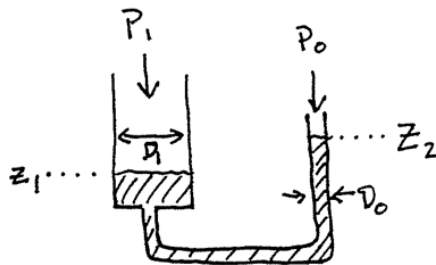


530.327 - Introduction to Fluid Mechanics - Su

HW 2 - due 23 September

60 pts

Problem 1. (10 pts) The manometer shown in the figure consists of tubes with two different diameters, with a liquid with density ρ inside. The left side, which is connected to pressure p_1 , has inner diameter D_1 , while the right side, which is connected to atmospheric pressure (p_0), has inner diameter $D_0 = 3$ mm. Let the height of fluid on the left side be z_1 and on the right be z_2 , and define $z_1 = z_2 = 0$ as the fluid height when $p_1 = p_0$. One point of having a manometer design like this is that you potentially only need to measure the fluid height on the one side with the thin tube. What is the minimum value of D_1 such that the quantity $\rho g z_2$ gives a reading for $p_1 - p_0$ that is within 1% of the true value? (You can assume that the free surface on the left side is always in the wide tube.)

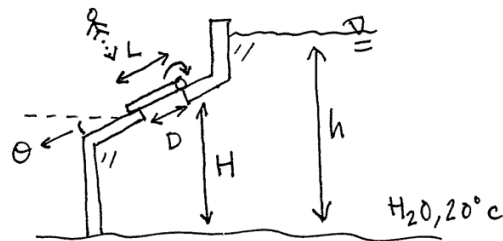


Problem 2. (10 pts) In class on 9/17 we derived Equation 3.11b in the text, which referred to Fig. 3.5. As we derived it, with the term F_R determined from the absolute (not gage) pressure due to the fluid on the left of the plane surface, Eq. 3.11 gives us the line of action of the force that acts on the left side of the plane surface only.

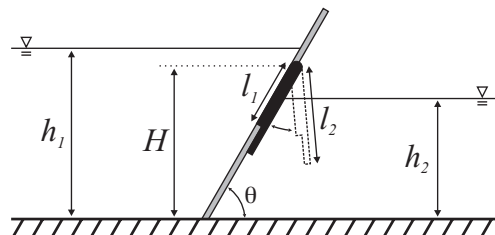
- (2 pts) If the right side of the plane surface is exposed to atmospheric pressure (p_0), what is the force and line of action of the force that acts on the right side of the surface?
- (4 pts) Using the above result and the form of Eq. 3.11 we derived in class, determine the net force acting on the plane surface, and also the line of action of the net force by equating moments of forces.
- (4 pts) If we work in gage pressures, we simplify the problem because the gage pressure on the right side is zero. Using gage pressures, determine y' in similar fashion to the way we derived Eq. 3.11 in class, and show that the result is the same as the result from b).

(over)

Problem 3. (10 pts) Consider a dam design similar to the one from HW 1. This time, the platform isn't horizontal, but is angled at 15° from horizontal, and the hole in the platform is square, with side length $D = 1$ m (i.e. it extends $D = 1$ m in the out-of-page direction too). There is now a square piece of massless plywood (side length $L = 1.2$ m) that plugs the hole that is hinged at the top of the hole, as shown. As before the dam operator (mass 80 kg) plugs the hole by standing somewhere (anywhere he wants) on the plywood. The reservoir height, h , is normally equal to H , the height of the hinge. One day rain starts falling at noon, raising the water level by 3 mm per minute. At what time will the dam operator no longer be able to plug the hole?



Problem 4. (15 pts) Consider a dam that is inclined at an angle $\theta = 60^\circ$ from horizontal. The water level on the left side of the dam is h_1 and on the right is h_2 . There is a door in the dam that is hinged so that water can only flow from left to right. The door hinge is located at height H . The door has span w in the out-of-page direction, and presents a length l_1 to the water on the left and a length l_2 on the right, as shown. If $h_2 = 9$ m, $H = 10$ m, $l_1 = 4$ m, $l_2 = 6$ m and $w = 4$ m, what is the maximum h_1 for which the door will stay closed? (Assume that the hinge is frictionless, the door has negligible thickness and mass, and that the water is at 15°C .)



Problem 5. (15 pts) A vertical dam holds back water at 10°C that has depth $d = 5$ m. You want to build an access port at the dam's base that will ordinarily be sealed by a hinged gate that presses up against a stop. Consider three gate cross-sections; one is a rectangle with height l and width $w = l/2$, one is a quarter-circle with radius l , and one is an isosceles right triangle with side length l , as shown. Each gate spans 1 m in the out-of-plane direction and has a total volume of 1 cubic meter. (Note: this means that l for the three designs can be different.) Assuming that the gates are massless, what force does the stop impose on the gate for each of the three designs? (You can assume that the stop has negligible height, and that the gates don't quite touch the ground.)

