Prof. Anchordoqui

Problems set # 11 **Physics 168**

1. A rectangular dam 30 m wide supports a body of water to a depth of 25 m. Find the total horizontal force on the dam due to both water and air pressure. (See Fig. 1)

2. You decide to enroll in a fitness program. To determine your initial fitness, the first meeting your percentage of body fat is measured. Your percentage of body fat can be estimated by measuring your body density (the average density of your body). Fat is less dense than muscle or bone. Assume the average density of fat is 0.9×10^3 kg/m^3 and the average density of lean tissue (everything except fat) is 1.1×10^3 kg/m^3. Measuring your body density involves measuring your apparent weight while you are submerged in water with the air completely exhaled from your lungs. (In practice, the amount of air remaining in the lungs is estimated and corrected for.) Suppose that your apparent weight when submerged in water is 5% of your weight. What percentage of your body mass is fat?

3. Find the fraction of the volume of an iceberg that is below sea level.

4. Water and then oil (which don't mix) are poured into a U-shaped tube, open at both ends. They come to equilibrium as shown in Fig. 1. What is the density of oil?

5 Water at gauge pressure of 3.8 atm at street level flows into an office building at the speed of 0.6 m/s through a pipe 5 cm in diameter. The pipe tapers down to 2.6 cm in diameter by the top floor, 18 m above, where the faucet has been left open. Calculate the flow velocity and the gauge pressure in such a pipe on the top floor. Assume no branch pipes and ignore viscosity. (See Fig. 2.)

6. In humans, blood flows from the heart into the aorta, from which it passes into the major arteries. These branch into small arteries (arterioles), which in turn branch into myriads of tiny capilars. The blood returns to the heart via the veins. The radius of the aorta is about 1.2 cm, and the blood passing through it has a speed of about 40 cm/s. A typical capilar has a radius of about 4×10^{-4} cm, and blood flows through it at speed of about 5×10^{-4} m/s. Estimate the number of capillars that are in the body.

7. Figure 2 shows the tropical storm Katrina as observed by the NASA's QuikSCAT satellite on August 25, at 4:37 am in Florida. At this time the storm had 50 miles per hour sustained winds. The storm does not appear to yet have reached hurricane strength. *(a)* Assume that the air pressure outside the storm is atmospheric pressure and that the speed of the wind in this region is negligible to give a rough estimate the air pressure inside the storm. (1 mile $\approx$ 1.6 km). The storm reached category 5 hurricane, with wind speed of 300 km/h. It was the sixth-strongest Atlantic hurricane ever recorded and the third-strongest hurricane on record that made landfall in the United States. Estimate the air pressure inside the category 5 hurricane and compare the results. *(b)* What is the net force on the roof of a house exposed to the storm force winds if its area is 240 m^2 and it is flat. Assume that there is no appreciable height difference between the two sides of the roof and that the windows and the doors of the house are closed.

8. A large tank of water, open at the top, has a small hole through its side a distance h below the surface of the water. Find the speed of the water as it flows out the hole. (See Fig. 3.)

9. If cholesterol build-up reduces the diameter of an artery by 15%, what will be the effect on blood flow?

10. Giraffes are a wonder of cardiovascular engineering. Calculate the difference in pressure (in

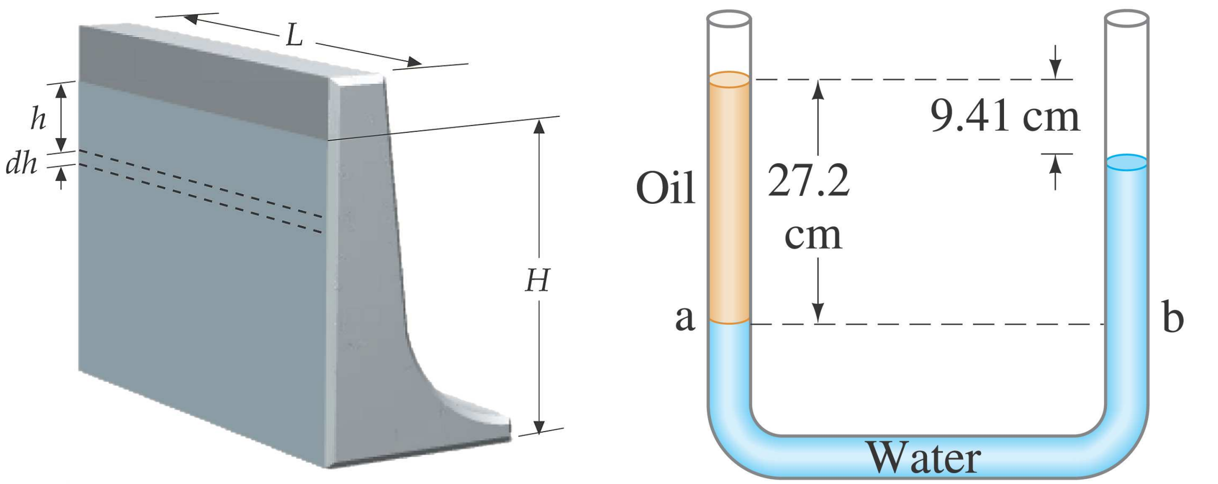

Figure 1: The situation in problem 1 and problems 4.

atmospheres) that the blood vessels of a giraffe's head have to accomodate as the head is lowered from a full upright position to ground level for a drink. The height of an average giraffe is about 6 m.

11. A patient is to be given a blood transfusion. The blood is to flow through a tube from a raised bottle to a needle inserted in the vein as shown in Fig. 3. The inside diameter of the 4 cm long needle is 0.4 mm, and the required flow rate is 4 cm^3 of blood per minute. How high h should the bottle be placed above the needle? Assume that blood has a viscosity of 4 mPa s, a density of 1060 kg/m^3, and the blood pressure is 18 torr above atmospheric pressure.

12. A simple model considers a continent as a block (density $\approx$ 2800 kg/m^3) floating in the manttle rock around it (density $\approx$ 3300 kg/m^3). Assuming the continent is 35 km thick (the average thickness of the Earth continental crust), estimate the height of the continent above the surrounding rock. (See Fig. 4.)

13 An airplane has a mass of 2×10^6 kg, and the air flows past the lower surface of the wings at 95 m/s. If the wings have a surface area of 1200 m^2, how fast must the air flow over the upper surface of the wing if the plane is to stay in the air? Consider only Bernoulli effect.

14. A house at the bottom of a hill is fed by a full tank of water 5 m deep and connected to the house by a pipe that is 110 m long at an angle of 58° from the horizontal. (a) Determine the water gauge pressure at the house. (b) how high could the water shoot if it came vertically out of a broken pipe in front of the house? See (Fig. 4.)

15. Calculate the Reynolds number for blood flowing at 30 cm/s through an aorta of radius 1 cm. Assume that blood has a viscocity of 4.0 mPa s and a density of 1060 kg/m^3.

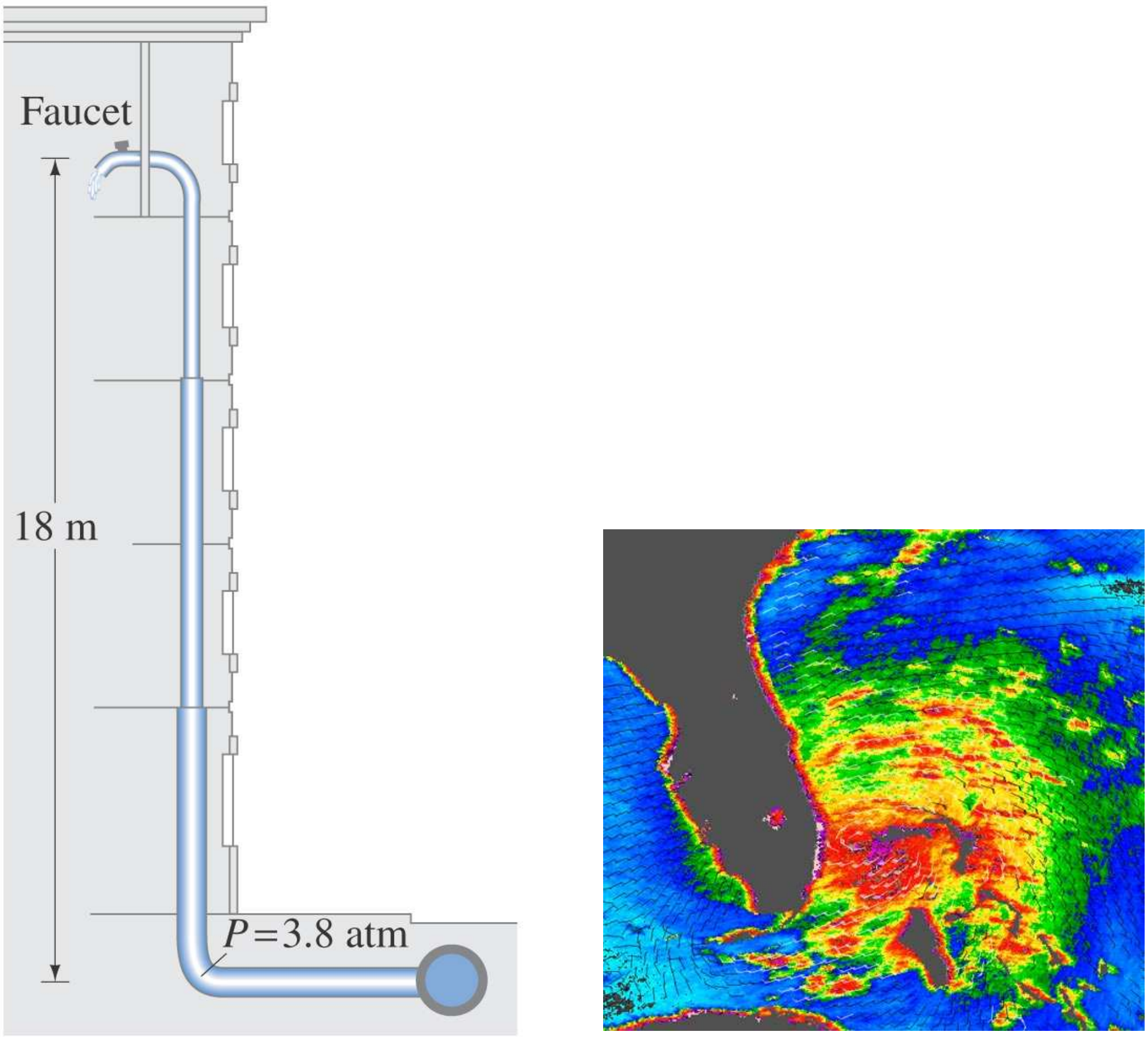

Figure 2: The situation in problem 5 and problem 7.

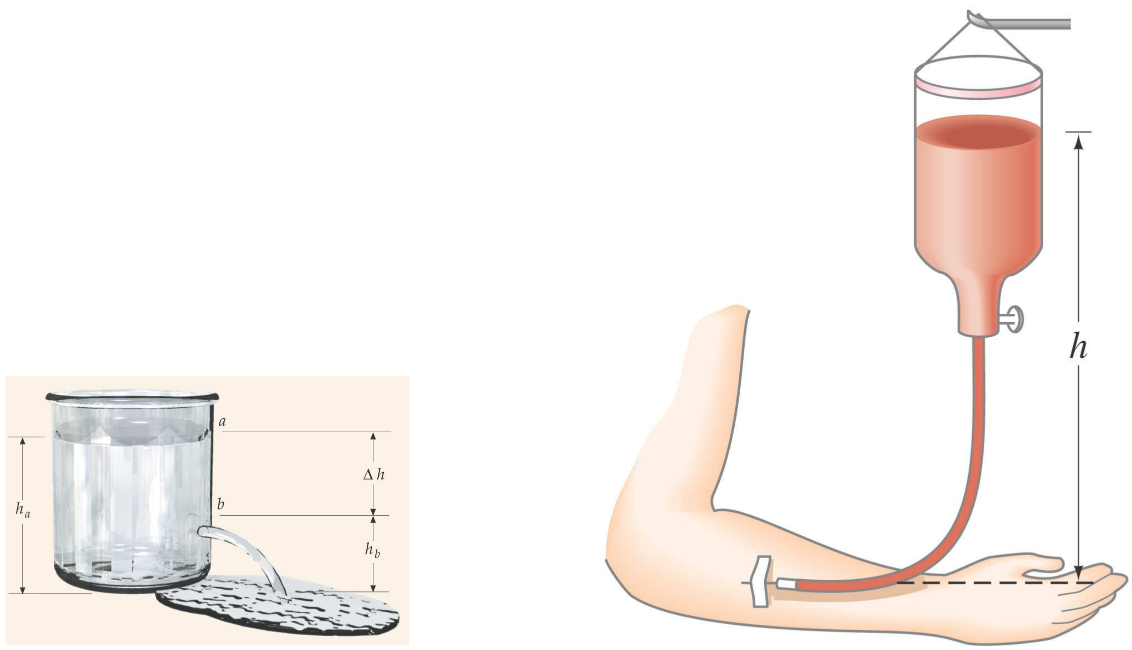

Figure 3: The situation in problem 8 and problem 11.

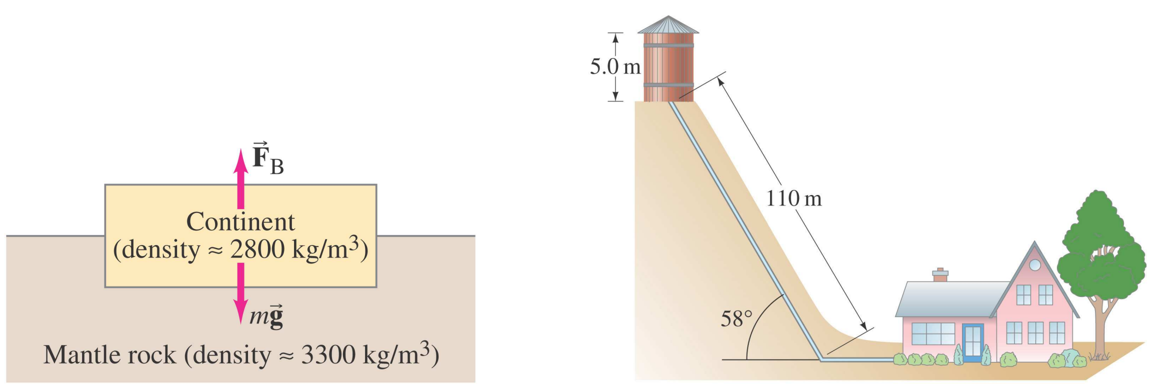

Figure 4: The situatrion in problem 12 and problem 14.