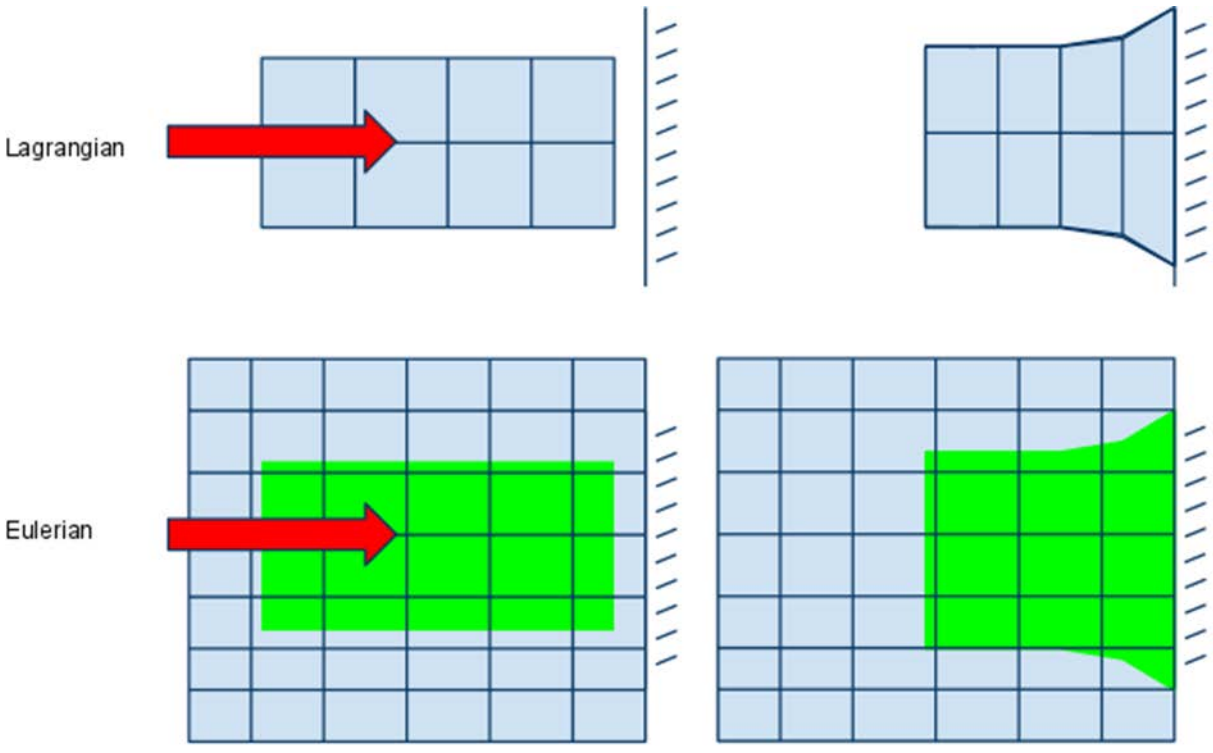
Lagrangian and Eulerian Reference Frames

(Source: https://www.sharcnet.ca/Software/Fluent13/help/wb_sim/exp_dyn_theory_lag_eul_360.html)

By default, all bodies in an Explicit Dynamics analysis system are discretized and solved in a Lagrangian reference frame: The material associated with each body is discretized in the form of a body-fitted mesh. Each element of the mesh is used to represent a volume of material. The same amount of material mass remains associated with each element throughout the simulation. The mesh deforms with the material deformation. Solving using a Lagrangian reference frame is the most efficient and accurate method to use for the majority of structural models. However, in simulations where the material undergoes extreme deformations, such as in a fluid or gas flowing around an obstacle, the elements will become highly distorted as the deformation of the material increases. Eventually the elements may become so distorted that the elements become inverted (negative volumes) and the simulation cannot proceed without resorting to numerical erosion of highly distorted elements.

In an Eulerian reference frame, the grid remains stationary throughout the simulation. Material flows through the mesh. The mesh does not therefore suffer from distortion problems and large deformations of the material can be represented. If the material you are going to model is likely to experience very large deformations, using an Eulerian reference frame is therefore preferable.



Solving using an Eulerian reference frame is generally computationally more expensive than using a Lagrangian reference frame. The additional cost comes from the need to transport material from one cell to the next and also to track in which cells each material exists. Each cell in the grid can contain one or more materials (to a maximum of 5 in the Explicit Dynamics system). The location and interface of each material is tracked only approximately (to first order accuracy).

The representative example below shows a block of material impacting a rigid wall. First the block is represented in the Lagrangian reference frame. During the impact process the nodes of the mesh follow the deformation of the material. The same problem can be modelled in an Eulerian reference frame; here the nodes of the mesh are fixed in space, they do not move. Instead the material is tracked as it moves through the mesh.

Solid, Liquid and Gaseous materials can be used with an Eulerian (Virtual) reference frame in the Explicit Dynamics system. Because of the computational cost and approximate tracking of material interfaces, the Eulerian reference frame should be used only when very large deformation or flow of the material is expected.