General Medical Equipment
and
Medical Equipment Maintenance
Laboratory tasks

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Content

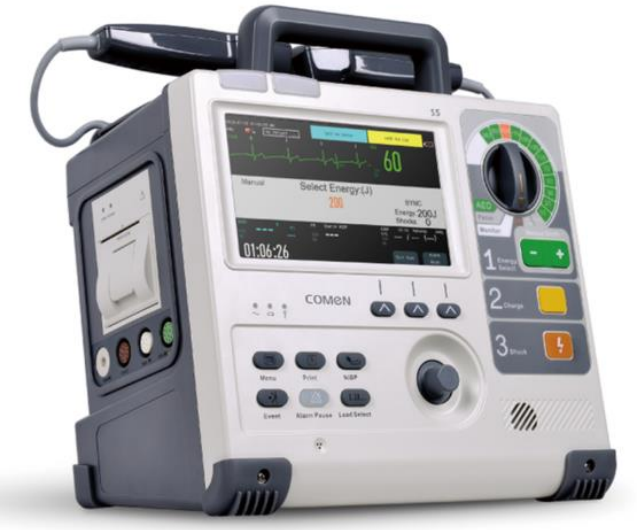
Defibrillator

Aim of the lecture:

- To learn how to use a defibrillator, including the differences between the different defibrillation operation modes.
- To know what safety tests are performed on defibrillators.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- What does it mean AED?
- What is the difference between defibrillation and cardioversion?
- What is the difference between monophasic and biphasic shock wave?
- What is the current, voltage, duration, and energy of the shock wave?
- What is a refractory and vulnerability zone?



Comen S5 Defibrillator

Tasks and measurements:

1. Take the user manual for the device Comen Defibrillator Monitor S5.

2. Read the information about the intended use and description of the device.
   a. What buttons are on the defibrillation paddles?
   b. What parameters does the device have connectors for?
   c. What parameters does the LCD screen display?

3. Explore the operating modes (Chapter 2.5).
   a. What operating modes does the device have?

4. Switch on the device (Chapters 3, 4 and 5).

a. Find out what Protective grounding and Equipotential grounding mean.

5. Set the parameter and screen style layout (Chapter 8).
- **a.** Set the speed, style, and color for different parameters.

6. ECG monitoring (Chapter 11).
- **a.** Read the information on the ECG monitoring.
- **b.** Select a volunteer, place the ECG electrodes on the volunteer, and start ECG monitoring according to the information in the manual.
- **c.** Set the ECG lead type you want to monitor.
- **d.** Set wave gain.
- **e.** Set filter mode.

7. Perform ST segment analysis and arrhythmia analysis (Chapters 11.6 and 11.7).

8. Read the instructions for using the AED operating mode (Chapter 14).

9. Print the measured ECG recording (Chapter 20).
- **a.** Set the recorder for printing.
- **b.** Insert the paper into the recorder.
- **c.** Print the ECG.

!!! ATTENTION !!!

In this task, follow the instructions of the lecturer and follow the manual of the defibrillator carefully. Apply defibrillation shocks only when instructed by the lecturer and in the presence of the lecturer. If these instructions are not followed, there is a risk of serious electric shock!

10. Measure the defibrillator charging time using the stopwatch at the selected pulse energy of 100, 200 and 360 J for the defibrillator disconnected from the mains. Compare these values with the charging times when the defibrillator is connected to the mains and with the values given in the device manual.

11. Perform maintenance of the device according to the manual (Chapter 24).
- **a.** Study the Maintenance and Test Schedule and the reusable accessory service life.
- **b.** Perform the Defibrillation Monitor Shift Checklist according to Appendix VII.
- **c.** Perform the User Test.
- **d.** Perform Recorder Test.
- **e.** Perform ECG Cable Test.

12. Perform ECG Calibration (Chapter 24.11).
- **a.** Password is “5188”.

References:

- Defibrillator Monitor S5 User’s Manual
- Defibrillator Monitor S5 Service Manual

Electrosurgical Unit

Aim of the lecture:

- To learn to use the electrosurgical unit in monopolar and bipolar mode.
- To understand the difference between coagulation and cutting.
- To understand how to ensure the safe use of the electrosurgical unit.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

1. Assign the thermal effects on the tissue to the most correct temperature range:

Temperature	Effect
< 45 °C	Tissue dissection
45–60 °C	Reversible changes
60–100 °C	Tissue carbonization
> 100 °C	Coagulation of proteins

2. Assign to each frequency range of electric current its most typical effect on tissue:

Frequency range	Effect
Galvanic current	Electro analgesic
Around 50 Hz	Electro stimulating
Around 100 Hz	Electrochemical
Around 3 MHz	Thermal

3. Assign to each mode of the electrosurgical unit the predominant desired effect on the tissue:

Mode	Effect
Cut	Tissue dissection
Coagulation	Reversible changes
	Tissue carbonization
	Coagulation of proteins

4. Which of the following statements about the electrosurgical unit is true:

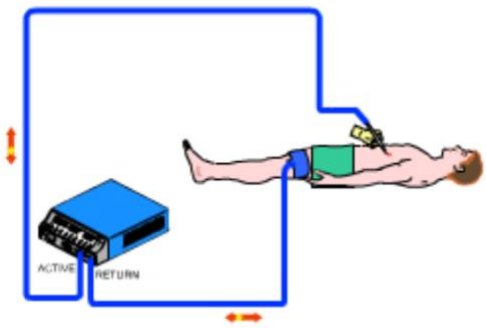
a. The penetration into the tissue is ensured by the cutting edge of the cutting tool. An electric current passes through the cutting tool and heats the cutting tool. The high temperature of the cutting tool ensures coagulation around the incision wound and prevents bleeding.

b. Penetration into the tissue is ensured by evaporation of the tissue due to the thermal effects of the high-frequency electric current applied to the tissue by the cutting tool. Part of the thermal energy is transferred to the surrounding area of the incision wound to ensure coagulation.

c. Penetration into the tissue is ensured by evaporation of the tissue due to the thermal effects of galvanic electric current applied to the tissue by the cutting tool. Part of the thermal energy is transferred to the surrounding area of the incision wound to ensure coagulation.

d. Penetration into the tissue is ensured by the cutting edge of the cutting tool. An electric current is applied to the tissue by the cutting instrument, which heats the tissue and thus coagulates it.

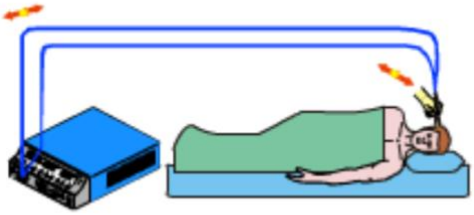
5. The picture shows which mode of use of the electrosurgical unit?



a. Monopolar

b. Bipolar

6. The picture shows which mode of use of the electrosurgical unit?



a. Monopolar

b. Bipolar

SMT BM 125 Electrosurgical Unit

Tasks and measurements:

1. Take the user manual for the SMT Electrosurgical Unit.
2. Find out what are the essential parts of the device and what are the other compatible attachable parts.
3. Read the description of front and back panel.
4. Prepare the device for use according to Chapter 5.3.
5. Read the cautions in Chapter 5.4 before use.
6. Set the monopolar mode, connect the neutral and active electrode.
7. Place the meat on the neutral electrode.
8. Try all types of operation outputs (coagulation, cut, blend cut, microcoagulation) and discuss the differences.

Note: Press the footswitch to start.

9. Try the same in bipolar mode.

10. When finished, clean the tools used.

Additional questions, answer them in the laboratory protocol:

- What is an active electrode and what is a neutral electrode?
- What causes the use of the Electrosurgical Unit in ECG monitoring?

References:

- Electrosurgical Unit SMT User's Manual

Electrotherapy

Aim of the lecture:

- To learn to use the electrotherapy unit.
- To be able to perform basic maintenance of the device.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- What is the purpose of electrotherapy?
- What current density must not be exceeded?
- What is carrier and base frequency?
- What does it mean rheobase and chronaxie?

Astar Etius Electrotherapy Unit

Tasks and measurements:

1. Read the intended use of the device (Chapter 2) and the unit description (Chapter 5).

2. Proceed the device installation and start-up (Chapter 6).

3. Follow-up with the patient preparation (Chapter 7).

4. Study the types of treatment programs and sequences, as well as their indications and contraindications (Chapters 8 and 9).

5. Check the cable and electrode condition (Chapter 10.3).
6. Check the electrode condition also using the alternative method (Chapter 10.3.2).

7. Perform the fuse replacement (Chapter 10.5).

!!! ATTENTION !!!

In this task, follow the instructions of the lecturer and follow the manual of the electrotherapy unit carefully. Start the therapy only when instructed by the lecturer and in the presence of the lecturer. If these instructions are not followed, there is a risk of skin irritation and burns.

8. Measure the I/t curve on the deltoid muscle (Chapter 7.8).

    a. Connect the patient's cable to socket A.
    b. Attach the rubber electrodes to the red and black banana plug of the patient cable.
    c. Moisten the viscose yellow pads and insert the rubber electrodes into them (the water should be warm and should not drip from the pads).
    d. Properly attach the electrodes with viscose pads ventrally and dorsally to the deltoid muscle using elastic bandage.
    e. Proceed according to the instructions in Chapter 7.8.

9. Try out one of the preset treatment programs on your body.

Principles for proper electrotherapy procedure:

When using electrotherapy, it is important to follow certain principles and principles to achieve optimal results and minimize the risk of side effects. Here are some important points to watch out for:

Diagnosis and indications: Electrotherapy should only be applied where clinically indicated.

Contraindications: These may include the presence of metal implants, epilepsy, pacemakers, etc.

Suitable type of electrotherapy: There are several different types of electrotherapy such as TENS (Transcutaneous Electrical Nerve Stimulation), EMS (Electrical Muscle Stimulation) or interferential therapy. It is important to choose the right type according to the goal of the therapy and the needs of the patient.

Correct electrodes placing: The electrodes should be correctly placed on the patient's body in accordance with the therapeutic goal. The correct placement of the electrodes can influence the effectiveness of the therapy.

Intensity and frequency: Adjustment of stimulation intensity and frequency should be made individually according to the patient's tolerance and the therapy goal. Too high an intensity may cause discomfort or even tissue damage.

Patient monitoring: During therapy it is important to continuously monitor the patient's response and adjust the stimulation parameters if necessary.

Safety: Make sure that the equipment used for electrotherapy is in good condition and meets safety standards. Ensure patient safety when handling electrodes and adjusting parameters.

Instructions to patients: Patients should be well informed about electrotherapy procedures, including what to expect, what sensations they may experience, and how to behave after therapy.

References:

- Electrotherapy Etius User's Manual

Electrotherapy 2

Electrotherapy uses a wide range of currents, from galvanic to high frequency. Galvanic currents have an electrolytic effect on tissue, causing ions to leach out of cells and causing an increase in local metabolism. Low-frequency currents then exert an irritant effect (stimulant, analgesic, myorelaxant, antiedematous, or trophotropic), and as the frequency increases, the thermal effects of the current gradually dominate with decreasing irritation.

Aim of the lecture:

- To understand the principles and physical background of electrotherapy and become familiar with the various electrotherapy modalities and their mechanisms of action.
- To improve skills in the practical application of electrotherapy devices, including electrode placement, parameter adjustments, and safe operation techniques.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- What is the frequency of the galvanic current?
- What is the frequency of the electrical current which can affect the function of the heart?

Astar Etius Electrotherapy Unit

Tasks and measurements:

1. Using an electrotherapy unit, oscilloscope and resistance decade, try to monitor and record the pulse shape, amplitude, width and repetition rate for the following therapeutic current settings:
    - **a.** TENS
    - **b.** Diadynamic currents
    - **c.** Rectangular pulse currents
    - **d.** Triangular pulse currents
    - **e.** Russian stimulation (Kotz)
    - **f.** USS – Unipolar Sine Surge
    - **g.** Microcurrents
    - **h.** Galvanic Current

Note: Scan the waveforms with a digital oscilloscope on a load resistor with a resistance value of 1 kΩ. Set the parameters and types of therapeutic currents. Set the time and start the application with the START button. Then increase the current intensity to 2 mA. You can interrupt the application at any time with the STOP button.

2. Measure the dependence of the output current at the set TENS current on the size of the load resistor for resistance values of Ω100, Ω200, Ω500, kΩ1, kΩ2, kΩ5, kΩ10, kΩ20.

Note: Select the Russian Stimulation currents waveform and connect a resistor decade instead of the original 1 kΩ load resistor on decade. Select the current mode on the device and the first resistance value on the resistor decade. Enter the application time (approx. 20 min), start the program and set the current intensity to 5 mA. When changing the resistance to the next value, make sure that there is no short circuit (i.e. always set a resistance of at least 100 Ω on the resistance decade).

3. Perform the electrotherapy on yourself using the device accessories. Do an experimental sensitivity test with your colleagues. Record the stimulation threshold and the sensations during stimulation.

Additional questions, answer them in the laboratory protocol:

- How do contraindications and safety precautions differ when using electrotherapy in different types of patients?
- How does the choice of electrotherapy device parameters affect the therapy outcomes and patient comfort?
- What is the importance of the correct current density setting when applying electrotherapy and how can it affect therapeutic outcomes and patient comfort? How can be the density of the electric current also changed?

References:

- Electrotherapy Etius User's Manual
- OWON SDS1022 Digital Oscilloscope User's Manual

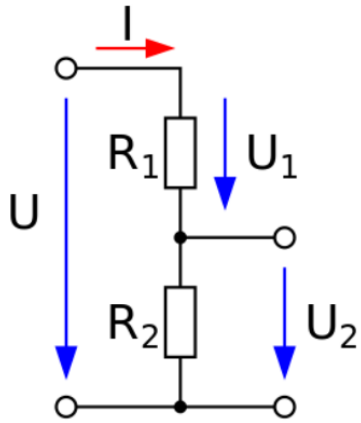
Temperature

Aim of the lecture:

- To understand the principle of temperature measurement using thermistors and their connection to a Wheatstone bridge circuit.
- To learn how to calibrate the temperature sensor of a vital signs monitor.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- Calculate the voltage drop of U_2 if the supply voltage is U = 5 V, R_1 = 400 Ω and R_2 = 4 kΩ.



$$U_1 = U \cdot \frac{R_1}{R_1 + R_2}$$

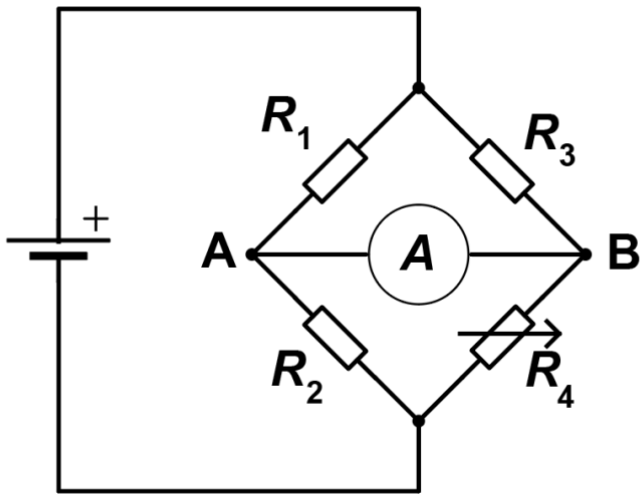
- Define a thermistor and explain the difference between NTC and PTC thermistors.

Tasks and measurements:

1. Connect all parts of the measuring apparatus. The components in the circuit are following:
   a. R_1, R_3 - known electrical resistances,
   b. R_2 - unknown resistance,
   c. R_4 - resistance decade,
   d. A - Ampere meter.

The bridge usually consists of two branches connected to a DC power supply. The two branches act as a voltage divider. The current flowing through the meter is proportional to

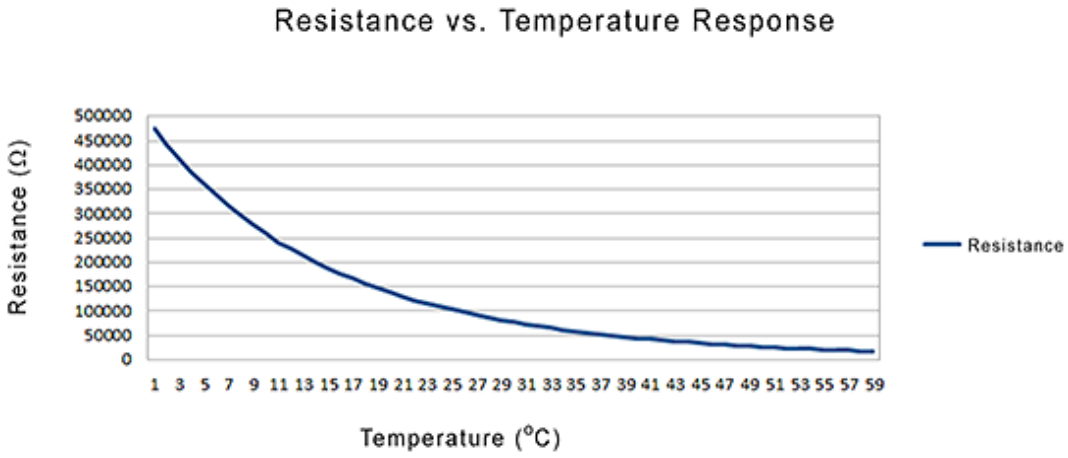
the potential difference of the two dividers. If the bridge is balanced (no current flows through the Ampere meter), the ratio of resistors in the two branches is the same.



2. Connect the Ampere meter to inputs A and B. Use a resistive decade to balance the Wheatstone bridge. The bridge is balanced when the electrical current between the points A and B is zero.

3. Based on the values of resistors R_1, R_3 and R_4, calculate the value of resistance R_2. The electric resistances of resistors are R_1 = 681 kΩ and R_3 = 39 kΩ.

4. Using the following graph, determine what temperature the sensor records when you calculate the electrical resistance of R_2.



5. Perform the Temperature accuracy test (Chapter 4.2.7) on the vital signs monitor EDAN X10 using the service manual. A resistive decade can be used instead of a "resistance box" for the calibration. Proceed according to the steps in the manual and decide if the temperature measurement is accurate enough.

6. Measure the temperature on yourself with the vital signs monitor.

Additional questions, answer them in the laboratory protocol:

- Would it be possible to check the balance of the bridge between points A and B with a voltage meter instead of an ampere meter?
- Explain the principle of a Wheatstone bridge. How does it determine an unknown resistance? Why is it convenient to use a Wheatstone bridge to measure temperature when using a thermistor?

References:

- Edan X10 vital signs monitor User's Manual

Invasive Blood Pressure (IBP)

Aim of the lecture:

- To understand the principles and physical background of the invasive blood pressure measurements and become familiar with the measurement process.
- To improve skills in working with different pressure units and performing calculations.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- Convert the following pressure values:

Pressure	**Expression in another unit of pressure**
80 mmHg	mbar
120 mmHg	atm
300 mmHg	cmH_2O
3 bar	Pa
50 cmH_2O	mmHg

Tasks and measurements:

1. Assemble the blood pressure measurement set-up and attach it to the patient's bloodstream model (glass container with red fluid).

2. Create a voltage-to-pressure calibration line for pressure values from 80 mmHg to 180 mmHg. To do so, convert the units from bar to mmHg.

3. When creating the calibration line, measure the voltage on the output of the pressure sensor when the pressure is zero. This value is offset which must be subtracted from all the voltages measured by multimeter.

4. Determine the effects of the created calibration equation on the measurement uncertainty you would write in the instruction manual for the catheter you are calibrating.

5. Place the patient-simulating vessel on the elevated part of the workbench and use the calibration equation to determine the height of the elevated part of the workbench.

Note:

Invasive blood pressure apparatus setup: To measure arterial blood pressure, the set needs to be flushed, for which a so-called pressurised infusion cuff is used. Placing the infusion solution bag together with the pressure bag of this cuff in one mesh bag and inflating the pressure bag increases the pressure in the infusion solution bag, which is forced out to flush the system. This ensures that the catheter pressure tubing is flushed of blood and vented.

Flushing the system ensures that no blood clots are formed in the pressure tubing that could enter the bloodstream. By venting, it is possible to prevent air embolism in the blood vessels.

Connect the correct luer port in the cap of the patient simulation bottle to the pressure measurement chamber with the tubing (use your expert judgement to determine which luer port is correct). Connect the wires according to their descriptions to the laboratory source (red wire, label +5V; black wire, label GND) and to the multimeter (blue wire, label SIG+; green wire, label SIG-). Connect the remaining luer port to the pressure source with the black tubing of the patient model.

Pressure source connection: Connect the Festo pressure reducing valve to the air compressor. To the outlet of the Festo valve connect the precise RPM 12-400 pressure valve. Then, connect the patient's bloodstream model to the outlet of the RPM 12-400 pressure valve (Connect the source of the air pressure to the tube which ends above the blood level inside the model. The second tube which ends at the bottom of the bottle connect to the pressure sensor.). By changing the pressure on the RPM 12-400 pressure valve, you will be able to change the pressure inside the patient's bloodstream model and see the voltage changes on the multimeter.

Additional questions, answer them in the laboratory protocol:

- What is a calibration curve? In your laboratory protocol, make a calibration curve based on your measurements.
- What pressure must the flushing solution have to perform its function reliably?
- Calculate the pressure at the bottom of the glass container due to the force of water (density 1000 $kg \cdot m^{-3}$). The level of water is 10 cm from the bottom of the container. State the relative pressure expressed in pascals.

Neonatal scale calibration

Calibration and verification of medical devices is a key element in the field of biomedical technology, where measurement accuracy plays an important role in making decisions about patient care procedures. This task will highlight key calibration steps and approaches to determining A and B measurement uncertainties, with an emphasis on compliance with regulatory requirements and required procedures. Verification is a necessary element to ensure the reliability and accuracy of neonatal scales in the healthcare environment.

Aim of the lecture:

- To understand and learn how to correctly perform the procedure of the verification of a neonatal scale as a medical device with measurement function.
- To understand to measurement uncertainties, get to know how to calculate and interpret the measurement uncertainties.

Calibration procedure for scales with non-automatic operation

The calibration procedure applies to scales with non-automatic operation included in the category of working meters with an upper limit of the measuring range of 10 kg from the accuracy allowed by the best measuring capability of the laboratory.

- Calibration conditions
    - Calibration of scales is carried out at the place where they are used and under conditions similar to those of use. It is assumed that influences such as vibration, air flow, etc. are already included in the measurement uncertainty.
    - The scales should be placed in the room on a fixed table so that they are protected from vibrations, drafts, and there is no one-sided heating of the scales and sudden changes in the room temperature. If the temperature is not specified by the manufacturer, then the constant temperature should not be too different from the temperature at which the scales were adjusted.
    - The temperature is considered constant when the difference between the extreme temperatures recorded during the test does not exceed 1/5 of the temperature range of the given scales but must not be greater than 5°C and the rate of change does not exceed ± 2°C per hour with a maximum of ± 3.5°C per 12 hours. The recommended humidity during calibration is in the range of 40% ÷ 60% with a maximum deviation of 15% in 4 hours.
    - The calibration is carried out at a temperature and relative air humidity, the values of which fall within the prescribed working range of the scale (usually indicated in the scale manual or on the scale label).
    - If the manufacturer does not specify a temperature range, the recommended values are from +10°C to +30°C.

- Procedure of calibration
    - Cleaning – The scale must not show obvious signs of damage and contamination. Small dirt is removed from the scales by blowing, using a brush or gentle wiping. If necessary, the scales are cleaned and adjusted by a professional service before calibration.

- Tempering – The temperature stabilization of the standard weights is carried out by storing them for a sufficient time near the scale to prevent the indication from changing due to air convection. The balance must be connected to the power source for a sufficient time before calibration (e.g. as recommended by the manufacturer or user).
- Preparation of calibration – Checking the reference position. (If the scale is equipped with a setting device and a position indicator, the setting of the scale is checked before the actual calibration.) Before calibration, the scales are pre-loaded approximately to the upper intermediate weighing capacity. The data needed to calibrate the meter is recorded in the worksheet.

- Calibration itself
  - Zeroing - the zeroing device must enable accurate zeroing and must not cause incorrect measurement results. The actual calibration consists of a repeatability test, a load eccentricity test and a weighing test.
  - Repeatability test – Two weighing series are performed, one with a load of approximately 1/3 Max and one with a load close to 2/3 Max. Each series must consist of at least 10 weighings. The reading is taken when the balance is loaded and when it has settled to zero after being unloaded between weighings, the number of pieces of weight being as few as possible.
  - Eccentric load test – Four quarter sectors, approximately equal to ¼ of the surface of the load carrier, must be loaded in a row with a test load with a value of 1/3 Max to the centre of gravity of the sectors in the following positions: centre, rear left, rear right, front left and front right. This test is not performed on scales where, due to construction, an eccentric load cannot occur (suspended pan, scales using a special device for centering the load, etc.).
  - Weighing test – At least five loads with different values evenly distributed over the calibrated range must be selected to determine the error. Selected test loads must include Max and Min. When weighing, increasing loads must be used in increments, with the scales being lightened between increments.

- Evaluation
  - Error calculation - Errors in load ratings are determined by comparison with secondary weight standards. The error (determined as the difference: the weight reading minus the load value) is expressed in the form of the standard weight.
  - So, we calculate the error according to the formula:

$$E = I - L,$$

where *I* is the average of the indications from repeated measurements of the same value and *L* load of the scale with the standard weight.

  - Determination of uncertainties - The standard uncertainty of type A is determined from repeated measurements of the same value under the same conditions by statistical methods. The A-type standard uncertainty is equal to the sample standard deviation and is determined from the:

$$u_{Ax} = \sqrt{\frac{1}{n \cdot (n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

where *n* is the number of measurements and $\bar{x}$ is the mean value. If the number of repeated measurements is less than 10, a correction for the number of measurements is made by multiplying by the coefficient *tr* according to the relationship:

$$u_A = tr \cdot u_{Ax}$$

The tr coefficient value depends on the number of measurements:

n	2	3	4	5	6	7	8	9	≥10
tr	7.0	2.3	1.7	1.4	1.3	1.3	1.2	1.2	1

- Determination of uncertainties - Type B uncertainties is based on non-statistical approaches. Type B uncertainty is estimated based on all available information. For example, data from the manufacturer of the measuring equipment, experience from previous series of measurements, knowledge of the behaviour of the materials, data obtained during calibration, and perhaps uncertainties in reference data in manuals. This is based on the partial uncertainties of each source. If the maximum deviation of the j-th source is known, then the uncertainty of the j-th source is determined by the relation:

$$u_{Bzj} = \frac{z_{jmax}}{k}$$

The value of *k* is a coefficient based on the distribution of the values ($\sqrt{3}$ for equal distribution and 2 for normal distribution). By summing the squares of all B-type uncertainty sources, we calculate the B-type standard uncertainty.

$$u_B = \sqrt{{u_{Bzj}}^2 + {u_{Bzi}}^2 + {u_{Bdj}}^2}$$

- Combined standard uncertainty - The sum of the squares of the standard uncertainties of types A and B gives the square of the combined standard uncertainty u_C.

$$u_C = \sqrt{{u_A}^2 + {u_B}^2}$$

The expanded standard uncertainty *U* is given by:

$$U = k \cdot u_C$$

where *k* is the expansion coefficient. The value *k* is chosen to be 2. With a normal probability distribution, this means that the true value lies with a probability of 95% in the interval defined by the expanded uncertainty.

- Calibration results
    - During the calibration, the measured values are recorded in the worksheet. Based on these data, a calibration sheet is drawn up.

- Validation and maintenance of the calibration procedure
    - This calibration procedure is validated during regular interlaboratory comparisons of tests usually organized by Metrological Institute. At least once a year, the validity of the calibration procedure is checked.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- What is the Type A measurement uncertainty? How it can be calculated? Describe the steps from which Type A uncertainty is determined.
- What is the Type C measurement uncertainty? How it can be calculated? Describe the steps from which Type C uncertainty is determined.

T-Scale FOX-I-BABY Infant Scale

Tasks and measurements:

1. Using the reference calibration weights kit, verify the accuracy of the neonatal scale T-Scale FOX-I-BABY.

2. Create a summary of the measurement conditions that should be met for the calibration/verification to take place according to the requirements mentioned above. Is it possible to use the presented weights for the correct calibration procedure?

3. Carry out the calibration according to “Calibration itself”.

4. Based on your measured values and findings from points “2.” and “3.”, use the procedure in the above-mentioned document to determine the type A and B uncertainty.

5. Evaluate whether the measurement accuracy of the neonatal scale is in accordance with the accuracy given by manufacturer.

Additional questions, answer them in the laboratory protocol:

- How often should newborn scales be calibrated/verified?
- What should be done if the neonatal scales do not pass calibration or verification?

Principles for proper calibration procedure:

When conducting the verification and calibration process for measuring equipment like neonatal scales, it's important to pay attention to several key aspects to ensure the accuracy and reliability of measurement results. Here are some fundamental points to consider:

Standard Reference Materials and Weights: Use calibration weights and materials that are accurate for the specific application and traceable to standards of a national or international metrological institution.

Environment: Ensure that environmental conditions (temperature, humidity, vibrations, etc.) are stable and in accordance with recommendations for calibration.

Equipment Condition: Check the scales before starting calibration to ensure they are undamaged, clean, and functioning correctly.

Pre-calibration and Zeroing: It's important to ensure that the scales are at a zero state without any weights before starting calibration.

Documentation: All steps and results of the calibration should be thoroughly documented for future reference and auditing.

Calibration Procedure: Follow standard operating procedures and the instrument manufacturer's guidelines or international calibration guidelines.

Post-calibration Verification: After calibration, verification is necessary to ensure that the scales are measuring accurately across their entire range.

Troubleshooting: If scales fail calibration, identify the cause, and resolve the issue before the instrument is used again.

Calibration Frequency: Ensure that calibration is performed at regular intervals according to the manufacturer's recommendations or internal procedures.

Personnel Qualification: Ensure that calibration is conducted by qualified and trained personnel.

Traceability: Calibration must be traceable to national or international standards.

Legislation and Standards: Comply with all relevant laws, regulations, and industry standards, including those related to patient personal data protection.

Safety: Follow safety procedures when handling calibration weights and instruments.

References:

- T-Scale neonatal scale User's Manual

Spirometry

Aim of the lecture:

- To learn to use the spirometer for spirometry testing.

- To learn the terminology of the parameters relating to human respiratory function.
- To be able to perform basic maintenance of the device.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- What parameters are measured during the spirometry testing?
- What is the physical principle of flow and volume measurement?
- What are the ranges and accuracies for flow and volume measurements?

MIR SPIROBANK II Spirometer

Tasks and measurements:

1. Switch on the Spirometer Spirobank II Basic.

2. Set the date and time in service menu.

3. Select the type of turbine (reusable or disposable).

4. Perform the turbine calibration with the calibration syringe (insert the password from the User's Manual).

5. Insert the data for a new patient.

6. Spirometry testing
    a. Insert the turbine in the appropriate housing until it reaches the mechanic stop and successively rotate the turbine clockwise until it stops.
    b. Insert the mouthpiece at least 0.5 cm inside the groove of the turbine.
    c. Place the nose clip on the nose.
    d. Hold the Spirobank II with both hands. The display must always face the patient taking the test.
    e. Perform the FVC test according to the instructions on the screen (it is possible to repeat the test several times).
    f. Perform the VC test.
    g. View the spirometry results and and discuss the acceptability, usability and repeatability of the results according to the User's Manual.
    h. Try to interpret the spirometry results.

7. Perform the proper turbine operation check according to the User's Manual.

References:

- Spirometer Spirobank II User's Manual

Suction Unit

Aim of the lecture:

- To learn to use the suction equipment.
- To be able to perform basic user maintenance of the device.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- For what purpose are suction units used?
- What is the vacuum pressure usually used for suction?
- What consumables are used for suction?
- What units are used for suction?

ASPEED 2 Professional Suction Unit

Tasks and measurements:

1. Check the cleanliness of the individual circuit components.
2. Connect the device as shown in Figure 1 in ASPEED2 User's Manual.
3. Switch on the device.
4. Set the required vacuum pressure by the rotary knob (the magnitude of the vacuum pressure can be checked by plugging the suction port).

!!! ATTENTION !!!

Never do this to check the vacuum pressure created by the vacuum pump from the vacuum distribution system.

5. Check that the maximum vacuum pressure is between 0.80–0.85 bar.
6. Check that the float inside the bottle is placed in the correct position.

7. Suction the prepared liquid (e.g. water) and check that the suction is interrupted when the bottle is completely filled.

References:

- Suction equipment ASPEED 2 User’s Manual

Maintenance of Suction Unit

Aim of the lecture:

- To be able to perform maintenance of the device.
- To learn how to change components of the device.

Introductory questions:
Please, answer the questions in the beginning of the laboratory task.

- What tests should be performed to check that the suction unit is working properly?

ASPEED 2 Professional Suction Unit

Tasks and measurements:

1. Visually check the cover and power cord for integrity.

2. Always check that the plug is removed from the power socket before opening the device. Do not attempt to adjust the machine if it is under tension.

3. The device case is formed by two metal halves attached together by 4 screws on the side of the bottom half. To open the device, loosen these screws and disconnect the earth connection on the casing.

4. Check the fuse.

5. Check the electrical continuity as follows:
    a. using an electronic measurement tester, select a 200 ohm scale,
    b. turn the switch to ON,
    c. attach the tips of the tester to the plug connectors,
    d. the resistance detected by the tester should normally be (for temperatures of approx. 25°C) about 33 ohm with tolerance ± 5%,
    e. if the tester detects a resistance value close to zero, then there is a short-circuit and the motor unit needs to be replaced.

6. Check the state of the electrical connections and check that they are all correctly connected.

7. If liquid accidentally enters the device, do NOT switch it on. Open the device, dry the damp parts and leave the device open so that the interior dehumidifies completely. Only then, and with utter caution, should the machine be switched back on.

8. Change the vacuum gauge:
    a. gently detach the rubber pipes,
    b. press simultaneously on the two attachment devices on the sides of the vacuum gauge and extract the gauge from the face of the device,
    c. insert the new vacuum gauge and reconnect the suction pipes.

9. Change the ON/OFF switch.

10. Change the motor unit.

11. Assemble and screw together the device.
12. Perform an electrical safety test.

13. Measure whether the measured vacuum pressure on the vacuum gauge corresponds to the pressure measured by the reference vacuum gauge.

14. Make this measurement at least at 5 levels of set vacuum pressure.

References:

- Suction equipment ASPEED2 User's Manual
- Suction equipment ASPEED2 Service Manual