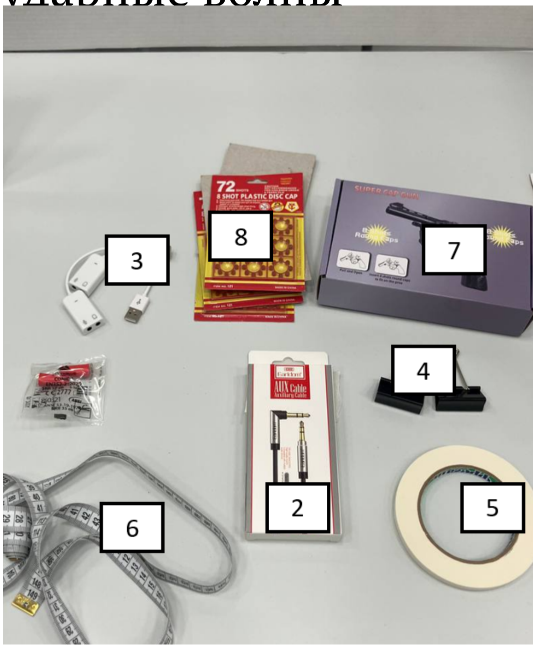
S2 - Взрывы и ударные волны

Оборудование:

1. Laptop
2. Two microphones
3. Tho sound cards
4. Two clips
5. Painter tape
6. Ruler
7. Gun
8. Percussion cap



Part A. Gunshot

To load the gun, pull the rod on the drum.

Connect the microphones through the sound cards to the computer. Launch the program "GetMic.bat".

In this program, you can use the «Record» button to record sound from both microphones, i.e., the dependence of the additional pressure Δp at the location of the microphone on time t. Using the «Acquire» button, you can smooth the already recorded data. The value $\Delta p = 0$ corresponds to atmospheric pressure $p_0 = 101\ \mathrm{kPa}$. The microphone readings are given in units proportional to pressure: $1\ \mathrm{a.u.} = 2\ \mathrm{mPa}$. If the message DEVICE NOT OK appears when both microphones are connected, reconnect the sound cards and microphones. If this does not resolve the issue, call the jury. To copy the coordinates of the point on the graph where the cursor is located, right-click the mouse. There is a delay of a few milliseconds between the triggering times of the microphones, which varies during the recording of the signal. To eliminate the influence of this factor, perform all measurements according to the following scheme:

1. Fire a shot midway between the microphones.
2. As quickly as possible, fire a shot in the studied configuration.

Instructions for data processing: All graphs must have **labeled axes**. **All columns** in all your tables must be labeled both in the file and on the answer sheets. Data processing and storage will be done using MS Excel. You can immediately record all measured quantities in spreadsheets. For the jury to correctly check your work, name the files exactly as specified in the instructions. On your computer's desktop, there is a folder named «*S2*». It contains files « *GetMic.bat* » «*explosion.mp4*» and a folder named «*First Name Last Name*». You must rename the folder to include your last name and first name; otherwise, your work will not be checked!!! After renaming the folder, open it. It contains subfolders with numbers corresponding to the sections they relate to, as well as a file «*Report.docx*». **Do not change the names of the subfolders or the file** «*Report.docx*»! In the subfolder of each section, save all measurements and solution files. All measured data must be formatted according to this template, named «*MesX.xlsx*», where X is the section number, and saved in the folder of that section. (For example, for question A1, the file with raw measurements should be named «*MesA1.xlsx*».) **Graphs with unlabeled axes WILL NOT be evaluated!**

All spreadsheet files must contain comments explaining what is happening and being calculated in each column. These comments must also be written on the answer sheets for the corresponding section. Solution files must be named «*SolX.xlsx*», where X is the section number, and saved in the folder of that section. (For example, for question A2, the solution file should be named «*SolA2.xlsx*».)

A1	Let the microphones be at a distance L apart. For different L, measure the delay Δt between the arrival times of the sound wave front (the first large pulse) at the microphones. The nearest microphone should be at a distance $L_0 = 3$ cm from the explosion. Perform 15 measurements for different L. Save the results of direct measurements in the file «*MesA1.xlsx*».	**2.5**

At sufficiently large L, the shock wave from the explosion has already significantly dissipated its energy by the time it reaches the far microphone and turns into an ordinary sound wave propagating at speed c.

A2	Determine the speed of sound in air cc. Copy the data from «*MesA1.xlsx*» into the file «*SolA2.xlsx*» and perform the necessary processing in «*SolA2.xlsx*». If a graph was used for processing, copy it into the file «*Report.docx*».	**0.5**

A3	Similarly to question **A1**, perform 8 measurements for $L < 50$ cm Save the results of direct measurements in the file «*MesA3.xlsx*».	**2.5**

A4	Plot the dependence of the radius R of the explosion wavefront on time. Perform the necessary processing in the file «*SolA4.xlsx*». Copy the final graph into the file «*Report.docx*».	**0.5**

Let's determine the energy of the shot.

A5	Record the shot fired at a distance $L_0 = 40$ cm from the explosion point. Click the «*Acquire*» button and obtain the smoothed dependence $p(t)$ for the explosion. Transfer 15 points from this curve to the file «*MesA5.xlsx*».	**2.0**

Waves in air are fast processes, and the processes occurring in the air are adiabatic, i.e., $pV^\gamma = \text{const}$ The adiabatic index $\gamma = 1.4$ for air.

The energy of the compression wave in air is:

$$E = \int \frac{\Delta p^2}{2\rho_0 c} dV,$$

where ρ_0 is the density of air at atmospheric pressure. The room temperature is $T_0 = 300$ K, and the gas constant is $R = 8.314$ J/(mol · K).

A6	Express the explosion energy E in terms of the dependence $p(t)$ recorded at a distance L_0 from the explosion, the adiabatic index γ, and the speed of sound c	**3.0**

A7	Determine the energy of the pistol explosion E in TNT equivalent. One ton of TNT equivalent is 4.184 GJ Perform the necessary processing in the file «*SolA7.xlsx*». Copy the final graph into the file «*Report.docx*».	**3.0**

Часть B. Взрыв

If we approximate the explosion with energy E as a spherical shock wave, its radius will depend on time as:

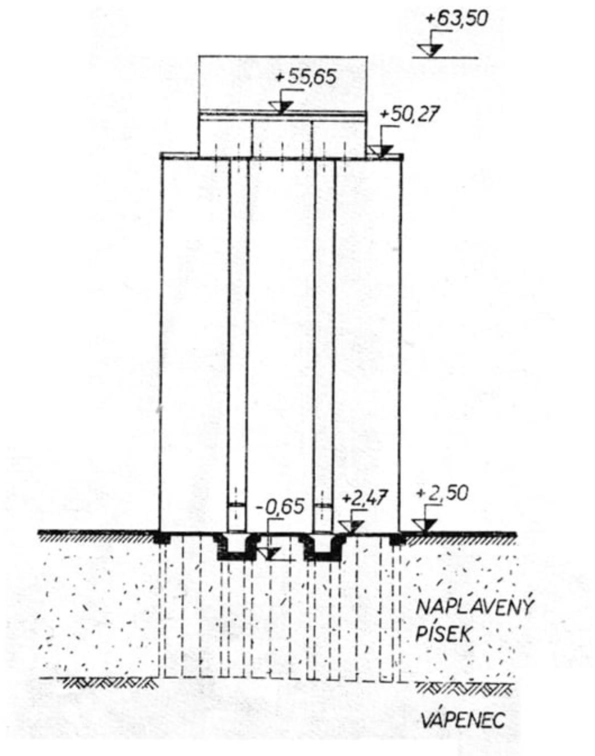
$$R(t) = S\rho^\alpha E^\beta t^\gamma,$$

where E is the explosion energy, ρ_0 is the density of air at atmospheric pressure. The dimensionless coefficient S is usually taken as unity.

B1	Determine the values of the coefficients α, β, γ	**1.0**

Watch the video clip «*Explosion.mp4*» of the explosion in Beirut on August 4, 2020.

Use the large white building located directly next to the explosion as a ruler. Its parameters are shown in the photograph, with data given in meters.



B2	For each video clip, measure the dependence of the fireball radius R on time t Note that the white spherical cloud formed during the explosion is not the shock wave we are studying. The video is slowed down by 50 times. To measure distances on the screen in pixels, you can use the key combination «Win» + «Shift» + «S» and Paint. ave the results of direct measurements in the file «*MesB2.xlsx*»	**4.0**

B3	Find the power of the Beirut explosion E in TNT equivalent. One ton of TNT equivalent is 4.184 GJ. Perform the necessary processing in the file «*SolB3.xlsx*». If graphs were used during processing, add them to «*Report.docx*».	**1.0**