Exercise 1: Icebergs, melting ice shelves and global sea levels

You might have heard in the (not so) recent news about the melting and collapse of Antarctica's ice shelves. An ice shelf is a very large glacier that extends out to sea and is floating on the water (as opposed to some Alaskan tide-water glaciers, which extend out into the ocean, but are grounded on the sea floor). The ice-shelf breakup is likely caused by global warming, and melting glaciers are expected to rise global sea levels in the near future.

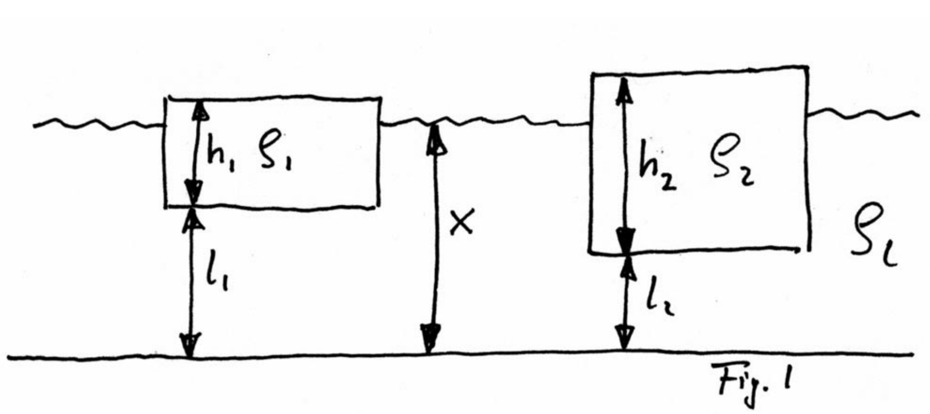
Does the breakup and melting of the Larsen ice shelf contribute to sea level rise? Remember, it's a floating glacier, and we can test the effect of its breakup on sea level rise quite easily.

- Take one of the large glass beakers and fill it with tap water until is about half full (or empty if you wish).
- Take one of the frozen ice blocks from the cooler, get it out of its yoghurt cup and drop it into your beaker. The block of ice simulates the ice sheet, which will collapse (melt) during the course of this lab.
- Using a Sharpie, mark the water level in the beaker (global sea-level before the collapse).
- Now let the ice cube melt (while you are doing experiments 2 and 3).
- At the end of this lab record any change in the water level in the beaker.

Exercise 2: Checking out the Physics

You've read about the underlying physical principle of buoyancy and isostasy. The weight of the floating body equals the weight of the displaced fluid. This principle led us to equation 5 in the math handout, which is reprinted (and slightly simplified) below. In this exercise we will verify this equation experimentally.

$$h_1 \rho_1 A + l_1 \rho_l A = x \rho_l A \quad \textbf{(1)}$$



- Fill one of the large plastic basins with water.
- Choose a large wooden block and measure its **Volume** and **mass**
- Calculate the density of the block and note the number written on the block
- Let the wooden block float in water and measure the appropriate depths
- Repeat at least two more times using the same block. The blocks are soaked in water, so make sure they stay wet during the experiment.
- Use your measurements to test whether equation (1) holds true
- Interpret and discuss your results

Note to test whether eq. 1 holds true it is necessary to show that both sides of the equation are equal. When substituting your measured values into eq.1 make sure to consider potential measurement errors. Repeating the same measurement several times (and switching the tasks around) lets you estimate your measuring error. You can, for example, use excel to calculate average values and standard deviations of your measurements and use these values to estimate the accuracy of your results (remember those significant figures!).

Exercise 3: Erosion and Sedimentation along a Passive Margin

You have already read about sedimentary systems along passive margins and the puzzling fact that we observe piles of sediment, up to several kilometers deep, that was entirely deposited in a shallow ocean environment. In this exercise we simulate a coastal mountain range, such as the Appalachians, and its associated coastal margin sediments ans sketched in Fig. 2.

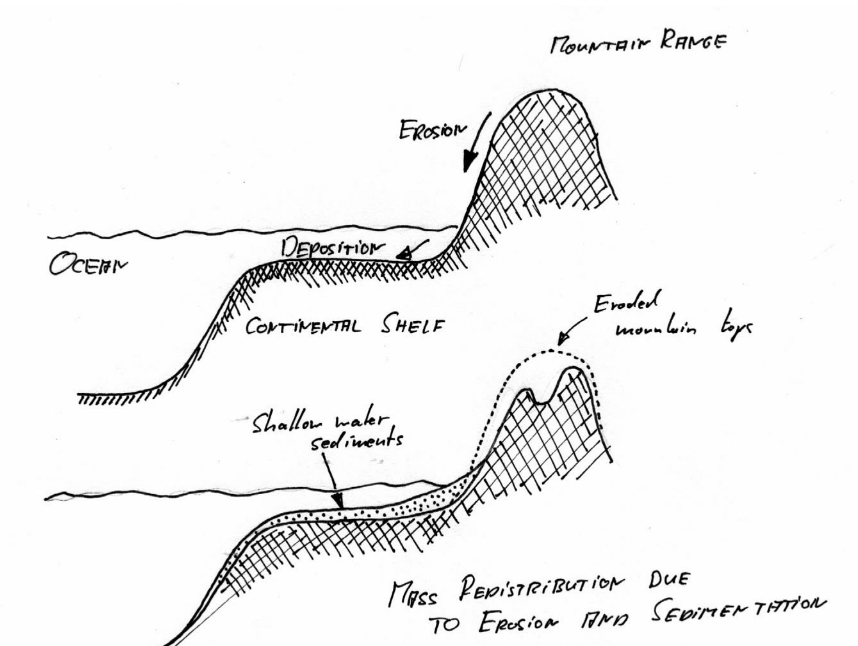


Fig. 2

We will simplify the system a bit by using two wooden blocks and a series of wooden plates as indicated in Fig. 3.

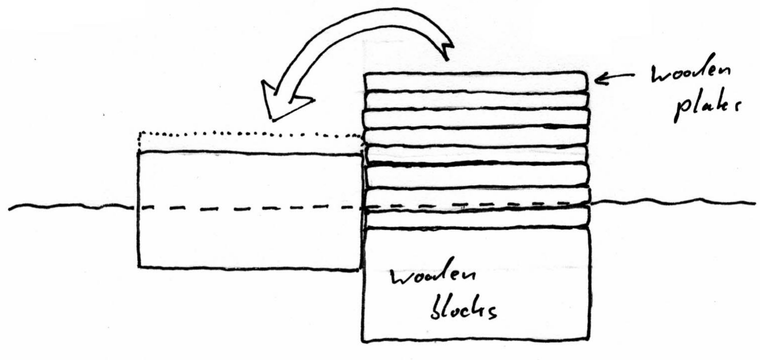


Fig. 3

- Select two blocks and a series of plates and determine their densities.
- Create a" mountain range" similar to the one shown in Fig. 3 That might be a bit tricky, but try to pile them as high as you can.
- Measure the elevation of the "mountain" and "plains", the depth of the liquid beneath the two blocks and the thickness of the two piles. Watch out: the density of the blocks is different from the density of the wooden plates, though the density of the plates should be the same for all plates.
- Using eq. 1, or a modified version of it, calculate the height of the mountain range and plains.
- Simulate erosion by moving plates from the mountain range onto the plains. After each step measure the height of the mountains and the plains.
- Continue until both blocks have about the same height (erosion stops now because there is no relief left).
- Graph the changes in elevation for the mountains and the basin after each erosion step.
- Calculate the final elevation of the basin and the (former) mountain range.

Note: In this example both the mountain range and the basin are above the water surface all the time. This is because the water in our experiment does not simulate the ocean, but deeper mantle rocks, while the wood represents the less dense crustal material.

Exercise 4: The Thickness of the Crust beneath the Ocean and Continents
(modified from Turcotte and Schubert, 1982)

Consider the oceanic and continental structures shown in Fig. 4. The continental crust has a thickness h_{cc} and a density ρ_{cc}; its upper surface is at sea level. The oceanic crust has a thickness h_{oc} and a density ρ_{oc}. The mantle density id ρ_m. The depth of the oceans is h_w. Seismic measurements show that the oceanic crust is approximately 6km thick. Apply the principle of isostasy to calculate the thickness of the continental crust.

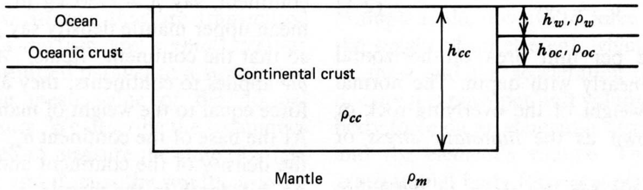


Fig. 4: Continent - ocean structure (from: Turcotte and Schubert, 1982)

Data needed for Exercise 4:

ρ_w	=	1000 kg/m^3	h_w	=	6.5 km
ρ_{oc}	=	2900 kg/m^3	h_{oc}	=	6.0 km
ρ_{cc}	=	2800 kg/m^3			
ρ_m	=	3300 kg/m^3			

For all exercises your Lab-report should include:

- the ideas you want to test in this exercise
- description of the experimental setup
- your experimental data (water level before and after)
- the required calculations
- an interpretation of your findings
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References:

D.L. Turcotte and G. Schubert, 1982, Geodynamics: Applications of continuum physics to geological problems, Wiley and Sons, 450 pp.