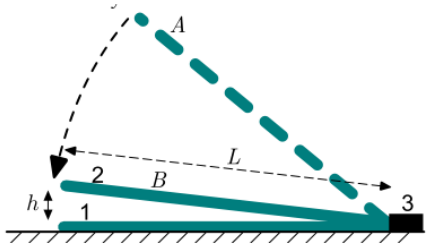
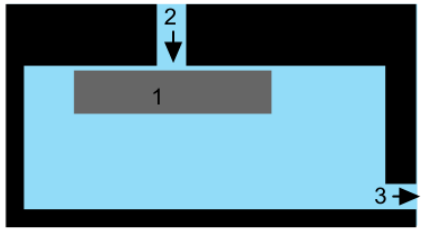
2. Gas and fluid flows (10 points) — *Jaan Kalda, Päivo Simson.*

i) *(1 point)* If you let a glass plate fall onto another glass plate, it will not break, but stop softly. The figure depicts, a plate (marked with '1') is resting on the floor, and another plate (marked with '2') is falling while a bump on the ground (marked with '3') prevents it from sliding. The falling plate started from the position A and is now at the position B, at a very small distance $h = h_0$ from the resting plate, and falling currently with the angular speed ω_0. What is the speed of air between the plates near the leftmost edge?

ii) *(2.5 points)* The glass plate has width $L \gg h_0$, thickness $t \ll L$, density ρ_g, and its length (into the depth of the figure) is much bigger than L. How will the angular speed of the plate depend on h during its subsequent motion if the density of air is ρ_a? Neglect the gravity as well as the viscosity and compressibility of the air. Assume that the air flow remains everywhere laminar.



iii) *(3 points)* A cylindrical stone disc (marked with '1' in the figure) of radius R, thickness h and density ρ_s is pressed against the ceiling of a basin filled with water of density ρ_w. Small bumps on the surface of the ceiling maintain a small gap of thickness $t \ll R$ between the ceiling and the surface of the disk. Water flows from a pipe (marked with '2'; the outflow pipe '3' is far away) of radius $r \ll R$ coaxially with the disk into the basin, see the figure. The radius of the pipe is much bigger than the gap between the disk and the ceiling, i.e. $r \gg t$. What should be the mass flow rate μ (kg/s) from the pipe so as to keep the disk from falling down? The free fall acceleration is g.



iv) *(0.5 points)* Steam turbines are widely used in power plants. According to a simplified model, water is being boiled at temperature $t_t = 180\,^\circ\mathrm{C}$ and pressure $p_t = 1 \times 10^6\,\mathrm{Pa}$ (real steam turbines can have much higher pressures than that), and the created vapour flows out through a cylindrical channel of cross-sectional area $A = 1\,\mathrm{cm}^2$ in the wall; the ambient pressure $p_0 = 1 \times 10^5\,\mathrm{Pa}$. Find the entropy difference ΔS of one mole of vapour and one mole of liquid water (molar mass $M = 18\,\mathrm{g/mol}$, latent heat of vaporisation at $100\,^\circ\mathrm{C}$: $L = 2.3\,\mathrm{MJ/kg}$) in the outflowing jet.

v) *(3 points)* Find the mass flow rate μ of the created steam jet, as well as the relative mass content r of liquid-phase-water in it. Assume that while flowing into and in the channel, the expansion of water vapours is reversible (i.e. heat conductivity can be neglected, and that there is always equilibrium between the liquid and gaseous phases); the adiabatic index of water vapours $\gamma = 4/3$.