HW 1, Fluid Dynamics

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0.1 Problem #1

It is quite easy to estimate from the animation that longitudinal gridlines are 20 degrees each. So as the length of the equator is about 40 000km, we can estimate that the wave traveled about:

$$\frac{14}{360} \cdot 40000km \approx 1550km = 1550000m$$

where 14 degrees is estimated from the orgin of the wave to Sri Lanka island. The speed of the tsunami is about

$$\frac{1550km}{3h} = 515\frac{km}{h} = 143\frac{m}{s}$$

and the average depth of the ocean in this region is

$$h = \frac{c^2}{g} = \frac{143^2\frac{m^2}{s^2}}{9.8\frac{m}{s^2}} = 2100m$$

Actually the result really depends on our estimation. I tried calculations for 13 degrees also and the final result was about 1600m instead.

For the tsunami on the Sun:

As it is known that the radius of the Sun is about 695000km, and again, the tsunami occurs really close to the equator of the Sun. Also, I would estimate from the video that the tsunami propagated about 30 degrees. So the estimated distance would be

$$\frac{30}{360} 2 \cdot \pi \cdot 695000km \approx 364000km = 364000000m$$

The time of propagation is about $8min = 480s$. So the speed would be

$$\frac{364000000m}{480s} = 758000\frac{m}{s}$$

If we would perform the depth calculation for the Sun, we'd see that it would be much larger than the radius of the Sun. So it couldn't be correct...

0.2 Problem #2

For $\vec{\delta v}$ parallel to $\vec{k}$ we can write the relation, derived in class, as follows

$$\frac{\delta\rho}{\rho_0} = \frac{\delta v}{c_0}$$

and as we know the relation $\delta P = c_0^2 \delta\rho$ it is pretty easy to derive the following relation $\delta\rho = \frac{1}{c_0^2}\delta P$. Using ideal gas law for finding P_0 we can get the relations

$$\frac{\delta\rho}{\delta\rho_o} = \frac{\delta v}{c_0} = \frac{\delta P}{P_o} \cdot \frac{RT}{c_0^2 M} = \frac{\delta P}{c_0^2 \rho_0},$$

where R is universal gas constant, M is molar mass of the gas, T is temperature (we use T=293K).

0.2.1 Pressure fluctuation of normal speech

It can be found really easily from given data: $\delta P = 2 \cdot 10^{-5} Pa \cdot 10^{6} = 20 Pa$ (which is, quite big, in my opinion...)

0.2.2 $\frac{\delta\rho}{\rho_0}$ for normal speech

Using equations above, we can find the value as follows:

$$\frac{\delta\rho}{\delta\rho_o} = \frac{\delta P}{c_0^2 \rho_0} = \frac{20Pa}{(331 + 0.6 \cdot 20)^2 \frac{m^2}{s^2} \cdot 1.2 \frac{kg}{m^3}} = 0.14 \cdot 10^{-3},$$

where the 20 is the temperature in Celsius and the relation $331 + 0.6 \cdot 20$ is the general formula for calculating the speed of the sound in the air.

0.2.3 δv for normal speech

δv could be found really easily from the previous formula:

$$\frac{\delta P}{c_0 \rho_0} = \delta v = 0.14 \cdot 10^{-3} \cdot (331 + 0.6 \cdot 20) \frac{m}{s} = 0.05 \frac{m}{s}.$$

0.3 Problem #3

Could be found in a separate file, matlab file...