Applied Geophysics – GEO 5660/6660
FINAL EXAM, April 27th

- ***Expected time to complete all 12 questions: ~2.5–3 hours;*** *Please show all work!*
- *This test is OPEN-TEXT/-NOTES. Some basic relations are given on the last page.*
- *SUBMIT AS A* ***SINGLE*** *DOCUMENT (DOCX, PDF, ODT, SCAN – no spreadsheets or codes)*

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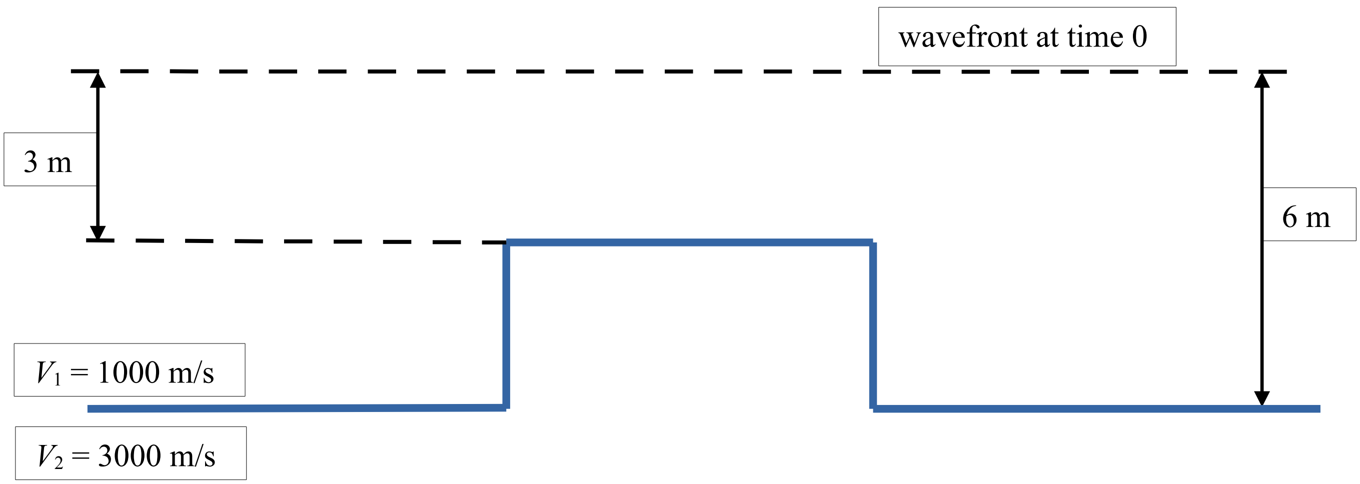
(1) Use Huygen's principle to determine wavefronts at 1 millisecond intervals for downward propagation of the planar wavefront (dashed line) shown. Sketch in the next ***five*** wavefronts.



(2) Massive limestone has a density ρ ~ 2700 kg/m^3. Assuming a depth to karst ≥ 20 m and a measurement uncertainty of 50 µGal, what is the smallest diameter of a spherical, water-filled cave you might hope to detect?

(3) Given a gravity measurement (relative to GRS67 reference gravity) Δg_{obs} = –78.2 mGal at an elevation of 1834 m, calculate:

(a) the free air correction & anomaly. How accurate must the elevation measurement be to get 0.1 mGal accuracy?

(b) the simple Bouguer correction & anomaly, using a standard reduction density ρ = 2670 kg/m^3. How accurate must the reduction density be to maintain 0.1 mGal accuracy?

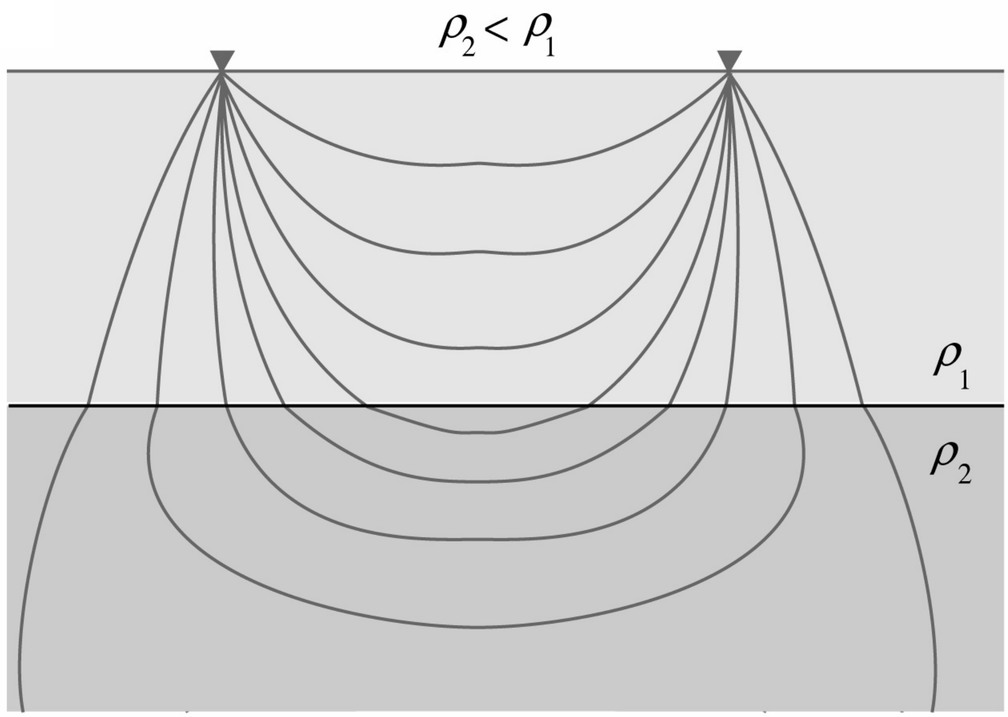
(4) Calculate the magnitude and direction of the induced magnetic field I inside a spherical body with magnetic susceptibility k = 1.0 at the South Magnetic Pole (H_E = 60,000 nT, inclination i = –90°). Is this body most likely to be diamagnetic, paramagnetic, ferrimagnetic, ferromagnetic, or antiferromagnetic?

(5) The **Poisson's Relation** relates which properties of the gravity and magnetic field anomalies? Identify the steps (equations) involved in estimating the *vertical* magnetic anomaly due to a buried, approximately spherical ore-body, given the mathematical expression for vertical gravity contribution from a spherical uniformly dense anomaly. Assume uniform magnetization within the body.

(6) Figure below shows **current flow lines** for a 2-layer model with resistivities as shown.

(a) Qualitatively sketch the current flow vectors (tangents) at the interface between the layers for the outermost (deepest) current line.

(b) Qualitatively sketch a few equipotential lines for each electrode, including at least one associated with each crossing the layer interface.



(7) You want to use potential field methods – gravity and magnetics – to investigate a potential ore body which has been identified from seismic imaging to have maximum dimensions of ~ 2 km x 2km x 2 km, and sitting with its top just below the Earth's surface. Local geological surveys estimate that the mean density contrast relative to surrounding rocks, $\Delta\rho$, for this ore-material, at least based on nearby surface outcrops to be ~ 500 kg/m^3, and its magnetic susceptibility, k, to be ~ 0.001. The magnetic field from local surveys was found to be, H_e ~ 52000 nT, with an inclination of 67 degrees.

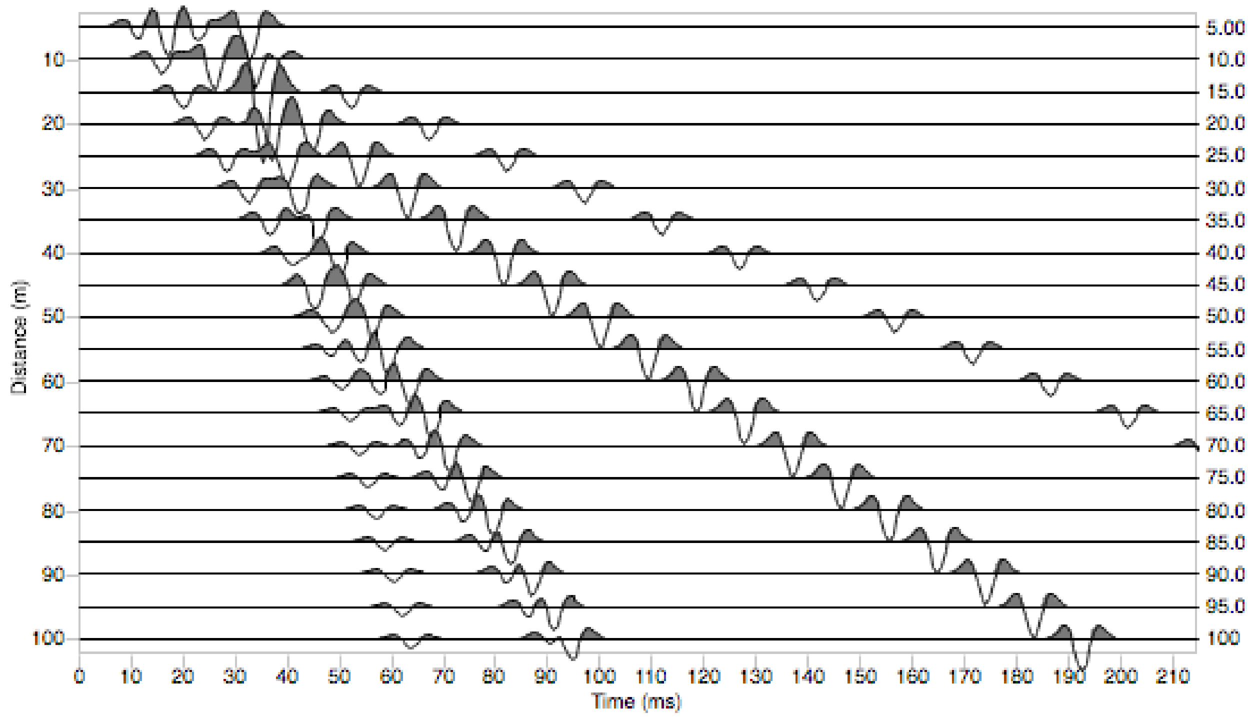
(a) Assume that the ore body is spherical. If the accuracy of your gravity survey is 50 μ-Gal, what is the diameter of the smallest detectable ore-body at a depth corresponding to the bottom of the seismic anomaly?

(b) What would be depth to the center of the largest possible ore-body given the seismic constraints? What would be its peak surface gravity anomaly?

(c) As a first approximation, assume the ore-body in (b) is predominantly magnetized in the vertical direction. What would be its peak surface magnetic anomaly?

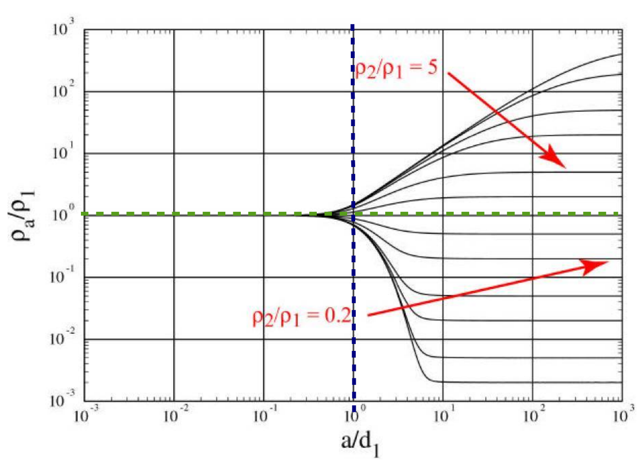
(8) Velocity of P-waves in a certain limestone layer is 3.75 km/s. What are the wavelengths of **(a)** 10 Hz, **(b)** 50 Hz, and **(c)** 100 Hz P-waves traveling through this layer? **(d)** If its Poisson's Ratio, v, equals 0.18, what is the S-wave velocity through this layer? Express your answer to the nearest 100th (*km/s*).

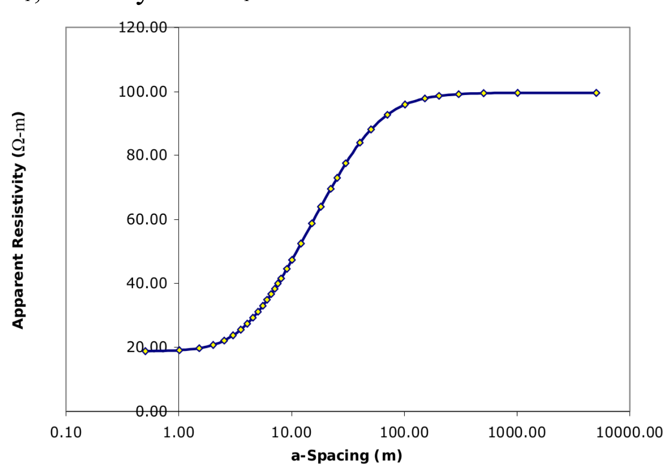
(9) For the seismogram below:



(a) Draw lines through picks of each of the wave arrivals you can see in the seismogram, and label each. Then draw schematically the simplest possible subsurface model that could produce these arrivals, and draw and label an example ray and raypath for each of the arrivals.
(b) Calculate approximate layer velocities and thicknesses associated with your simple model. Use two methods to get parameters if possible. Show all work.

(10) Using the layer-over-halfspace universal curve plot shown below-left, **(a)** interpret the apparent resistivity curve at right to estimate layer resistivities (ρ_1 and ρ_2) and thickness (d_1) of the upper layer. This procedure is illustrated with an example in Section 5.9.3 of text, but can be summarized as follows: First figure out ρ_1 and ρ_2 from the right plot. Trace the blue right curve on tracing paper, marking the y-axis for reference. Replot this curve on tracing paper, scaling its y-axis to that of the left plot – do not touch x-axis. Align the scaled trace such that its left-asymptote lines up with the green dashed line. On the trace paper, mark $a/d_1 = 1$ (10^0, blue dashed line). Finally, realign the trace paper x- and y-axes with those of the right plot. Read off the value of depth, d_1, where your $a/d_1 = 1$ line crosses the x-axis.



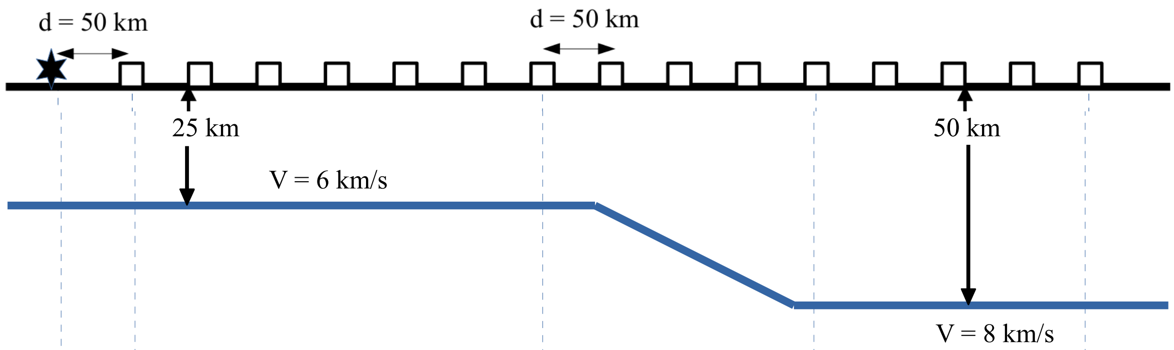


(b) Calculate the angle of incidence of current flow lines in the second layer at a layer boundary location where current flow lines in the first layer have angle of incidence $\theta_1 = 40°$.

(11) In a seismic experiment, head-waves first appear at a critical distance, $x_{cr} = 200\ m$. and a single cross-over distance, $x_{CO} = 480\ m$ is observed. Recall that x_{cr} is the distance at which the first refracted wave arrives at the surface, and x_{co} is the distance at which the direct and refracted waves arrive at the same time at the surface. The direct wave velocity was inferred to be 1.5 *km/s* from the travel-time plot. What is the velocity of the bottom layer? And its depth? Round to the nearest 0.1 *km/s* & 10 *m*.

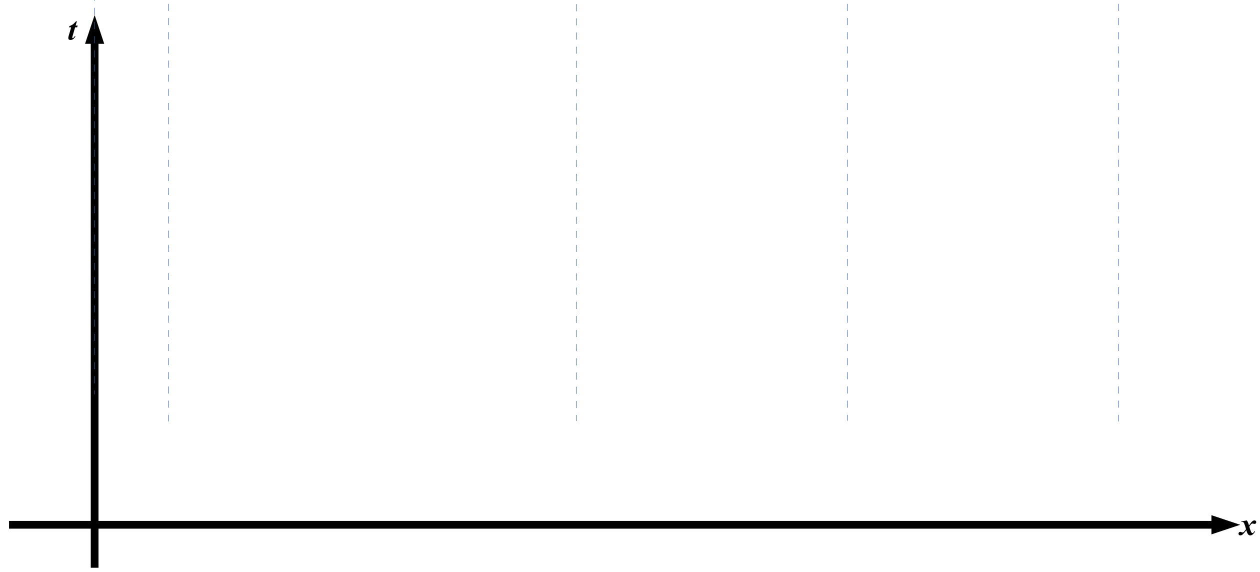
(12) You are preparing to shoot a crustal seismic refraction survey crossing the transition from the Basin-Range province to the Colorado Plateau. One possible crustal model of the transition as viewed from the South is shown below. **NOTE:** Horizontal and vertical distances are not to the same scale!

(a) Draw the raypaths expected for the head wave arriving from the mantle for the shot-point (*) and uniformly spaced receivers (boxes) shown. (A ***rough approximation*** is sufficient; no need to calculate angles of incidence).



(b) Calculate the critical and cross-over distances, x_{cr} & x_{co}.

(c) Draw an ***approximate*** travel-time plot of the head wave arrivals from this geometry.



RELEVANT EXPRESSIONS

I. Basic Trigonometric relations:

$$\sin(\theta)=\frac{y}{h};$$

$$\cos(\theta)=\frac{x}{h};$$

$$\tan(\theta)=\frac{y}{x};$$

$$h=\sqrt{x^2+y^2}$$