25 Years
Previous Solved Papers

ESE 2024

UPSC ENGINEERING SERVICES EXAMINATION

Preliminary Examination

CIVIL ENGINEERING

Objective Solved Papers

Volume-II

- Topicwise presentation
- Thoroughly revised & updated

Also useful for
State Engineering Services Examinations, Public Sector Examinations & Other Competitive Examinations

MADE EASY PUBLICATIONS

www.madeeasypublications.org

MADE EASY Publications Pvt. Ltd.

Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016

Contact: 9021300500

E-mail: infomep@madeeasy.in

Visit us at: www.madeeasypublications.org

ESE-2024 : Preliminary Examination
Civil Engineering : Volume-II
Topicwise Objective Solved Questions : (1999-2023)

1st Edition : 2006
2nd Edition : 2007
3rd Edition : 2008
4th Edition : 2009
5th Edition : 2010
6th Edition : 2011
7th Edition : 2012
8th Edition : 2013
9th Edition : 2014
10th Edition : 2015
11th Edition : 2016
12th Edition : 2017
13th Edition : 2018
14th Edition : 2019
15th Edition : 2020
16th Edition : 2021
17th Edition : 2022

18th Edition : 2023

Director's Message

B. Singh (Ex. IES)

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a career option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Volume-II

CIVIL ENGINEERING

Objective Solved Questions

of UPSC Engineering Services Examination

Contents

■■■■

UNIT

I

Fluid Mechanics & Hydraulic Machines

Syllabus

Fluid Mechanics, Open Channel Flow, Pipe Flow: Fluid properties; Dimensional Analysis and Modeling; Fluid dynamics including flow kinematics and measurements; Flow net; Viscosity, Boundary layer and control, Drag, Lift, Principles in open channel flow, Flow controls. Hydraulic jump; Surges; Pipe networks.

Hydraulic Machines and Hydro power: Various pumps, Air vessels, Hydraulic turbines–types, classifications & performance parameters; Power house–classification and layout, storage, pondage, control of supply.

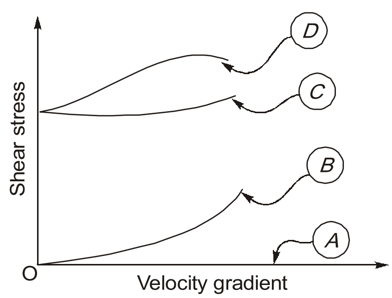
Contents

■■■■

1 Fluid Properties

1.1 Match **List-I** (Curves labelled *A*, *B*, *C* and *D* in figure) with **List-II** (Type of fluid) and select the correct answer using the codes given below the lists:

List-I



List-II

1. Ideal plastic
2. Ideal
3. Non-Newtonian
4. Thixotropic
5. Rheopectic

Codes:

	A	B	C	D
(a)	2	3	1	5
(b)	3	2	1	5
(c)	4	2	5	1
(d)	2	3	5	1

[ESE : 1999]

1.2 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I

A. Concentrated sugar solution
B. Sewage sludge
C. Blood
D. Air

List-II

1. Dilatant fluid
2. Bingham plastic fluid
3. Pseudo-plastic fluid
4. Newtonian fluid

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	2	4	3
(c)	2	1	3	4
(d)	2	1	4	3

[ESE : 2001]

1.3 Match **List-I** (Definitions) with **List-II** (Properties) and select the correct answer using the codes given below the lists:

List-I

A. Newtonian fluid
B. Ideal fluid
C. Thixotropic fluid
D. Rheological fluid

List-II

1. Frictionless and incompressible
2. Viscosity is invariant with shear stress
3. Viscosity decreases at higher shear stress
4. Viscosity increases at higher shear stress

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	3	1	4	2
(c)	2	1	3	4
(d)	3	4	1	2

[ESE : 2002]

1.4 Which one of the following statements is correct?
(a) Dynamic viscosity of water is nearly 50 times that of air.
(b) Kinematic viscosity of water is 30 times that of air.
(c) Water in soil is able to rise a considerable distance above the groundwater table due to viscosity.
(d) Vapour pressure of a liquid is inversely proportional to the temperature.

[ESE : 2003]

1.5 Which of the following fluids can be classified as non-Newtonian?

1. Kerosene oil
2. Diesel oil
3. Human blood
4. Toothpaste
5. Water

Select the correct answer using the codes given below:

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

[ESE : 2003]

1.6 **Assertion (A):** At the standard temperature, the kinematic viscosity of air is greater than that of water at the same temperature.

Reason (R): The dynamic viscosity of air at standard temperature is lower than that of water at the same temperature.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE : 2004]

1.7 The velocity distribution for flow over a plate is given by $u = 0.5y - y^2$ where 'u' is the velocity in m/s at a distance 'y' meter above the plate. If the dynamic viscosity of the fluid is 0.9 N-s/m^2, then what is the shear stress at 0.20 m from the boundary?

(a) 0.9 N/m^2 (b) 1.8 N/m^2
(c) 2.25 N/m^2 (d) 0.09 N/m^2

[ESE : 2005]

1.8 A flat plate of 0.15 m^2 is pulled at 20 cm/s relative to another plate, fixed at a distance of 0.02 cm from it with a fluid having μ = 0.0014 N-s/m^2 separating them. What is the power required to maintain the motion?

(a) 0.014 W (b) 0.021 W
(c) 0.035 W (d) 0.042 W

[ESE : 2006]

1.9 Which one of the following expresses the height of rise or fall of a liquid in a capillary tube?

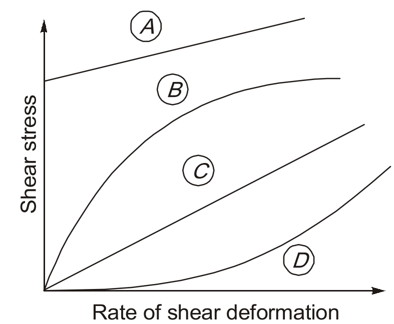
(a) $\dfrac{4wd}{\sigma\cos\alpha}$ (b) $\dfrac{\sigma\cos\alpha}{4w\alpha}$

(c) $\dfrac{4\sigma\cos\alpha}{wd}$ (d) $\dfrac{wd}{4\sigma\cos\alpha}$

where,
w = Specific weight of the liquid
α = Angle of contact of the liquid surface
σ = Surface tension

[ESE : 2007]

1.10 Match **List-I** (Curve identification in figure) with **List-II** (Nature of fluid) and select the correct answer using the codes given below the lists:



List-I	List-II
A. Curve *A*	**1.** Newtonian
B. Curve *B*	**2.** Dilatant
C. Curve *C*	**3.** Ideal bingham plastic
D. Curve *D*	**4.** Pseudo-plastic

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	2	4	1	3
(c)	3	1	4	2
(d)	2	1	4	3

[ESE : 2010]

1.11 **Assertion (A):** The movement of two blocks of wood welted with hot glue requires greater and greater effort as the glue is drying up.

Reason (R): Viscosity of liquids varies inversely with temperature.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE : 2010]

1.12 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I
A. Specific Gravity
B. Coefficient of viscosity
C. Kinematic viscosity
D. Stress

List-II
1. $M^{\circ}L^{2}T^{-1}$
2. $M^{\circ}L^{\circ}T^{\circ}$
3. $ML^{-1}T^{-1}$
4. $ML^{-1}T^{-2}$

Code:

	A	B	C	D
(a)	2	3	1	4
(b)	4	3	1	2
(c)	2	1	3	4
(d)	4	1	3	2

[ESE : 2011]

1.13 Poise has the unit of
(a) Dyne-cm/s^2 (b) Dyne-cm/s
(c) Dyne-s/cm (d) Dyne-s/cm^2
[ESE : 2011]

1.14 Which one of the following statements is correct?
(a) For water at 100° Celsius at sea level, the vapour pressure is equal to atmospheric pressure.
(b) Surface energy (or tension) is caused by the force of adhesion between liquid molecules.
(c) Viscosity of a fluid is the property exhibited by it both in static and in dynamic conditions.
(d) Air is 50, 000 times more compressible than water.
[ESE : 2011]

1.15 Which one of the following statements is correct?
(a) Dynamic viscosity is the property of a fluid which is not in motion
(b) Surface energy is fluid property giving rise to the phenomenon of capillarity in water
(c) Cavitation results from the action of very high pressure
(d) Real fluids have lower viscosity than ideal fluids
[ESE : 2011]

1.16 **Statement (I):** As temperature increases, viscosity of air decreases.
Statement (II): As temperature increases, activity of the air molecules increases.
(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
[ESE : 2013]

1.17 The surface tension in a soap bubble of 50 mm diameter with its inside pressure being 2.5 N/m^2 above the atmospheric pressure is
(a) 0.0125 N/m (b) 0.0156 N/m
(c) 0.2 N/m (d) 0.0312 N/m
[ESE : 2015]

1.18 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
[ESE : 2016]

1.19 **Statement (I):** The shear strain graph for a Newtonian fluid is linear.
Statement (II): The coefficient of viscocity μ of the fluid is not constant.
(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
[ESE : 2016]

1.20 The surface tension in a soap bubble of 20 mm diameter, when the inside pressure is 2.0 N/m^2 above atmospheric pressure, is
(a) 0.025 N/m (b) 0.0125 N/m
(c) 5×10^{-3} N/m (d) 4.25×10^{-3} N/m
[ESE : 2018]

1.21 A jet of water has a diameter of 0.3 cm. The absolute surface tension of water is 0.072 N/m and atmospheric pressure is 101.2 kN/m^2. The absolute pressure within the jet of water will be
(a) 101.104 kN/m^2 (b) 101.152 kN/m^2
(c) 101.248 kN/m^2 (d) 101.296 kN/m^2
[ESE : 2018]

1.22 A glass tube of 2.5 mm internal diameter is immersed in oil of mass density 940 kg/m^3 to a depth of 9 mm. If a pressure of 148 N/m^2 is needed to form a bubble which is just released, what is the surface tension of the oil?
(a) 0.041 N/m (b) 0.043 N/m
(c) 0.046 N/m (d) 0.050 N/m
[ESE : 2018]

1.23 A plate 0.025 mm distant from a fixed plate moves at 60 cm/s and requires a force of 0.2 kgf/m^2 to maintain this speed. The dynamic viscosity of the fluid between the plates will be nearly
(a) 9.2×10^{-10} kgfs/cm^2
(b) 8.3×10^{-10} kgfs/cm^2
(c) 7.4×10^{-10} kgfs/cm^2
(d) 6.5×10^{-10} kgfs/cm^2
[ESE : 2019]

1.24 What is the minimum size of glass tube that can be used to measure water level if the capillary rise in the tube is to be restricted to 2 mm? (Take surface tension of water in contact with air as 0.073575 N/m)
(a) 1.5 cm (b) 1.0 cm
(c) 2.5 cm (d) 2.0 cm
[ESE : 2021]

1.25 The pressure outside the droplet of water of diameter 0.04 mm is 10.32 N/cm^2 (atmospheric pressure). What is the pressure within the droplet if surface tension is 0.0725 N/m of water?
(a) 11.045 N/cm^2 (b) 10.32 N/cm^2
(c) 9.45 N/cm^2 (d) 8.595 N/cm^2
[ESE : 2022]

1.26 What is the viscosity of a liquid whose kinematic viscosity is 6 stokes and specific gravity is 1.90?
(a) 1.14 poise (b) 11.40 poise
(c) 0.114 Ns/m^2 (d) 11.40 Ns/m^2
[ESE : 2022]

■■■■

Answers Fluid Properties

1.1 (a)	**1.2** (a)	**1.3** (c)	**1.4** (a)	**1.5** (b)	**1.6** (b)	**1.7** (d)	**1.8** (d)	**1.9** (c)
1.10 (a)	**1.11** (a)	**1.12** (a)	**1.13** (d)	**1.14** (a)	**1.15** (b)	**1.16** (d)	**1.17** (b)	**1.18** (c)
1.19 (c)	**1.20** (c)	**1.21** (c)	**1.22** (a)	**1.23** (b)	**1.24** (a)	**1.25** (a)	**1.26** (b)	

Explanations Fluid Properties

1.1 (a)

The curve (*A*), horizontal line representing zero shear stress for any velocity gradient is the condition for ideal fluid.

The curve B represents dilatant fluid.

$$\tau = \mu\left(\frac{du}{dy}\right)^n \qquad n > 1$$

For pseudoplastic fluid,

$$\tau = \mu\left(\frac{du}{dy}\right)^n \qquad n < 1$$

For thixotropic fluid,

$$\tau = \tau_0 + \mu\left(\frac{du}{dy}\right)^n \qquad n < 1$$

For rheopectic fluid,

$$\tau = \tau_0 + \mu\left(\frac{du}{dy}\right)^n \qquad n > 1$$

For ideal plastic fluid,

$$\tau = \tau_0 + \mu\left(\frac{du}{dy}\right) \qquad n = 1$$

1.2 (a)

Newtonian Fluids: Air, water, mercury, glycerine, kerosene and other engineering fluids under normal circumstances.

Pseudoplastic: Fine particle suspension, gelatine, blood, milk, paper pulp, polymeric solutions such as rubbers, paints.

Dilatant fluids: Ultra fine irregular particle suspension, sugar in water, aqueous suspension of rice starch, quicksand, butter.

Ideal plastics or Bingham fluids: Sewage sludge, drilling muds.

Visco-elastic fluids: Liquid solid combination in pipe flow, bitumen, tar, asphalt, polymerized fluids with drag reduction features.

Thixotropic: Printer's ink, crude oil, lipstick, certain paints and enamels.

Rheopectic fluids: Very rare liquid-solid suspensions, gypsum suspension in water and bentonite solutions.

1.3 (c)

For thixotropic fluid $\tau = \tau_0 + \mu\left(\frac{du}{dy}\right)^n \quad n < 1$

As shear stress τ increases viscosity decreases with higher rates of shear strain.

1.4 (a)

- The dynamic viscosity of water is approximately 50 to 55 times of air at 20°C.
- The kinematic viscosity of air is nearly 15 times of water at 20°C.
- Water in soil rises due to capillary (not due to viscosity)
- Vapour pressure of a liquid is directly proportional to the temperature.

1.5 (b)

Example of Newtonian fluids: Air, Water, Kerosene oil, Diesel oil

Example of non-Newtonian fluids: Toothpaste, Human blood, Paint, Shampoo.

1.6 (b)

Kinematic viscosity of air is greater because the density of air is very small compared to that of water.

1.7 (d)

Shear stress,

$$\tau = \mu\frac{du}{dy} = \mu(0.5 - 2y)$$

at $y = 0.2$ m

$$\tau = 0.9 \times (0.5 - 2 \times 0.2) = 0.09 \text{ N/m}^2$$

1.8 (d)

Force, $F = \tau A$

$$F = \mu\frac{du}{dy} \times A$$

$$= 0.0014 \times \frac{0.2}{0.02 \times 10^{-2}} \times 0.15$$

$$= 0.21 \text{ N}$$

Power required

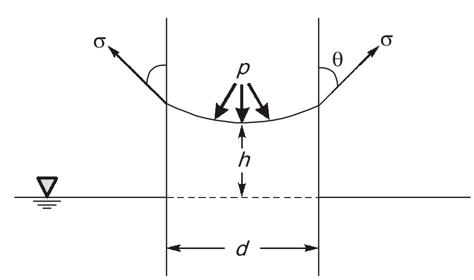
$$= F \times v$$

$$= 0.21 \times 0.2$$

$$= 0.042 \text{ W}$$

1.9 (c)

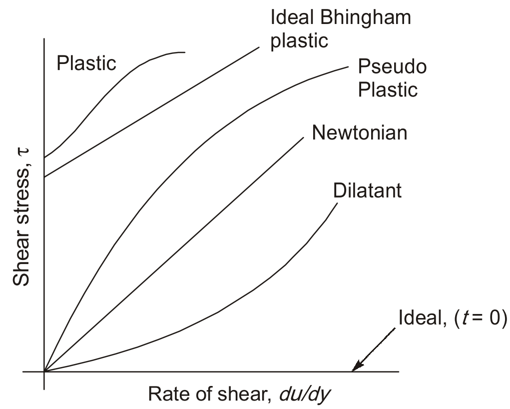
Let us suppose that the level of liquid has risen (or fallen) by 'h' above (or below) the general liquid surface when a tube of diameter 'd' is inserted in the liquid. For equilibrium of vertical forces acting on the mass of liquid lying above (or below) the general liquid level, the weight of liquid column 'h' (or the total internal pressure in the case of capillary depression) must be balanced by the force, at surface of the liquid, due to surface tension σ. Thus, equating these two forces we have



$$\frac{w\pi d^2}{4} \times h = \pi d\,\sigma\cos\theta$$

$$\Rightarrow \quad h = \frac{4\sigma\cos\theta}{wd}$$

1.10 (a)



1.11 (a)

Viscosity of liquids varies inversely with temperature so as the glue is dries up and cools down, its viscosity increases. Thus movement of two blocks of wood welted with hot glue would require greater effort.

1.12 (a)

Specific gravity is the ratio of specific weight of a fluid to the specific weight of a standard fluid. Being a ratio of two quantities with same units, specific gravity has no unit.

$\therefore M^oL^oT^o$

Coefficient of viscocity $= \mu$

$$\text{unit of } \mu = Ns/m^2 = (MLT^{-2})T/L^2 = ML^{-1}T^{-1}$$

Kinematic viscocity :

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

$$\text{unit of } \nu = m^2/s = L^2T^{-1} = M^oL^2T^{-1}$$

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$$

1.13 (d)

Poise is unit of dynamic viscocity.

$$\text{Poise} = \frac{\text{Dyne}-\text{s}}{\text{cm}^2}$$

$$1 \text{ Poise} = 0.1 \text{ Ns/m}^2$$

1.14 (a)

- At boiling point the vapour pressure of a fluid becomes equal to the atmospheric pressure. Water boils at 100°C therefore at 100°C at sea level the vapour pressure, is equal to the atmospheric pressure.
- Surface tension is caused by the force of cohesion between liquid molecules.
- Air is about 20000 times more compressible than water.

$$k_{air} = 1.03\times 10^5 \text{ N/m}^2$$
$$k_{water} = 2.06 \times 10^9 \text{ N/m}^2$$

1.15 (b)

Dynamic viscosity is the property of fluid in motion in which one layer of fluid exerts viscous force on the other layer. Cavitation occurs due to negative pressure.

Ideal fluids have no viscosity and surface tension and they are incompressible.

1.16 (d)

As the temperature increases, molecules move faster and there is an increase in molecular interaction. Molecules start colliding with each other, retarding the motion of gases, resulting in increase in viscosity of gases.

1.17 (b)

$$p\times\frac{\pi d^2}{4} = \sigma\times 2(2\pi r) = \sigma\times 2\pi d$$

$$\sigma = \frac{pd}{8} = \frac{2.5\times 0.05}{8} = 0.0156 \text{ N/m}$$

1.18 (c)

In this problem, the bore is not defined properly. Here bore is used for radius.

$$h = \frac{2\sigma\cos\theta}{\rho\cdot g\cdot R} = \frac{2\left(75\times 10^{-3}\right)}{10^3\times 9.81\times\left(1\times 10^{-3}\right)} = 15.29 \text{ mm}$$

1.20 (c)

For soap bubble

$$\Delta P = \frac{4\sigma}{R}$$

$$2 = \frac{4\sigma}{0.01}$$

$$\sigma = 5 \times 10^{-3} \text{ N/m}$$

1.21 (c)

For jet of water

$$\Delta P = \frac{\sigma}{R}$$

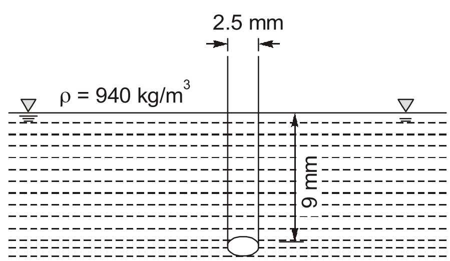
$$\Delta P = \frac{0.072}{0.15 \times 10^{-2}}$$

$$\Delta P = 0.048 \text{ kPa}$$

Absolute pressure within the jet

= 101.2 + 0.048 = 101.248 kPa

1.22 (a)



$$\Delta P = \frac{2\sigma}{R}$$

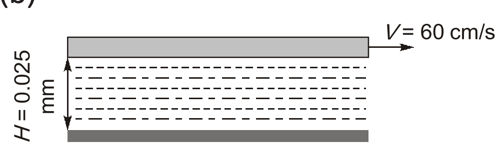
$$\Delta P = 148 - (940 \times 9.81 \times 0.009)$$

$$= 148 - 82.99 = 65.01$$

Now, $65.01 = \dfrac{2\sigma}{1.25 \times 10^{-3}}$

$$\sigma = 0.04063 \text{ N/m}$$

1.23 (b)



$$\frac{F}{A} = 0.2 \text{ kgf/m}^2 = \frac{0.2}{10^4} \text{ kgf/cm}^2$$

We know that

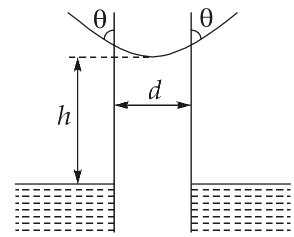
$$\tau = \mu . \frac{V}{H}$$

$$\frac{F}{A} = \mu . \frac{V}{H}$$

$$\frac{0.2}{10^4} = \mu \frac{(60)}{0.025 \times 10^{-1}}$$

$$\mu = 8.3 \times 10^{-10} \text{ kgfs/cm}^2$$

1.24 (a)



Capillary rise

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

Given: Capillary rise

$$h = 2 \text{ mm}$$

Surface tension

$$\sigma = 0.073575 \text{ N/m}$$

For glass tube – water contact,

Angle of contact,

$$\theta = 0^\circ$$

$$\therefore \quad 2 \times 10^{-3} = \frac{4 \times 0.073575 \times 1}{9.81 \times 1000 \times d}$$

$$d = \frac{4 \times 0.073575}{9.81 \times 2}$$

$$= \frac{3}{200} \text{ m} = 1.5 \text{ cm}$$

∴ Size of the glass tube

$$d = 1.5 \text{ cm}$$

1.25 (a)

Excess pressure,

$$\Delta P = \frac{2\sigma}{R} = \frac{2(.0725)}{0.02 \times 10^{-3}}$$

$$= 7250 \text{ N/m}^2 = 0.7250 \text{ N/cm}^2$$

$$= \frac{2(.0725)}{0.02 \times 10^{-3}}$$

$$= 7250 \text{ N/m}^2 = 0.7250 \text{ N/cm}^2$$

Now, $P_i - P_o = 0.725 \text{ N/cm}^2$

$\Rightarrow \; P_i = 10.32 + 0.725 = 11.045 \text{ N/cm}^2$

1.26 (b)

Given, $\nu = 6 \text{ stokes} = 6 \times 10^{-4} \text{ m}^2/\text{s}$

$$S_l = 1.9$$

$$\therefore \quad \rho_l = 1.90 \times 10^3 \text{ kg/m}^3$$

Now, $\nu = \dfrac{\mu}{\rho}$

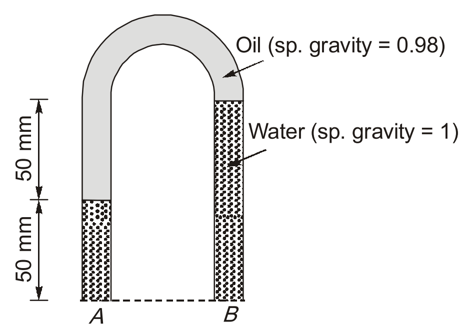
$$\mu = 6 \times 10^{-4} \times 1.9 \times 10^3$$

$$\mu = 1.14 \text{ Ns/m}^2 = 11.4 \text{ poise}$$

■■■■

2 Manometry

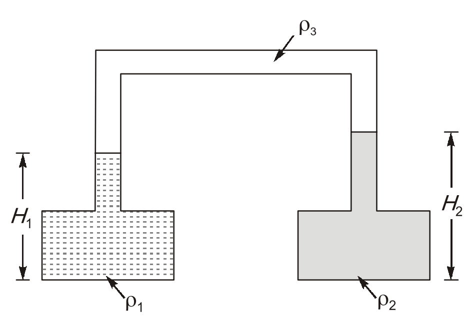
2.1 In the set-up shown in the given figure, assuming the specific weight of water as 10,000 N/m^3, the pressure difference between the points *A* and *B* will be



(a) 10 N/m^2 (b) –10 N/m^2
(c) 20 N/m^2 (d) –20 N/m^2

[ESE : 1999]

2.2 Which one of the following expresses the difference in the pressure at the floors of the tank shown above in the figure?



(a) $(\rho_2 - \rho_1)gH_2$
(b) $(\rho_2 - \rho_1)gH_1$
(c) $\rho_1 gH_1 + \rho_3 gH_2 - \rho_2 gH_2$
(d) $\rho_1 gH_1 + \rho_3 g(H_2 - H_1) - \rho_2 gH_2$]

where ρ_1, ρ_2 and ρ_3 are the densities of the different fluids.

[ESE : 2006]

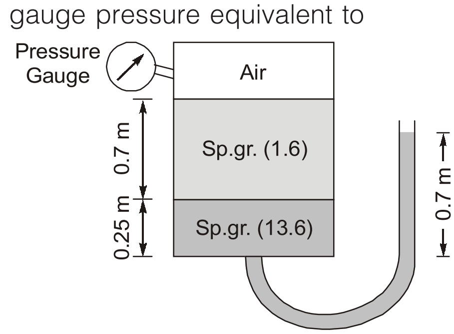
2.3 Multi U-tube manometers with different fluids are used to measure
(a) low pressures
(b) medium pressures
(c) high pressures
(d) very low pressures

[ESE : 2006]

2.4 A pressure gauge reads 57.4 kPa and 80 kPa, respectively at heights of 8 m and 5 m fitted on the side of a tank filled with liquid. What is the approximate density of the liquid in kg/m^3?
(a) 393 (b) 768
(c) 1179 (d) 7530

[ESE : 2008]

2.5 In the below figure the pressure gauge will record a gauge pressure equivalent to



(a) 6.12 m of water
(b) 1.21 m of mercury
(c) 0.5 bar
(d) 34,000 Pa

[ESE : 2011]

2.6 The absolute pressure at a point 2.5 m below the clear water surface is measured as 125.703 kN/m^2. If the atmospheric pressure is taken as 101.325 kN/m^2, the gauge pressure in kN/m^2 at this point would be
(a) 113.514 (b) 24.378
(c) 45.401 (d) 56.757

[ESE : 2013]

2.7 The standard atmospheric pressure is 101.32 kPa. The local atmospheric pressure is 91.52 kPa. If a pressure at a flow path is recorded at 22.48 kPa (gauge), it is equivalent to
(a) 69.04 kPa (abs) (b) 88.4 kPa (abs)
(c) 114.0 kPa (abs) (d) 123.0 kPa (abs)
[ESE : 2014]

2.8 What is the depth of a point below water surface in sea, where pressure intensity is 1.006 MN/m^2? (Specific gravity of sea water is 1.025)
(a) 60 m (b) 80 m
(c) 100 m (d) 120 m
[ESE : 2021]

2.9 Two pressure points in a water pipe are connected to a manometer which has the form of an inverted U-tube. The space above the water in the two limbs of the manometer is filled with toluene (specific gravity is 0.875). If the difference of level of water columns in the two limbs reads 12.0 cm, what is the corresponding difference of pressure? (Take g = 9.81 m/s^2)
(a) 110.49 N/m^2 (b) 128.12 N/m^2
(c) 131.34 N/m^2 (d) 147.15 N/m^2
[ESE : 2021]

2.10 If pressure head of water is 100 m and specific gravity of kerosene is 0.81, what is the pressure head of kerosene?
(a) 123.5 m of kerosene
(b) 241.3 m of kerosene
(c) 75.1 m of kerosene
(d) 52.4 m of kerosene
[ESE : 2021]

Answers Manometry

2.1 (b) 2.2 (d) 2.3 (c) 2.4 (b) 2.5 (c) 2.6 (b) 2.7 (c) 2.8 (c) 2.9 (d) 2.10 (a)

Explanations Manometry

2.1 (b)

The equation for pressure at B is

$$p_A - \rho_w gh - \rho_{oil} gh + 2\rho_w gh = p_B$$

$$\therefore \quad p_A - p_B = \rho_{oil} gh - \rho_w gh$$
$$= (0.98 - 1) \times 10000 \times 0.05$$
$$= -10 \text{ N/m}^2$$

2.2 (d)

$$p_1 - \rho_1 g H_1 - \rho_3 g(H_2 - H_1) + \rho_2 g H_2 = p_2$$
$$\therefore \quad p_1 - p_2 = \rho_1 g H_1 + \rho_3 g(H_2 - H_1) - \rho_2 g H_2$$

2.3 (c)

To measure a very high pressure, a single U-tube manometer used may become too tall. So a number of U-tubes of reasonable sizes are used with same or different manometric fluids.

2.4 (b)

The pressure difference may be given as

$$p_1 - p_2 = \rho g (h_2 - h_1)$$
$$\Rightarrow \quad 80 \times 10^3 - 57.4 \times 10^3 = \rho \times 9.81 \times (8 - 5)$$
$$\Rightarrow \quad 22600 = \rho \times 29.43$$
$$\Rightarrow \quad \rho = 768 \text{ kg/m}^3$$

2.5 (c)

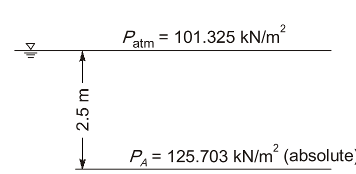
Let gauge pressure be = P

$P + (1.6 \times \rho_w) \times g \times 0.7 + (13.6 \times \rho_w) \times g \times 0.25 - (13.6 \times \rho_w) \times g \times 0.7 = 0$

$P = 5 \times g \times \rho_w$

$$= 50000 \frac{\text{N}}{\text{m}^2} = \frac{50000}{10^5} \text{bar} = 0.5 \text{ bar}$$

2.6 (b)



Gauge pressure at 2.5 m depth level

$\therefore \quad = 125.703 - 101.325$

$= 24.378 \text{ kN/m}^2$

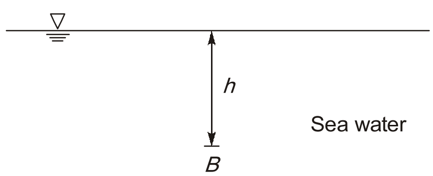
2.7 (c)

Absolute pressure

$$= \text{Local atmospheric pressure} + \text{Gauge pressure}$$
$$= 91.52 + 22.48$$
$$= 114 \text{ kPa}$$

2.8 (c)

Given: $P_B = 1.006 \text{ MN/m}^2 = 1.006 \times 10^6 \text{ N/m}^2$



Special gravity,

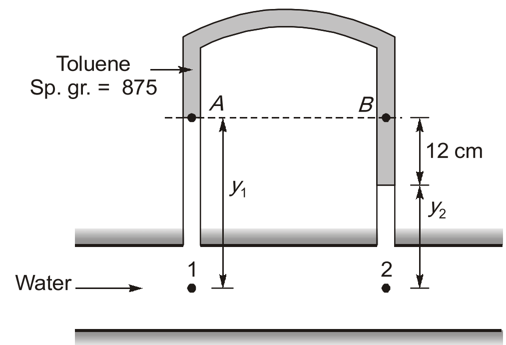
$$s = 1.025$$

Pressure at any depth '*h*' below water surface:

$$P_B = \gamma_{sea} h = \rho_{sea}\, gh = s\rho_w gh$$
$$1.006 \times 10^6 = 1.025 \times 10^3 \times 9.81 \times h$$
$$h = 100.05 \text{ m} \simeq 100 \text{ m}$$

2.9 (d)

Inverted U-tube manometer



From figure, we write

$$P_A = P_B$$
$$P_1 - \rho g y_1 = P_2 - \rho g y_2 - \rho_{toluene}\, g\,(0.12)$$
$$P_1 - P_2 = \rho g y\,(y_1 - y_2) - \rho_{toulene} \times g \times 0.12$$
$$= 1000 \times 9.81 \times 0.12 - 0.875 \times 1000 \times 9.81 \times 0.12$$
$$= 1000 \times 9.81 \times 0.12\,(1 - 0.875)$$
$$\Rightarrow \quad P_1 - P_2 = 147.15 \text{ N/m}^2$$

2.10 (a)

For equal pressure at any point in two liquid column

$$(P)_{water} = (P)_{kerosene}$$
$$\rho_w g h_{water} = S\rho_w g h_{kerosene}$$
$$100 = 0.81 \times h_{kerosene}$$
$$\therefore \quad h_{kerosene} = \frac{100}{0.81} = 123.456 \text{ m} \simeq 123.5 \text{ m}$$

■■■■