Tutorial 4 - Buoyancy and Pressure

Problem 1: Up

In the movie *Up* Carl Fredricksen saves his house by tying thousands of helium balloons to it so that it floats, and he escapes to South America where he has many adventures.

Perhaps you have wondered how many balloons it would really take to float a house or maybe to float you. Let's figure out the minimum size balloon it would take to really lift a person so we don't ever buy too many helium balloons at the amusement park.

Specifically, your goal is to determine an algebraic expression for the *diameter* of a spherical, helium balloon of mass M_B necessary to just lift an a person of mass M_m. Let the density of air be ρ_a and the density of helium be ρ_H.

1. **System** - Begin by choosing the person plus the *helium-filled* balloon as the system
2. **List all forces on the system**
3. **Draw a Free Body Diagram**
4. **Apply the momentum principle** ($\vec{F}_{net} = m\vec{a}$) - Solve the equations to obtain the volume of a balloon large enough to just lift the person, then get an expression for the diameter of this balloon.
5. **Get a numeric value** - Using $M_m = 80$kg, $M_B = 5$ kg, the density of air at STP $\rho_a = 1.3 \times 10^{-3}\text{g}/\text{cm}^3$ and the density of helium is $\rho_H = 1.8 \times 10^{-4}\text{g}/\text{cm}^3$, obtain a numeric value for the diameter.

Problem 2: Rising Seas

1. Two identical glasses are filled to the same level with water. One of the two glasses has ice cubes floating so that a large percentage of their mass is not submerged in the water. When the ice cubes melt, in which glass is the level of water higher?

2. What does this imply about the melting of the polar ice caps and why?

Problem 3: Sliding box with friction

If you slide a box with an initial velocity v_0 and it moves some distance Δx, how far will it slide if you give it an initial velocity $2v_0$?

1. **System** - the box
2. **List all forces on the system** - List the forces on the box
3. **Draw a Free Body Diagram** - Draw a free body diagram for the system
4. **Apply the momentum principle** ($\vec{F}_{net} = m\vec{a}$) - Use the Momentum Principle and the kinematic equations of motion to determine the ratio of how far the box will slide if the initial velocity is doubled.