23 Consider the following statements:
1. A small bubble of one fluid immersed in another fluid has a spherical shape.
2. The droplets of a fluid move upward or downward in another fluid due to unbalance between gravitational and buoyant forces.
3. Droplets of bubbles attached to a solid surface can remain stationary in a gravitational fluid if the surface tension exceeds buoyant forces.
4. Surface tension of a bubble is proportional to its radius while buoyant force is proportional to the cube of its radius.

Which of these statements are correct?
(a) 1, 2, 3 and 4 (b) 1, 2 and 4 only
(c) 1 and 3 only (d) 2, 3 and 4 only

Q.24 The normal stresses within an isotropic Newtonian fluid are related to
1. Pressure
2. Viscosity of fluid
3. Velocity gradient

Which of the above are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Q.25 A 150 mm diameter shaft rotates at 1500 rpm within a 200 mm long journal bearing with 150.5 mm internal diameter. The uniform annular space between the shaft and the bearing is filled with oil of dynamic viscosity 0.8 poise. The shear stress on the shaft will be
(a) 1.77 kN/m² (b) 2.77 kN/m²
(c) 3.77 kN/m² (d) 4.77 kN/m²

Q.26 The work done in blowing a soap bubble of diameter 20 cm is ________ $\times 10^{-3}$ Nm.

[Assume the surface tension of soap solution as 0.040 N/m.]

(a) 14.88 (b) 10.05
(c) 6.01 (d) 4.32

Q.27 In an experiment, the tip of a glass tube with an internal diameter of 2 mm is immersed to a depth of 1.5 cm into a liquid of specific gravity 0.85. Air is forced into the tube to form a spherical bubble just at the lower end of the tube. If the air pressure in the bubble is 200 N/m^2, then the surface tension of the liquid will be

(a) 0.018 N/m (b) 0.025 N/m
(c) 0.037 N/m (d) 0.042 N/m

Q.28 If the surface tension at air-water interface is 0.073 N/m, the pressure difference between inside and outside of an air bubble of diameter 0.1 mm will be __________ kPa.

Q.29 The surface tension at air-water interface is 0.088 N/m. The pressure difference between inside and outside of a water bubble of diameter 0.02 mm in air is

(a) 9.8 kN/m^2 (b) 11.9 kN/m^2
(c) 17.6 kN/m^2 (d) 21.2 kN/m^2

Q.30 If angle of contact of a drop of liquid is acute, then

(a) cohesion is equal to adhesion
(b) cohesion is more than adhesion
(c) adhesion is more than cohesion
(d) both adhesion and cohesion have no connection with angle of contact

Q.31 **Statement (I) :** The mercury level inside the tube shall rise above the level of mercury outside.

Statement (II) : The cohesive force between the molecules of mercury is greater than the adhesive force between mercury and glass.

(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but Statement (II) is false
(d) Statement (I) is false; but Statement (II) is true

Q.32 The surface tension of water at 20°C is 75×10^{-3} N/m. The difference in water surfaces within and outside an open-ended capillary tube of 1 mm internal bore, inserted at the water surface, would nearly be

(a) 7 mm (b) 11 mm
(c) 15 mm (d) 19 mm

Q.33 Mercury (density = 13600 kg/m^3, σ = 0.49 N/m; θ = 0°) is contained in a wide beaker. A 2 mm internal diameter open ended capillary tube is inserted in the middle of the beaker into the mercury. The meniscus in tube will be below the external mercury surface by how much distance?

(a) 4.2 mm (b) 5.7 mm
(c) 6.8 mm (d) 7.3 mm

Q.34 A clean tube of internal diameter 3 mm is immersed in a liquid with a coefficient of surface tension of 0.48 N/m. The angle of contact of the liquid with the glass can be assumed to be 130°. The density of the liquid is 13600 kg/m^3. What would be the level of the liquid in the tube relative to the free surface of the liquid outside the tube? [Take sin 40° = 0.643]

(a) 1.54 mm (b) –1.54 mm
(c) 3.08 mm (d) –3.08 mm

Q.35 Consider the following statements:

1. In thixotropic fluid, viscosity decreases at higher shear stress.
2. Viscosity of Rheopactic fluid decreases at higher shear stress.
3. In thixotropic fluid, viscosity increases at higher shear stress.
4. Viscosity of Rheopactic fluid increases at higher shear stress.

Which of the above statements are CORRECT?

(a) 1 and 2 (b) 1 and 4
(c) 2 and 3 (d) None of the above

Q.36 Oil in a hydraulic cylinder is compressed from an initial volume 2 m^3 to 1.96 m^3. If the pressure of oil in the cylinder changes from 40 MPa to 80 MPa during compression, the bulk modulus of elasticity of oil is

(a) 1000 MPa (b) 2000 MPa
(c) 4000 MPa (d) 8000 MPa

Multiple Select Questions (MSQ)

Q.37 Calculate the capillary effect in mm in a glass tube of 4 mm diameter when immersed in water and mercury respectively.

Temperature of the liquid = 20°C
Surface tension of water in contact with air = 0.073 N/m
Surface tension of mercury in contact with air = 0.51 N/m
Angle of contact for water is zero and for mercury is 130°
Density of water = 998 kg/m^3
(a) Capillary rise of 2.46 mm for mercury
(b) Capillary depression of 7.46 mm for water
(c) Capillary depression of 2.46 mm for mercury
(d) Capillary rise of 7.46 mm for water.

Q.38 Consider the following statements:
(a) For rheopectic fluids, apparent viscosity (η) increases with time under constant shear stress.
(b) For thixotropic fluids, dynamic viscosity (μ) decreases with time under constant shear stress.
(c) Variation of viscosity with temperature in case of gases is due to molecular cohesion.
(d) Dilatant fluids are shear thickening fluids.

Q.39 If a tube of diameter 5 mm is inserted in mercury (G_s = 13.6) above which water lies, then the capillary height will be (θ = 120°) (σ = 0.51 N/m)
(a) Capillary rise of 3.30 mm
(b) Capillary depression of 1.65 mm
(c) Capillary depression of 3.30 mm
(d) Capillary rise of 1.65 mm

Q.40 A Newtonian fluid fills the clearance between a shaft and a sleeve, when a force 800 N is applied to the shaft, parallel to the sleeve, the shaft attains a speed of 1.5 cm/sec. If a force of 2.4 kN is applied instead, the shaft would move with a speed of:
(a) 1.5 cm/sec (b) 13.5 cm/sec
(c) 0.5 cm/sec (d) 4.5 cm/sec

Answers Fluid Properties

1. (a)	2. (a)	3. (a)	4. (c)	5. (c)	6. (a)	7. 1	8. (c)	9. (a)	10. (c)
11. (a)	12. (d)	13. (a)	14. (d)	15. (d)	16. (c)	17. (c)	18. (a)	19. (b)	20. (d)
21. (d)	22. (a)	23. (a)	24. (d)	25. (c)	26. (b)	27. (c)	28. 2.92	29. (c)	30. (c)
31. (d)	32. (c)	33. (d)	34. (d)	35. (b)	36. (b)	37. (c, d)		38. (a, b, d)	
39. (b)	40. (d)								

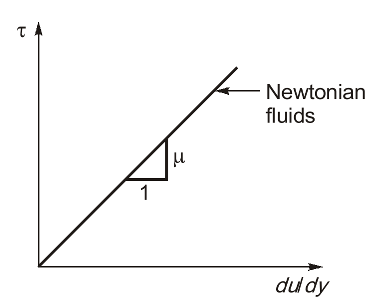
Explanations Fluid Properties

1. (a)
Newtonian fluid: A real fluid which obeys the Newton's law of viscosity is known as Newtonian fluid.
We know that Newton's law of viscosity,

Shear stress: $\tau \propto \frac{du}{dy}$, velocity gradient

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

where μ = Dynamic viscosity of fluid

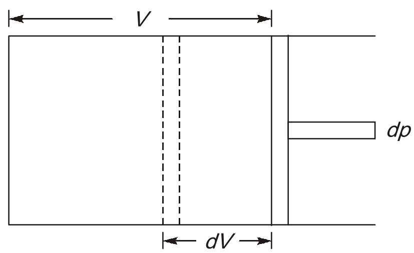


Examples of Newtonian fluids:
Water, Alcohol, Gasoline, Air, Kerosene

2. (a)

Bulk modulus,

$$K = -\frac{dp}{dv/v} \quad \text{... (i)}$$



Specific volume,

$$v = \frac{1}{\rho} = \rho^{-1}$$

Taking $\log_e$ both sides, we get

$$\log_e v = -\log_e \rho$$

On differentiating

$$\frac{dv}{v} = -\frac{d\rho}{\rho}$$

Substituting $\frac{dv}{v} = -\frac{d\rho}{\rho}$ in Eq (i), we get

$$K = \frac{-dp}{-d\rho/\rho} = \rho\frac{dp}{d\rho}$$

4. (c)

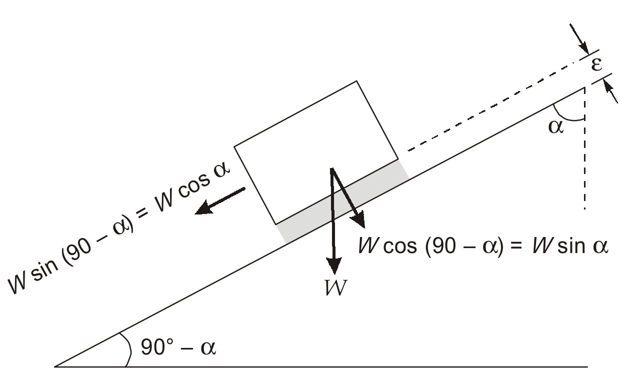
$$K = \frac{\rho dp}{d\rho}$$

$$\frac{d\rho}{\rho} = \frac{\rho g dh}{K}$$

$$\left[-\frac{1}{\rho}\right]_{\rho}^{\rho_0} = \frac{gh}{K}$$

$$h = \frac{K}{g}\left[\frac{1}{\rho_0} - \frac{1}{\rho}\right]$$

5. (c)



For zero acceleration,

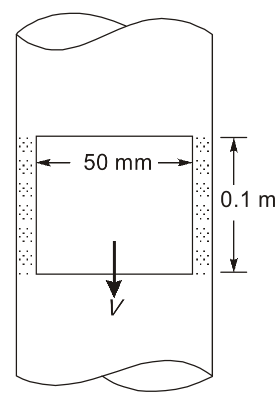
$$W\cos\alpha = \text{Drag force}$$

Here, Drag force = Shear force = $\mu A\frac{V}{\varepsilon}$

$$\Rightarrow \quad W\cos\alpha = \mu A\frac{V}{\varepsilon}$$

$$\Rightarrow \quad V = \frac{\varepsilon W\cos\alpha}{\mu A}$$

6. (a)



Let V be its terminal velocity of fall

Shear stress τ will be

$$\tau = \mu\frac{dv}{dy} = 1.9\times\frac{V}{1\times10^{-3}}$$

$$= 1.9\times10^3\ V\ \text{N/mm}^2$$

The shear stress will act on the surface of the cylinder.

Hence, Total force,

$$F = \tau\times A$$

$$= 1.9\times10^3\times V\times3.142\times50\times10^{-3}\times0.1$$

$$= 29.849\ U$$

Under equilibrium condition, the weight will be balanced by total shear force.

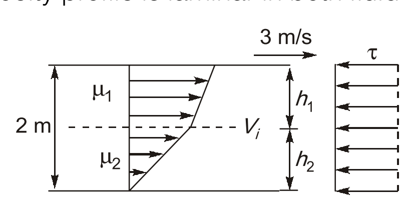
Hence,

$$16 = 29.849\ U$$

or $\quad U = 0.536$ m/s

7. (1)

Velocity profile is laminar in both fluids



$$\frac{d^2u}{dy^2} = 0$$

$$\frac{du}{dy} = c_1$$

$$u = c_1 y + c_2$$

i.e. we can assume linear velocity profile.

If velocity profile is linear shear stress will be constant in gap everywhere i.e. in fluid (1) and fluid (2)

Also at the interface shear stress will be constant.

$$\tau_1 = \tau_2$$

$$\mu_2 \frac{V_i}{h_2} = \mu_1 \frac{(V - V_i)}{h_1}$$

where V_i is velocity at the interface.

$$2\mu_1 \frac{V_i}{1} = \frac{\mu_1(3 - V_i)}{1}$$

$$2V_i = 3 - V_i$$

$$3V_i = 3$$

$$V_i = 1 \text{ m/s}$$

8. (c)

Weight of block = 25 kg

Block dimensions = 30 × 30 × 30 cm^3

Driving force along the plane,

$$F = W \sin 30°$$

$$= 30 \times 9.81 \times 0.5$$

$$= 147.15 \text{ N}$$

Shear force, $\tau = \frac{F}{A} = \frac{147.15}{(0.3)^2} = 1635 \text{ N/m}^2$

Contact area, $A = 0.3 \times 0.3 \text{ m}^2$

Also, $\tau = \mu \frac{dv}{dy}$

$$\Rightarrow 1635 = 2 \times 10^{-3} \times \frac{V}{0.025 \times 10^{-3}}$$

$$\Rightarrow V = \frac{1635 \times 0.025}{2} = 817.5 \times 0.25 = 20.44 \text{ m/s}$$

9. (a)

Specific weight,

$$\gamma = \frac{\text{Weight}}{\text{Volume}} = \frac{30 \text{ kN}}{4 \text{ m}^3} = 7.5 \text{ kN/m}^3$$

Mass density,

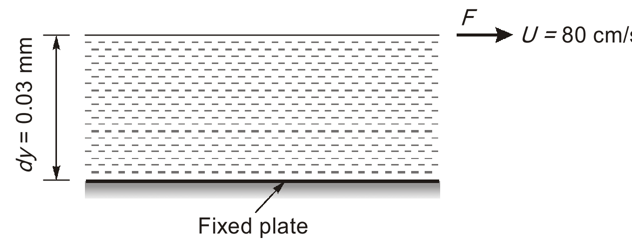
$$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{W/g}{V} = \frac{7.5 \times 10^3 (\text{N/m}^3)}{9.81 (\text{m/s}^2)}$$

$$= 764.53 \text{ kg/m}^3$$

$\therefore$ Relative density of oil $= \frac{\text{Density of oil}}{\text{Density of water}}$

$$= \frac{764.53}{1000} = 0.76453 \simeq 0.765$$

10. (c)



Distance between plates,

$$dy = 0.03 \text{ mm} = 3 \times 10^{-5} \text{ m}$$

Velocity of upper plate,

$$u = 80 \text{ cm/s} = 0.8 \text{ m/s}$$

Force on upper plate,

$$F = 4 \text{ N/m}^2$$

This is the value of shear stress i.e. τ

Let the fluid viscosity between the plates is μ

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

$$4.0 = \mu \times \frac{0.80}{3 \times 10^{-5}}$$

$$\mu = \frac{4 \times 3 \times 10^{-5}}{80} = \frac{3 \times 10^{-5}}{20} = 0.15 \times 10^{-5}$$

$$= 1.5 \times 10^{-4} \times 10 \text{ poise}$$

$$= 1.5 \times 10^{-3} \text{ poise}$$

11. (a)

Velocity profile,

$$V = 7y^2 + y$$

Coefficient of dynamic viscosity,

$$\mu = 8.35 \text{ poise} = 8.35 \times 10^{-1} \text{ Ns/m}^2$$

Velocity gradient,

$$\frac{dv}{dy} = 14y + 1$$

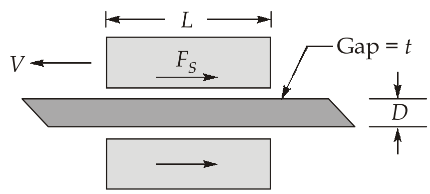
$$\tau = \mu \frac{dV}{dy} = \mu(14y + 1)$$

At $y = 7.5 \text{ cm} = 0.075 \text{ m}$

$$\tau = 8.35 \times 10^{-1} \times (14 \times 0.075 + 1)$$

$$= 1.71 \text{ N/m}^2$$

12. (d)



Force, $F = L \times \pi D \times \frac{V}{t} \times \mu$

In the given set up L, D, μ and t are invariant

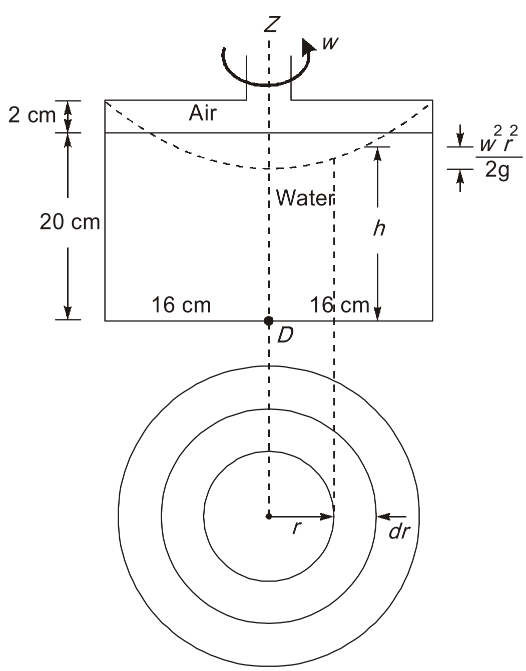
Hence, $\frac{F}{V}$ = Constant

Thus, $\frac{F_1}{V_1} = \frac{F_2}{V_2}$

$\Rightarrow \quad F_2 = \frac{F_1}{V_1} \times V_2$

$F_2 = \frac{1500}{2} \times 3 = 2250$ N

13. (a)



$\because$ Water just touches point A

$\therefore \quad 0.04 = \frac{w^2(0.16)^2}{2g}$

dF = Pressure × Area

$= \rho g h \times 2\pi r dr$

$\therefore \quad F = \int dF$

$$= \int \rho g \left(0.18 + \frac{w^2 r^2}{2g}\right) \times 2\pi r dr$$

$$\Rightarrow \quad F = 2\pi\rho g \int_0^{0.16} \left(0.18 + \frac{w^2 r^2}{2g}\right) r dr$$

$$= 2\pi\rho g \left[\frac{0.18 r^2}{2} + \frac{w^2}{2g} \times \frac{r^4}{4}\right]_0^{0.16}$$

$$= 2\pi\rho g \left[0.09(0.16)^2 + \frac{w^2(0.16)^2}{2g} + \frac{(0.16)^2}{4}\right]$$

= 157.8 N

15. (d)

Ideal fluid is inviscid so there will be zero shear stress at all values of rate of shear strain. Thus it is represented by (5)

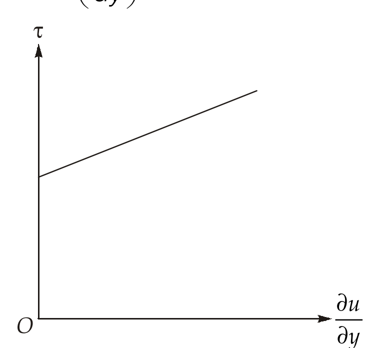
For Newtonian fluid $\tau = \mu\left(\frac{du}{dy}\right)$ means that shear stress in linearly proportional to rate of shear strain. Thus it is represented by curve (4).

Curve	Fluid
(1)	Thixotropic fluid ($n < 1$)
(2)	Ideal Bingham plastic
(3)	Pseudoplastic ($n < 1$)
(4)	Newtonian
(5)	Ideal

16. (c)

Given fluid has linear shear stress vs shear rate behaviour, however at $\frac{\partial u}{\partial y} = 0$, the shear stress is 1 unit. Hence the fluid is classified as Bingham plastic. A general relationship between shear stress and velocity gradient (rate of shear strain) for non-newtonion fluid is

$$\tau = A\left(\frac{du}{dy}\right)^n + B$$



At $\tau = 1$ and $\frac{du}{dy} = 0$

$B \neq 0$ and also, $n = 1$

$\Rightarrow$ Fluid is Bingham plastic.

17. (c)
Poise is the unit of dynamic viscosity (μ) in C.G.S. system. Stokes is the unit of kinematic viscosity (v) in C.G.S. system.

$$\text{Specific gravity } G = \frac{\rho}{\rho_w} = \frac{(\mu/v)}{\rho_w}$$

$$\therefore \quad v = \frac{0.5}{0.5} = 1 \text{ stokes}$$

18. (a)
Dynamic viscosity of gases increase with increase in temperature,
i.e., $\mu \propto \sqrt{T}$
and density of gases decrease with increase in temperature at constant pressure.
i.e., $\rho \propto \frac{1}{T}$
Kinematic viscosity,

$$\nu = \frac{\mu}{\rho}; \quad \nu \propto \frac{\sqrt{T}}{1/T} \propto T^{3/2}; \quad \frac{\nu}{T^{3/2}} = C$$

$$\frac{\nu_1}{T_1^{3/2}} = \frac{\nu_2}{T_2^{3/2}}$$

where $T_1 = 20°C = (20 + 273)\text{ K} = 293\text{ K}$
$\nu_1 = 1.6 \times 10^{-5}\text{ m}^2/\text{s}$
$T_2 = 70°C = (70 + 273)\text{ K} = 343\text{ K}$
$\nu_2 = ?$

$$\therefore \frac{1.6 \times 10^{-5}}{(293)^{3/2}} = \frac{\nu_2}{(343)^{3/2}}$$

or $\nu_2 = \mathbf{2.02 \times 10^{-5}\ m^2/s}$

19. (b)

$$\frac{du}{dy} = 2 - 2y; \quad \left.\frac{du}{dy}\right|_{y=0.15} = 1.7$$

$$\tau = \mu\frac{du}{dy} = 0.86 \times 1.7 = \mathbf{1.46\ N/m^2}$$

20. (d)
In liquid, viscosity is due to cohesion with rise in temperature, volume of liquid increases, the distance between molecules increases, thus decreasing the cohesion. Therefore the viscosity of liquid decreases with rise in temperature.
In case of gases, viscosity is due to molecular momentum exchange with rise in temperature of gas, kinetic energy of molecules increases, thus increasing the molecular momentum exchange. Therefore, the viscosity of gases increases with rise in temperature.

21. (d)
When temperature is increased the reduction of cohesion in the water molecules reduces viscosity. For air, the molecular momentum transfer increases and the viscosity also increases.

22. (a)
Only first statement is correct.
(i) Vapour pressure of water at 373K is $101.5 \times 10^3 \times \text{N/m}^2$
(ii) Capillary height in cm for water in contact with glass tube = 0.3/d
(iii) Blood is a pseudoplastic fluid.

24. (c)
Using Newtons law of viscosity

$$\tau = \frac{zv}{h} = \frac{2v}{c_1}$$

$z = 0.8$ poise $= 0.08$ Pa-s

$$v = \frac{\pi DN}{60} = \pi(0.15) \times \frac{1500}{60}$$

$= 11.781\text{ m/s}^2$

$$h = G = \text{Radial clearance} = \frac{D_1 - D}{2}$$

$= 0.25\text{ mm} = 0.25 \times 10^{-3}\text{ m}$
$\tau = 3769.92\text{ N/m}^2 \simeq 3.77\text{ kN/m}^2$

26. (b)
The soap bubble has two interfaces and thus work done
= Surface tension × Total surface area

$$= 0.040 \times 4\pi \times \left(\frac{20}{2} \times 10^{-2}\right)^2 \times 2$$

$= 10.05 \times 10^{-3}$ N.m

27. (c)
Pressure inside the bubble = 200 N/m^2
Pressure outside the bubble = ρgh

$$= 1000 \times 9.81 \times \frac{1.5}{100} \times 0.85 = 125.1\text{ N/m}^2$$

$$\because \quad \Delta P = \frac{2\sigma}{R} = (200 - 125.10) = \frac{2 \times \sigma}{1 \times 10^{-3}}$$

$\Rightarrow \quad \sigma = 0.037$ N/m

28. (2.92)
Air bubble in water will have only one surface,

$$\Delta p = \frac{2\sigma}{R} = \frac{2 \times 0.073}{\left(\frac{0.1}{2}\right) \times 10^{-3}} = 2920\text{ N/m}^2$$

= 2.92 kPa

29. (c)
A water bubble has only one surface

Hence, $\Delta p = \frac{2\sigma}{R} = \frac{2 \times 0.088}{\left(\frac{0.02}{2}\right) \times 10^{-3}}$

$= 17600 \text{ N/m}^2 = 17.6 \text{ kN/m}^2$

31. (d)
Cohesive force is the action or property of like molecules sticking together, being mutually attractive. Mercury has large adhesion force with most container materials and strong cohesive forces. This causes the depression in mercury level inside the tube.

32. (c)
In this problem, the bore is not defined properly. Here bore is used for radius.

$$h = \frac{2\sigma\cos\theta}{\rho \cdot g \cdot R}$$

$$= \frac{2(75 \times 10^{-3})}{10^3 \times 9.81 \times (1 \times 10^{-3})}$$

$= 15.29$ mm

33. (d)

$$h = \frac{4\sigma \cdot \cos\theta}{\gamma d}$$

$$= \frac{4 \times 0.49 \times \cos(0°)}{13.6 \times 9810 \times 2 \times 10^{-3}}$$

$= 7.3$ mm

34. (d)
The capillary rise,

$$h = \frac{4T\cos\theta}{\rho g d}$$

$\because \cos 130° = \cos(90° + 40°) = -\sin 40°$

$$\therefore \quad h = -\frac{4 \times 0.48 \times (0.643)}{13600 \times 9.81 \times 3 \times 10^{-3}}$$

$= -3.08 \times 10^{-3} \text{ m} = -3.08 \text{ mm}$

Therefore, there is capillary depression of 3.08 mm.

36. (b)
Given data:

$V_1 = 2 \text{ m}^3,\ V_2 = 1.96 \text{ m}^3$

$\therefore \quad dV = V_2 - V_1 = 1.96 - 2 = -0.04 \text{ m}^3$

$p_1 = 40 \text{ MPa},\ p_2 = 80 \text{ MPa}$

$\therefore \quad dp = p_2 - p_1 = 80 - 40 = 40 \text{ MPa}$

Bulk modulus of elasticity,

$$K = -\frac{dp}{dV/V_1} = -V_1\frac{dp}{dV} = \frac{-2 \times 40}{-0.04}$$

$= 2000$ MPa

37. (c, d)
Diameter of tube $= 4 \times 10^{-3}$ m

$$h = \frac{4\sigma}{\rho g d}$$

$$= \frac{4 \times 0.073 \times \cos 0°}{998 \times 9.81 \times 4 \times 10^{-3}}$$

$= 7.46 \times 10^{-3}$ m

In case of mercury

$$h = \frac{4\sigma\cos\theta}{\rho_{Hg} g d}$$

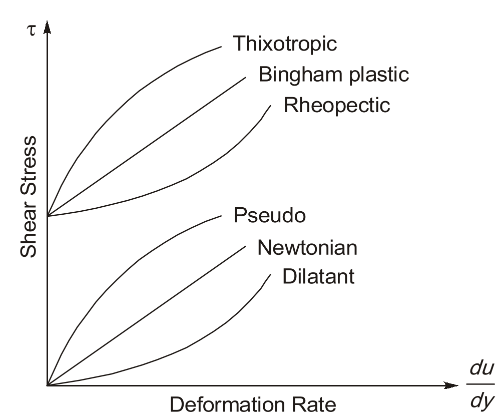
$$= \frac{4 \times 0.51 \times \cos 130°}{13.6 \times 998 \times 9.81 \times 4 \times 10^{-3}}$$

$= -2.46 \times 10^{-3}$ m

$= -2.46$ mm

(–ve) sign indicates capillary depression of 2.46 mm.

38. (a, b, d)



(a) In Rheopectic fluids, apparent viscosity increases with time under constant shear stress.
(b) In Thixotropic fluids apparent viscosity decreases with time under constant shear stress but dynamic viscosity remains constant.
(c) Variation of viscosity is gases is due to molecular momentum transfer (number of collisions).
(d) Dilatant fluid is shear thickening fluid.