Final exam questions

Subject group name: **Fluid Mechanics**

Neptun code: ZVEGEÁTBG11

Credit points: 6

Subject(s) in this subject group:

- **Fluid Mechanics** (BMEGEÁTBG11)

Program: Mechanical Engineer, BSc (2NAAG0)

Specialization(s): Process Engineering

Responsible person(s):

- Dr. János Vad, vad.janos@gpk.bme.hu, Department of Fluid Mechanics, Faculty of Mechanical Engineering

You can check the current subject forms at the Educational Portal of the Faculty of Mechanical Engineering.

https://oktatas.gpk.bme.hu/

Always check for updates at edu.gpk.bme.hu before preparing for the exam, especially if the subject group contains at least one subject from your final semester!

Valid from 1 September 2024

Dr. János Vad

professor

1. Provide the integral form of the continuity equation and provide its physical meaning. Define the parameters and provide their units. Apply the equation for a streamtube. Under what conditions can the equation be simplified? Provide the simplified form of the continuity equation for a streamtube, defining each parameter and providing units.

2. Provide the differential form of the continuity equation and give the conditions for which it is valid. Define each parameter and provide units. Under what conditions can the equation be simplified? Provide simplified forms of the continuity equation, along with the conditions under which they can be applied.

3. How can the volume flow rate of a medium flowing in a circular cross-section tube be calculated given the velocity distribution $v=v(r)$ (fully developed flow)?

4. Provide the hydrostatic equation and provide its physical meaning. Define the parameters and provide their units. Provide the solution to the hydrostatic equation for incompressible fluids.

5. Define pathline, streamline, and streakline. Describe steady flow (stationary flow) and unsteady flow (instationary flow).

6. Using Eulerian description, provide the total acceleration of a fluid particle.

7. Provide the Euler equation, give the conditions for which it is valid, and provide its physical meaning. Define all parameters and provide their units.

8. Define the Euler-equation in the natural coordinate system for steady flow. Define each parameter and provide their units. What conclusions can be drawn from the component equations? Show the advantages of using the natural coordinate system through application examples.

9. Provide the integral form of the Bernoulli equation. Define each parameter and provide their units. Analyze each member of the equation and show what conditions must be satisfied to simplify the equation.

10. Provide the Bernoulli equation in a rotating reference frame. Analyze each member of the equation and show what conditions must be satisfied to simplify the equation.

11. Explain the concepts of static, dynamic, and total pressure and their means of measurement.

12. Describe the method of measuring velocity with a Pitot or Pitot-static probe. Illustrate your explanation with a sketch.

13. Describe the method of measuring volume flow rate based on velocity measurements for pipes with circular and rectangular cross-sections.

14. Describe the methods of measuring volume flow rate using flow contraction based methods (flange/orifice and venturi meter). Describe in detail how the contraction ratio (α) is chosen.

15. Based on their advantageous and disadvantageous properties, compare the volume flow rate measurement methods based on velocity measurements and those based on flange/orifice measurements.

16. Provide the general form of the integral momentum equation. Explain what physical principle it expresses. Define each parameter and provide their units.

17. Draw the lift force and drag force vectors generated on an airfoil placed in flow. Define the lift and drag coefficients of a body placed in a flow. Provide a diagram of the lift and drag coefficients as a function of angle of attack to scale.
18. Describe the pressure change equation as provided by the Allievi theory. Under what conditions is it valid? Provide an example for the practical application of the equation.
19. Provide and explain Newton's law of viscosity and draw typical rheological curves.
20. What do we mean by the laminar and turbulent nature of a flow? Describe the Reynolds experiment.
21. Provide the Navier-Stokes equation. Describe the physical content of the equation and the conditions under which it is applicable. Explain the meaning of the terms of the equation.
22. Explain the term boundary layer and the process of boundary layer separation. What methods can be used to influence boundary layer separation?
23. Provide the Bernoulli equation with the loss term and determine its physical meaning.
24. Provide the equations that describe the pressure loss of a straight pipe section, an expanding nozzle (diffuser), a Borda-Carnot sudden-expansion, and one fitting (e.g. gate valve, elbow).
25. Determine the pipe friction factor and draw a diagram of how it depends on the Re number and the pipe wall roughness to scale. Explain the concepts of hydraulically smooth and rough pipes.
26. Provide the energy equation and state under which conditions it is valid. Explain what physical principle the equation expresses.
27. What does the similarity of flows mean? Provide the conditions for the similarity of two flows in the case of an incompressible medium.
28. Determine the outflow velocity of compressed air from a tank in the case of a simple outlet opening at various pressure ratios.
29. Describe why Laval nozzles are applied in the range below the critical pressure ratio. In such a case, what is the flow velocity in the narrowest and the outlet cross-sections of the Laval nozzle?
30. Explain the concept of speed of sound. Provide the formula for the speed of sound in differential form for an arbitrary medium and a gas medium in the case of isentropic flow. Discuss the relationships!
31. Explain the concept of cavitation, providing technical examples for cavitating flow. How can cavitation be eliminated?
32. Describe Thomson’s theorem (Kelvin’s circulation theorem) and Helmholtz’s I. and II. theorems!