Ultrasonics 2025
Demo exercise 1 (Exercise 6)

Be prepared to present your solutions in the exercise session on Wed 5.3.

1. Transducers-demo (4 pts)

During the transducer demo session, you chose a delay line of an unknown material. To determine the material, you measured the length of the delay line with a calliper, and the time of flight of an ultrasonic pulse travelling through the delay line.

a) Using your data, determine the speed of sound in the material with uncertainty (Exercise 1, problem 1). Remember to use the correct propagation path for the pulse (pulse-echo/through-transmission). For error propagation, use reasonable assumptions for the uncertainty of your measurements.
b) What is the most likely material of the delay line?

2. Levitator (6 pts)

a) Consider a single axis Langevin acoustic levitator consisting of a flat transducer and a flat reflector. The transducer plate vibration was measured in the resonant frequency with Laser Doppler Velocimetry (LDV): peak-to-peak amplitude: 40 μm and frequency: 35 kHz.

   Calculate the optimal distance for the reflector and the maximum density of a small spherical sample that still levitates.

   Hint: Gor'kov potential, what is the relation between pressure, particle velocity, and particle displacement amplitudes?

b) A phased array acoustic levitator consisting of 16 acoustic sources was built. When the sources were positioned at a distance of 5 cm from the levitation spot, the heaviest material that could be levitated was Styrofoam ($\rho \approx 20$ kg/m^3). The next iteration needs to be able to levitate a small rock ($\rho \approx 3000$ kg/m^3).

   How many similar transducers are needed (at least), if they cannot be positioned any closer than 10 cm.

   Hint: Gor'kov potential, geometric spread of a point like transducer is inversely proportional to the square of distance r, what is the relation between maximum particle density and pressure amplitude – what is the total pressure amplitude from multiple sources proportional to?