Water Pressure

Problem 61 Solution:

The depth $h$ is calculated from the water surface.

$$p = \rho gh = 1000 \times 10 \times (5 - 0.5) = 45000 \text{ Pa} = 45 \text{ kPa}$$

(Answer C)
Reynolds Number

Problem 63 Solution:

Reynolds number determines the fluid type:

Re < 2100 → laminar flow
2100 < Re < 4000 → critical flow
Re > 4000 → turbulent flow

\[
Re = \frac{\rho vD}{\mu} = \frac{vD}{\nu} = \frac{(2 \text{ m/s})(0.05 \text{ m})}{7.3 \times 10^{-7} \text{ m}^2/\text{s}} = 1.37 \times 10^5 \rightarrow \text{turbulent}
\]

(Answer D)
Open Channel Flow

Problem 66 Solution:

Uniform flow: the flow cross section does not vary with time at any location along an open channel.

Steady flow: the flow quantity does not vary with time at any location along an open channel.

(Answer A)
Pipe Head Loss

Problem 67 Solution:

From the given information, we obtain some known values:

\( p_1 = 0 \) (reservoir is at atmospheric pressure)
\( p_2 = 0 \) (pipe outlet is at atmospheric pressure)
\( v_1 = 0 \) (the water in reservoir doesn’t have velocity)

\( v_2 = \frac{5 \text{ m}^3/\text{s}}{0.25 \times \pi \times (0.5 \text{ m})^2} = 25.5 \text{ m/s} \) (flow rate is given)

\( z_1 = 220 \text{ m} \) (given in the problem statement)
\( z_2 = 180 \text{ m} \) (given in the problem statement)

Using energy equation:

\[
\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + h_f
\]

\[
0 + 0 + 221 = 0 + \frac{25.5^2}{2 \times 9.8} + 168 + h_f
\]

\( h_f = 20 \text{ m} \)

(Answer A)
Minimum Sewage Flow

Problem 70 Solution:

From the sewage flow ratio curves above, we can find the ratio of minimum-to-average daily sewage flow for population of 8000 people follows curve $A_2$:

$$\frac{Q_{\text{min}}}{Q_{\text{avg}}} = \frac{P^{0.2}}{5}$$

$$\frac{Q_{\text{min}}}{4000} = \frac{8^{0.2}}{5}$$

$$Q_{\text{min}} = 1213 \text{ m}^3/\text{day}$$

(Answer A)
Peak Sewage Flow

Problem 71 Solution:

From the sewage flow ratio curves above, we can find that the ratio of peak-to-average daily sewage flow for a population of 8000 people follows the curve G:

\[
\frac{Q_{\text{peak}}}{Q_{\text{avg}}} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}}
\]

\[
\frac{Q_{\text{peak}}}{4000} = \frac{18 + \sqrt{8}}{4 + \sqrt{8}}
\]

\[
Q_{\text{peak}} = 12201 \text{ m}^3/\text{day}
\]

(Answer C)
BOD Analysis

Problem 91 Solution:

Substitute the five-day values into the BOD equation:

\[ Y_t = L \left( 1 - e^{-kt} \right) \]

\[ 234 = L \left( 1 - e^{-(0.13)(5)} \right) \]

\[ L = 489.6 \approx 490 \text{ mg/L} \]

(Answer C)
BOD Analysis

Problem 92 Solution:

From the previous solution, the ultimate BOD was obtained. Now, substitute the seven-day values into the BOD equation:

\[ y_t = L \left( 1 - e^{-kt} \right) \]
\[ = 489.6 \left( 1 - e^{-(0.13)(7)} \right) \]
\[ = 292.5 \approx 290 \text{ mg/L} \]

(Answer A)
Dissolved Oxygen

Problem 94 Solution:

The dissolved oxygen (DO) at atmospheric pressure (760 mmHg) is obtained by using linear interpolation of data from the table.

\[
\frac{DO_{24.6\,^\circ C} - 8.9}{8.6 - 8.9} = \frac{24.6 - 24}{25 - 24}
\]

\[
DO_{24.6\,^\circ C} - 8.9 = -0.18
\]

\[
DO_{24.6\,^\circ C} = 8.72 \, \text{mg/L}
\]

Oxygen is only slightly soluble in water and does not react with water. Therefore, Henry’s law is applicable for this case, and the solubility of oxygen is directly proportional to its partial pressure.

\[
\text{% saturation} = \left(\frac{740}{760}\right) \left(\frac{6.2}{8.72}\right) \times 100\% = 69.2\% \approx 70\%
\]

(Answer C)