Physics 123 section 2 CID ____________

Homework 1

Score ________ / 30

1. (3 pts)When a particular man is riding on his bike, each of the two tires makes contact with the ground over an area of $9.31 \times 10^{-4}\,\mathrm{m}^2$. A gauge on each of the bicycle's tires reads a gauge pressure of 55 psi ($3.792 \times 10^5\,\mathrm{Pa}$). What is the combined mass of the bicycle and the rider? Assume that atmospheric pressure is $1.013 \times 10^5\,\mathrm{Pa}$ and that the acceleration due to gravity is $9.8\,\mathrm{m/s}^2$.

2. (3 pts) Knowing that the radius of the Earth is $6.37 \times 10^6\,\mathrm{m}$ and that atmospheric pressure at the surface of the Earth is $1.013 \times 10^5\,\mathrm{Pa}$, what is the total mass of all of the gas in the Earth's atmosphere? Assume that the acceleration due to gravity is $9.8\,\mathrm{m/s}^2$ throughout the entire atmosphere.

3. (5 pts) A particular vacuum cleaner can generate pressures as low as 100 Pa at the end of its hose. We place the end of the hose on a big slab of rubber, making a seal with the rubber. We then pull on the hose and pick up the rubber using the suction of the vacuum. (a) If the end of the hose is 2 cm in diameter, what is the mass of the heaviest slab of rubber that it can pick up? (b) Now imagine that your cousin, the door to door salesman, tries to convince you to purchase an expensive "ideal" vacuum cleaner that could produce a pressure of 0 Pa at the end of the hose. What is the mass of the heaviest slab of rubber that it could pick up? (After working this you might want to ask your self how much more effective this vacuum cleaner will be and whether it is worth the extra money?) (c) If we put an adapter on the ideal vacuum cleaner that increased the diameter of the end of the hose to 4 cm, what would the mass of the heaviest piece of rubber that it could pick up be? (d) Now imagine that our ideal vacuum cleaner can run underwater. If we take it 20 meters underwater by what factor will the "suction" force increase compared to the force it generates in air?

Note that the book has an example similar to the following problems, but the wording that they use is a bit confusing — it sounds like they are asking for just the force due to the water, but end up solving for the total force. We'll solve things piece by piece to make sure things are clear.

4. (6 pts) A dam is made of a thin rectangular slab of concrete which is a distance L wide and a height L tall. The reservoir on the left side of the slab is filled with water with a density ρ to a depth h (of course $h < L$). The pressure of the surrounding atmosphere is P_0.

- **(a)** If the local acceleration due to gravity is g, what is the pressure at the top and the bottom of the water in the reservoir?
- **(b)** What is the force exerted on the dam by the air on the right side of the dam?
- **(c)** What is the force exerted by the air above the water on the left side of the dam? (Here I want just the force exerted directly by the air, not including the effect that the air has on the pressure of the water, which "indirectly" exerts a force on the dam).
- **(d)** What is the force exerted on the dam by the water? (Note that this force depends on the water pressure which is influenced by the air pressure above the water — so the answer to this part should depend on P_0.)
- **(e)** What is the total force exerted on the dam by the air and the water?
- **(f)** How much does this total force increase if the pressure of the surrounding atmosphere increases by a factor of 2?

5. (6 pts) Now lets think about the tendency for the dam to topple over — lets consider the torque about the bottom of the concrete slab. And to make things simple, lets assume that the dam is on a planet with no atmosphere, such that $P_0 = 0$ (it's going to cancel in the end anyway). What is the torque exerted by the water on the dam about a pivot point at the bottom of the concrete slab?

6. (3 pts) Two cylindrical pistons are connected together with a hose and filled with water. The first piston has a diameter of 20 cm. The second piston has a diameter of 35 cm. An 82.2 kg man is standing on the first piston. If the top of the two pistons are initially at the same height, how much mass must be placed on the second piston to keep the man from rising or falling?

7. (4 pts) *The Cartesian Diver*: Visit the Cartesian diver exhibit on the north-west side of the lobby of the Eyring Science Center. (a) Play with the diver, and read the explanation on the wall. Once you have done this, respond "Yes" to part (a). (b) Why is the diver inside the bottle affected when you squeeze the outside of the bottle?

Extra problems I recommend you work (not to be turned in)

- Show that you get the same answer for problem 5 even if $P_0 \neq 0$.

- Work problems 4 and 5 for a dam which is triangular such that the top of the dam is L wide, and the bottom comes to a point.

- A fishbowl is made from a glass sphere of radius r with a tiny opening at the top. The fishbowl is filled to the top, and a fish is swimming at the very center of the fishbowl. The cat, trying to get to the fish, leans on the table that the fishbowl is on, causing it to accelerate horizontally at a rate a. This causes the surface of the water to tilt a tiny amount, but does not cause the water to spill. (a) Which direction will the water tilt — in the direction of the acceleration or away from the acceleration? (b) If the acceleration due to gravity is g, what is the pressure at the location of the fish while the bowl is being accelerated?