Ultrasonics 2021
Exercise 1

Be prepared to present your solutions in the exercise session on Wed 3.2.

1. An ultrasound pulse is sent perpendicularly to a flat piece of aluminium immersed in water (NTP conditions). Calculate the reflection and transmission coefficients for the water-aluminium interface (amplitude and power).

2. You have measured the shear modulus G = 48 GPa and the Poisson's ratio v=0.34 of copper. Calculate the bulk modulus B and the Young's modulus E.

3. Plane waves propagating in an isotropic solid medium fulfil the dispersion relations:

$$k^2 c_{44} = \rho\omega^2 \quad\quad\quad\quad (1)$$

$$k^2 c_{11} = \rho\omega^2 \quad\quad\quad\quad (2)$$

where k = absolute value of the wave vector, c_{11} and c_{44} are elastic stiffness constants, ρ= density of the matter and ω= the angular frequency. Equation 1 is valid for x- and/or y polarized plane waves propagating in the direction of the z-axis. Equation 2 is valid for a plane wave whose particle displacement is parallel to the wave propagation.

Calculate the phase velocities c_l and c_t of the longitudinal and transverse waves. Compare these to the equations:

$$c_t = \sqrt{\frac{E}{2\rho(1+v)}}$$

$$c_l = \sqrt{\frac{E(1-v)}{\rho(1+v)(1-2v)}}$$

By using these, write down the stiffness constants c_{11} and c_{44} as a function of Young's modulus E and Poisson ratio v.

4. You have measured time of flights from a 25 mm ±1 mm thick object immersed in water. From the oscilloscope you read the following values for the time difference between the surface and bottom echoes: 15.0 µs, 15.5 µs, 15.5 µs, 15.0 µs, 16.0 µs. Determine the speed of sound (with uncertainties) from the given data. What is the likely colour of the metal?

5. Determine the depth and the width of the -3dB (power) field of a focused ultrasound transducer in water. The centre frequency of the transducer is 30 MHz and the fractional bandwidth is 70%. The transducers diameter is 12.7 mm and it is focused at a distance of 19 mm. What is the resolution of the transducer in water?