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New Delhi
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UNIT-1 FLUID MECHANICS

SYLLABUS

(A) FLUID MECHANICS, OPEN CHANNEL FLOW, PIPE FLOW

(B) HYDRAULIC MACHINES AND HYDROPOWER
Centrifugal pumps, types, performance parameters, scaling, pumps in parallel; Reciprocating pumps, air vessels, performance parameters; Hydraulic ram; Hydraulic turbines, types, performance parameters, controls, choice; Power house, classification and layout, storage, poundage, control of supply.

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FLUID PROPERTIES

IES-1997

1. Which one of the following pressure units represents the LEAST pressure?
   (a) millibar  
   (b) mm of mercury  
   (c) N/mm²  
   (d) kgf/cm²

IES-1998

2. The surface tension of water at 20°C is \(75 \times 10^{-3}\) N/m. The difference in the water surface within and outside an open-ended capillary tube of 1mm internal bore, inserted at the water surface would nearly be
   (a) 5 mm  
   (b) 10 mm  
   (c) 15 mm  
   (d) 20 mm

IES-1999

3. Match List-I (curves labelled A, B, C and D in figure) with List-II (types of fluid) and select the correct answer:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear stress</td>
<td>1. Ideal plastic</td>
</tr>
<tr>
<td></td>
<td>2. Ideal</td>
</tr>
<tr>
<td></td>
<td>3. Non-Newtonian</td>
</tr>
<tr>
<td></td>
<td>4. Pseudoplastic</td>
</tr>
<tr>
<td></td>
<td>5. Thixotropic</td>
</tr>
</tbody>
</table>

Code:
(a) 2 3 1 5  
(b) 3 2 1 5  
(c) 4 2 5 1  
(d) 2 3 5 1

IES-2001

4. Consider the following statements
   In order to have cavitation
   1. Local velocity is increased so that the local pressure is decreased below vapour pressure.
   2. Elevation is kept so high that the local pressure is reduced below vapour pressure.
   3. General ambient pressure is increased to a very high magnitude.
   4. Water hammer must occur in the system.
   Which of these statements are correct?
   (a) 2 and 3  
   (b) 3 and 4  
   (c) 1 and 2  
   (d) 1 and 4

5. Match List-I with List-II and select the correct answer:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Concentrated sugar solution</td>
<td>1. Dilatant fluid</td>
</tr>
<tr>
<td>B. Sewage sludge</td>
<td>2. Bingham plastic fluid</td>
</tr>
<tr>
<td>C. Blood</td>
<td>3. Pseudoplastic fluid</td>
</tr>
<tr>
<td>D. Air</td>
<td>4. Newtonian fluid</td>
</tr>
</tbody>
</table>

Code:
(a) 1 2 3 4  
(b) 1 2 4 3  
(c) 2 1 3 4  
(d) 2 1 4 3

IES-2002

6. Match List-I (Definitions) with List-II (Properties) and select the correct answer:

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>B.</td>
</tr>
<tr>
<td>(a) 2 3 1 5</td>
<td></td>
</tr>
<tr>
<td>(b) 3 2 1 5</td>
<td></td>
</tr>
<tr>
<td>(c) 4 2 5 1</td>
<td></td>
</tr>
<tr>
<td>(d) 2 3 5 1</td>
<td></td>
</tr>
</tbody>
</table>
7. 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

8. 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

9. Assertion (A) : At the standard temperature, the kinematic viscosity of air is greater than that of water at same temperature
Reason (R) : The dynamic viscosity of air at standard temperature is lower than that of water at the same temperature.
1. (a) 1 millibar = $10^{-3} \times 10^5 \text{ N/m}^2 = 100 \text{ N/m}^2$

   1 mm of Hg = $10^{-3} \text{ m of Hg}$
   = $10^{-3} \times 13.6 \text{ m of water}$
   = $10^{-3} \times 13.6 \times 9810$
   = 133.41 N/m

2. (c) For equilibrium

   \[
   2 \pi \sigma = \pi r^2 h g
   \]

   \[
   h = \frac{2 \sigma}{\pi r g} = \frac{2 \times 75 \times 10^{-3}}{(10^{-3} \times 10^3 \times 10)} = 15 \times 10^{-3} \text{ m}
   \]

   \[
   h = 15 \text{ mm}
   \]

3. (a) Curve between shear stress ($\tau$) and velocity gradient ($\frac{du}{dy}$) is:

   - Thixotropic - Printer’s ink
   - Ideal Plastic (Bingham Plastic, Toothpaste, Drilling mud)
   - Rheopetic
   - Pseudo plastic - (Paint, Blood, Paper pulp)
   - Newtonian - (Water, Air, Gasoline)
   - Dilatant (Solution with suspended sand, Starch and butter)
   - Ideal Fluid

4. (c) Cavitation is the formation of vapour bubbles of a flowing liquid in a region where pressure falls below the vapour pressure and sudden collapsing of these vapour bubbles in a region of high pressure. Pressure may fall below vapour pressure due to increase in local velocity, increase in elevation etc.

5. (a)

   (i) Dilatant Fluid: Shear thickening fluid e.g., Solution with suspended sand, conc. sugar solution.

   (ii) Pseudo Plastic Fluid: Shear thinning fluid. Apparent viscosity decrease with increase in velocity gradient e.g., blood, milk

   (iii) Bingham Plastic/Ideal Plastic: It has some initial strength beyond which deformation starts e.g., Toothpaste, Sewage sludge.

   (iv) Newtonian fluid: Water, air, gasoline and oil.

6. (c) Correct sequence should be (c).
10. (d) Power = force × velocity

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

\[ \therefore \tau = \left\{ A \left( \frac{du}{dy} \right)^{n-1} \right\} \left( \frac{du}{dy} \right) + B \]

where, Apparent viscosity = \( A \left( \frac{du}{dy} \right)^{n-1} \)

Now when \( B = 0 \),

\( n = 1 \) ... Newtonian fluid, viscosity invariant of shear stress.

\( n > 1 \) ... Shear thickening fluid i.e., apparent viscosity increases with increase in deformation

\( n < 1 \) ... Shear thinning i.e., apparent viscosity decreases with increase in shear stress (Psedo plastic)

Now when \( B \neq 0 \),

\( n = 1 \) ... Ideal Bingham fluid (tooth paste)

\( n > 1 \) ... Rheological fluid i.e., apparent viscosity increases with increase in shear stress

\( n < 1 \) ... Thixotropic i.e., apparent viscosity decreases with increase in shear stress.

7. (a) Dynamic viscosity of water is nearly 50 times that of air.

\[ \mu_w = 8.90 \times 10^{-4} \text{ Pa.sec} \]

\[ \mu_{air} = 1.81 \times 10^{-5} \text{ Pa.sec} \]

\[ \frac{\mu_w}{\mu_{air}} = \frac{8.90 \times 10^{-4}}{1.81 \times 10^{-5}} = 49.17 = 50 \]

- Water in soil is able to rise a considerable distance above ground water table due to capillary action.
- Vapour pressure increases with the increase in temperature

8. (b) Example of Newtonian fluid → Kerosene oil, Air, Water, Diesel oil.
Example of Non-Newtonian fluid → Human blood, Tooth paste etc.

9. (b) Dynamic viscosity of water is approximately 50 times that of air, but density water is around 850 times more than air so kinematic viscosity of air is more than that of water and defined as

\[ \text{Kinematic viscosity} = \frac{\text{Dynamic viscosity}}{\text{Density}} \]

Hence, both the statements are correct but R is not the correct explanation of A.

10. (d) Power = force × velocity

\[ = \mu A \left( \frac{du}{dy} \right) \times V \]

\[ = 0.0014 \times 0.15 \times \frac{20}{0.02} \times 20 \times 10^{-2} \]

\[ = 0.042 \text{ W} \]

11. (c)

Surface tension force in upward direction

\[ = \sigma \pi d \cos \alpha \text{ ... (i)} \]

.: Weight of the liquid in the downward direction

\[ = \left( \frac{\pi}{4} d^2 h \right) w \text{ ... (ii)} \]

Equating (i) and (ii)

\[ \Rightarrow \sigma \pi d \cos \theta = \left( \frac{\pi}{4} d^2 h \right) w \]

\[ h = \left( \frac{4 \sigma \cos \alpha}{wd} \right) \text{ ... (iii)} \]

12. (b)

- Cavitation is the formation of vapour bubble in a flowing liquid in the region where the pressure falls below the vapour pressure and sudden collapsing of these vapour bubbles in the high pressure region.
- We know Bernoulli’s equation

\[ \frac{P}{\gamma} + \frac{v^2}{2g} + z = \text{constant} \]

If we increase either elevation or velocity of flow, it would result in decrease in pressure head so chances of cavitation are more.