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Universitat Politècnica de Catalunya, Barcelona, April 15–19, 2013

Numerical Simulation of Fast Transient Dynamic Phenomena in Fluid-Structure Systems

Questions/Exercises on Part II

Note: some questions may admit more than one answer. You may mark all answers you think are appropriate, and eventually add some comments of your own.

1. In dealing with explicit transient dynamics for fluids (explosions, shocks, impacts), Euler equations (and not full Navier-Stokes equations) are considered because:
    a. Compressibility is often important while viscosity is not
    b. Viscous forces may not be neglected
    c. Pressure forces are prevailing but viscosity may never be neglected
2. In a purely fluid problem (possibly with some rigid boundaries) the most natural description is typically:
    a. The Lagrangian description
    b. The ALE description
    c. The Eulerian description
3. In an ALE description the so-called “referential domain” (mesh):
    a. Follows the motion of material particles
    b. Is fixed
    c. Moves arbitrarily
4. The most important difference between an ALE and a Lagrangian formulation is:
    a. The presence of convective terms
    b. The presence of pressure terms
    c. The presence of body forces
5. In the FE approach to fluids presented, time integration of the governing equations:
    a. Is fully explicit like for structures (Lagrangian)
    b. Is implicit
    c. Requires a fractional step method that leads to an implicit solution
    d. Requires a fractional step method but in practice remains explicit
6. The accuracy of the proposed FE time integration scheme for fluids is:
    a. Second order like for structures (Lagrangian)
    b. First order
    c. Somewhat between first and second order

7. In a numerical model based upon the ALE formulation, the local description of motion (Lagrangian, Eulerian, ALE):
    a. Must be chosen element by element
    b. Must be chosen node by node
    c. Must be the same for the whole domain
    d. Must be uniform over each sub-domain (structure, fluid)
8. Pseudo-viscosity (in the form of a pseudo-viscous pressure term) in the fluid is:
    a. Useful to smooth out numerical solutions
    b. Essential in Lagrangian solutions to stabilize shock fronts
    c. Useful in Eulerian/ALE solutions to avoid excessive oscillations at shock fronts
    d. Not applicable in Lagrangian solutions
9. The pseudo-viscous term acts:
    a. Over the entire fluid sub-domain
    b. Only in fluid regions subjected to rapid compression
    c. Only in fluid regions subjected to rapid rarefaction
    d. Only in fluid regions where the fluid pressure is varying rapidly
10. Upwinding is used to treat:
    a. The pressure terms in Euler equations
    b. The transport terms
    c. The body force terms
11. Full-donor upwinding ($\alpha = 1$) is:
    a. More diffusive than a centred approximation ($\alpha = 0$)
    b. Less diffusive than a centred approximation
    c. Approximately as diffusive as a centred approximation
12. Lagrangian solutions for fluid problems are:
    a. Impossible to obtain
    b. Difficult to obtain but always quite accurate
    c. Easy to obtain but quite inaccurate
    d. Difficult to obtain and accurate only as long as the mesh does not deform too much
13. The so-called “mesh rezoning” techniques discussed in the course:
    a. Operate at constant mesh topology (just move the mesh)
    b. Just add or remove nodes where required
    c. Move the mesh and add or remove nodes where required
    d. Compute a new mesh but by keeping the same number of nodes and of elements
14. The most important task of mesh rezoning in an ALE description is:
    a. To keep the fluid mesh as uniform as possible
    b. To prevent excessive distortions in the fluid mesh
    c. To keep the fluid mesh attached to the structural mesh
15. In the chosen ALE formulation, the motion of free surfaces may be modeled:
    a. By just setting them as Lagrangian
    b. By just setting them as Eulerian
    c. By just setting them as ALE
    d. Up to a certain point (moderate distortion) by setting them as Lagrangian only in the normal direction

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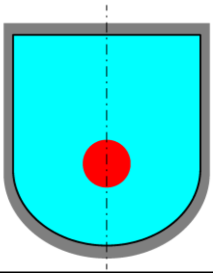
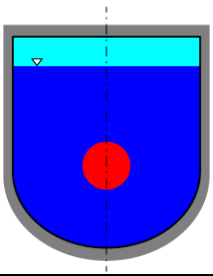
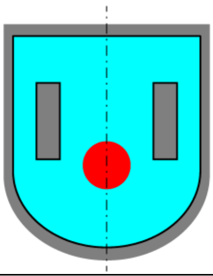
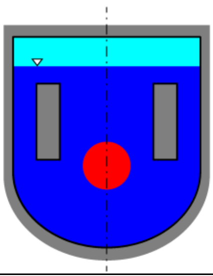
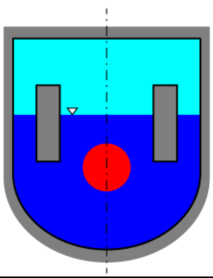
Exercise 1

A rigid container is subjected to an internal explosion, represented by a bubble of high-pressure gas (red zone). The rest of the container is filled by the same gas at atmospheric pressure (cyan zone). In addition, one may optionally consider a pool of liquid (blue zone) and the presence of some internal rigid structures (grey blocks). For each case, indicate whether each solution type is (likely) easy, possible, difficult or impossible to obtain, and why. For ALE solutions, specify which mesh parts should be modeled as Lagrangian, Eulerian or ALE. Assume first to use the basic, single-component fluid material model.

Problem	Solution(s) with single-phase single-component material model
	□ Lagrangian □ Eulerian □ ALE
	□ Lagrangian □ Eulerian □ ALE
	□ Lagrangian □ Eulerian □ ALE
	□ Lagrangian □ Eulerian □ ALE
	□ Lagrangian □ Eulerian □ ALE

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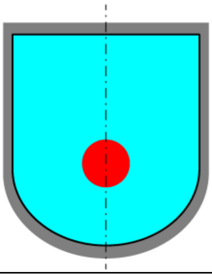
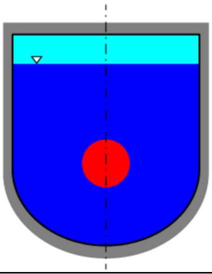
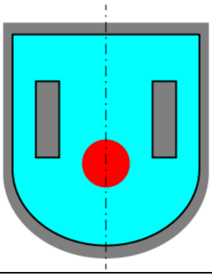
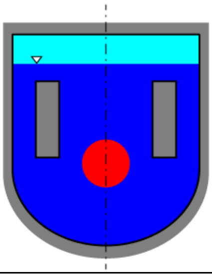
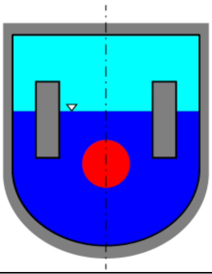
Now assume having at disposal a multi-component fluid material model, which allows mixing up various materials in the same finite element. In which cases would you use it to obtain a (better) solution? And how? Put your comments and observations.

Problem	Solution(s) with multi-phase multi-component material model
	
	
	
	
	

Additional comments/observations:

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