

# Medical Physics I.

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## *Topic list and topics for the physics part of the oral examination (1st semester)*

Oral examination is offered to students directly after the 3rd failed attempt. Following a short preparation, two randomly selected topics (one related to the lectures, one related to the laboratory practicals) is to be presented in a concise and coherent manner.

## **Lecture topics**

1. The SI unit system.
2. Defining the position of a particle in Cartesian and polar coordinates. Mathematical operations with vectors with examples in physics.
3. Physical quantities in kinematics. Linear motion of particles.
4. Circular motion of particles.
5. Newton's laws, properties and types of the forces, forces in human motion. Friction.
6. Linear momentum and angular momentum.
7. The properties and the role of torque. Conditions of equilibrium for a rigid body. Centre of mass.
8. Elastic deformation of solid objects.
9. Work, energy, power.
10. Structure and functions of skeletal muscles. Relationships between muscle length and tension. Force, speed and power for skeletal muscles. The mechanical model of skeletal muscles.
11. Pressure-wall tension relations for hollow organs (Laplace's law). Mechanical work done by the heart.
12. Oscillations: definition and types. Kinematics and dynamics of simple harmonic motion. Adding harmonic oscillations. Damped oscillations and forced oscillations, resonance.
13. Resolving a general oscillation to harmonic components. Fourier analysis.
14. Mechanical waves: types and characteristics. Definition and units of wavelength and wave number. Relationship between the frequency, the wavelength and the speed of waves.
15. Reflection and refraction of sound at the boundary between two media. Acoustic impedance.
16. Doppler effect, blood flow velocity measurement based on the Doppler effect.
17. Definition and characteristics of ultrasound. Attenuation of ultrasound in a medium: Beer's law.
18. Characteristics of sound: pitch, timbre and loudness. Objective and subjective sound intensity. The frequency profile of human hearing: equal loudness curves.
19. Block diagram of human hearing. The physical model of the eardrum and the inner ear. The cochlea. Place theory of hearing. The function and role of hair cells. The principle of cochlear implantation.
20. Temperature: concept and measurement. Temperature scales.
21. Heat capacity and specific heat. Thermodynamic description of phase changes.
22. State of changes of ideal gases.
23. Heat transfer: radiation, convection, conduction and evaporation. Newton's cooling law.

24. Flow of ideal fluids: equation of continuity, hydrostatic pressure and Bernoulli's law.
25. Pressure, flow velocity, cross-section in the human blood circulation system.
26. Flow of real (viscous) fluids; viscosity. Laminar and turbulent flow.
27. Non-invasive measurement of arterial pressure.
28. Fick's first law: factors that influence the diffusion coefficient. Fick's second law: interpretation and medical importance.
29. The definition of osmosis and the measurement of osmotic pressure. The medical importance of osmosis.
30. Comparison of different membrane transport processes: passive, facilitated and active transport.
31. The main principles of thermodynamics. The definition of entropy and its role in thermodynamic equilibrium.
32. Geometrical optics: refraction, reflection, dispersion and total internal reflection of light.
33. Optical imaging. Properties of the image. Types of optical lenses. The lensmaker's equation and the lens equation. Refraction in the human eye.
34. Vision defects and their correction.
35. Wave nature of light: interference, diffraction, polarisation.
36. Physical principles of vision. Accommodation, field of vision. Limits of clear vision. Special properties of lasers.
37. Measurement of physiological signals. Main types of deterministic and non-deterministic signals.
38. Digitisation of signals; the sampling theorem.

## Laboratory practical topics

1. Calculation and importance of body mass index. Calculation of body surface area.
2. Types of measurement errors; possibility of elimination.
3. Adding oscillations. Frequency and spectrum of the beat signal. Fourier analysis.
4. Properties of sound. The dB scale.
5. Blood pressure measurement: hydrostatic pressure, characteristic blood pressure values.
6. Blood pressure measurement: Korotkov method.
7. Blood pressure measurement: oscillometric method
8. Measurement of vision acuity; illustration through a numerical example.
9. Amplitude of accommodation: meaning, biophysical background, age-dependence, measurement.
10. Eyeglass correction of myopia and hypermetropia. Optical properties of lenses. Estimation of the refractive power.

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