Final exam questions

Subject group name: **Fluid Mechanics elective – Advanced Fluid Mechanics**

Neptun code: ZVEGEÁTNW01

Credit points: 4

Subject in this subject group:

- **Advanced Fluid Mechanics** (BMEGEÁTNW01)

Program: Mechanical Engineering Modelling, MSc (2N-MW0)

Specialization: Fluid Mechanics

Responsible person(s):

- Dr. Gergely Kristóf, kristof@ara.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 the 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 01 September 2021

Dr. Gergely Kristóf

associate professor

1. Derive the evolution equation of the elementary fluid line, and show it's analogy with the vorticity transport. What conclusions can be drawn? Formulate and explain the vorticity transport equation! For what reasons may the vorticity of a fluid parcel change in incompressible flow? Please classify the terms.
2. How can the pressure field be calculated from the velocity field, in the case of irrotational flows of an ideal fluid and in the case of Darcy flow? From what equation can the velocity potential of a constant density irrotational fluid flow be obtained? Define the vector potential for the velocity field of a constant density fluid flow! Show its relation to the stream function and explain the physical meaning of the stream function.
3. Define the complex potential and prove that the Couchy-Riemann conditions are fulfilled! Show the complex velocity is related to the stream function! Explain the Joukowskiy transformation!
4. Define the displacement thickness! How is it related to the boundary layer thickness for laminar flow past a flat plate of zero angle of inclination? Derive the relation between δ/x and Re_x for laminar boundary layers!
5. Show the self-similar form of the boundary layer equation for laminar flow!
6. Derive the velocity profile for the laminar sub-layer and for the fully turbulent layer! Describe the structure of the turbulent boundary layer!
7. Explain the numerical method for solving the boundary layer equation of turbulent flow!
8. Derive the relation between the relative velocity increase (dv/v) and the relative increase of the channel cross-section (dA/A)! What conclusions can be drawn from this relation?
9. Derive the quadratic equation for the square of upstream and the downstream Mach numbers from the conservation laws applied to a steady normal shock! Draw qualitatively correct graphs of the pressure, density, temperature, Mach number and stagnation pressure ratios for a normal shockwave!
10. What are the major differences between a Mach wave and an oblique shock? Prove that the tangential velocity component does not change and that the normal velocity component will change according to the laws valid for normal shocks!
11. Draw the qualitatively correct contour graph of the change of the angle of the flow direction (δ) as a function of the upstream Mach number (M_1) and the angle of the oblique shock (β)! What conclusions can be drawn from this graph?
12. Describe the Cross method that is used for calculating the flow rates in looped networks and derive the loop correction formula!