

Thematic Quiz for the “Introductory Course on Modelling of Multiphysics Problems”

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Instructions: *Brief, concise answers are expected for the questions presented below. No formal mathematical derivations are required and, in general, mathematical expressions are not necessary – except for a few questions where a simple formula may be helpful or is explicitly asked for.*

1. What are types of 2nd order linear Partial Differential Equations? Provide an example for each kind.
2. What is Boundary Value Problem (BVP)?
3. Name three kinds of boundary conditions for 2nd order BVP. Provide examples (e.g.: in case of the displacement formulation of elasticity, temperature formulation of heat transfer, pressure formulation of acoustics).
4. What are transient and steady-state problems? Give examples. What is the time-harmonic approach?
5. Explain briefly the main concept of Finite Element Method (FEM). What are the main steps of FEM algorithm?
6. What are the weak and strong formulations of BVP? Comment on their mutual relation and describe briefly steps of derivation.
7. What are trial (or shape) functions and test (or weight) functions? What are degrees of freedom?
8. Explain briefly the Galerkin Method (general idea, a distinguished feature).
9. What are three mechanisms of heat transfer? Explain briefly the Fourier law of heat conduction. What is thermal conductivity?
10. Describe shortly Initial Boundary Value Problem (IBVP) for elastodynamics. Mathematical expressions are *not* required, simply name: the unknown fields, equations/relations, boundary and initial conditions.
11. Explain briefly the Hooke’s law of elasticity. What are material constants in case of isotropy. How many material constants are there for fully anisotropic case, for orthotropy, and for transversal isotropy?
12. What are two general kinds of nonlinearity in mechanics?
13. State the principle of virtual work.

14. How thermoelastic effects can be introduced in a simple way? (i.e., explain the approach of “thermal loads”).
15. What is piezoelectricity? Explain the direct and converse piezoelectric effects. What are the forms of piezoelectric constitutive relations? How many material constants are there for a transversally isotropic piezoelectric medium and what are these material constants?
16. Write the formula for convective derivative and explain its terms.
17. What are streamlines and particle paths? For what kind of flow do they form the same pattern?
18. What is ideal fluid? Specify the incompressibility condition (no derivation, only a formula and explanation).
19. When a flow is irrotational? What is vorticity?
20. Discuss briefly the reasons for the lift force acting on an airfoil (in two-dimensional flow) on the basis of ideal flow theory.
21. What is Newtonian fluid? What are dynamic and kinematic viscosities?
22. Compare briefly the incompressible Navier-Stokes equations with the nearly-incompressible version (for isothermal flows with small compressibility) and the complete set of compressible Navier-Stokes equations. Here, mathematical expressions are *not* required, simply name: the unknown fields, equations/relations involved, and their number.
23. What is Reynolds number? What does it indicate?
24. What is a wave? What are two general classes of wave motion? What is stationary wave?
25. What is wavenumber?
26. What are phase and group velocities?
27. What is dispersion? What are two general sources of dispersion?
28. Compare features of capillary waves versus gravity waves (on a liquid surface).
29. What are sound waves?
30. What is acoustic pressure?
31. How the wave equation is derived? *No* mathematical expressions *nor* formal derivation are required, simply state the assumptions and what classic equations are linearised and combined during the derivation. What material constants are involved?
32. What are acoustic impedance and characteristic acoustic impedance?
33. Discuss briefly three types of boundary conditions (see Question 3) for the pressure formulation of acoustic wave equation.
34. What is Sound Pressure Level (SPL)? How is it related to loudness?
35. Name the mechanisms of acoustic energy dissipation.