DD2365 ADVANCED COMPUTATION IN FLUID MECHANICS EXAM PREPARATION QUESTIONS

JOHAN HOFFMAN

Questions based on the lecture notes and the lab reports (a subset of these questions will be part of the exam):

(1) State the Navier-Stokes equations for incompressible flow.
(2) Define the Reynolds number.
(3) Derive the non-dimensional Navier-Stokes equations with the only parameter being the Reynolds number.
(4) State the Stokes equations.
(5) State the Euler equations.
(6) State three numerical methods to solve Navier-Stokes equations.
(7) Formulate a weak (variational) formulation of the Stokes equations.
(8) Formulate a mixed finite element method for Stokes equations.
(9) Derive the discrete (matrix) system corresponding to mixed a FEM method of the Stokes equations.
(10) Derive the Schur complement of the discrete (matrix) system corresponding to mixed FEM method of the Stokes equations.
(11) Formulate the inf-sup (LBB) condition.
(12) What is the consequence if the inf-sup (LBB) condition is not satisfied: what did you see in your lab work?
(13) State an inf-sup (LBB) stable mixed finite element.
(14) Define the Taylor-Hood finite elements.
(15) State a stabilized finite element method for Stokes equations with equal order interpolation.
(16) Explain why unphysical oscillations may appear in a finite element approximation of the Navier-Stokes equations at high Reynolds number.
(17) Formulate a stabilized finite element method for the Navier-Stokes equations.
(18) Formulate the Galerkin least squares stabilized finite element method for the Navier-Stokes equations.
(19) Derive a semi-discretization of the time-dependent Navier-Stokes equations using the θ-method in time and a stabilized finite element method in space.
(20) What is the difference between semi-discretization of the Navier-Stokes equations with the Implicit Euler method and the Midpoint rule for the same mesh? What did you see in your lab work?
(21) State the residual of the Navier-Stokes equations.

(22) State the Navier-Stokes equations in weak (variational) form using the weak residual.
(23) What is an adaptive finite element method? What is a refinement criterion? What is a stopping criterion?
(24) Formulate the adjoint (dual) Navier-Stokes equations.
(25) Derive an a posteriori error estimate for a finite element solution of the Navier-Stokes equations using the adjoint (dual) problem.
(26) Formulate an adaptive finite element algorithm for the Navier-Stokes equations?

Describe your project in relation to the following aspects (prepare for this question at the exam):

(1) Background (What is the state of the art in the area of your project?)
(2) Research question (What is the research question of your project?)
(3) Method (What method do you use in your project?)
(4) Results (Describe the results of your computational studies.)
(5) Discussion (Describe how your results connect to your research question and the state of the art. Was your method appropriate? How would you like to continue if you had one more month to work on the project?)