Design by Parisa Sarmadi (parisa.sarmadi@mech.ubc.ca)

1. Heat exchangers often consist of many triangular passages. Typical is Fig. 1 with $L = 60 \text{ cm}$ and an isosceles-triangle cross section of side length $a = 2 \text{ cm}$ and included angle $\beta = 80^\circ$. If the average velocity is $V = 2 \text{ m/s}$ and the fluid is SAE 10 oil with $\rho = 870 \text{ kg/m}^3$, estimate the pressure drop.

![Figure 1](image1.png)

2. Two pipes of identical diameter and material are connected in parallel. The length of pipe A is twice the length of pipe B. Assume the flow in both pipes is fully turbulent, i.e. fully rough. Ignore all minor losses. Determine the ratio of the flow rates in the two pipes.

Hint: How does friction factor relate to Reynolds number when the flow is fully rough?

3. The parallel galvanized-iron pipe system of Fig. 2 delivers gasoline at $T = 20^\circ C$ with a total flow rate of $0.036 \text{ m}^3/\text{s}$. Determine the flow rate in each branch and the overall pressure drop under these two conditions:

   (a) The pump is wide open, not running, and causes a loss coefficient of $K = 1.5$.

   (b) The pump is running and delivers $45 \text{ kW}$ to the flow in the pipe 2.

![Figure 2](image2.png)

4. If the 38 – in pump from Fig. 3 is used to deliver kerosene at $T = 20^\circ C$, at $850 \text{ rpm}$ and flow rate of $22000 \text{ gal/min}$, what head and brake horse power will result?
5. A 14.62-in-diameter centrifugal water pump at 2134 rpm is tested and following data are obtained:

<table>
<thead>
<tr>
<th>$Q$, $ft^3/s$</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H$, ft</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>330</td>
<td>300</td>
<td>220</td>
</tr>
<tr>
<td>bhp</td>
<td>135</td>
<td>160</td>
<td>205</td>
<td>255</td>
<td>330</td>
<td>330</td>
</tr>
</tbody>
</table>

(a) Determine the BEP and specific speed and estimate the maximum discharge possible.

(b) This pump at the same rpm as tested is used to transfer water from two reservoirs as shown in Fig. 4. In order to operate at BEP, what is the proper elevation $z_2$? If $z_2 = 225$ ft what is the flow rate, if $d = 8$ in?