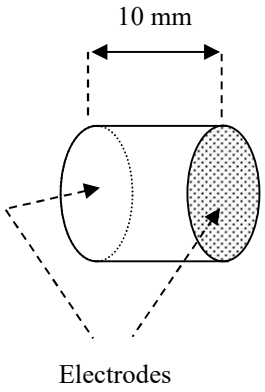
## EXPERIMENTAL PROBLEM[1]

The following equipment is provided:

1. Two piezoelectric discs of thickness 10 mm with evaporated electrodes (Fig. 4.1) fixed in holders on the jaws of the calipers;

Fig. 4.1




2. The calibrated sine wave oscillator with a photograph of the control panel, explaining the functions of the switches and regulators;
3. A double channel oscilloscope with a photograph of the control panel, explaining the functions of the switches and regulators;
4. Two closed plastic bags containing liquids;
5. A beaker with glycerin (for wetting the discs surfaces to allow better mechanical coupling);
6. Cables and a three way connector;
7. A stand for support the bags with the liquids;
8. Support and calipers.

A piezoelectric material changes its linear dimensions under the influence of an electric field and vice-versa, the distortion of a piezoelectric material induces an electrical field. Therefore, it is possible to excite the mechanical vibrations in a piezoelectric material by applying an alternating electric field, and also to induce an alternating electric field by mechanical vibrations.

**A.** Knowing that the velocity of longitudinal ultrasonic waves in the material of the disc is about $4 \cdot 10^3$ m/s, estimate roughly the resonant frequency of the mechanical vibrations parallel to the disc axis. Assume that the disc holders do no restrict the vibrations. (Note that other types of resonant vibrations with lower or higher frequencies may occur in the discs.)

Using your estimation, determine experimentally the frequency for which the piezoelectric discs work best as a transmitter-receiver set for ultrasound in the liquid. Wetting surfaces of the discs before putting them against the bags improves penetration of the liquid in the bag by ultrasound.

**B.** Determine the velocity of ultrasound for both liquids without opening the bags and estimate the error.

**C.** Determine the ratio of the ultrasound velocities for both liquids and its error.

[1] The Organizing Committee planned to give another experimental problem: a problem on high $T_c$ superconductivity. Unfortunately, the samples of superconductors, prepared that time by a factory, were of very poor quality. Moreover, they were provided after a long delay. Because of that the organizers decided to use this problem, which was also prepared, but considered as a second choice.

Complete carefully the synopsis sheet. Your report should, apart from the synopsis sheet, contain the descriptions of:

- method of resonant frequency estimation;
- methods of measurements;
- methods of estimating errors of the measured quantities and of final results.

Remember to define all the used quantities and to explain the symbols.

| **Synopsis Sheet**[2] | | | |
|---|---|---|---|
| | Formula for estimating the resonant frequency: | Results (with units): | |
| | Measured best transmitter frequency (with units): | | Error: |
| | Definition of measured quantity: Symbol: | Results: | Error: |
| | Final formula for ultrasound velocity in liquid: | | |
| | Velocity of ultrasound (with units): | | Error: |
| | Liquid A<br>Liquid B | | |
| | Ratio of velocities: | Error: | |

[2] In the real Synopsis Sheet the students had more space for filling.