Geol 483.3

Lab project #4 – Study of Vibroseis sweep

In this lab, you will use a computer to simulate 1-D propagation of a plane shear seismic wave.

Theory

Plane shear wave in a uniform isotropic medium propagates as a scalar wave in the *x* direction satisfies the following equation:

$$\frac{\partial^2 u}{\partial t^2} = \beta^2 \frac{\partial^2 u}{\partial x^2} \, ,$$

where $u(x,t)$ is the displacement and β is the wave velocity. In numeric finite-difference form, the wavefield is described by a vector (array) u_i spaced at dx apart and whose values are updated at finite time increments dt. In discrete form, the second derivatives are replaced by their finite-difference approximations. For example, the second derivative in x becomes:

$$\frac{\partial^2 u}{\partial x^2} = \frac{u_{i+1} - 2u_i + u_{i-1}}{(dx)^2} \, .$$

With such substitutions, the wave equation above allows to determine $u_i(t+dt)$ from the previous values:

$$u_i(t+dt) = 2u_i(t) - u_i(t-dt) + (dt)^2 \beta^2 \frac{u_{i+1}(t) - 2u_i(t) + u_{i-1}(t)}{(dx)^2} \, .$$

Note that in order to evaluate this expression, you need to always keep three copies of vector u corresponding to the previous time steps.

Assignments

1. [40%] Write a Matlab or another programming language program to implement the fnite-difference scheme above.
2. [30%] Perform simulation using dx=1 km, dt = 0.1 s, a total extent of the model of 0 to 100 km, and assuming β=4 km/s. Place a point source at the middle of the model (at i=50) with the following time function:

   ??

   Apply a stress-free boundary condition (du/dx=0) at x=0 and fixed-boundary condition (u=0) at x=100 km.

   Run the simulation for 33 s and plot the output in the form of seismic trace display (this can be easily achieved in Matlab or GMT).

3. [30%] Verify that the pulses travel at velocities of 4 km/s. What happens to the pulses at the end points? What happens when the pulses cross? Discuss and provide legible plots.

Hand in:

Codes, plots, and report by email.