11.44 Information and assumption

Assume $T_{\text{air}} = 60^\circ F$; $\rho_{\text{air}} = 0.00237$ slugs/ft$^3$; $\mu_{\text{air}} = 3.74 \times 10^{-7}$ lbf-sec/ft$^2$
provided in problem statement

Find

largest raindrop that will fall in the Stokes’ flow regime.

Solution

$$F_D = 3\pi \mu V_0 D$$
$$\frac{(1/6)\pi D^3 \gamma_{\text{water}}}{\rho_{\text{air}} V_0} = 3\pi \mu_{\text{air}} V_0 D$$
$$D^2 \gamma_{\text{water}} = 18\mu_{\text{air}} V_0$$

Also

$$\frac{V_0 D}{\nu} = 0.5$$
$$V_0 = \frac{0.5 \nu_{\text{air}}}{D}$$

Solving for $D$:

$$D^2 = 9\mu_{\text{air}}^2 / (\rho_{\text{air}} / \gamma_{\text{water}}) = 9 \times (3.74 \times 10^{-7}) / (0.00237 \times 62.4)$$
$$= 8.51 \times 10^{-12} \text{ ft}^3$$
$$D = 2.042 \times 10^{-4} \text{ ft} = 0.000204 \text{ ft} = 0.0024 \text{ in.}$$
13.2 Information and Assumptions

A stagnation tube \((d = 1 \text{ mm})\) is used to measure the speed of water

**Find**
Velocity such that the measurement error is \(\leq 1\%\)

**Solution**
From Prob. 13.1, Re = 60;

\[ V = 60\nu/d \]

where \(\nu = 10^{-6} \text{ m}^2/\text{s}\). Then

\[ V = 60 \times 10^{-6}/0.001 = 0.06 \text{ m/s} \]
13.13 Information and assumptions

Velocity data for a river is given

Find
Discharge: \( Q \)

Solution

\[
Q = \sum V_i A_i
\]

<table>
<thead>
<tr>
<th>( V ) (m/s)</th>
<th>( A ) (m²)</th>
<th>( V A )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.32</td>
<td>7.6</td>
<td>10.0</td>
</tr>
<tr>
<td>1.54</td>
<td>21.7</td>
<td>33.4</td>
</tr>
<tr>
<td>1.68</td>
<td>18.0</td>
<td>30.2</td>
</tr>
<tr>
<td>1.69</td>
<td>33.0</td>
<td>55.8</td>
</tr>
<tr>
<td>1.71</td>
<td>24.0</td>
<td>41.0</td>
</tr>
<tr>
<td>1.75</td>
<td>39.0</td>
<td>68.2</td>
</tr>
<tr>
<td>1.80</td>
<td>42.0</td>
<td>75.6</td>
</tr>
<tr>
<td>1.91</td>
<td>39.0</td>
<td>74.5</td>
</tr>
<tr>
<td>1.87</td>
<td>37.2</td>
<td>69.6</td>
</tr>
<tr>
<td>1.75</td>
<td>30.8</td>
<td>53.9</td>
</tr>
<tr>
<td>1.56</td>
<td>18.4</td>
<td>28.7</td>
</tr>
<tr>
<td>1.02</td>
<td>8.0</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Summing the last column gives

\[
Q = 549.1 \text{ m}^3/\text{s}
\]
13.29 Information and assumptions

Water flows \((Q = 0.03 \text{ m}^3/\text{s})\) through an orifice. Pipe diameter, \(D = 15 \text{ cm}\). Manometer deflection is 1 m-Hg.

Find

Orifice size: \(d\)

Solution

\[
\Delta h = 12.6 \times 1 = 12.6 \text{ m of water}
\]

Orifice discharge expression

\[
A = \frac{Q}{(K \sqrt{2g \Delta h})}
\]

Guess \(K = 0.7\), then

\[
d^2 = \frac{(4/\pi)Q}{(K \sqrt{2g \Delta h})}
\]

\[
d^2 = \frac{(4/\pi) \times 0.03}{\left[0.7 \sqrt{2g \times 12.6}\right]} = 3.47 \times 10^{-3} \text{ m}^2
\]

\[
d = 5.89 \text{ cm}
\]

\[
d/D = 0.39
\]

\[
Re_d = 4 \times 0.03/(\pi \times 0.0589 \times 10^{-6}) = 6.5 \times 10^5
\]

\[
K = 0.62
\]

so

\[
d = \sqrt{(0.7/0.62)} \times 0.0589 = 0.0626 \text{ m}
\]

Recalculate \(K\) to find that \(K = 0.62\). Thus,

\[
d = 6.26 \text{ cm}
\]