CEE 331 Fluid Mechanics: Prelim 1
June, 9 1999 - 10:00 AM -11:15 PM
Closed book, one 8.5” x 11” summary sheet

May the time you spent preparing for this exam pay off. Note that there are constants and equations on the last sheet of the exam.
Read each problem carefully before beginning to work on the answer!
Make sure you answer each part of each question. Solve all problems using symbols and then substitute numerical values (with units) as a last step. Show your work and underline your final answers.

1) Calculate the tensile force (per unit length of pipe) at the top and at the bottom of a 1 m diameter horizontal pipe filled with oil (S=0.8). The pressure at the center of the pipe is 5 kPa.
2) A water manometer is used to measure the pressure drop through a 20-cm-diameter sand filter. The top of the manometer is pressurized with air at 10 kPa (gage pressure). The water source for the filter is a large tank.
A) What is the pressure in kPa at the top of the filter column?

B) What is the pressure in kPa at the bottom of the filter column?

C) What is the change in pressure (in kPa) through the filter due to head loss?

D) Calculate the elevation of the water in the supply tank relative to the bottom of the filter column.

E) Calculate the magnitude and direction of the force acting on the horizontal surface at the bottom of the filter column.

F) Which direction is the water flowing?
3) Calculate the flow rate of water through the nozzle. The losses in the pipe and nozzle are
\[\frac{4V_1^2 + 0.1V_2^2}{2g}\]
where \(V_1\) is the velocity in the 30 cm diameter pipe and \(V_2\) is the velocity in the 10 cm diameter nozzle. Draw the control volume and label the control surfaces. You may assume that \(\alpha\) is equal to 1.
Physical constants (for water at 20°C)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>998 Kg/m³</td>
</tr>
<tr>
<td>Specific weight</td>
<td>9789 N/m³</td>
</tr>
<tr>
<td>Viscosity</td>
<td>$1 \times 10^{-3}$ N·s/m²</td>
</tr>
<tr>
<td>Kinematic viscosity</td>
<td>$1 \times 10^{-6}$ m²/s</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>2340 Pa</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>101.3 kPa</td>
</tr>
</tbody>
</table>

Some Equations

\[
\frac{dp}{dz} = -\gamma
\]

\[
p + z = \text{constant}
\]

\[
\gamma
\]

\[
\tau = \mu \frac{du}{dy}
\]

\[
x_p = x + \frac{I_{xy}}{yA}
\]

\[
F = p_c A
\]

\[
y_p = \frac{I_x}{yA} + y
\]

\[
p_1 + z_1 + \alpha_1 \frac{V_1^2}{2g} + H_p = p_2 + z_2 + \alpha_2 \frac{V_2^2}{2g} + H_l + h_l
\]

\[
\gamma_1 \frac{V_1^2}{2g} + \gamma_2 \frac{V_2^2}{2g} = h_l
\]