Homework 8 – Due April 24

Questions: 7.12, 7.14, 7.20, 7.24 and 7.38

1) At a sudden contraction in a pipe the diameter changes from $D_1$ to $D_2$. The pressure drop $\Delta p$, which develops across the contraction is a function of $D_1$ and $D_2$ as well as velocity, $V$, in the larger pipe, and the fluid density, $\rho$, and viscosity, $\mu$. Use $D_1$, $V$ and $\mu$ as repeating variable to determine a suitable set of dimensionless parameters. Why would it be incorrect to include the velocity in the smaller pipe as an additional variable?

2) Under certain conditions, wind blowing past a rectangular speed limit sign can cause the sign to oscillate with a frequency $\omega$ (see figure below). Assume that $\omega$ is a function of the sign width $b$, sign height $h$, wind velocity, $V$, air density $\rho$, and an elastic constant, $k$ (dimensions of Force x Length). Develop a suitable set of pi terms for this problem.

3) The buoyancy force $F_B$, acting on a body submerged in a fluid is a function of the specific weight, $\gamma$, of the fluid and the volume $V$, of the body. Show by dimensional analysis that the force must be directly proportional to the specific weight.
4) A liquid flows with a velocity $V$ through a hole in the side of a large tank. Assume that

$$V = f(h, g, \rho, \sigma)$$

where $h$ is the depth of fluid above the hole, $g$ is acceleration due to gravity, $\rho$ is the fluid density and $\sigma$ is the surface tension. The following data were obtained by changing $h$ and measuring $V$, with a fluid density $1000 \text{ kg/m}^3$ and surface tension $= 0.074 \text{ N/m}$

<table>
<thead>
<tr>
<th>$V$ (m/s)</th>
<th>3.13</th>
<th>4.43</th>
<th>5.42</th>
<th>6.25</th>
<th>7.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h$ (m)</td>
<td>0.50</td>
<td>1.00</td>
<td>1.50</td>
<td>2.00</td>
<td>2.50</td>
</tr>
</tbody>
</table>

Plot these data by using appropriate dimensionless variable. Could any of the original variables have been omitted?

5) The drag, $D$, on a sphere located in a pipe through which a fluid is flowing is to be determined experimentally (see figure). Assume that the drag is a function of the sphere diameter, $d$, the pipe diameter, $D$, the fluid velocity, $V$, and the fluid density, $\rho$.

(a) What dimensionless parameters would you use for this problem?

(b) Some experiments using water indicate that for $d=0.2 \text{ in}$, $D=0.5 \text{ in}$ and $V=2 \text{ ft/s}$ the drag is $1.5 \times 10^{-3} \text{ lb}$. If possible estimate the drag on a sphere located in a 2 ft diameter pipe through which water is flowing with a velocity of 6 ft/s. The sphere diameter is such that geometric similarity is maintained. If it is not possible, explain why not.