Questions for state doctoral exam – field of study: Chemical and Process Engineering
Subtopic: Momentum transport/Hydromechanical processes

1. Physical properties of fluids: density - definition, measurement, dependence of density on temperature; viscosity - definition, measurement, dependence of viscosity on temperature; compressibility and extensibility of fluids.

2. Continuity equations for spatial flow. Velocity field measurement.

3. Examples of use of Bernoulli equation for one-dimensional flow: flow in pipes, local resistances in fittings, energy dissipation, calculation of pressure loss; liquid outlet through the orifice through the reservoir, flow rate correction for real fluids, liquid discharge time from the vessel through the orifice.

4. Equation of motion of an ideal fluid: Euler equation for multidimensional flow - derivation.

5. Real fluid flow: Navier-Stokes equations - basic differences from Euler equation, meaning of terms in NS equations, adjustment of NS equation for fluids.

6. Laminar flow (Navier-Stokes equations): steady laminar fluid flow between two parallel walls: adjustment of NS equations for x-direction, definition of boundary conditions, velocity profile - solution.

7. Laminar flow (Navier-Stokes equations): steady laminar flow of a liquid flowing down a sloping wall in the x-direction, definition of boundary conditions, velocity profile - solution.

8. Numerical solution of steady laminar fluid flow in circular pipes, definition of boundary conditions, solution: Hagen-Poiseuille law.

9. Transport of liquids by pumps, classification of pumps, characteristics of pump and piping, maximum suction head, arrangement of pumps, flow regulation, cavitation.

10. Fluid flow past bodies: using an example of a body such as sphere, explain how the flow around a body changes depending on the Reynolds criterion. Define the drag coefficient and generally describe the dependence of the drag coefficient on the Reynolds number on the shape of the body (detailed for a sphere), the effect of surface smoothness on the drag coefficient, balance of forces on a solid spherical particle in a fluid - settling velocity calculation.