Exercise 1. Pressure I

Find the total force exerted on a 10 [cm] by 10 [cm] section of a wall exerted by atmospheric pressure, assumed to be $P = 10^5$ [Pa].

(a) 100 [N]
(b) 1000 [N]
(c) 10000 [N]
(d) 100000 [N]

Exercise 2. Pressure II

Find the total force exerted on a 1 [cm] by 10 [cm] strip of a wall exerted by atmospheric pressure, assumed to be $P = 10^5 + 10^3 x$ [Pa], where x ranges from 0 to 10 [cm].

(a) 100.05 [N]
(b) 1000.5 [N]
(c) 10005 [N]
(d) 100050 [N]

Exercise 3. Pressure III

Find the total force on a 0.1 [m] by 0.1 [m] section of a wall exerted by atmospheric pressure, assumed to be $P = 10^5 + 10^3 \cos(2\pi x/0.1)\cos(2\pi y/0.1)$ [Pa]. Hint: set your origin in the center of the square.

(a) 969 [N]
(b) 1000 [N]
(c) 1031 [N]
(d) 1062 [N]

Exercise 4. Pool

Find the pressure at the bottom of a 3 [m] deep pool if the pressure at the surface is 10^5 [Pa], the gravitational constant is $g = 10$ [m/s^2], and the density of water is 10^3 [kg/m^3].

(a) 0.7 [bar]
(b) 1.0 [bar]
(c) 1.3 [bar]
(d) 1.7 [bar]

Exercise 5. Manometer I

Suppose that one end of a mercury manometer (density 13.5 [g/cm^3]) experiences a pressure of 5.063×10^5 [bar] above a dewar of liquid nitrogen, and the other end experiences atmospheric pressure of 1.013 [bar]. Sketch the experimental setup.

Exercise 6. Manometer II

What is the difference in heights?

(a) 3 [m]
(b) 0.3 [m]
(c) 0.03 [m]
(d) 0.003 [m]

Exercise 7. Buoyancy I

Suppose that a diver of density 0.85 [g/cm^3] is at a depth of 20 [m] below the surface of the ocean, and 20 [m] above the sea floor. Draw a free body diagram. In which direction is the net force?

Exercise 8. Buoyancy II

How long does it take to reach the surface/bottom by just floating?

(a) 5.60 [s]
(b) 5.16 [s]
(c) 4.76 [s]
(d) 4.33 [s]

Exercise 9. Continuity

Suppose that air enters a jet of radius 1 [m] at 10 [m/s], and leaves at a radius of 0.1 [m]. If the engine does no work, what speed does the air leave at?

(a) 10 [m/s]
(b) 100 [m/s]
(c) 1000 [m/s]
(d) 10000 [m/s]

Exercise 10. Discontinuity

Now, suppose that the engine does 1000 [J] of work on each kilogram of air. Assuming constant pressure, what speed does the air leave at?

Exercise 11. Conversion I

Suppose that hydrogen peroxide H_2O_2 is generated as a byproduct of a reaction at a rate of 1 [mol/s], and is carried in a tube by 10 [mol/s] of water, H_2O. If the tube has a diameter of 2.54 [cm], and the densities of peroxide and water are 1450 [kg/m^3] and 1000 [kg/m^3] respectively, what is the flow rate? Note: the molar masses of peroxide and water are 34 [g/mol] and 18 [g/mol] respectively.

Exercise 12. Conversion II

Now suppose that all of the peroxide is reduced on a platinum catalyst in the presence of hydrogen according to the reaction $H_2O_2 + H_2 \rightarrow 2H_2O$. What is the new flow rate? Hint: the number of moles have changed!

Exercise 13. Bernoulli I

Suppose that water enters a tube of 20 [cm] diameter at UCLA (elevation of 96 [m]), and travels to the pier at Santa Monica, 10.4 [km] away. If the water starts at 1 [m/s] how fast is it moving when it reaches the pier?

Exercise 14. Bernoulli II

The Stone Canyon Reservoir is at a height of 258 [m] and provides water to UCLA. If water starts in a tube at rest, and the tube breaks into 10000 faucets each 1 [cm] in diameter, how much power can a hydroelectric motor extract if the water leaves the faucets at 5 [m/s]?

Exercise 15. Submersion

Consider a solid, small plastic sphere rising in a large tank of more dense liquid. Assume that the sphere is initially at rest at the bottom of the tank.

Solve the differential equation below to obtain an algebraic expression for the sphere's position as a function of time:

$$F_{\text{net}} = F_{\text{buoyancy}} + F_{\text{gravity}} + F_{\text{drag}}$$

Where:

$$F_{\text{net}} = m_s a = \frac{4}{3}\pi r^3 \rho_s \frac{dv}{dt}$$
$$F_{\text{buoyancy}} = m_f g = \frac{4}{3}\pi r^3 \rho_f g$$
$$F_{\text{gravity}} = -m_s g = -\frac{4}{3}\pi r^3 \rho_s g$$
$$F_{\text{drag}} = -6\pi \mu r v$$

How would this analysis be complicated if the sphere were a gas bubble instead of a solid plastic sphere? Explain.