1) (40 points) A large tank is mounted on a cart. The tank has a hole in the bottom that is 3 cm in diameter. The entrance to the hole is well rounded so there is no vena contracta. The water level in the tank is almost constant. Assume the cart is frictionless and free to move in a horizontal direction and is attached to a cable and pulley that lifts a weight. The vertical dimension of the vane is negligible and similarly, you may neglect the weight of water in contact with the vane. You may also assume that the cart is traveling at a constant velocity. For parts A, C, D clearly label the points or surfaces to which you are applying the equations.

A) (10 points) Calculate the velocity of the water where it leaves the tank.
B) (5 points) Calculate the flow rate out of the tank.
C) (10 points) Calculate the velocity of the water where it contacts the vane.
D) (15 points) Calculate the mass of the weight such that the cart travels at a constant velocity.

2) (25 points) A 1/2 scale model of the apparatus in question #1 is to be built.
A) (5 points) Which dimensionless parameter is required for similitude?
B) (10 points) What should the ratio of the weights be ($W_p/W_m$)?
B) (10 points) What will the velocity ratio be ($V_p/V_m$)?

3) (35 points) A curved piece of metal is used as part of the structure in an above-ground swimming pool. The radius of curvature is 2 m.
A) (25 points) Calculate the forces per unit width, $T_1$ and $T_2$, required to hold the curved piece of metal in place.
B) (10 points) Calculate the magnitude of the moment about point O (per unit width) required to hold the curved piece of metal in place.
Name _______________________

Equation/Table Sheet

Physical constants (for water at 20°C)
density = 998 Kg/m³
specific weight = 9789 N/m³
viscosity = 1 x 10⁻³ N·s/m²
kinematic viscosity = 1 x 10⁻⁶ m²/s
vapor pressure = 2340 Pa
atmospheric pressure = 101.3 kPa

Some Equations

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

\[ \rho \nu \cdot dA = -\frac{\partial}{\partial t} \rho \nu \gamma \]

\[ Q_{out} - Q_{in} = -\frac{d\gamma}{dt} \]

\[ M_1 + M_2 = W + F_{p_1} + F_{p_2} + F_{ss} \]

\[ M_1 = -(\rho Q)V_1 \quad M_2 = (\rho Q)V_2 \]

\[ R = \frac{\rho V l}{\mu} \quad F = \frac{V}{\sqrt{gl}} \]

\[ W = \frac{V^2 l \rho}{\sigma} \quad C_p = -\frac{2k}{\rho V^2} \]

\[ M = \frac{V}{c} \]

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Area</th>
<th>Location of Centroid</th>
<th>I or Ic</th>
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<tbody>
<tr>
<td>Rectangle</td>
<td>bh</td>
<td>( y_c = \frac{h}{2} )</td>
<td>( I_c = \frac{bh^3}{12} )</td>
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<tr>
<td>Triangle</td>
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<td>( y_c = \frac{h}{3} )</td>
<td>( I_c = \frac{bh^3}{36} )</td>
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<tr>
<td>Circle</td>
<td>( \pi r^2 )</td>
<td>( y_c = r )</td>
<td>( I_c = \frac{\pi r^4}{4} )</td>
</tr>
<tr>
<td>Semicircle</td>
<td>( \frac{\pi r^2}{2} )</td>
<td>( y_c = \frac{4r}{3\pi} )</td>
<td>( I = \frac{\pi r^4}{8} )</td>
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<td>( y_c = \frac{4r}{3\pi} )</td>
<td>( I = \frac{\pi r^4}{16} )</td>
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<tr>
<td>Semiellipse</td>
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<td>( I = \frac{\pi ba^3}{8} )</td>
</tr>
<tr>
<td>Parabola</td>
<td>( \frac{2}{3} bh )</td>
<td>( y_c = \frac{3h}{5} )</td>
<td>( x_c = \frac{3b}{8} )</td>
</tr>
</tbody>
</table>