Questions: GPR

1. Which of the following statements is incorrect when considering skin depth in GPR
   a. Skin depth is the distance at which the signal amplitude has decreased by a factor of 1/e
   b. Skin depth is dimensionless
   c. As conductivity increases, the skin depth increases
   d. As electrical permittivity increases, the skin depth decreases
   e. b and d are incorrect statements

2. Which of the following statements about GPR is incorrect?
   a. “Common Shot Gather” is the most commonly used geometry when performing GPR measurements in practice
   b. Electrical permittivity is one of the main material properties that affect GPR responses
   c. We can observe higher attenuation of EM waves when the medium has a higher conductivity
   d. GPR is capable of resolving relatively near surface structures

3. Which is the first wave that we can measure in GPR measurement?
   a. Critically refracted wave
   b. Reflected wave
   c. Direct ground wave
   d. Direct air wave

4. Of the following list, what are inappropriate situations to use GPR
   a. Mapping Peat Thickness
   b. Detecting offshore hydrocarbon
   c. Mapping Glacier Thickness
   d. Mapping fracture locations in resistive rock

5. Of the following statements about GPR, which ones are appropriate?
   a. We can identify lateral positions of distinct buried objects with GPR
   b. Common offset gather is proper geometry to detect lateral variations of the earth
c. Common offset gather can give us better estimation of the wave velocity than common midpoint gather
d. a) and b) are correct
e. a) and c) are correct

6. What statements about variables seen in Electromagnetism is incorrect?
   a. Permittivity in free space (ε₀) is 8.844 E-12 Farads/meter
   b. Unit of conductivity is σ is S/m
   c. The flux density B is in Wb/m²
   d. Strength of the magnetic field H is in Teslas

7. Consider the following common offset gather collected with GPR.

   Which of the following could have resulted in the hyperbolic anomaly indicated by the red arrow
   a. A till layer
   b. A pipe
   c. An aquifer
   d. These cannot be distinguished in the data
8. A GPR survey is conducted. The center frequency is 100 MHz, the relative permittivity of the layer of interest is 25. What is the minimum thickness of that layer so that it can be detected?
   a. 7.5cm
   b. 15cm
   c. 30cm
   d. 60cm

9. Which of the following statements regarding GPR antennas is true?
   a. The smaller the antenna, the higher the frequency
   b. The longer the antenna, the higher the frequency
   c. The frequency is independent of the antenna length
   d. The period is independent of the antenna length

10. In a GPR measurement, which of the following physical properties is primarily responsible for the speed of the wave?
    a. Electrical conductivity
    b. Magnetic permeability
    c. Electrical permittivity
    d. Chargeability

11. Consider the following GPR section collected over a paleochannel.

Which of the following is the most likely reason for the lack of reflections on the south and north of the section?
   a. conductive fine-grained silts and clays at depth attenuate the signal
   b. magnetic soil overlies the survey area, attenuating the signal
   c. dense bedrock at depth impedes signal propagation
   d. the material is completely homogeneous

12. You want to locate steel piping that runs through the foundation of a building. Which survey would be best suited for determining both the depth and extent of the piping?
a. Gradient magnetic field survey  
b. Total magnetic field survey  
c. GPR  
d. Seismic

13. You are using a GPR survey to delineate a subsurface aquifer present in a sandstone layer. Which of the following features is mostly likely to indicate the presence of water?
   a. An increase of radar signal below the region of interest  
b. A lack of radar signal below the region of interest  
c. A scattering event  
d. A decrease in signal above the region of interest

14. __________________ describes how easily charges can be pushed into disequilibrium by an imposed electric field.
   a. Magnetic susceptibility  
b. Electrical conductivity  
c. Electrical permittivity  
d. Electrical permeability

15. When computing the electric permittivity from a velocity obtained in a GPR survey, which of the following assumptions is typically made?
   a. $\mu_r = 1$  
b. $\mu_r = 0$  
c. $\varepsilon_r = 1$  
d. $\varepsilon_r = 0$

16. Electrical permittivity is related to:
   a. Ability for electrical charges to separate under application of an electric field  
b. Number of water molecules per unit volume  
c. Ease with which a material generates electric dipoles  
d. All of the above

17. Comparing GPR with seismic, which of the following statements is INCORRECT?
   a. Ray path tracing holds for both of them  
b. Snell’s law holds for both of them  
c. When considering the reflection coefficient, the dielectric constant for GPR is analogous to the acoustic impedance in seismology.  
d. The first arrival for both cases is always the wave propagating in the top
layer of the earth.

18. The water table lies 3 meters beneath earth’s surface. The upper region has a
dielectric constant of 4. Water has a dielectric constant of 80. If the amplitude of
the down-going pulse is 5 units, what is the amplitude of the radar pulse when it
returns to the surface? For this question neglect all aspects attenuation.
   a. -0.64
   b. 0.64
   c. -3.2
   d. 3.2

19. The dipping reflecting horizon in the GPR data set below can be interpreted more
accurately by

   a. Adjusting dip via migration using circular arcs
   b. Changing the image’s plotting colours
   c. Re-surveying with transmitter and receiver further apart
   d. Using the equation for a hyperbola to accurately find the reflector’s
      geometry.

20. What analysis is needed if GPR common offset data are to be used to estimate
the depth to a small confined target?
   a. Slope from T vs X plots
   b. Slope from T(squared) vs X(squared) plots.
   c. Two-way travel time when the GPR is directly above the target
   d. A combination of (b) and (c)

21. Imagine that you are interested in estimating the depth to the bottom of a glacier.
   Why is GPR possibly a good method, in spite of its normally “shallow”
   investigation depth?
   a. Because ice is nearly transparent to radio signals of a few megahertz.
   b. Because the dielectric contrast between ice and air should make for a
      reasonable reflector at the ice/rock interface.
   c. Because the method is relatively high resolution so long as measurements
      are gathered at tight station and line spacings.
   d. All of the above.

22. A CMP (Common Midpoint) survey is often carried out in GPR surveys to find:
   a. The dip of a sloping interface
   b. The average velocity between the surface and the reflector
c. The attenuation coefficient  
d. All of the above

23. The water table lies 3 meters beneath earth’s surface. The upper region has a dielectric constant of 9. What is the critical angle for the refracted wave?  
   a. 70 degrees  
   b. 45 degrees  
   c. 20 degrees  
   d. 5 degrees

24. What is the maximum amount of information that can be obtained by analyzing a hyperbolic curve on a GPR cross section?  
   a. Location of the target, velocity of the upper region and dielectric constant  
   b. Velocity of upper region and depth of the target  
   c. Conductivity, dielectric constant and velocity of the upper region  
   d. Horizontal and vertical location of the target

25. Two small-diameter plastic pipes are buried beneath each other and separated by 25 cm in the vertical direction. The pipes are in dry sand that has a dielectric constant of 4. Of the following choices, what is the lowest frequency radar system that you can use and still resolve the two pipes?  
   a. 1 MHz  
   b. 10 MHz  
   c. 100 MHz  
   d. 1000 MHz

26. What is the best definition of attenuation rate?  
   a. The speed of radio waves in a material  
   b. Loss of energy per unit distance.  
   c. Signal amplitude as a function of time.  
   d. The rate at which velocity changes as a function of time.

27. Consider the GPR section shown below. What are likely reasons why the depth of penetration on the left side of the section is shallower than on the right hand side?  
   a. The region on the left coincides with generally higher conductivity  
   b. The region on the left has multiple scatters at depth that are reflecting the
energy
c. Spherical attenuation is larger on the left side compared to the right
d. All of the above.

28. Consider the following diagram.

Assuming the GPR velocity in the air is $v_0$ and in layers 1 and 2 is $v_1$ and $v_2$, respectively. Which of the following best describes the travel time of GPR signal (1)?

a. $t = x / v_0$
b. $t = x / v_1$
c. $t = x / v_0 + \text{const}$
d. $t = x / v_1 + \text{const}$

Short Answer Questions

29. Consider an earth whose upper layer is made of dry and saturated sand separated by a vertical contact. The parameters are provided below.

The radar transmitter uses a 100 MHz antenna and the transmitter and receiver are almost coincident. Radar data are taken every meter along a profile that extends across the contact.
a. (2 pts) Sketch the characteristic GPR wavelet as a function of time. Label the axis so that the time length of the pulse is seen.

b. (2 pts) What are the reflection coefficients for the layer beneath A and B?

c. (4 pts) Generate the expected radar signal from two locations, A and B. Use the characteristic radar pulse you had in (a). Plot the expected radar signals on the plot below. Show the primary and reflected events with approximately the right relative amplitude. In doing this, you can neglect the amplitude loss due to attenuation and geometrical spreading.

30. Consider the following common offset GPR section collected in a region where there is an interface between fresh and saline groundwater.

a. Using your knowledge of the physical properties of fresh and saline groundwater, explain why GPR is sensitive to the contrast between fresh and saline groundwater.

b. draw where you interpret the interface between the fresh and saline groundwater
31. Use the below diagram to answer the following questions.

![Diagram](image)

a. Four raypaths are shown on this diagram. There are two direct rays; what raypath numbers in the diagram correspond to these rays? Where do each of these rays propagate? With what velocity does each propagate?

b. One of the raypaths is a reflected ray. Which number corresponds to this raypath?

c. One of the raypaths is a critically refracted ray. Which number corresponds to this raypath? To generate such a raypath, what must the relationship between the permittivity of the air and the first layer be?

d. A common shot gather data set was collected in a setting where \( v_0 > v_1 > v_2 \). On the below plot, sketch and label the first arrivals for each of the raypaths.
32. Consider the survey setup shown in the figure below. The center frequency of the GPR system is 200kHz. Can we distinguish between the two direct arrivals?

\[ \begin{align*}
\text{TX} & \quad 1\text{m} \quad \text{RX} \\
\text{air:} & \quad \varepsilon_{r,0} = 1 \\
\text{layer 1:} & \quad \varepsilon_{r,1} = 4 \\
\text{layer 2:} & \quad \varepsilon_{r,2} = 10
\end{align*} \]