Ultrasonics 2017
Exercise 3

Exercise session 2.2.

1. The characteristic impedance of a piezo-ceramic transducer is 37 Mrayl. What percentage of the sonic power of a longitudinal wave is transferred into a surrounding fluid that is:
   a) air
   b) water
   Approximate the situation as an interface phenomenon.

2. You possess a piezo-element that should be acoustically matched to water as well as possible (to generate maximal power transfer from the element to water). You can choose one material from which you fabricate the matching layer between the piezo and water. What is the characteristic impedance of the matching material? What is the thickness of the piezo-element if the center frequency is ≈ 2 MHz? The piezo ceramic is P6 - lead zirconate titanate –longitudinal crystal, Z ≈ 35 Mrayl.

3.

a) The group velocity of a 120 kHz flexural wave (the antisymmetric mode of a Lamb wave) in a metallic plate is ~ 600 m/s. From which angle should a US wave be directed to the plate, from air, so that this mode can be exited?
b) A plane wave is directed perpendicularly to a steel plate. How much power is transmitted through the plate if we assume that the thickness of the plate is equal to the wavelength λ. (Presume d ≈ 1mm.)

4. Explain what the Hertz contact law is and how it is associated with sound propagation in granular material.

5. Justify the following claims:

a) An air backed transducer is able to produce twice the transmitting power of a transducer that has the backing matched.
b) The input admittance of an ultrasonic transducer is changed when the transducer is transferred e.g. from air to water.
c) A piezoelectric ceramic is stiffer than an equivalent non-polarized ceramic.
d) The impedance of an ultrasonic transducer is complex.
e) How does a transducer based on symmetric reflection improve the efficiency of the US equipment? (Picture)