
Algorithm 1 Time Stepping Method

1: **procedure** TIME STEPPING METHOD

2: Solve for the max flux over the time step and attain the end of step fluid mass m^n and end of step pressure p^n ,

- $m^{n+1} = m^n + k^n \rho^n (\nabla p^n) \Delta t$

3: Update the velocity to the mid-step

- $\mathbf{v}^{n+\frac{1}{2}} = \mathbf{v}^n + \mathbf{a}^n \frac{\Delta t}{2}$

4: Update the displacement to the end of step

- $\mathbf{x}^{n+1} = \mathbf{x}^n + \mathbf{v}^{n+\frac{1}{2}} \Delta t$

5: Calculate deformation input to constitutive model and update material state to Q^{n+1}

6: Solve for the acceleration $t^{n+1}(a_i^{n+1})$. Note that this includes the fluid pressure p^{n+1} applied as a boundary condition.

7: Update the velocity to the end of step

- $\mathbf{v}^{n+1} = \mathbf{v}^{n+\frac{1}{2}} + \mathbf{a}^{n+1} \frac{\Delta t}{2}$

8: **end procedure**
