EOSC 350 Midterm Exam 2018

Instructions

- There are 29 multiple choice questions for foundations, magnetics, seismology and GPR. Each question is worth 1 point.
- There are short answer questions after multiple choice questions (worth 22 points). The number of points for each is listed.
- Make sure your name and ID are clearly written.
- For multiple choice questions register your answers on the bubble sheet. Any additional writing will NOT be graded.
- Turn in BOTH the bubble sheet and the question paper before 1:50pm.
- Dark pencil and an eraser are recommended for better optical mark recognition.
- All formulas are at the end of the exam

Questions

Q1. What is the correct seven-step process?

(a) Setup, surveys, data, processing, properties, interpretation, synthesis
(b) Setup, properties, surveys, data, processing, interpretation, synthesis
(c) Properties, setup, surveys, data, processing, interpretation, synthesis
(d) Setup, properties, surveys, data, processing, synthesis, interpretation

Q2. Geophysical surveys can provide information about the distribution of a physical property. What is the principle difficulty encountered when trying to use this information to identify a rock type?

(a) Geophysical surveys can only differentiate minerals.
(b) Different rock types can have different values of a physical property
(c) Different rock types can have the same value of a physical property
(d) A single sample of rock has multiple values of a physical property

Q3. Which statement in the list below is TRUE?

(a) A geophysical target is detectable so long as it has non-zero physical property values.
(b) A geophysical target is detectable so long as there is a sufficiently large physical property contrast between the target and the surrounding material.
(c) A geophysical target is detectable if its dimensions are larger than its depth of burial.
(d) A geophysical target is detectable if it has two physical properties that are not the same.

Q4. Which of the following groups only includes the physical properties that can be diagnostic in a geophysical survey?

(a) Density, dielectric permittivity, magnetic susceptibility, electrical conductivity
(b) Electrical conductivity, seismic velocity, magnetic susceptibility, porosity
(c) Grain size, seismic velocity, magnetic permeability, dielectric permittivity
(d) Velocity, magnetic susceptibility, electrical conductivity, fluid content

Q5. The total field magnetic anomaly can be best described as:

(a) The amplitude of Earth's magnetic field.
(b) The distribution of magnetic material that differs from the background.
(c) The amplitude of induced magnetic fields projected onto the direction of Earth's magnetic field.
(d) The vertical component of the measured magnetic field

Q6. Which of the following CAN be corrected for using data gathered at a base station?

(a) magnetic storms and regional trends.
(b) diurnal variations and effects of geologic features larger than the survey area
(c) regional trends and geologic features larger than the survey area.
(d) small geologic features and diurnal variations.

Q7: When choosing the station spacing for a magnetic survey which of the following items is the most important

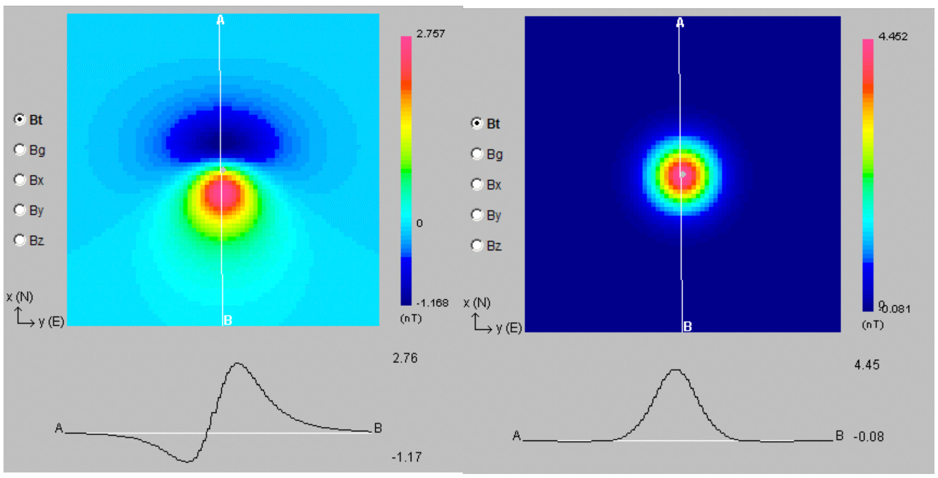
(a) The inclination and declination of Earth's magnetic field.
(b) The expected size and depth of the target.
(c) The type of magnetometer used (that is, a total field magnetometer or a magnetometer that measures the individual components).
(d) The distance between your survey area and the base station.

Q8. Which parameters can be altered without changing the magnetic response (both amplitude and anomaly width) of a susceptible sphere buried in an otherwise homogeneous half-space?

(a) Increase the depth of burial as well as the volume of the sphere

(b) Increase the depth of burial as well as the susceptibility of the sphere
(c) Increase susceptibility and decrease the volume of the sphere
(d) All of the above

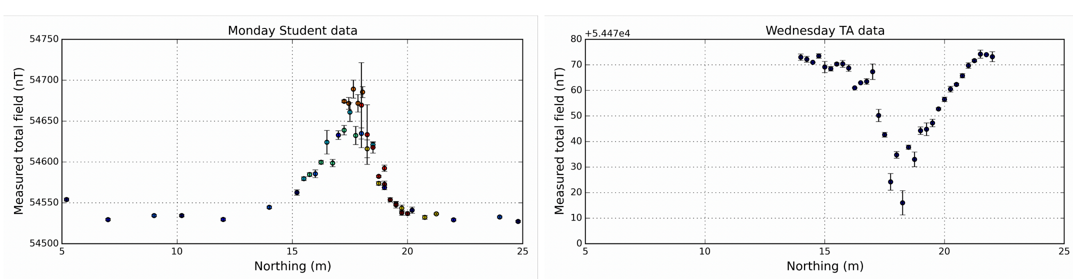
Q9: The first picture below was processed to produce the second. What is the name of the processing step applied?



(a) Initial Data (b) Processed data

(a) diurnal correction
(b) reduction to pole
(c) regional field removal
(d) coordinate transformation

Q10: The data shown below are total magnetic field data collected over two different pieces of rebar on two different days on Wreck Beach. Both data collection lines were collected South to North.



(a) Monday Data (b) Tuesday Data

Which of the following is the most likely explanation for the difference in the observed anomalies between the two data sets.

(a) Significant variations in the Earth's magnetic field between the collection times of the two data sets magnetized the rebar in opposite directions.
(b) Background noise is contaminating the Wednesday data set causing the anomaly to be negative.
(c) The rebar was buried horizontally on Monday and Vertically on the Wednesday.
(d) The rebar is remanently magnetized, and the direction of magnetization for each piece of rebar was oriented differently

Q11. How does the seismic method differ from the magnetic method?

(a) Seismic is sensitive to density changes while magnetics is sensitive to magnetic susceptibility.
(b) The magnetic method uses a natural source field while the seismic method can use either a natural or artificial source.
(c) Collecting seismic measurements requires contact with the ground while collecting magnetic data can be done at the surface or airborne.
(d) All of the above.

Q13. Which statement is NOT true?

(a) A P-wave is a body wave.
(b) An S-wave is affected by water saturation of medium
(c) A Rayleigh wave travels along surfaces and interfaces.
(d) A Love wave is a surface wave.

Q14. A seismic wave travels in a 2-layer earth. It is normally incident onto a planar interface. Which of the following statements is FALSE?

(a) If the acoustic impedance of the two layers is the same, then the reflection coefficient is zero.
(b) If the acoustic impedance of the two layers is the same, then the transmission coefficient is 1.
(c) If the acoustic impedance of the top layer is much greater than that for the layer below it, the reflection coefficient will be -1.
(d) If the acoustic impedance of the bottom layer is much greater than that for the layer above it, the transmission coefficient will be 2.

Q15. To define the velocity of a layer using the refraction seismic method, we need at least two geophones with first arrivals from that interface to ___________ . (The data are plotted the T-X plot.)

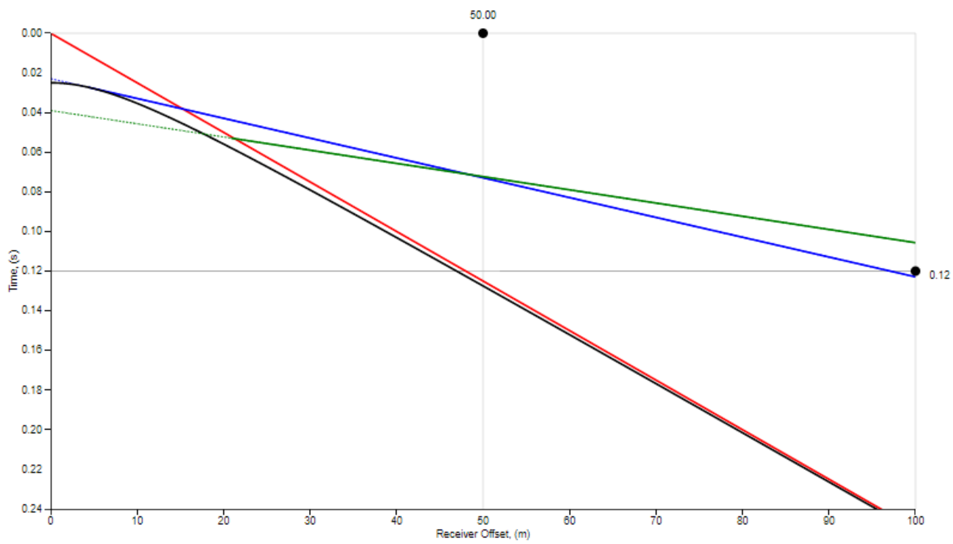
(a) account for noise
(b) compute the slope
(c) determine the offset distance

(d) compute the critical angle

Q16. The data recorded by a seismometer consists of:

(a) first break picks, which are time versus geophone position.
(b) a recording of ground motion for 10s to 100s of milliseconds following the initial source energy.
(c) depths to refraction interfaces as a function of distance along a line.
(d) distance from shot to detector.

Q17. Consider the figure below. There are 3 layers. Layer 1 has a velocity of 400 m/s and thickness of 5 m. Layer 2 has a velocity of 1000 m/s and a thickness of 10 m. Layer 3 has a velocity of 1500 m/s and extends to depth. Which statement is false?



(a) The crossover distance for the first critically refracted ray is ~15 m.
(b) The critical distance for the second critically refracted ray is~50m.
(c) The black line is the arrival for the reflected ray.
(d) The red line is the arrival for the direct ray.

Q18. Refer to the figure in Question 6. Why do the refracted rays arrive before the direct ray at offsets greater than the crossover distance?

(a) The refracted rays travel in layers that have faster velocities.
(b) The refracted rays travel closer to the surface.
(c) The direct ray actually takes an indirect path from the source to the receiver so it travels a much longer path.
(d) The refracted rays travel through the air.

Q19. To find the two depths that define a dipping layer, what is the minimum number of shots needed?

(a) 1
(b) 2
(c) 3

(d) It is not possible to define the depths for a dipping layer.

Q20. When looking at first arrival times for a seismic refraction survey, what relationship between the layer velocities allows us to determine the velocity of layer 3 and know that it is in fact the velocity for layer 3 (and not for layer 1 or 2)?

(a) v1 < v2 < v3
(b) v2 < v1 < v3
(c) as long as v2 > v3
(d) v1 > v2 < v3

Q21. Suppose you have three horizontal layers. For the critically refracted ray path traveling along the second interface (i.e., between the second and third layer) what is the incident angle at the first interface (i.e., between the first and second layer).

(a) $\sin^{-1}(v2/v3)$
(b) $\sin^{-1}(v1/v3)$
(c) $\sin^{-1}(v2/v2)$
(d) $\sin^{-1}(v3/v1)$

Q22. An MASW survey might be useful for geological engineers because:

(e) observed compressional waves are inverted to yield P-wave velocity which is related to rigidity
(f) observed shear waves are inverted to yield S-wave velocity which is converted to shear modulus
(g) observed surface waves are inverted to yield S-wave velocity which is related to Young's modulus
(h) observed shear waves are inverted to yield the depth to the sought interface

Q23. Before stacking reflection seismic data, a normal moveout (NMO) correction is applied. This correction is applied to data that is sorted in:

(a) common shot gathers
(b) common receiver gathers
(c) common midpoint gathers
(d) common offset gathers

Q24. The operating frequency of the GPR transmitter refers to:

(a) The single sine wave that generates the wavelet
(b) How often the transmitter emits a pulse into the ground
(c) The central frequency of the frequency spectrum defining the wavelet
(d) The time in nanoseconds for the GPR signal to go from transmitter to receiver

Q25. When applying a gain correction to the raw GPR signal, which of the following occurs?

(a) The signal to noise ratio improves
(b) The amplitude of late time signals is increased so that it is as visible as early time signals
(c) The amplitude of random noise is increased at later times

(d) 'b' and 'c' are correct

Q26. Which of the following situations would you avoid using GPR?
(a) Profiling the depth of a brackish lake
(b) Examining glacier thickness up to depths of roughly a kilometer
(c) Mapping irrigation infrastructure on farms
(d) Mapping buried structures at archeological sites

ϵr. What assumptions were made to obtain this formula?
(a) We assumed the earth material was non-magnetic
(b) We assumed that we were operating in the wave regime
(c) 'a' and 'b' are correct
(d) No assumptions were made

Q28. Consider the portion of a GPR wavefront, which transmits from medium 1 into medium 2. As this portion of the wavefront crosses the interface, it spreads out (refracts towards the horizontal). From this information, what can we deduce?
(a) That $V_2 > V_1$
(b) That the wavelength is greater in medium 2 than it is in medium 1
(c) 'a' and 'b' are correct
(d) 'a' and 'b' are incorrect

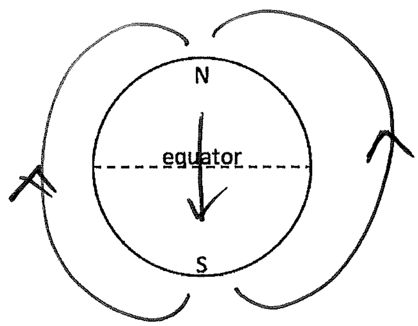
Q29. If we assume we are in the wave regime, which of the following is true?
(a) The skin depth no longer depends on the operating frequency
(b) The wave velocity depends on the conductivity
(c) The probing distance is no longer equal to 3 skin depths
(d) None of the above

Short Answer:

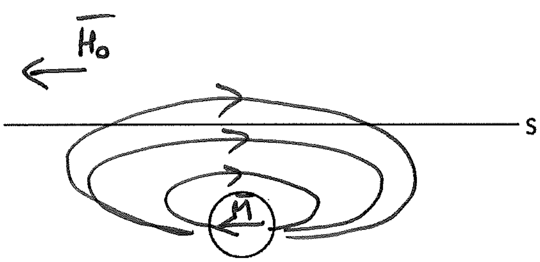
1. (5 pts) Suppose you are provided with a total field magnetometer and asked to carry out a magnetic survey at the equator to find a compact magnetic object buried at depth. Your survey line passes in a north-south direction directly over the item.

- On the first plot sketch the magnetic field lines of the earth.
- On the second, sketch the inducing field and the secondary magnetic field lines corresponding to the magnetized body.
- On the third plot, sketch
    - o the total field anomaly
    - o the anomaly you would obtain if you measured only the vertical component of the field.

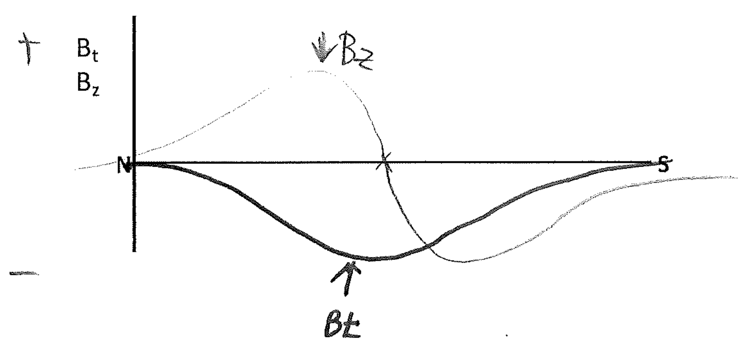
Plot 1: Earth's field



Plot 2: Field Lines



Plot 3: Anomaly



2. (6 pts) Consider the seismic refraction survey above a three-layer earth shown in Figure 1(a). Figure 1(b) shows the measured data. (Note: velocity increases with depth, i.e. v1<v2<v3)

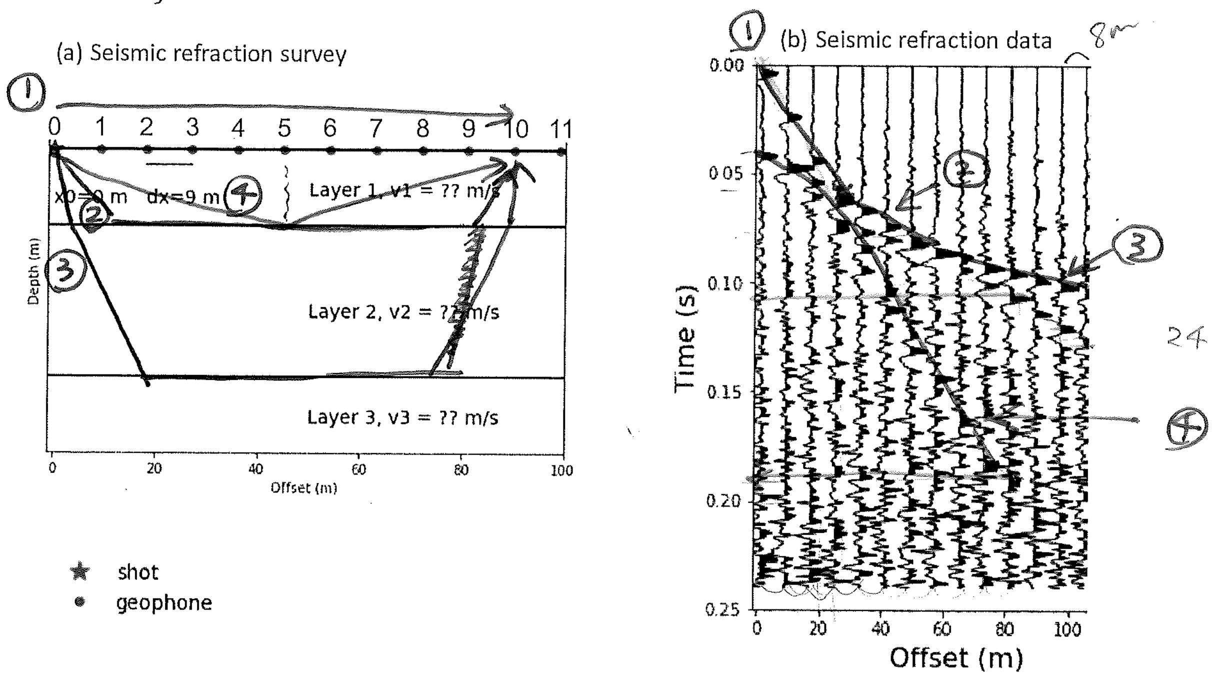


Figure 1. (a) Seismic refraction survey. (b) Seismic refraction data from a single shot.

a. Identify four different seismic arrivals in Figure 1(b). Write their names and mark them in Figure 1(b).

① direct

④ reflection

② refraction 1

③ refraction 2

b. Draw ray paths of the seismic waves from the origin to geophone #10. (Note: when drawing ray paths consider Snell's law, but you don't have to compute exact angles.)

c. Estimate velocities of layer 1 and 2, and the thickness of layer 1.

$v_1: \dfrac{80\,m}{0.19\,s} = 420\ m/s$

$v_2: \dfrac{80\,m}{0.11\,s} = 727\ m/s$

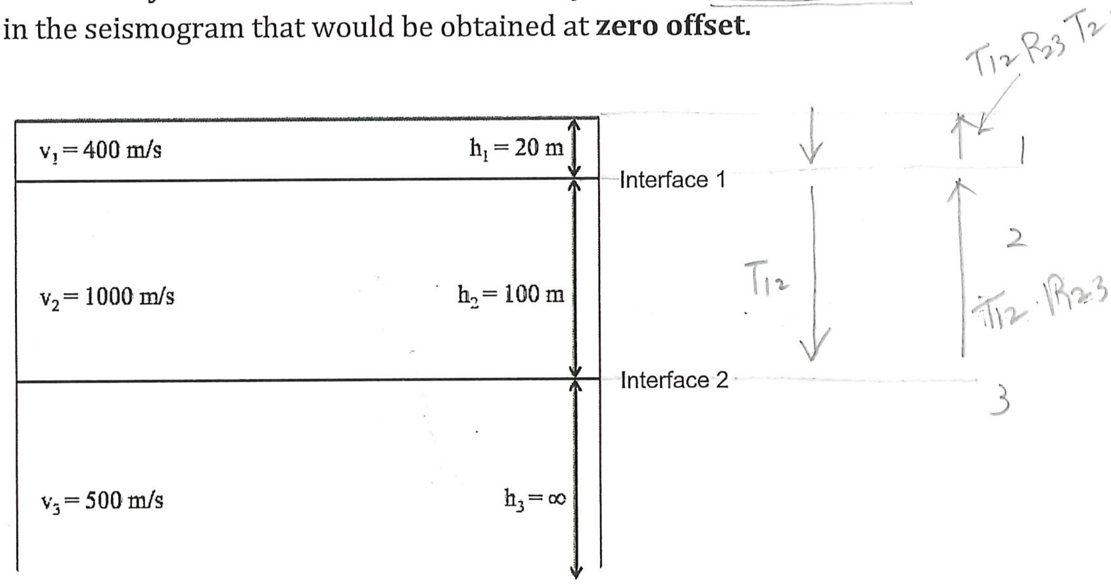
$t_i = 2z \dfrac{\sqrt{v_2^2 - v_1^2}}{v_1 v_2} = 0.04\,s$

or use $x_{cross} = \dfrac{v_1 v_2}{v_2 - v_1} t_i$

$\therefore z = \dfrac{t_i}{2} \dfrac{v_1 v_2}{\sqrt{v_2^2 - v_1^2}}$

$= 10.29\ m$

3. (6 pts) Consider the three-layer earth described below. All layers have the same density. We're interested in the seismogram that would be obtained at **zero offset.**



a. Fill out below table:

	Two way Travel time (s)	Reflection Coefficient	Transmission Coefficient	Reflectivity
Interface 1	$\frac{20 \cdot 2}{400} = 0.15$	$\frac{1000-400}{1000+400} \cong 0.43$	$\frac{2 \cdot 400}{1000+400} \cong 0.57$	0.43
Interface 2	$0.15 + 0.25 = 0.35$	$\frac{500-1000}{500+1000} \cong -0.33$	$\frac{2 \cdot 1000}{500+1000} \cong 1.33$	-0.27

$T_{12} \cdot R_{23} T_{21} \cong -0.27$

$0.57 \cdot -0.33 \cdot 1.43$

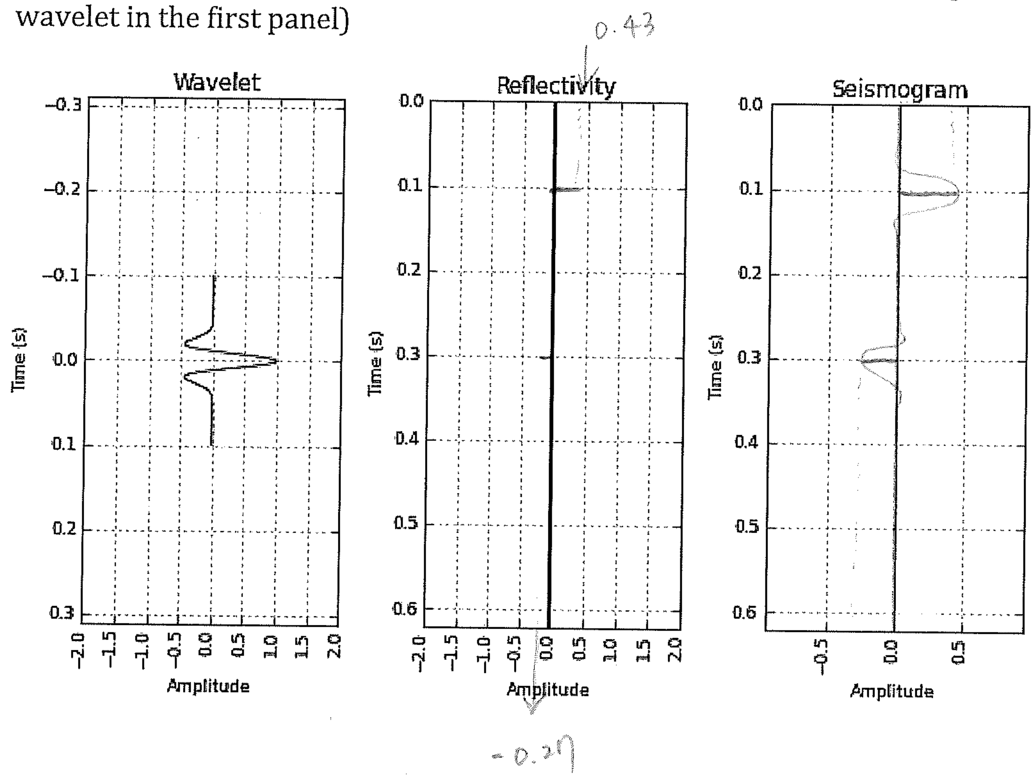
$T_{21} = \frac{2 \cdot 1000}{1000+1400} = 1.43$

$t = \frac{2h}{v}$ (two way travel time)

$R = \frac{Z_2 - Z_1}{Z_2 + Z_1} = \frac{v_2 - v_1}{v_2 + v_1}$ $(\because \rho_1 = \rho_2)$

$T = \frac{2Z_1}{Z_2 + Z_1} = \frac{2v_1}{v_2 + v_1}$

b. From values in your table, plot reflectivity and the synthetic in the panels below. (Note: when plotting seismogram consider travel time, polarity, and amplitude of the wavelet in the first panel)



4. (5pts) Consider the radargram (Figure 2) obtained from a zero offset GPR survey seeking for buried pipes. (Note: the GPR equipment is not shielded)

   a. Mark hyperbolas due to the buried pipes in Figure 3.

   b. Estimate the relative electric permittivity of the background medium.

$$t = \frac{2\sqrt{x^2+h^2}}{v} \approx \frac{2x}{v} \quad (\text{when } x \gg h) \qquad \therefore v = \frac{2x}{t} = \frac{2 \cdot 2.4\,m}{30\,ns} = 0.16\,m/ns$$

$$\varepsilon_r = \left(\frac{c}{v}\right)^2 = \left(\frac{0.3\,m/ns}{0.16\,m/ns}\right)^2 = 3.51$$

   c. What is the horizontal location and depth of each pipe?

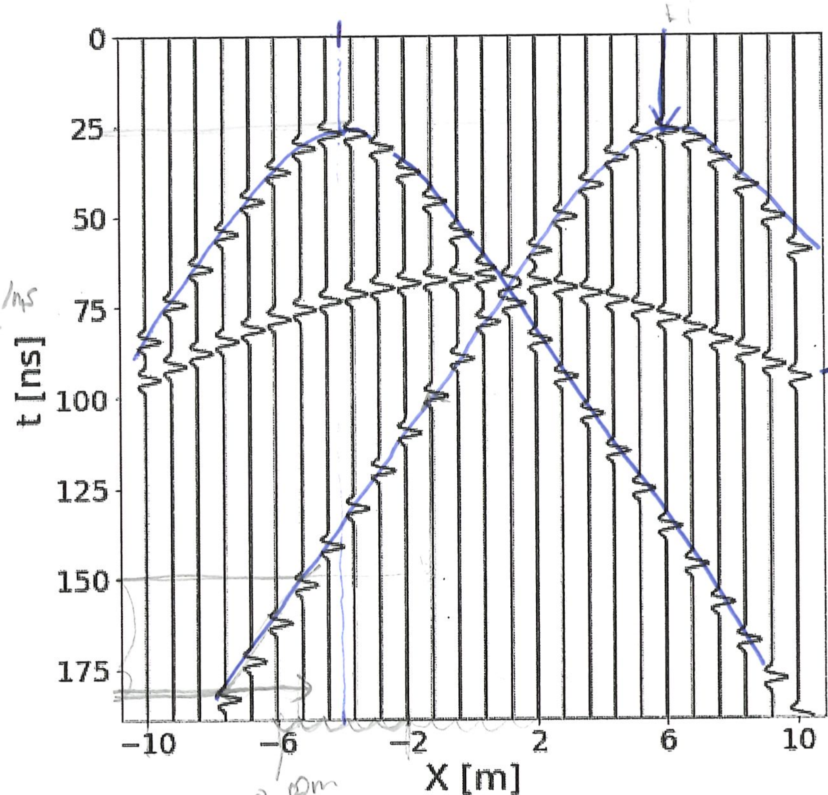
~~$\Delta t = 4m$~~

① $x = -4m$

$$z = \frac{t \cdot v}{2} = \frac{25\,ns \cdot 0.16\,m/ns}{2} = 2\,m$$

② $x = -6m$

$z = 2m$



→ This is not !? (expected to same slope of (or similar) hyper-bola)

0.8m

Figure 2. Radargram.

$\frac{4m}{5}$

Seismic:

Velocities	$v_p = \sqrt{\frac{K + 4/3\mu}{\rho}}$ $\quad v_s = \sqrt{\frac{\mu}{\rho}}$
Acoustic impedance	$Z = \rho v$ $\quad R = \frac{Z_2 - Z_1}{Z_2 + Z_1}$ $\quad T = \frac{2Z_2}{Z_2 + Z_1}$
General	$d = vt$ $\quad \lambda = vT = \frac{v}{f}$
Vertical resolution	$L = \frac{\lambda}{4}$
Refraction arrivals	$t = \frac{x}{v_2} + 2z\frac{\sqrt{v_2^2 - v_1^2}}{v_1 v_2} = \frac{x}{v_2} + t_i$
Cross-over distance	$x_{cross} = \left(\frac{v_1 v_2}{v_2 - v_1}\right) t_i = 2z\sqrt{\frac{v_2 + v_1}{v_2 - v_1}}$
Refraction Angles	$\frac{\sin\theta_1}{v_1} = \frac{\sin\theta_2}{v_2}$
Reflection hyperbola	$t(x)^2 = t_0^2 + \frac{x^2}{v^2}$ $\quad$ x=distance from Tx to Rx

GPR:

Reflection coefficient:	$R = \frac{\sqrt{\varepsilon_1} - \sqrt{\varepsilon_2}}{\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}}$
Transmission coefficient:	$T = \frac{2\sqrt{\varepsilon_2}}{\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}}$
Rulse length (Δt) and central frequency (f_c) of wavelet:	$\Delta t = \frac{1}{f_c}$
GPR signal velocity:	$v \approx \frac{c}{\sqrt{\varepsilon_r}}$
GPR wavelength:	$\lambda = \frac{V}{f_c}$
Vertical resolution limit:	$L > \frac{\lambda}{4} = \frac{V}{4f_c}$
Horizontal resolution limit:	$L > \sqrt{\frac{Vd}{2f_c}}$
Refraction Angles	$\frac{\sin\theta_1}{v_1} = \frac{\sin\theta_2}{v_2}$
Skin depth (quasi-static)	$\delta = 503\sqrt{\frac{1}{\sigma f}}$
Skin depth (wave regime)	$\delta = \frac{0.0053\sqrt{\varepsilon_r}}{\sigma}$
Velocity of light	$c = 0.3m/ns$ or $3 \times 10^8 m/s$