Homework: Fluid concepts and applications

Full Name, Period, AP/Honors:

1 Ram Pressure

Ram pressure is a term used in engineering that corresponds to the pressure that results from a fluid flowing into an object.

1. Using equations and concepts from the class (but not energy), justify why the ram pressure that an object should experience when hit directly with a fluid that has a speed of v should be about $P_r \sim \rho v^2$. (the symbol $\sim$ in physics means within a factor of 10)

2. How could we have instead gotten to the previous expression with an energy argument?

3. Hurricane force winds are defined as winds that are sustained above 74 mph (33 $\frac{\text{m}}{\text{s}}$). Estimate the force you would experience from ram pressure if you attempted to walk through hurricane force winds.

4. If hurricane force winds run into a mountain range, the air must stop. Where would the lost energy go?

2 Water under the bridge

Sometimes during floods, water is able to tear trees from the ground. In what types of terrain would you expect this to occur and why?

3 Water in your pipes

Some very tall buildings have issues with water coming out of the tap very slowly. Explain using concepts and equations why this might be, and why the problem can usually be fixed by storing a water tank on the building's roof.

4 Water near the ocean floor

(**AP only**) We discussed in class how water is actually compressible, but said it was a "good enough" approximation to assume that it was incompressible. Lets quantify that.

1. The depth of the deepest part of the ocean is about 10 km. What would the pressure be there?

2. Water's compressibility is $\beta = 46 \cdot 10^{-11} \frac{\text{m}^2}{\text{N}}$. The equation for compressibility is $\frac{\Delta V}{V}$. Using the previous result, show that water at the deepest part of the ocean would be a bit less than 5% more dense as a result of compression.

3. Now use that the energy needed to compress something should be given by $P\Delta V$ to compare the energy density in the water's compression to the total pressure of the water (the ratio of these will be dimensionless and thus comparable.)

5 Water everywhere

You put a water bottle (idealized as a massless cylinder with thin walls) filled completely with water into a dense liquid. The bottle floats with 1/4 of the volume visible above the liquids surface. What is the density of the unknown liquid?

A. $\frac{4}{3} \frac{\text{g}}{\text{cm}^3}$
B. $\frac{3}{4} \frac{\text{g}}{\text{cm}^3}$
C. $\frac{1}{4} \frac{\text{g}}{\text{cm}^3}$
D. $4 \frac{\text{g}}{\text{cm}^3}$
E. We need to know the total mass of the liquid to answer