POSTAL Book Package 2023

CIVIL ENGINEERING

Fluid Mechanics

Objective Practice Sets

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MADE EASY Publications

Part-I

1 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) $\rho\dfrac{dp}{d\rho}$ (b) $\dfrac{dp}{\rho d\rho}$

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

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

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

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

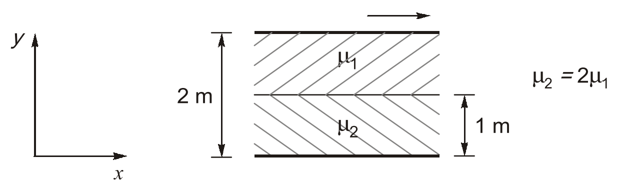
(c) $\dfrac{\varepsilon W\cos\alpha}{A\mu}$ (d) $\dfrac{\mu W\sin\alpha}{\varepsilon A}$

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

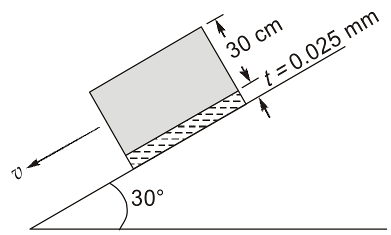
Q.7 Two immiscible, incompressible, viscous fluids having same densities but different viscosities are contained between two infinite horizontal parallel plates, 2 m apart as shown below. The bottom plate is fixed and the upper plate moves to the right with a constant velocity of 3 m/s. With the assumptions 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

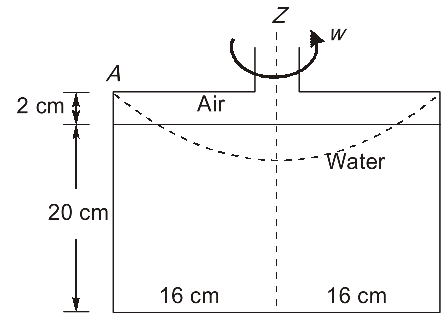
Q.9 The 4 m^3 of a certain oil weighs 30 kN. The relative density of oil is
(a) 0.765 (b) 0.813
(c) 0.872 (d) 0.965

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



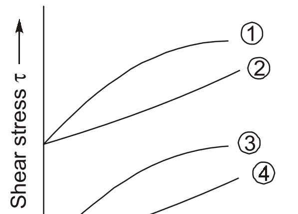
(a) 157.8 (b) 187.5
(c) 142.1 (d) 117.5

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

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

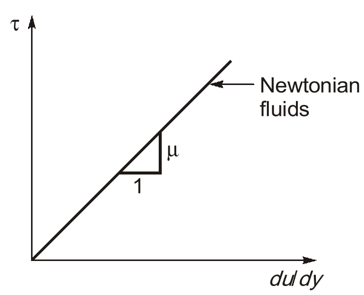
1. (a)

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

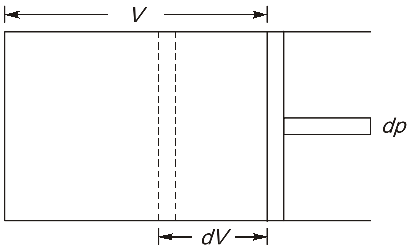


Examples of Newtonian fluids:
Water, Alcohol, Gasoline, Air, Kerosene

2. (a)

Bulk modulus,

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



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)

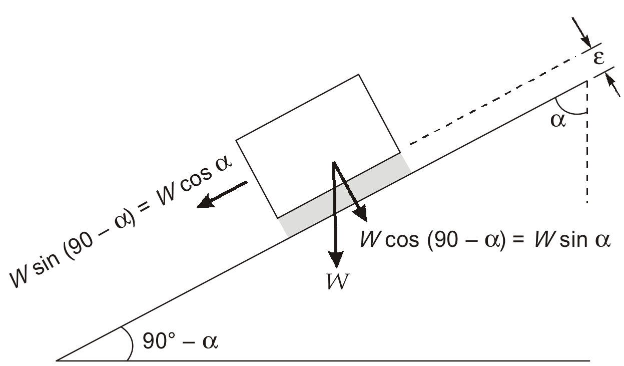
$$K = \frac{\rho\, dp}{d\rho}$$

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

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

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

5. (c)



For zero acceleration,

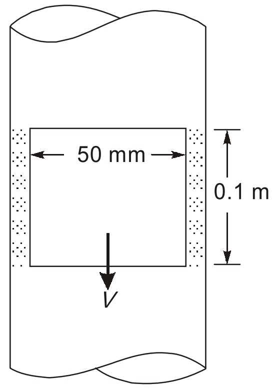
$$W\cos\alpha = \text{Drag force}$$

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

$$\tau = \mu\frac{dv}{dy} = 1.9 \times \frac{V}{1 \times 10^{-3}}$$

$$= 1.9 \times 10^3\ V\ \text{N/mm}^2$$

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

Hence, Total force,

$$F = \tau \times A$$

$$= 1.9 \times 10^3 \times V \times 3.142 \times 50 \times 10^{-3} \times 0.1$$

$$= 29.849\ U$$

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

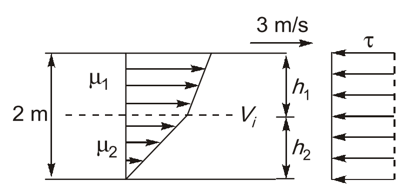
Hence,

$$16 = 29.849\ U$$

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,

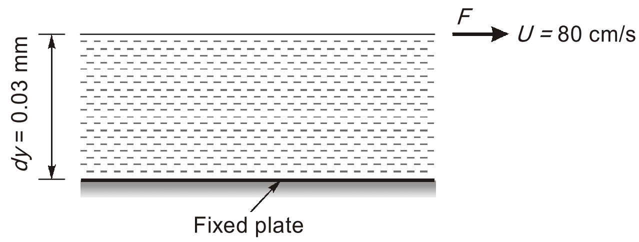
$$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{W/g}{V} = \frac{7.5 \times 10^3 (\text{N/m}^3)}{9.81 (\text{m/s}^2)}$$

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

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

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

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

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

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

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

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

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

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

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

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