Vibrations

13$^\text{th}$ of October 2023

Tasks

1. Use available resources to find or determine the frequency of the first natural mode of air vibrations inside a Christmas bauble. Provide a numerical value for Christmas bauble with bauble volume of $V = 0.2\,\text{dm}^3$, and neck length of $L = 1\,\text{cm}$.

2. Violin string, fixed at both ends, with length $L = 0.3\,\text{m}$ and linear density $\mu = 0.65\,\text{g/m}$ is placed near a speaker. The speaker can play sound in range between $500\,\text{Hz}$ and $1500\,\text{Hz}$, but the string only vibrates when frequency of the speaker sound is set to $880\,\text{Hz}$ or $1320\,\text{Hz}$. Determine the tension of the string.

3. [HARD Problem] Świstak Ś. is living on a flat, horizontal plain. To defend against predators that also inhabit the same plain, Ś. emits a short squeak at a frequency f_0 at certain intervals. Based on the sound reflected from the attacker (the echo of the squeak), Ś. throws a stone in the direction from which the sound came at a speed of v_0 and at an angle α to the horizontal plane. Assuming that the time interval between emission of the sound and hearing the echo back is Δt, the frequency of the echo heard by Ś. is f_1 ($f_1 > f_0$), and that the attacker is running towards Ś. with a constant velocity, determine the time t at which Ś. should throw the stone to hit the attacker.

   The speed of sound in the air is denoted as u, gravitational acceleration as g, and Świstak remains stationary throughout this scenario.