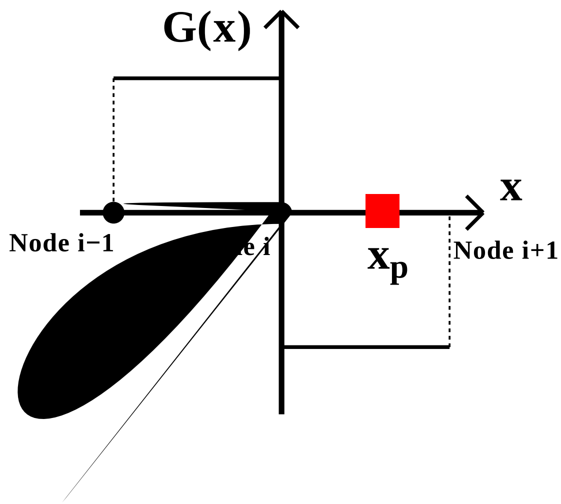
$$\mathbf{M}_i = \sum_p S_{ip} m_p \tag{2}$$

$$\mathbf{v}_i = \frac{\sum_p S_{ip} m_p \mathbf{v}_p}{\mathbf{M}_i} \tag{3}$$

$$\mathbf{Fext}_i = \sum_p S_{ip} \mathbf{Fext}_p. \tag{4}$$

m_p is the particle mass, $\mathbf{v}_p$ is the particle velocity, and $\mathbf{Fext}_p$ is the external force on the particle. The external force on the particle is generally an applied load of some type. In Equation 3, the numerator is the nodal momentum, which



$$
\begin{array}{lll}
G(x) = & 1/(x_i - x_{i-1}) & x_{i-1} < x < x_i \\
G(x) = & -1/(x_{i+1} - x_i) & x_i < x < x_{i+1} \\
G(x) = & 0 & x < x_{i-1} \quad x > x_{i+1}
\end{array}
$$

Figure 3: One dimensional linear shape function derivative, $G(x)$.

where v_p is the particle volume. The internal force can be thought of as the force that holds a material together. For a given deformation, this force is larger for stiffer materials.

Everything is now available to solve Equation 1 for $\mathbf{a}_g$. With that, the backward Euler method is used for all time integrations. A convective grid velocity $\mathbf{v}_g^L$ is computed:

$$\mathbf{v}_g^L = \mathbf{v}_g + \mathbf{a}_g dt \qquad (7)$$

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Note that the initial (t=0) deformation gradient is simply the identity, i.e. $\mathbf{F}(0) = \mathbf{I}$. Now with the deformation gradient, one can compute J by:

$$J$$

6. If the stress state is plastic, all the strain rate is considered to the plastic and an elastic correction along with a radial return step move the stress state to the yield surface. The hydrostatic part of the stress state is calculated using the Mie-Gruneisen equation of state or the Neo-Hookean model.
7. A scalar damage parameter is calculated and used to determine whether material points are to be eroded or not.