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SPH and SPG Methods for Fluid and Solid Applications

Instructors: Jingxiao Xu (Ph.D.) – SPH, Youcai Wu (Ph.D.) – SPG
2 Days - $400, Students $200 w/student ID
Includes on-site continental breakfasts, lunches, breaks, class notes, class dinner
Includes 30-day demonstration license

Prerequisite: Students should be familiar with LS-PrePost, understand the basic LS-DYNA keywords and be able to run a LS-DYNA simulation

Objective: This is an intermediate level class for two distinct particle methods in LS-DYNA, the smoothed particle hydrodynamics (SPH) method and the smoothed particle Galerkin (SPG) method. The class aims to provide engineers and researchers the necessary information of the SPH and SPG methods, and demonstrate how those two particle methods can be brought together to take advantages of the LS-DYNA code in advancing their fields of applications.

Description: While the SPH method is a well-established particle method for modeling the fluid-like motion, the SPG method is a new particle method developed to simulate the ductile failure in solids. On the other hand, these two methods also share many numerical similarities in modeling the large deformation and high-strain rate problems.

This class begins with an introductory section that offers a balanced coverage of the review on SPH and SPG methods. Subsequently, the methodology section is self-supporting for each method with the fundamental theory, keywords and distinguished applications. Attendees can easily identify numerical advantages and disadvantages of each method, similarity and dissimilarities in comparison to other methods, and exclusive industrial applications.

Both SPH and SPG can be coupled in some FSI problems as well as used to couple with the FEM. In-class workshop will be offered to demonstrate the numerical advantages of the two particle methods for many challenging fluid and solid applications.

1. **Contents: Overview of LS-DYNA SPH and SPG methods**
    1.1. General features, various meshfree kernels
2. **The LS-DYNA SPH method**
    2.1. SPH formulations and LS-DYNA implementation
        2.1.1. Lagrangian and Eulerian kernels
        2.1.2. Consistency and renormalization
        2.1.3. Characteristic lengths and variable smoothing length
    2.2. SPH thermal formulations
    2.3. LS-PREPOST: creation and visualization of SPH particles
    2.4. Practical examples of SPH
        2.4.1. General capabilities / applications (solids and fluids)
        2.4.2. LS-DYNA keywords for an SPH simulation
            2.4.2.1. SPH control and output control cards, part and section cards
        2.4.3. Generic keywords and options
            2.4.3.1. Boundary conditions, contact cards, material cards
    2.5. <u>Workshop I: set up an SPH analysis and post-processing</u>
3. **The LS-DYNA SPG method**
    3.1. Motivation, fundamentals, keywords
    3.2. Application of SPG in non-failure analysis
        3.2.1. Elastic wave propagation & Taylor impact
    3.3. <u>Workshop II: Taylor impact (SPG vs FEM)</u>
    3.4. Industrial applications of the SPG method
        3.4.1. SPG bond failure mechanism
        3.4.2. LS-DYNA keywords for SPG failure analysis
            3.4.2.1. SPG control cards, contact cards, material cards
        3.4.3. Numerical simulations of impact penetration and fragmentation processes
            3.4.3.1. Penetration and perforation of metal and concrete targets
            3.4.3.2. Convergence study and sensitivity study to SPG parameters
    3.5. <u>Workshop III: rod tension and perforation of steel plate</u>
4. **Coupling schemes**
    4.1. Coupling between SPH/SPG and FEM
        4.1.1. Natural coupling between SPG and FEM
        4.1.2. Keywords for SPH/FEM coupling
    4.2. Coupling options between particle methods
        4.2.1. Between multiple SPH parts
        4.2.2. Between SPH and other particle methods (SPG, DEM, Peridynamics)
    4.3. Examples of coupled analysis
        4.3.1. Waterjet impact on concrete structure
    4.4. <u>Workshop IV: coupled SPH/SPG analysis</u>