<table>
<thead>
<tr>
<th>Week</th>
<th>Contents</th>
<th>Topics</th>
<th>week</th>
<th>Contents</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fluid properties &amp; Definitions</td>
<td></td>
<td></td>
<td>Fluid statics , pressure at apoint , variation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pressure</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pressure measurement , Manometers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Forces on plane &amp; curved surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Buoyant force</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Stability of floating and submerged bodies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Relative equilibrium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Kinematics of flow – Definitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Continuity &amp; Bernoulli’s equations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Energy equation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Applications – flow through orifice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Applications - measurement of flow velocity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Applications - measurement of flow rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Momentum equation &amp; Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Flow in pipes – Definitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Laminar flow in circular pipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Turbulent flow in pipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Major losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Minor losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Pipes in series</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Pipes in parallel Branching pipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Applications on flow in pipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Cavitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Dimensional analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Dynamic similarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Fluid properties & Definitions
2. Fluid statics, pressure at a point, variation pressure
3. Pressure measurement, Manometers
4. Forces on plane & curved surface
5. Buoyant force
6. Stability of floating and submerged bodies
7. Relative equilibrium
8. Kinematics of flow – Definitions
9. Continuity & Bernoulli’s equations
10. Energy equation
11. Applications – flow through orifice
12. Applications - measurement of flow velocity
13. Applications - measurement of flow rate
14. Momentum equation & Applications
15. Flow in pipes – Definitions
16. Laminar flow in circular pipes
17. Turbulent flow in pipes
18. Major losses
19. Minor losses
20. Pipes in series
21. Pipes in parallel Branching pipes
22. Applications on flow in pipes
23. Cavitation
24. Dimensional analysis
25. Dynamic similarity

Topics:
1. Fluid properties & Definitions
2. Fluid statics, pressure at a point, variation pressure
3. Pressure measurement, Manometers
4. Forces on plane & curved surface
5. Buoyant force
6. Stability of floating and submerged bodies
7. Relative equilibrium
8. Kinematics of flow – Definitions
9. Continuity & Bernoulli’s equations
10. Energy equation
11. Applications – flow through orifice
12. Applications - measurement of flow velocity
13. Applications - measurement of flow rate
14. Momentum equation & Applications
15. Flow in pipes – Definitions
16. Laminar flow in circular pipes
17. Turbulent flow in pipes
18. Major losses
19. Minor losses
20. Pipes in series
21. Pipes in parallel Branching pipes
22. Applications on flow in pipes
23. Cavitation
24. Dimensional analysis
25. Dynamic similarity
1. Fluid properties
   1.1 Definitions
   1.2 Newton Law of Viscosity
   1.3 Bulk Modulus of Elasticity
   1.4 Surface tension

2. Fluid Static
   2.1 Definitions
   2.2 Pressure at a point
   2.3 Hydrostatic law
   2.4 Units and Scales of Pressure Measurement
   2.5 Manometers (Pressure Measurement)
   2.6 Force on Plane Surface
   2.7 Force on Curved Surface
   2.8 Buoyant Force
   2.9 Stability of Floating and Submerged Bodies
   2.10 Relative Equilibrium

3. Fluid Flow Concept and Basic Equations
   3.1 Definitions
   3.2 Continuity Equation
   3.3 Euler Equation of motion along streamline
   3.4 Bernoulli Equation (Energy equation)
   3.5 Flow measurement
   3.6 Resistance to Flow in Open and Closed Conduits
   3.7 Linear Momentum Equation and its
Application

3.8 Introduction for pumping and Turbines application

4. Dimensional analysis and dynamic similitude

4.1 The T- Theorem

4.2 Disc of Dimensionless Parameters
Reynolds No., Froude No., Euler No.
Weber No., Mach No.

4.3 Similitude: Model Studies

References:
1. Fluid Mechanics, Vector L. Streeter
   E. Benjamin Wylie

2. Fluid Mechanics and Engineering application
   Robert L. Dogarti and Joshef B. Frinzing
1. Fluid: It is a substance that deforms continuously when subjected to a shear stress. It is either gas or liquid.

2. Shear stress \( \tau = \frac{F}{A} = \frac{\text{shear force}}{\text{surface area}} \)

3. Shear force: It is the force components tangential to a surface of liquid.

4. Viscosity \( \mu \): It is the property of fluid by virtue of which it offers resistance to shear.
   - Molasses (\( \mu \)) and tar (\( \mu \)) are examples for highly viscous liquids.
   - Water and air have very small resistance.

   - The viscosity of gas increase with temperature.
   - " " = liquid decrease " "

Units: \( \mu = \text{N.s/m}^2 \) or \( \text{kg/m.s} \)
A common unit is Poise (\( P \)) =
1. **Poise (g/cm.s)** = 0.1 N.s/m² (Pa.s) 
   = 0.1 kg/m.s 
   10 P = 1 kg/m.s.

5. **Kinematic viscosity**: \( \nu \); it is the ratio of viscosity to mass density. 
   \[ \nu = \frac{M}{\rho} = 1 \text{ m}^2/\text{s} \text{ (stoke)} \]

6. **Density**: \( \rho \); it is the mass per unit volume. 
   \[ \rho = \frac{m}{V} = \text{kg/m}^3 \]
   
   Water: \( \rho = 1000 \text{ kg/m}^3 \)

7. **Specific weight \( g \)** (unit gravity force). The force per unit volume. It changes with location. 
   \[ g = \rho g = 9.81 \times 1000 = 9810 \text{ N/m}^3 \]

8. **Specific gravity \( S \)** (relative density) 
   \[ S = \frac{g_s}{g} = \text{Specific weight of substance,} \]
9. Pressure: $P$, the normal force pushing against a plane area divided by the area. Units: $\text{N/m}^2$ or Pascal ($\text{Pa}$)

10. Vapor pressure: The vapor molecules exert a partial pressure in the space known as vapor pressure.

11. Perfect gas: It is a substance that satisfies the Perfect gas Law: $PV = nRT$ or $P = \frac{nRT}{V}$

**Newton's Law of Viscosity**

Experimentally shown that

\[ F \propto \frac{AU}{t} \]

$A$ is the area of the moving plate in fixed

$U$ is the velocity of the moving plate in $\text{m/s}$

$t$ is the distance between the plates in

\[ F = \mu \cdot \frac{AU}{t} \]
Since \( T = \frac{F}{A} \)

\[ T = \mu \frac{U}{t} \]  \hspace{1cm} (2)

\( U \) \( t \) is the angular deformation of fluid.

\[ \frac{du}{dy} = 2 \]

Newton's law of viscosity

\( \eta = \mu \), shear stress

\( F = 500 \text{ N} \hspace{1cm} U = 1 \text{ m/s} \)

Since

\[ F = \mu \frac{A U}{t} \]

\[ 500 = \mu \frac{A \times 1}{t} \]

\( \mu = \frac{500}{A} \)

Since \( T \) is constant

\[ F_{2} = \mu \frac{A U}{t} \]

\[ 1500 = \frac{500 \times A}{t} \]

\( U = 3 \text{ m/s} \)
12. Specific Volume: \( V_s \), it is the reciprocal of density

\[ V_s = \frac{1}{\rho} = \text{m}^3/\text{kg} \]

13. Surface tension

\[ \gamma = \pi r^2 \text{ cos } \theta \]

\[ \sigma = \text{surface tension constant} \]

\[ h = \frac{2 \pi \sigma}{r} \]

14. Bulk modulus of Elasticity: \( K \)

\[ K = -\frac{dP}{dV/V} = \text{N/m}^2 \]

or

\[ K = -\frac{\Delta P}{\Delta V/V} = -\frac{P_2 - P_1}{V_2 - V_1} \]

\( K \): The Volumetric Compressive Stress per Unit Volumetric Strain.
Ex: A liquid compressed in a cylinder has a volume of 1 dm$^3$ (1000 cm$^3$) at 1 MN/m$^2$ and volume of 995 cm$^3$ at 2 MN/m$^2$. What is its bulk modulus of elasticity?

$$K = \frac{\Delta P}{\Delta V/V} = \frac{(2-1) \text{MN/m}^2}{(995 - 1000) \text{cm}^3} = 200 \text{ MPa}.$$  

$$\sigma = 0.142 \times 10^5 \text{ N/m}^2$$

$$P = \frac{26}{u} = \frac{2 \times 0.0736 \times 1000}{0.05} = 5.89 \text{ kPa}.$$  

$$1.18 \text{ dm} = 50 \text{ cm} \quad 0.001 \text{ dm} = 50 \text{ cm}$$

$$t = \frac{50 \times 5}{2} = 0.05 \text{ cm}$$

$$\mu \text{ at } 0^\circ C = 1.6 \times 10^{-2} \text{ Pa.s}$$

$$\mu \text{ at } 120^\circ C = 2 \times 10^{-3} \text{ Pa.s}$$

$$F_1 \propto \frac{A \mu}{l^2} \quad F_2 \propto \frac{1}{0.05 \times 10^{-3}} = 5 \times 10^5 \text{ N}$$

$$F_1 = \frac{A \mu}{0.05 \times 10^{-3}} = 5 \times 10^5 \text{ N}$$

$$F_2 = \frac{2 \times 10^{-3} \times 1}{0.05 \times 10^{-3}} = 40 \text{ kN}$$

$$\frac{F_1 - F_2}{F_1} = \frac{5 \times 10^5 - 40}{5 \times 10^5} = 0.97$$
upper surface is in contact with air, which offers almost no resistance to the flow. Using Newton’s law of viscosity, decide what the value of $\mu$ and $\gamma$ is normal to the inclined plane, must be at the upper surface. Would a linear variation of $\mu$ with $\gamma$ be expected?

1.4 What kinds of rheological materials are paint and grease?

1.5 A Newtonian fluid is in the clearance between a shaft and a concentric sleeve. When a force of 500 N is applied to the sleeve parallel to the shaft, the sleeve attains a speed of 1 m/s. If a 1500-N force is applied, what speed will the sleeve attain? The temperature of the sleeve remains constant.

1.6 Determine the gravity force in newtons of 3 kg mass at a place where $g = 9.7$ m/s².

1.7 When standard scale masses and a balance are used, a body is found to be equivalent in force of gravity to two of the 1-kg scale masses at a location where $g = 9.7$ m/s². Calculate the gravity force on a correctly calibrated spring balance (for sea level) at this location.

1.8 Determine the unit gravity force $g$ for water at 25°C and $g = 9.75$ m/s².

1.9 On another planet, where gravity is 3 m/s², find the force of gravity on 400 L of material $\rho = 800$ kg/m³.

1.10 A correctly calibrated spring scale records the gravity force of a 2-kg body as 17.0 N at a location away from the earth. What is the value of $g$ at this location?

1.11 The gravity force on a bag of flour at sea level is 20 N. What is its mass at a location where $g = 9.6$ m/s²?

1.12 What is the kinematic viscosity of liquid of viscosity 0.002 Pa·s and a relative density of 0.8?

1.13 A shear stress of 4 mPa causes a Newtonian fluid to have an angular deformation of 1 rad/s. What is its viscosity?

1.14 A plate, 0.5 mm distant from a fixed plate, moves at 0.25 m/s and requires a force per unit area of 2 Pa to maintain this speed. Determine the viscosity of the substance between the plates.

1.15 Determine the viscosity of fluid between shaft and sleeve in Fig. 1.6.

1.16 A flywheel weighing 600 N has a radius of gyration of 300 mm. When it is rotating 600 rpm, its speed reduces 1 rpm/s owing to fluid viscosity between sleeve and shaft. The sleeve length is 50 mm; shaft diameter is 20 mm; and radial clearance is 0.05 mm. Determine the fluid viscosity.

1.17 A 25mm diameter steel cylinder 300 mm long falls, because of its own gravity force at a uniform rate of 0.1 m/s inside a tube of slightly larger diameter. A castor-oil film of constant thickness is between the cylinder and the tube. Determine the clearance between the tube and the cylinder. The temperature is 38°C. Relative density of steel = 7.85.

1.18 A piston of diameter 50.00 mm moves within a cylinder of 50.10 mm. Determine the percent decrease in force necessary to move the piston when the lubricant warms up from 0 to 120°C. Use crude-oil viscosity from Fig. C.1, Appendix C.

1.19 How much greater is the viscosity of water at 0°C than at 100°C? How much greater is its kinematic viscosity for the same temperature range?
1.20 A fluid has a viscosity of 0.6 Pa·s and a relative density of 0.7. Determine its kinematic viscosity.
1.21 A fluid has a relative density of 0.78. For a kinematic viscosity of \( 1.0 \times 10^{-3} \) m²/s determine the viscosity.
1.22 A body with gravity force of 500 N with a flat surface area of 0.2 m² slides down a lubricated inclined plane making a 30° angle with the horizontal. For viscosity of 0.1 Pa·s and body speed of 1 m/s determine the lubricant film thickness.
1.23 What is the viscosity of gasoline at 25°C?
1.24 Determine the kinematic viscosity of benzene at 27°C.
1.25 Calculate the value of the gas constant \( R \) for relative molecular mass of 44.
1.26 What is the specific volume of a substance of relative density 0.75?
1.27 What is the relation between specific volume and unit gravity force?
1.28 The density of a substance is 2900 kg/m³. What is its (a) relative density, (b) specific volume, and (c) unit gravity force?
1.29 A force, expressed by \( \mathbf{F} = 4i + 3j + 9k \), acts upon a square area, 2 by 2 cm, in the xy plane. Resolve this force into a normal-force and a shear-force component. What are the pressure and the shear stress? Repeat the calculations for \( \mathbf{F} = -4i + 3j - 9k \).
1.30 A gas at 20°C and 0.2 MPa abs has a volume of 40 L and a gas constant \( R = 210 \text{ m·N/kg·K} \). Determine the density and mass of the gas.
1.31 What is the density of air at 400 kPa abs and 30°C?
1.32 What is the density of water vapor at 0.3 kPa abs and 30°C?
1.33 A gas with relative molecular mass 28 has a volume of 100 L and a pressure and temperature of 80 kPa abs and 330 K, respectively. What are its specific volume and density?
1.34 One kilogram of hydrogen is confined in a volume of 150 L at -40°C. What is the pressure?
1.35 Express the bulk modulus of elasticity in terms of density change rather than volume change.
1.36 For constant bulk modulus of elasticity, how does the density of a liquid vary with the pressure?
1.37 What is the bulk modulus of a liquid that has a density increase of 0.02 percent for a pressure increase of 0.6 MPa?
1.38 For \( K = 2.2 \) GPa for bulk modulus of elasticity of water what pressure is required to reduce its volume by 0.5 percent?
1.39 A steel container expands in volume 1 percent when the pressure within it is increased by 70 MPa. At standard pressure, \( P = 101.3 \) kPa it holds 450 kg water, \( \rho = 1000 \text{ kg/m}^3 \). For \( K = 2.06 \) GPa when it is filled, how many kilograms mass water need be added to increase the pressure to 70 MPa?
1.40 What is the isothermal bulk modulus for air at 0.4 MPa abs?
1.41 At what pressure can cavitation be expected at the inlet of a pump that is handling water at 20°C?
1.42 What is the pressure within a droplet of water of 0.05 mm diameter at 20°C if the pressure outside the droplet is standard atmospheric pressure of 101.3 kPa?
1.43 A small circular jet of mercury 0.1 mm in diameter issues from an opening. What is the pressure difference between the inside and outside of the jet when at 20°C?
1.44 Determine the capillary rise for distilled water at 40°C in a circular 6 mm diameter glass tube.
1.45 What diameter of glass tube is required if the capillary effects on the water within are not to exceed 0.5 mm?
1.46 Using the data given in Fig. 1.4, estimate the capillary rise of tap water between two parallel glass plates 5 mm apart.
1.47 A method of determining the surface tension of a liquid is to find the force needed to pull a
platinum wire ring from the surface (Fig. 1.7). Estimate the force necessary to remove a 20-mm-diameter ring from the surface of water at 20°C. Why is platinum used as the material for the ring?
1.14 \[ \frac{F}{A} = 2 \text{ Pa} \ (N/m^2) \]
\[ t = 0.5 \text{ m/s} \]
\[ U = 0.25 \text{ m/s} \]

Since
\[ F = \mu \frac{A U}{t} \]
\[ \text{or } F = \frac{\mu U}{t} = 2 \text{ Pa} \]
\[ \mu = 0.004 \text{ Pa.s} \]

\[ F_2 = \frac{\mu A V}{t} = \frac{0.25}{0.5 \times 10^{-3}} = 5000 \text{ N} \]

1.17 -
\[ U = 0.4 \text{ m/s} \]
\[ T = 38 \degree C \]
Caster oil \[ \mu = 3 \times 10^{-1} \]

\[ S_{stred} = 7.85 \]
\[ t = ? \]

\[ F_2 = \frac{\mu A V}{t} = W \]
\[ A = \pi DL = \pi \times 0.025 \times 0.3 \]
\[ = 0.023562 \text{ m}^2 \]
\[ W = mg = \rho V g = \gamma_s V \]

Since \[ S = \frac{\gamma_s}{\gamma_w} \]
\[ \gamma_s = 7.85 \times 9810 = 77008.5 \text{ N/m}^2 \]
\[ V = \frac{\pi D^2 L}{4} = \frac{\pi}{4} \times (0.025)^2 \times 0.3 = 1.47 \times 10^{-3} \text{ m}^3 \]
\[ W = 11.34 \text{ Nm} \]
\[ 11.34 = 0.3 \times \frac{0.023562 \times 0.1}{t} \]
\[ t = \frac{0.3 \times 0.023562 \times 0.1}{11.34} = 6.233 \times 10^{-5} \text{ s} \]
\[ D_s = 0.06233 \text{ mm} \]
\[ W = 600 \text{ N} \quad R = 300 \text{ mm} \]
\[ \omega = 600 \text{ rpm reduced by 1 rpm} \]

Find \( \mu \)

\[ T = F_1 R = I \alpha \]
\[ F_1 \times \frac{300}{100} = MR^2 \alpha \]
\[ \frac{W_2}{30} = \frac{\pi N_2}{30} + \alpha = 1 \]

\[ \alpha = \frac{599 \pi - \frac{600 \pi}{3}}{30} = \frac{300}{9.81} \text{ deceleration} \]

\[ I = MR^2 = \frac{600 \times 300}{9.81} \]

\[ F_1 = 1.92 \text{ kN} \]

\[ \tau M \text{ shaft} \]

\[ F_1 R = F_1 R_2 \]
\[ 1.92 \times 0.3 = M \times \frac{\pi DN}{60} \times \frac{\pi \times 20 \times 54}{10^3} \times 0.01 \]
\[ \mu = 0.46 \text{ N.m} \]

\[ M = 2.146 \text{ N.m} \]
1.6 \( W = \text{mg} = 3 \times 9.8 = 29.1 \text{ N} \)

1.22 \( W = 500 \text{ N} \quad A = 0.2 \text{ m} \quad \Theta = 30^\circ \)
\( M = 0.1 \text{ Pas} \quad U = 1 \text{ m s}^{-1} \)
\( F_2 = \frac{W \sin \Theta}{U} 
\)
\[ 500 \sin 30^\circ = \frac{0.2 \times 1}{6} \]
\[ = 0.08 \times 10^{-3} \text{ m} \]
\[ = 0.08 \text{ mm} \]

1.15
\[ F_2 = \frac{M \frac{A \mu}{U}}{6} \]

1.485 \( \mu = \frac{0.00 \times 0.75 \times 10^{-3}}{0.075 \times 0.2 \times 0.1} = 0.1 \text{ Pas} \)

1.25
\( R = \frac{8312}{44} = 188.9 \text{ m} \cdot \text{N} \cdot \text{kg}^{-1} \cdot \text{K}^{-1} \)

1.29 a1 \( F = F_x + F_y + F_z \)
\[ = 41 + 3j + 9k \sqrt{16 + 9} = 5\]
\[ P_N = \frac{9}{4} = 2.25 \text{ Pa} \quad P_S = \frac{5}{4} = 1.25 \text{ Pa} \]

b) \[ F = -4 \delta + 3 \delta + 9k \]

\[ F_2 = F_3 = -9 \quad F_5 = 5 \]

\[ P_N = -\frac{9}{4} = -2.25 \text{ Pa} \]

\[ P_S = \frac{5}{4} = 1.25 \text{ Pa} \]

1.30 \[ PV = mRT \quad \rho V = \frac{P}{R}T \]

\[ 0.2 \times 10^6 \times 0.04 = m \times 210 \times 293 \]

\[ m = 0.13 \text{ kg} \]

\[ 0.2 \times 10^6 = \rho \times 210 \times 293 \]

\[ \rho = 3.25 \text{ kg/m}^3 \]

1.37 \[ K = \frac{\Delta P}{\rho} \]

\[ K = \frac{0.6 \times 10^6}{0.02 \times 10^2} = 3 \times 10^9 \text{ Pa} \]

1.38 \[ K = \frac{\Delta P}{V} = \frac{-\Delta P}{0.5 \times 10^2} = 2.2 \times 10^4 \text{ Pa} \]

\[ \Delta P = 0.5 \times 2.2 \times 10^7 = 1.1 \times 10^7 \text{ Pa} \]

\[ \Delta P = 11 \text{ MPa} \]

1.39 \[ V_2 = 1.01V_1 \quad V_1 = \frac{m}{\rho} = \frac{450}{1000} = 0.45 \text{ m}^3 \]

\[ V_2 = 1.01 \times 0.45 = 0.4545 \text{ m}^3 \]

\[ \Delta P = \rho \frac{\Delta V}{K} = 1000 \times \frac{70 \times 10^6}{2.2 \times 10^3} = 33.98 \text{ MPa} \]
\[ P_2 = 1000 + 33.98 = 1033.98 \text{ kg/m}^2 \]

\[ M_2 = P_2 V_2 = 1033.98 \times 0.4545 \]

\[ M_2 = 464.94 \text{ kg} \]

\[ \Delta M = 464.94 - 450 = 14.94 \text{ kg} \text{ be added} \]

1.40 \[ K = \frac{dP}{dV/V} \text{ and } PV = \frac{dE}{V} \]

\[ \frac{dP}{V} = \frac{\Delta E}{V^2} \]

\[ K = \frac{\Delta E}{V^2} = \frac{MRT}{V} = P \]

\[ K = 0.4 \text{ MPa} \]

1.41 \[ 5.74 \text{ DP } C-1 \text{ d}^2 \]

1.43 \[ F = F_p \text{ or } 25L = P_D D \]

\[ P_1 = \frac{26}{0.1 \times 10^{-3}} \text{ Pa} \]

1.44 \[ h = \frac{25}{\kappa Y} = \frac{2 \times 0.0736}{9.888 \times 3 \times 10^{-3}} = 4.8 \text{ mm} \]

1.45 \[ \text{fig. 1.4} \]

1.46 \[ f = 2(T + 6) = 2 \times \pi \times 0.002 \times 0.0736 = 9.25 \times 10^{-4} \text{ N} \]

\[ \text{Corrosion} \]
It can be divided into two parts

1. Study of pressure and its variation throughout a fluid.

2. Study of pressure forces on a finite surface.

Pressure at a point

At a point a fluid at rest has the same pressure in all directions.

To determine this assume an element, its coordinates dx, dy, ds, and unit depth. Since there only are gravity force and pressure force:

\[
\sum F = ma = 0
\]  
(static fluid)

\[
\sum F_x = P_x S_y x_1 - P_s S_s \sin \theta = \rho S_x S_y x_1 a_x = 0
\]
\[ \sum F_y = P_x \delta x \delta y - P_s \delta x \cos \theta - \gamma \delta x \delta y = 0 \]

Since \( P_x, P_y, P_s \) is the average pressure on each phase, \( \alpha_x + \alpha_y = 0 \) static fluid

\[ S \delta x \sin \theta = S_y - S \delta x \cos \theta = 0 \]

also

\[ \sum F_y = P_y \delta x - P_s \delta x - \gamma \frac{\delta x \delta y}{z} = 0 \]

Since \( S \delta x \delta y \rightarrow 0 \) with respect to \( S_x \) or \( S_y \)

\[ P_y = P_s \]

and

\[ P_x = P_y = P_s = P \]

Pressure variation in static fluid

\[ \sum F_y = P_s \delta y \delta z - \left( P + \frac{\delta P}{\delta y} \right) \delta x \delta y \delta z = 0 \]

\[ = P_s \delta y \delta z - P_s \delta x \delta y \delta z - \gamma \delta x \delta y \delta z = 0 \]
\[
\frac{\partial P}{\partial y} = -Y
\]

\[
\frac{\partial P}{\partial y} = -P \frac{\partial s_y}{\partial s_x} = 0
\]

\[
\Sigma F_x = P_s s_y s_z - \left( P + \frac{\partial P}{\partial x} \right) s_y s_z = 0
\]

\[
\frac{\partial P}{\partial s} = 0
\]

\[
\text{Sinc., } s_x s_y s_z \neq 0 \quad \text{(Volume not zero)}
\]

\[
\Sigma F_z = -\frac{\partial P}{\partial z} s_x s_y s_z = 0
\]

\[
\frac{\partial P}{\partial z} = 0
\]

\[
\implies P = c
\]

\[
\text{Also, } \frac{\partial P}{\partial x} = 0
\]

\[
\text{In } x \text{ and } z \text{ direction, } P \text{ is constant, and in } y \text{-dir. only.}
\]
\[ dp = -\gamma dy \]
for a fluid homogeneous and incompressible, \( \gamma \) is constant.

\[ P = -\gamma y + c \]
in which \( c \) is the constant of integration.

The hydrostatic law of pressure variation is frequently written in the form:

\[ P = \gamma h \]
when \( h = -y \)

\( h \) = the depth of fluid from the surface to a certain point.
Pressure Variation in a Compressible Fluid:

When the fluid is a perfect gas at rest and constant temperature,

\[ P = \rho RT, \quad T = \text{Const.} \quad \text{and} \quad R = \text{Const.} \]

or \[ \frac{P}{\rho} = \text{Const.} \]

\[ \Rightarrow P = P_0 \frac{P}{\rho_0} \]

\[ \text{from eq. 1, 2} \]

\[ dP = -\rho \frac{P}{\rho_0} g dy \]

\[ \int_{y_0}^{y} dy = -\frac{P_0}{\rho_0 g} \int \frac{dP}{P} \]

\[ y - y_0 = -\frac{P_0}{\rho_0 g} \ln \frac{P}{P_0} \]

\[ P = P_0 \exp \left( -\frac{(y - y_0)}{P/\rho_0 g} \right) \]

Which is the equation of variation of pressure for isothermal gas, \( T = \text{Const.} \)

Since the atmospheric frequently is assumed...