5. Bottle's sound (8 points) — *Jaan Kalda and Eero Uustalu.*

Tools: an empty 1-litre bottle, a small (about 100 ml) cup of known volume (or other tool for measuring water volumes), a smartphone with installed "Physics Toolbox Sensor Suite" or "Physics Toolbox Pro" (mark on your paper, which version did you use).

If you blow near the bottle's mouth, a whistling sound can be generated: a gentle (to moderately strong) air flow needs to pass the bottle's mouth perpendicularly to the bottle's axis. Your task is to study the dependence of the frequency $\boldsymbol{f}$ of the generated sound as a function of the volume $\boldsymbol{V}$ occupied by water inside the bottle.

i) *(4 points)* While blowing near the bottle's mouth, measure the sound frequency using either the "tone detector" or "spectrum analyzer" of the "Physics Toolbox" (once the app is launched, the menu can be pulled from the left top corner of the screen). If you manage to obtain a nice distinct sound, use the "tone detector"; otherwise use the "spectrum analyzer" to determine the frequency of the spectrum's peak. Tabulate your measurement data.

ii) *(1 point)* Either based on theoretical consideration or on the data analysis, suggest a functional dependence of $\boldsymbol{f}$ on $\boldsymbol{V}$.

iii) *(3 points)* Test the validity of your suggestion for this dependence graphically, and determine the parameters of it. Error analysis is not required.