Geophysics 223 Assignment 4 : Ground penetrating radar

This assignment will be due on **Thursday April 9th 2009**

Question 1 – Travel time for a reflection

A GPR survey is used to measure the depth of an interface. TX-RX offset varies from 0 to 5 m in increments of 0.2 m

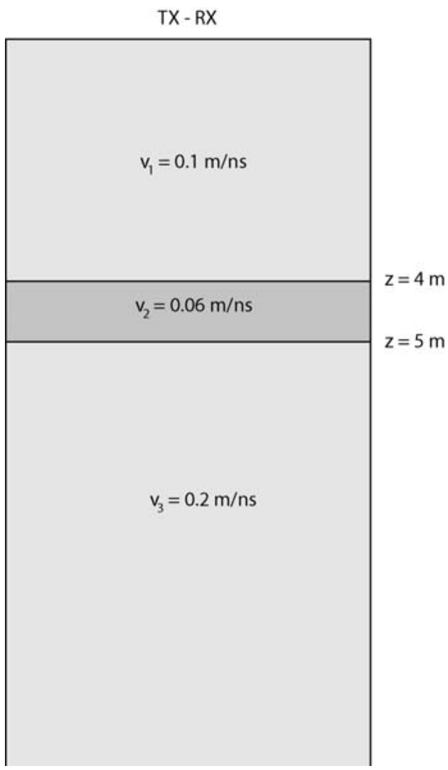
The velocity above the interface is v_1= 0.1 m/ns and below the velocity is v_2 = 0.2 m/ns. The interface is at a depth of 2 m.

(a) Use EXCEL to compute the travel time for the reflected wave. Also compute the travel time predicted by the NMO approximation.

(b) At what TX-RX offset is the error in the NMO approximation equal to 10% ?

Question 2 – Reflection coefficients

A radar survey takes place over a layered Earth shown below.

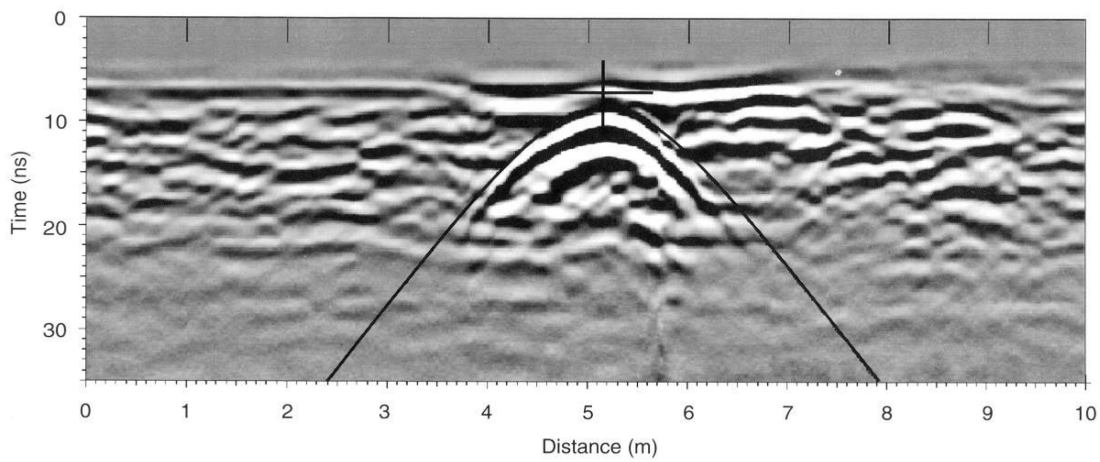


(a) Sketch **ray paths** for the first three reflections that will be recorded at normal incidence.

(b) Calculate the **travel time** for each reflection at normal incidence.

(c) The outgoing pulse has an amplitude A =1. Calculate the **amplitude** of each reflection at normal incidence.

Question 3 – Analysis of a diffraction



The data above shows a diffraction from a metal pipe recorded during a GPR survey.

In this question we will use these data to determine the depth of the pipe (*d*) and the velocity of the soil (v_1)

Approximate solution for v_1 and d

First we will simplify the travel time by assuming that the TX and RX are coincident. In class we derived the travel time as

$$t_{diff} = \frac{2\sqrt{x^2 + d^2}}{v_1}$$

where *d* is the depth of the diffractor and *x* is the horizontal distance from the TX-RX to the diffractor.

(a) At large values of *x* this equation becomes a straight line. Use the slope of this line to estimate v_1

(b) Measure the minimum travel time (conveniently marked with a '+' sign). Use this travel time to estimate the depth of the object.

Exact solution for v_1 and d

Now we will use the more general result that the TX and RX are not coincident, but separated by a distance $t = 0.8$ m.

It can be shown that in this case

$$t_{diff} = \frac{\sqrt{(x-\frac{t}{2})^2 + d^2} + \sqrt{(x+\frac{t}{2})^2 + d^2}}{v_1}$$

(c) Again consider the case that x is large and estimate v_1 from the slope of the travel time curve.

(d) Consider the minimum travel time for the diffraction. Use this to estimate d.

Question 4 – Soil properties

(a) The ground wave in a GPR survey in a vineyard travels at 0.1 m/ns. Estimate the water content.

(b) A GPR survey is being used to map bedrock depth. Unfortunately, the bedrock is covered with a layer of clay with resistivity 5 Ωm. What is the maximum depth at which the basement can be detected with 50, 100 and 500 MHz GPR data?