Examination of the heart using ECG and PCG
I. Background theory.

1. Construction and functioning of the heart.
2. Electrical and mechanical aspects of a myocardial infarction:
   a) cell membrane action potential;
   b) resting potential and functioning of cardiac muscles;
   c) functioning of the heart’s electrical conduction system;
   d) electric dipole model of cardiac function;
   e) heart sounds.
3. Electrocardiography:
   a) action potential mechanism;
   b) recording electrical activity in the heart (ECG) – interpretation of waves, segments, intervals, QRS complexes;
   c) types of leads in an ECG;
   d) EMF vectors in the heart; electrical axes of the heart.
4. Conducting an ECG examination.
5. Phonocardiography – analysis of time-amplitudes and frequencies.
6. Description of physiology and pathology of ECG and PCG – characteristics.

II. Experimental tasks.

1. Refer to the set-up in Picture 1.

*Picture 1. Set-up for recording ECG and PCG signals: 1 – computer; 2 – amplifier; 3 – Cobra 3 module; 4 – ECG electrodes; 5 – scale.*
2. Prepare a 1% aqueous KCl solution (molecular weight - 74.55 g/mol).

3. Preparing a subject for an ECG exam:
   a) prepare compresses the size of the electrodes and soak them in a solution of KCl, then apply them to the skin where the electrodes are attached.
   b) the subject should sit relaxed, with hands resting on knees.
   c) attach the electrodes according to the scheme in Picture 2 of Appendix A – connect the red electrode to the right arm inside the wrist, the yellow electrode to the left arm inside the wrist and the green electrode on the left leg on the inner ankle.

4. An example set-up can be seen in Picture 2 of Appendix A.

5. Using the instructions in Appendix B, record an ECG using limb lead II according to Eindhoven for a control group (minimum of 3 men and 3 women aged 19 - 25 years, who have no history of circulatory or cardiac diseases).

6. Assemble the apparatus for PCG as shown in Picture 4 of Appendix A.

7. Following the instructions given in Appendix B, record a PCG for the control group.

8. Repeat ECG and PCG measurements for the control group after exercising.

9. Record ECG and PCG measurements for a subject(s) with a diagnosed cardiac disease / aged >25 years / after consuming energy drinks.

10. Save the PCG and ECG results to a .txt file and analyse with the software package ORIGIN.

11. Based on the ECG and PCG results, analyse the obtained measurement data:

   a) for the control group
      – combine the ECG data with their corresponding PCG results and interpret the ECG waves, sections, spacing and PCG sounds;
      – determine the isoelectric line for all recorded ECG waves; interpret;
      – analyse the observed ECG waves, segments, intervals: determine the average durations and amplitudes of waves for men and women studied before and after exercise;
      – compare the results for the men and women before and after exercise, and for the whole control group before and after exercise;
      – analyse the PCG heart sounds’ durations: find their mean value for the control group for women and men, before and after exercise;
      – calculate the heart rate based on the ECG results.
   
   b) for subjects with a diagnosed disease:
      – combine the ECG data with their corresponding PCG results and interpret the ECG waves, sections, spacing and PCG sounds;
      – determine the isoelectric line for all recorded ECG waves; interpret;
      – analyse the observed ECG waves, segments and intervals and determine the durations and amplitudes of the waves for each case;
      – analyse the PCG heart sounds’ durations: record the results for each case;
      – compare the wave durations, episodes, intervals, wave amplitudes and heart sounds for the control group;
      – calculate heart rate based on the results of the ECG;
      – based on the analysis, indicate the diagnosis for each recorded ECG based on the literature.
III. Apparatus.

1. Bioelectric signal amplifier.
2. Basic measuring unit: Cobra 3 BASIC-UNIT.
3. ECG electrodes (3 pieces).
4. Microphone.
5. Chemical reagents and equipment: KCl, distilled water, spatula, cylinder, compresses, disinfectant, disposable gloves, scale.

IV. Literature.

Experiment 12: Examination of the heart using ECG and PCG

Appendix A
Illustration of experiment 12

ATTENTION!
During the exercise, remember to respect the principles of occupational health and safety during the measurements: use disposable personal protective equipment and disinfectants.

![Electrode circuit diagram](image)

Picture 3. Electrode circuit diagram (according to Phywe).

ATTENTION!
Personal details of subjects and the results obtained are legally protected and may not be distributed. It is therefore necessary to use a system to anonymise the subjects.
Experiment 12: Examination of the heart using ECG and PCG

Measurements performed during the experiment are not true ECG results because they are not performed by trained personnel. The results can therefore not be used as a basis for the diagnosis and determination of the health status of subjects.

Picture 3. ECG Measuring system – bioelectric signal amplifier: 1 - control lamp; 2 - amplification gain switch (for ECG measurements × 100); 3 – mode switch (ECG mode – left position); 4 - input (connect 3 ECG electrodes using the bulk cable as shown in Picture 2); 5 – earth socket; 6 – trigger input; 7 – trigger output; 8 – amplifier output connected to the computer.

Picture 4. PCG measuring apparatus: 1 – measurement module socket; 2 – socket to connect other measuring units; 3 – analogue input 1 with range ±10V and ±30V; 4 – port for the sensor, measurement module and special equipment analogue input 1; 5 – sensor port for the measuring module and special equipment analogue input 2; 6 – analogue input 2 with ranges ±30V, ±10V, ±3V, ±1V, ±0.3V, ±0.1V; 7 – meter; 8 – time-gated meter; 9 - RS232 connection; 10 – supplemental measuring unit connection; 11 – connector and mounting foot; 12 - Cobra 3 interface socket; 13 – control lamp; 14 – constant voltage output (max. 5V); 15 – tripod link; 16 – “dovetail” adjustment; 17 – signal lamp; 18 – connector and mounting foot for connection to a supplemental measuring unit.

ATTENTION!

Measurements performed during the experiment are not true ECG results because they are not performed by trained personnel. The results can therefore not be used as a basis for the diagnosis and determination of the health status of subjects.
Appendix B

Description of the measurement procedure using the biomedical signal amplifier with the Cobra 3 BASIC-UNIT

I. Recording and electrocardiogram (ECG).

1. Start the program for ECG:

2. Initiate recording: Plik → Nowy pomiar

3. Set up the parameters: Dalej→ Rozpocznij pomiar

4. Record measurements:
   a) Plik → Zapisz pomiar jako...
Experiment 12: Examination of the heart using ECG and PCG

II. Recording a phonocardiogram (PCG).
   1. Set up the system as shown in Picture 2.
   2. Attach a microphone to the carotid artery of the subject.
   3. Initiate recording:
      Plik → Nowy pomiar

4. Set up the parameters: Dalej → Rozpocznij pomiar

5. Record measurements:
   a) Plik → Zapisz pomiar jako...
   b) Pomiar → Eksport wartości pom... (save to file with extension .txt).

**ATTENTION!**
Select the measurement range [V] depending on signal intensity.