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**FEDERAL STATE AUTONOMOUS EDUCATIONAL INSTITUTION OF
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NORTH-CAUCASUS FEDERAL UNIVERSITY**

Methodological Guidelines
for Students on arranging and performing independent work
in the Discipline of Physics
for Students majoring (Specialty) in 31.05.01 General Medicine

Methodological Recommendations for Studying Theoretical Material

When performing the independent study of theoretical material, the student must follow the rules as set below. The working curriculum of the respective academic discipline shall be recommended to be used as the basis for such activity. According to the schedule of classroom lessons and independent work, a different number of hours is to be allocated for studying individual topics. A significant portion of the student's independent work should be allocated to mastering the material on the covered topic, writing a summary (notes) on the specified theoretical blocks, and searching for additional literature based on the NCFU library and via the Internet system. The lecture material shall not cover all theoretical material; the greater part of it must be mastered through independent work. Given the above, working with the recommended literature is mandatory. Special attention must be paid to the content of the main provisions and conclusions, the explanation of phenomena and facts, and the understanding of the practical application of the theoretical issues under consideration. In the process of this work, the student should strive to understand and memorize the main provisions of the material being considered, the examples illustrating it, as well as to understand the illustrative material. Preparation should be completed by drawing up a plan (summary/notes) on the material (issue) being studied. This allows for the creation of a concentrated, concise representation of the issues being studied. First, studying the recommended literature is to be done. Special attention must be paid to the content of the main provisions and conclusions, the explanation of phenomena and facts, and the understanding of the practical application of the theoretical issues under consideration.

During this work, the student should strive to understand and memorize the main provisions of the material being considered, the examples illustrating it, as well as to understand the illustrative material. Preparation should be completed by drawing up a plan (summary/notes) on the material (issue) being studied. This allows for the creation of a concentrated, concise representation of the issues being studied. If necessary, one should seek (advice) consultation from the instructor. When going to a consultation, it is necessary to thoroughly think through the questions that require clarification. Keeping records contributes to turning reading into an active process, mobilizing motor memory along with visual memory. The following should be born in mind: a student who systematically keeps records creates their own individual stock of auxiliary materials for a quick review of what has been read and for the mobilization of accumulated knowledge. Records are especially important and useful when they reflect the thoughts that arose during independent work.

It is important to develop the students' capacity to compare sources and to think through the material being studied.

Improving note-taking skills among students is of great importance.

The instructor may recommend the following main forms of recording to students: a plan (simple and detailed), excerpts, and theses (abstracts).

The results of note-taking can be presented in various forms.

- A plan is an outline of the read material, a brief (or detailed) list of questions reflecting the structure and sequence of the material.
- A detailed plan fully replaces a summary.
- A summary (notes) is a systematized, logical presentation of the source material. Four types of summaries are distinguished:
 - Outline-summary (Plan-notes) – this is an expanded, detailed plan in which sufficiently detailed records are provided for those points of the plan that need explanation.
 - Textual summary – this is the reproduction of the most important provisions and facts of the source.
 - Free summary – these are clearly and briefly formulated (stated) main provisions resulting from a deep understanding of the material. It may contain excerpts, quotations, and theses; part of the material may be represented by a plan.

- Theme-based summary – this is compiled on the basis of studying a number of sources and gives a more or less exhaustive answer according to a certain scheme (issue).

Methodological Guidelines for the Preparation for Practical Activities

When preparing for practical activities, the recommendation implies studying the control questions for the given lesson and the theoretical material from one's own notes.

The main form of work during the lessons is an interview (discussion). Each student must be ready to speak on all issues raised in the plan and demonstrate maximum activity during their consideration.

The speech must be constructed freely, convincingly, and with arguments. The instructor ensures that the speech is not reduced to a reproductive level (simple reproduction of the text); simple reading of the summary is also not allowed.

It is necessary for the speaker to show their own attitude towards what they are talking about, express their personal opinion and understanding, substantiate it, and be able to draw the correct conclusions from what has been said. In doing so, the student may refer to the entries in the summary, directly to the primary sources, use knowledge of previously studied disciplines, etc. In addition, to obtain a grade at an advanced level, students solve situational tasks based on the results of the mastered topics.

During the execution of practical works, a defense of practical skills is provided, the full list of which is specified in the fund of assessment tools.

Use these guidelines to help students prepare effectively for practical sessions and get the most out of the questions below.

1. Core reading.

Before each class, students should read the corresponding chapter in a standard university physics textbook (e.g., Halliday, Resnick & Walker; Serway; Giancoli) and the lecture notes. For medical applications, they should also consult brief clinical references (physiology textbooks or short summaries) to see how physical laws manifest in the body (e.g., Poiseuille's law in hemodynamics, Ohm's law in bioimpedance).

2. Focus on definitions and units.

Physics in medicine relies heavily on precise language. Students should write down and memorize:

- exact definitions of key terms (e.g., "pressure," "current," "intensity");
- SI units and common clinical units (mm Hg, mSv, dB) and their conversions;
- dimensional analysis: check whether equations are dimensionally consistent.

3. Practice unit conversions.

Many clinical errors come from unit mistakes. Students should practice converting between:

- pressure (Pa, mm Hg, atm);
- radiation dose (Sv, mSv, μ Sv);
- frequency (Hz, beats per minute);
- energy and power.

They should keep a small conversion table handy and use it actively in problem solving.

4. Learn to distinguish concepts.

For each topic, students should be able to clearly separate similar but different ideas, for example:

- mass vs. weight;
- average vs. instantaneous values;
- laminar vs. turbulent flow;
- heat capacity vs. specific heat capacity.
- A good exercise is to write a 2–3 sentence explanation of each pair in their own words.

5. Work with formulas, not just memorize them.

Students should:

- write each formula and state what each symbol means (including units);
- derive one formula from another when possible (e.g., from basic definitions to Poiseuille's law conceptually);
- identify which quantities are measurable in a clinical setting and which are calculated.

6. Link physics to clinical scenarios.

After solving a problem, students should answer: "How would this principle be used or misused in real practice?" Examples:

- Why does a small change in vessel radius dramatically affect blood flow?
- How does skin resistance affect the safety of electrical stimulation?
- This builds clinical reasoning grounded in physics.

7. Practice drawing and interpreting graphs.

Many diagnostic tools rely on graphs (ECG, flow-volume loops, pressure tracings).

Students should practice:

- sketching position–time, velocity–time, and pressure–flow graphs;
- reading slopes and areas under curves;
- relating graph features to physiological events.

8. Do step-by-step problem solving.

Encourage a consistent method:

1. Read the problem and underline given data and what is asked.
2. List known quantities with units.
3. Choose the appropriate formula(s).
4. Convert units if needed.
5. Substitute values and calculate.
6. Check the answer: units, order of magnitude, physical plausibility.
7. Interpret the result in a clinical context.

8. Review common pitfalls.

Typical mistakes to avoid:

- mixing up units (e.g., cm and m, minutes and seconds);
- confusing scalar and vector quantities;
- ignoring assumptions in idealized models (e.g., incompressible fluid, steady flow);
- overgeneralizing formulas that apply only under specific conditions.

10. Use active self-check techniques.

To verify understanding, students can:

- explain each concept to someone else in simple terms;
- create their own short questions and solve them;
- compare textbook derivations with lecture notes and note differences;
- annotate diagrams with labels and arrows showing forces, flows, or fields.

Introduction to Physics

1. Which of the following are physical quantities and which are not: body temperature, blood type, arterial pressure, skin color? Briefly explain the criterion that makes a quantity "physical" in the scientific sense.
2. Give two examples of physical models used in medicine (e.g., modeling blood flow as fluid flow) and explain why simplifications and idealizations are necessary in such models.
3. Distinguish between direct and indirect measurements. Provide one clinical example of each (e.g., measuring temperature with a thermometer vs. estimating cardiac output via dye dilution).
4. Why are reproducibility and accuracy critical in clinical laboratory diagnostics? Illustrate with an example such as a glucose analyzer or hematology counter.
5. Explain why standardized units are essential in clinical medicine, and describe a potential error and its consequences if units are omitted or confused (e.g., dosing errors or misinterpreting blood pressure).

Units, Physical Quantities

1. Convert 120 mm Hg to pascals, given that $1 \text{ mm Hg} \approx 133.3 \text{ Pa}$. State which clinical parameter this value typically represents.
2. Express a radiation dose of 2.5 mSv in sieverts and explain why fractional SI units (mSv, μSv) are commonly used in radiology and radiation safety.
3. Differentiate between mass and weight. How could this distinction affect the interpretation of patient weight measurements in different environments (e.g., varying gravity or accelerating elevators)?
4. Give an example of a medical quantity measured in derived SI units (e.g., W/m^2 or J/kg) and explain its physical meaning and clinical relevance.
5. Why must clinical protocols and medical records always include units with numerical values? Describe a realistic error scenario and its possible consequences.

Kinematics of a Point

1. A patient walks 15 m along a corridor in 30 s. Calculate the average speed and explain how this metric can be used to assess mobility and rehabilitation progress.
2. Describe the shape and meaning of a position–time graph for uniform motion. Relate this to a patient walking at a constant speed during a timed walk test.
3. Explain how to determine the distance traveled from a velocity–time graph. Apply this to interpreting data from a pedometer or activity tracker for a patient with limited mobility.
4. Define acceleration and give a clinical situation where acceleration matters (e.g., patient transfer on a trolley, risk of falls during sudden stops).
5. Compare average speed and instantaneous speed using a practical example from a hospital ward, such as monitoring a patient’s movement with sensors or observation.

Point Dynamics

1. A force of 350 N acts on a 70 kg patient. Calculate the resulting acceleration and discuss a clinical context where this is relevant (e.g., moving a patient on a gurney or in an elevator).
2. State Newton’s third law and provide a medical example of action–reaction forces (e.g., using a walker, standing on scales, or pushing against handrails).
3. Why is friction important in designing hospital footwear and floor surfaces? Describe the forces acting on a patient while walking and conditions that increase fall risk.
4. Explain how the normal reaction force affects joint loading when a patient stands or walks. Give a simple way to estimate load distribution.
5. What happens to a patient’s stability if their center of mass moves outside the base of support? Provide a common real-life example and describe preventive measures.

Laws of Conservation

1. State the law of conservation of energy and give an example of energy conversion in a medical device (e.g., nebulizer, ECG machine, defibrillator).
2. How does the law of conservation of momentum apply when a trolley collides with an obstacle? Describe possible consequences for the patient and ways to mitigate them.
3. Why should energy losses be minimized in oxygen delivery systems (tubing, masks, humidifiers)? Relate this to efficiency (η) and patient safety.
4. Describe the conversion between potential and kinetic energy when a patient falls from a bed. List engineering and procedural measures that reduce associated risks.
5. Give an example of using energy conservation principles to estimate a patient’s energy expenditure at rest and during exercise (e.g., treadmill or cycle ergometer).

Rigid Body Dynamics and Statics

1. Define torque (moment of force) and apply it to a healthcare scenario: a nurse turning a patient in bed or using a patient lift.
 2. Explain how the lever arm (moment arm) affects the force needed to lift a patient with a mechanical lift or during manual handling.
 3. What is the center of mass of the human body, and why is its location important for fall risk assessment and designing rehab exercises?
 4. State the conditions for static equilibrium and apply them to the design of a wheelchair, crutches, or walker.
 5. How do lever mechanisms (e.g., in orthopedic devices or patient handling aids) reduce the physical load on healthcare workers and lower injury risk?
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Elasticity

1. Explain Hooke's law and give examples of elastic deformation in medical devices (e.g., bandage, sphygmomanometer cuff, compression stocking).
 2. Define Young's modulus and discuss how it influences material selection for orthotic insoles, splints, or prosthetics.
 3. How are elastic properties considered when designing compression garments or bandages? Relate to pressure distribution and therapeutic effect.
 4. Why is it important to control stress and strain in surgical sutures? Link this to ultimate tensile strength and the risk of suture failure.
 5. Provide an example where permanent (plastic) deformation of a medical device (e.g., catheter, drainage tube) could lead to complications, and explain the underlying physics.
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Mechanics of Fluids

1. State the equation of continuity and explain its relevance to blood flow in vessels of different diameters (e.g., arteries vs. capillaries).
 2. According to Poiseuille's law, how does a change in vessel radius affect volumetric flow rate? Give a clinical example (e.g., stenosis, vasospasm, plaque buildup).
 3. Differentiate laminar and turbulent blood flow and explain how this relates to auscultation of sounds (e.g., Korotkoff sounds, pathological murmurs).
 4. Use Bernoulli's principle to explain the pressure drop in a narrowed vessel segment. Describe its clinical interpretation (e.g., Venturi effect, pressure gradient estimation).
 5. How does blood viscosity affect hemodynamics, and which pathological conditions can alter it (e.g., dehydration, polycythemia, anemia)?
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Oscillations and Waves

1. Define simple harmonic motion and give biological/medical examples of oscillatory processes (e.g., pulse, breathing, tympanic membrane vibrations).
 2. Explain resonance and discuss its potential benefits or hazards in medical technology and the body (e.g., vibration exposure, ultrasound, mechanical oscillations).
 3. Relate frequency and period. Calculate the frequency in hertz for a pulse rate of 72 beats per minute and interpret the result physically.
 4. Describe damped oscillations and give examples in healthcare equipment (e.g., trolley suspension, vibration isolation, sensor damping).
 5. Define standing waves and suggest a simplified application relevant to hospital acoustics or certain diagnostic instruments.
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Sound and Hearing

1. Explain the relationship between sound intensity and decibel level. Why are noise levels regulated in hospitals, and what are the effects on patients and staff?
2. Describe the audible frequency range for humans and its clinical significance (e.g., audiometry, age-related hearing loss).

3. How is the Doppler effect applied in ultrasound assessment of blood flow (e.g., Doppler ultrasound, duplex scanning)?
4. Outline the physical principles behind a stethoscope: how it transmits and amplifies sounds from the body, and what factors influence auscultation quality.
5. Why do high-frequency sound waves attenuate more rapidly in tissues, and how is this considered in ultrasound imaging (transducer frequency selection, depth vs. resolution trade-off)?

Thermal Properties of Matter

1. Calculate the heat required to warm 2 L of water from 20 °C to 100 °C (specific heat capacity of water: 4200 J/(kg·°C)). Suggest a clinical scenario where such a calculation is useful.
2. Distinguish between heat capacity and specific heat capacity, using an example involving heating instruments or warming tissues.
3. How does thermal conductivity influence the choice of materials for operating table surfaces or patient warming blankets?
4. Explain the role of evaporation in thermoregulation and how this is considered in the care of febrile patients.
5. Why is thermal expansion important when sterilizing metal instruments? Describe potential risks and standard precautions.

Electric Charge and Electric Field

1. Define electric field and give a medical example where electric fields influence equipment operation (e.g., EEG, EMG, shielding requirements).
2. Why is static electricity a concern in operating rooms? Describe common prevention strategies.
3. Explain charge distribution on a conductor and its importance for shielding sensitive medical electronics.
4. Describe the physics of a defibrillator: how electric charge is stored and discharged to deliver a therapeutic shock.
5. Define electric field strength and discuss its relevance to personnel safety around high-voltage medical equipment.

Direct Current

1. State Ohm's law and explain its use in calculating current through a patient during electrical stimulation therapy.
2. Calculate the power of a heating element carrying 2 A at 12 V. Suggest a possible medical application for such a heater.
3. Why does skin resistance matter for the safety of electromedical devices? Discuss factors that change skin impedance.
4. Compare series and parallel circuits using examples from diagnostic or monitoring equipment wiring.
5. How does internal resistance of a power source affect the performance of portable medical devices? Explain the practical implications.

The Nature and Propagation of Light

1. Contrast geometric optics and wave optics, giving one medical application for each (e.g., endoscopy vs. interference-based diagnostics).
2. Explain how an endoscope transmits light via optical fibers, focusing on total internal reflection.
3. Describe dispersion of light and why it is minimized in microscopy and ophthalmic lenses.

4. Define total internal reflection and explain its role in fiber-optic technologies used for diagnosis or illumination.
5. How can polarization of light be useful in tissue analysis (e.g., dermatoscopy, polarizing microscopy)? Briefly describe the principle.

Methodological Recommendations for the Preparation of Presentations and Reports

The report must contain elements of novelty; along with the fundamental aspect, an analysis of the current state of the problem under study must be carried out, as well as inclusion in regional issues. The report must include an introduction, a theoretical part, a conclusion, a list of literature, and a presentation that reveals the essence of the topic in graphs, pictures, diagrams, and formulas.

The report is recommended to be submitted on 1 printed sheet. The text of the work must be printed with 1.5 line spacing on one side of a standard sheet (A4) of white paper.

The text and other printed elements of the work must be black, and the contours of letters and signs must be clear, without halos and shading. The font must be Times New Roman, size 14. The titles of chapters and paragraphs are highlighted in bold. The sheet with text must have margins: left – 30 mm, right – 10 mm, top – 20 mm, bottom – 20 mm.

Page numbering of the text is done in the lower right corner of the sheet. It is necessary to number pages starting from the page where the Introduction is printed, on which the number 3 is placed. After that, all pages, including appendices, are numbered.

A space equal to two intervals is placed between the title of the chapter and the title of the paragraph of this chapter, and the title of the paragraph must not be separated from the text of this paragraph by a space. The titles of paragraphs shall be separated from the text of the previous paragraph by a space equal to two intervals. Each chapter, as well as the introduction, conclusions, appendices, and the list of used literature, begin on a new page. The word Chapter is not to be written. Chapters have ordinal numbers within the entire work, designated by Arabic numerals (for example: 1, 2, 3), followed by a period.

The word **PARAGRAPH** or the paragraph symbol (§) is not placed in the title. Paragraphs have ordinal numbers within the chapters, designated by Arabic numerals (for example: 1.1. and 1.2.).

Headings of chapters and paragraphs in the text must be centered; a period shall not be placed at the end of the title of the chapter and paragraph. It is not allowed to hyphenate (transfer) a part of a word in a heading. 4.5. The numbering of tables and figures can be running (continuous) or relate to the number of the chapter and paragraph. For example, if a table or a figure is included in the text of the first paragraph of the second chapter, the numbering is as follows: Table 2.1.1., Fig. 2.1.1.

The last digit means the ordinal number of the table (or figure) in this paragraph.

The table is to be placed as the next page after the first mention of it in the text.