Ultrasonics 2025
Exercise 2

Be prepared to present your solutions in the exercise session on Wed 29.1.

1. Acoustic intensity is defined as the average energy flow per unit area. The unit is J/s/m^2 = W/m^2. A sound source emitting a "plane wave" is placed under water. The acoustic intensity of the emitted sound is 200 W/m^2 and the frequency 15 kHz. Assume that the plane wave travels through a circular ring with a radius of 50 cm.
   Calculate:
   a. Acoustic power through the ring
   b. The pressure amplitude of the plane wave
   c. The amplitude of the particle speed
   d. The amplitude of the particle displacement
   e. Root mean square of the pressure
   f. Static radiation pressure (= Langevin pressure)

   (ρ_{water} = 1000kg/m^3 and c_{water} = 1500m/s)

2. Calculate the speed of sound in air that has the temperature:
   a. -25°C
   b. 0°C
   c. +25°C
   d. +100°C

   What is the sensitivity of a US based thermometer?

3. A wave propagating on the surface of a solid object (Rayleigh wave) is a superposition of two waves, longitudinal and shear, propagating at identical velocities on the interface. A surface wave propagates with a phase velocity approximately given by

$$\frac{c_R}{c_t} = \frac{0.87 + 1.12\nu}{1 + \nu}$$

   Where c_R = phase velocity of the surface wave, c_t = velocity of a transverse wave in the material and ν= Poisson's ratio. Show that the phase velocity can be presented in the form:

$$c_R = \alpha \sqrt{\frac{G}{\rho}}$$

   where α = constant, G = shear modulus and ρ= density. What is the velocity of the surface wave on aluminium?

4. Explain briefly:
    a. Sonoluminescence
    b. Piezoelectric effect
    c. Dispersion
    d. Cavitation
    e. Rayleigh criterion (in ultrasound microscopy)

    (What are the physical quantities and units describing these?)

5. You are driving your old Corolla around the city and its subwoofer is playing bass beats at 50 Hz with a sound pressure level of 90 dB measured 1 meter away. Consider your vehicle's sound system as a point source emitting a hemispherical wave that does not interact with the ground. How far away can this sound be heard if there is no background noise? Use a sound attenuation coefficient of $\alpha = 10^{-3}$ 1/m and the hearing threshold of p_{th} = 20 μPa.