CVEN 311-501 “Fluid Dynamics”

**HOMEWORK 3**

*Due Friday, 9/21/2012 at 8:00 AM
(No late papers accepted without documented university excuse)*

**PART I** – Optional textbook problems. Do not turn these problems in with your assignment.

*Hydrostatic Forces on Planar Surfaces*

1. Textbook Problem 2.73, p. 89 (6th ed.: 2.52, p. 84)
2. Textbook Problem 2.81, p. 90 (6th ed.: 2.57, p. 84-85)

*Hydrostatic Forces on Curved Surfaces*

3. Textbook Problem 2.117, p. 95 (6th ed.: 2.84, p. 88)
4. Textbook Problem 2.123, p. 96 (6th ed.: 2.89, pg. 89)

*Buoyancy*

5. Textbook Problem 2.138, p. 97 (6th ed.: 2.100, pg. 90)
6. Textbook Problem 2.148, p. 98 (Not in the 6th ed.)
PART II – Required problems. You must turn these problems in with your assignment. All multiple choice problems should be answered with a complete solution; simply stating a letter answer will receive no credit. Problems 1, 3, 6, and 7 will be graded on effort alone. Problems 2, 4, 5, and 8 will be graded for accuracy.

Hydrostatic Forces on Planar Surfaces

1. {From Fall 2008 Midterm 1} Dr. Cahill is currently expanding the fountains on his palatial estate. He is installing 2 new pools and wants to minimize the work to keep them filled with water. He has designed the connecting conduit sketched below with a (frictionless) hinged gate at its end. The weight of the gate will keep it closed until the surface of the left, upper pool is sufficiently above the surface of the right, lower pool. At that point water will flow into the lower pool. What will be the maximum depth of water in the upper pool for which the gate will remain closed?
2. {From Fall 2011 Final Exam} A tank filled with seawater ($\gamma = 64.0$ lb/ft$^3$) has one side that is trapezoidal in shape and inclined at a $70^\circ$ angle as shown in the drawing below. The total force (lb) acting on the side wall is:

- (A) 44,100
- (B) 46,800
- (C) 57,600
- (D) 71,100

**Hydrostatic Forces on Curved Surfaces**

3. {From Fall 2010 Midterm 1} A swimming pool will be built with a rounded transition between its vertical walls and horizontal bottom. The rounded transition will be in the shape of a quarter-circle and will require special fabrication; thus, the total fluid force acting on the quarter-circle surface needs to be calculated. The cross-section of the pool is sketched below, and the curved surface will extend 40 m (i.e., in the dimension in and out of the page). What will be the total pressure force acting on the curved surface?
4. {From Fall 2011 Midterm 1} Drawn below are four different hydraulic gate designs. Each gate (drawn in red) rotates about a single pivot (drawn in purple), and a counterweight is also attached to each gate and pivot so that the gate and counterweight are able to rotate as a rigid unit. You should assume that the weight of each gate is negligible, and the weight of each counterweight is uncertain but greater than zero.

For each gate, answer the question, “Could this gate remain closed for some non-zero counterweight?” I.e., is there a value of weight for the counterweight for which the gate could be held closed and in static equilibrium? Justify your Yes/No answer.

(a) ![Gate Design A](image-a)

(b) ![Gate Design B](image-b)

(c) ![Gate Design C](image-c)

(d) ![Gate Design D](image-d)
5. {From Fall 2011 Final Exam} A tank with a semi-circular side will require this side to be braced. If the liquid contained in the tank is fresh water, what will be the brace position \((x_b, y_b)\) and bracing angle \(\theta_b\) to support the tank side in direct opposition to the fluid static force?

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\begin{align*}
&\text{(A)} \quad (2.55, -2.00) \text{ and } 57.5^\circ \\
&\text{(B)} \quad (2.55, -2.00) \text{ and } 32.5^\circ \\
&\text{(C)} \quad (3.22, -5.06) \text{ and } 57.5^\circ \\
&\text{(D)} \quad (4.08, -4.40) \text{ and } 57.5^\circ
\end{align*}
\]
Buoyancy

6. {From Fall 2010 Midterm 1} A semi-submersible oil platform uses the buoyancy of two horizontal pontoons and four columns to float (see figure below). If the weight of the platform (including the weight of the pontoons and columns) is \(60 \times 10^6\) lb, what will be the height of the platform deck above the water surface (ft)?

The pontoons and columns are hollow. The columns are cylinders 25 ft in diameter and 75 ft tall (i.e., from the top of the pontoons to the deck). The pontoons are cylinders with hemispherical ends; the diameter of each pontoon is 45 ft, and the length of each pontoon (including the hemispherical ends) is 300 ft. Assume the platform is floating in seawater.

The formula for volume of a sphere is \(V = \frac{4}{3} \pi r^3\), where \(r\) is the sphere radius.
7. {From Fall 2008 Final Exam} A tank has a 0.8 ft diameter circular hole in its bottom (see figure below). A 1 ft diameter circular plate of weight 35 lb covers the hole. An air-filled sphere of volume 3.4 ft$^3$ is attached to the circular plate by a 0.5 ft long cord of negligible weight. The depth of water in the tank is 8.0 ft. Which of the following statements are true?

(A) The plate will be held in place over the hole, but lowering the water level will eventually cause the plate to lift off of the hole.

(B) The plate will be held in place over the hole, and lowering the water level will not cause the plate to lift off of the hole.

(C) The plate will not be held in place over the hole, but raising the water level will eventually cause the plate to be held in place over the hole.

(D) The plate will not be held in place over the hole, and raising the water level will not cause the plate to be held in place over the hole.
8. {From Fall 2011 Midterm 1} A submarine is sketched in cross-section below (assume that the body is a 100 ft long cylinder with no other shapes of consequence). While submerged at a depth of 85 ft in the Atlantic Ocean, the submarine experiences a series of equipment failures, and at time “0” the ballast tank is filled with seawater, as shown in the drawing. At time “0” the pressure of compressed air in the air tanks is 577 psia. At time “1” another equipment failure causes the compressed air release valve to stick in the fully open position causing a release of compressed air into the ballast tank with possible expulsion of seawater through the ballast purge valve. The weight of the submarine and its contents (not including any seawater in the ballast tank) is 2.5\cdot10^6 lbs. Air in the compressed air tanks can be assumed to behave according to the ideal gas law at a constant temperature of 70°F.

(a) At time “0,” what is the magnitude and direction of net weight and buoyancy force on the submarine?
(b) After time “1,” what is the magnitude and direction of net weight and buoyancy force on the submarine?
(c) Should the submarine issue a distress call?

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**Time “0”**

Compressed Air Vol. 550 ft³

20 ft

**Time “1”**

25 ft