Homework 7

Questions: 7.10, 7.14, 7.20, 7.24 and 7.38

0) Please send your group video to Diogo via email. If you’ve already done so great!

1) The pressure drop \( \Delta p \), across a pump can be expressed as

\[
\Delta p = f(D, \rho, \omega, Q)
\]

Where \( D \) is the impeller diameter, \( \rho \) the fluid density, \( \omega \) the rotational speed and \( Q \) the volume flowrate. Determine a suitable set of dimensionless parameters.

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 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 $d=0.2$ in, $D=0.5$ in and $V=2$ ft/s the drag is $1.5 \times 10^{-3}$ 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.