Applied Geophysics – GEO 5660/6660
Quiz # 2, March 10th

NOTE: 4 Questions – Duration: 60 min

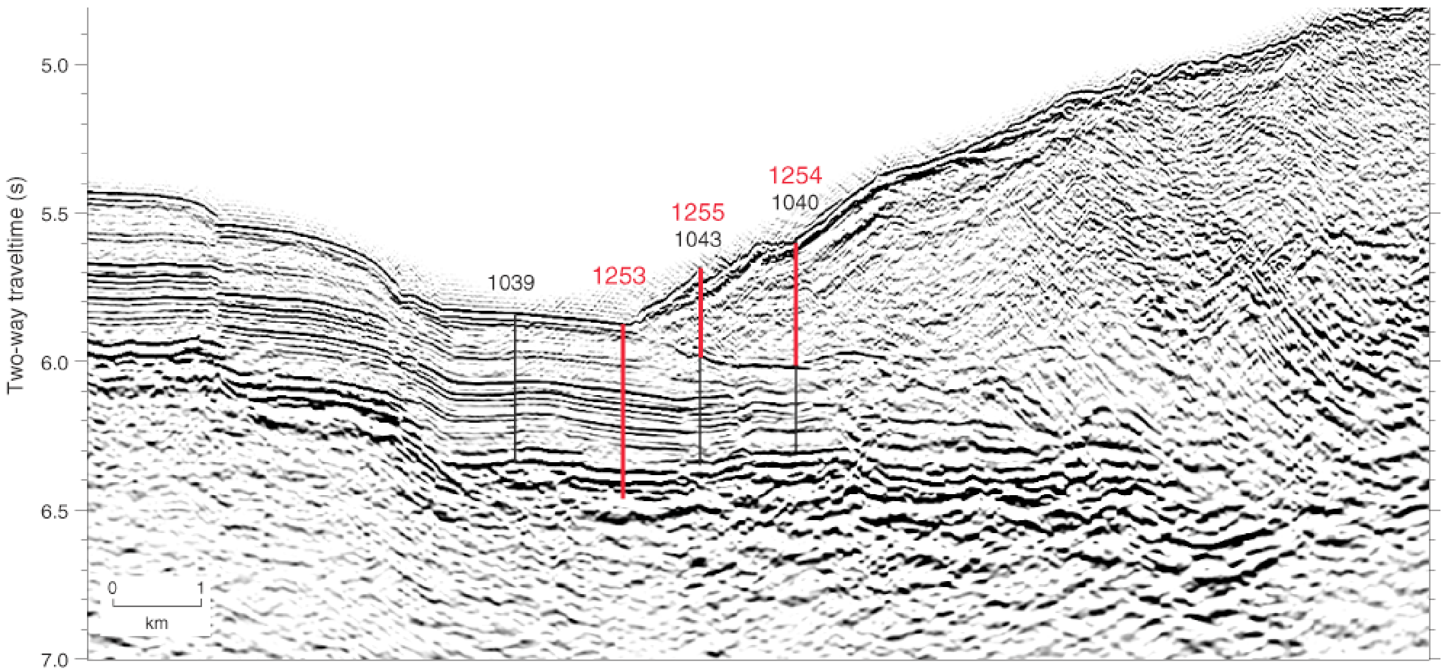
Relevant data/expressions on last page!

Show all work & assumptions for credit – extra space on the back of each page

Name:______________________________

1. The seismic section below is a pre-migration common-midpoint stack.

(a) Interpret it by line tracing and labeling major structures and/or other features (note that the vertical lines – black & red – are drill-holes).

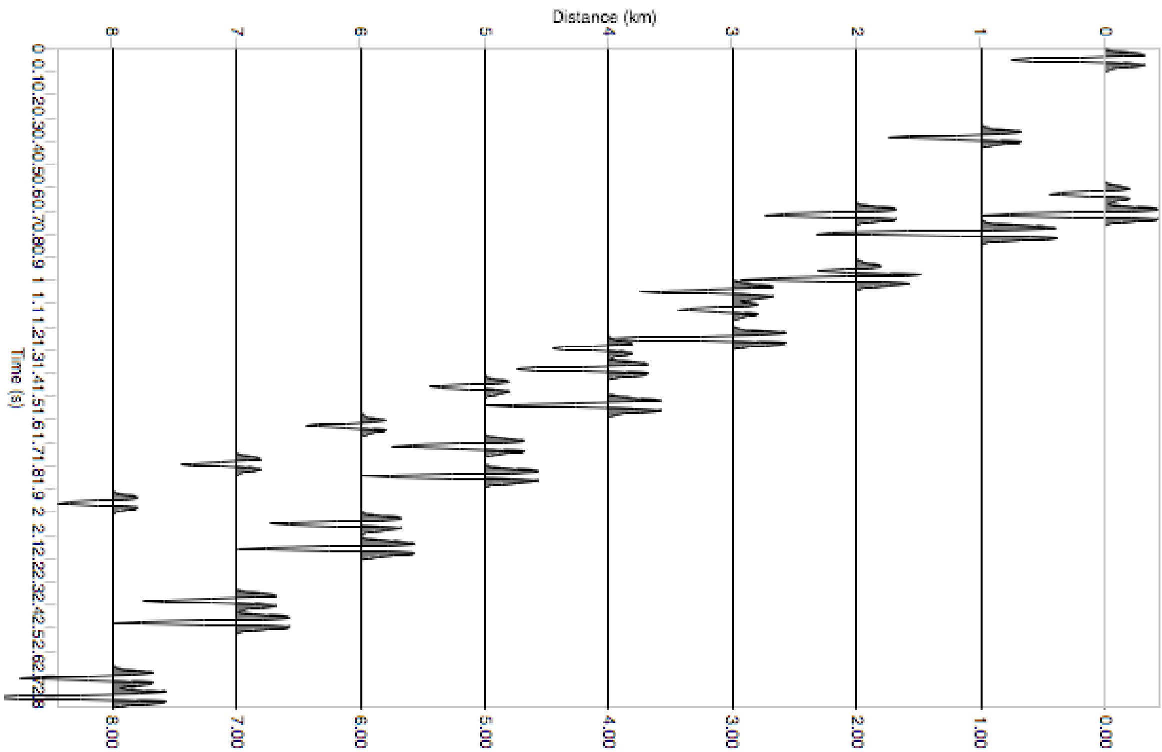


(b) What is the tectonic environment of the region?

(c) Based on your assessment of the tectonic setting and plausible rock-type(s), **approximately** how deep below the ocean bottom was well #1253 drilled? What kind of rocks can we expect to find at the bottom of this well?

Name:______________________________ **Quiz # 2, March 10th**

2. You have completed a seismic survey and obtained the travel-time curves below for wave arrivals.



(a) Draw a line or curve through each of three different arrivals, and label them A, B and C.

(b) Draw the simplest possible subsurface model that could have produced these arrivals. Then draw (and label) the rays and ray-paths that produced each of your arrivals A, B and C at one of the geophones.

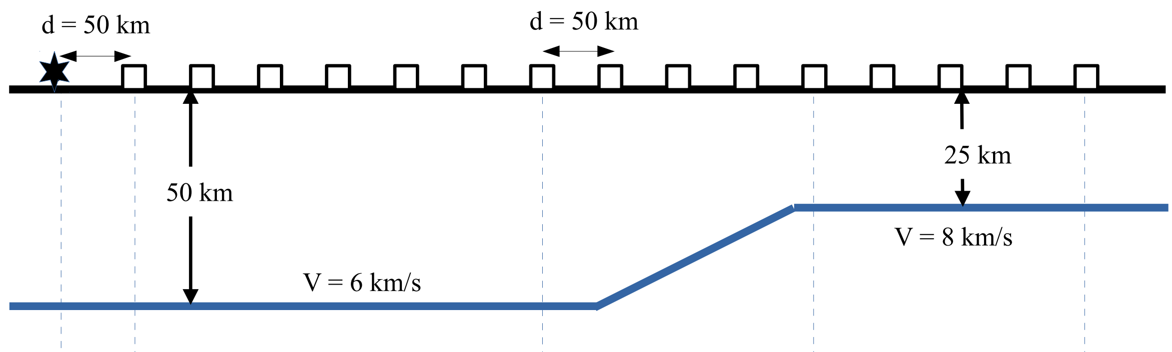
(c) Determine the layer velocities and thicknesses associated with your simple model ***using first arrivals (refraction method) as well as the reflection method***. Show all work.

Name:______________________________ **Quiz # 2, March 10th**

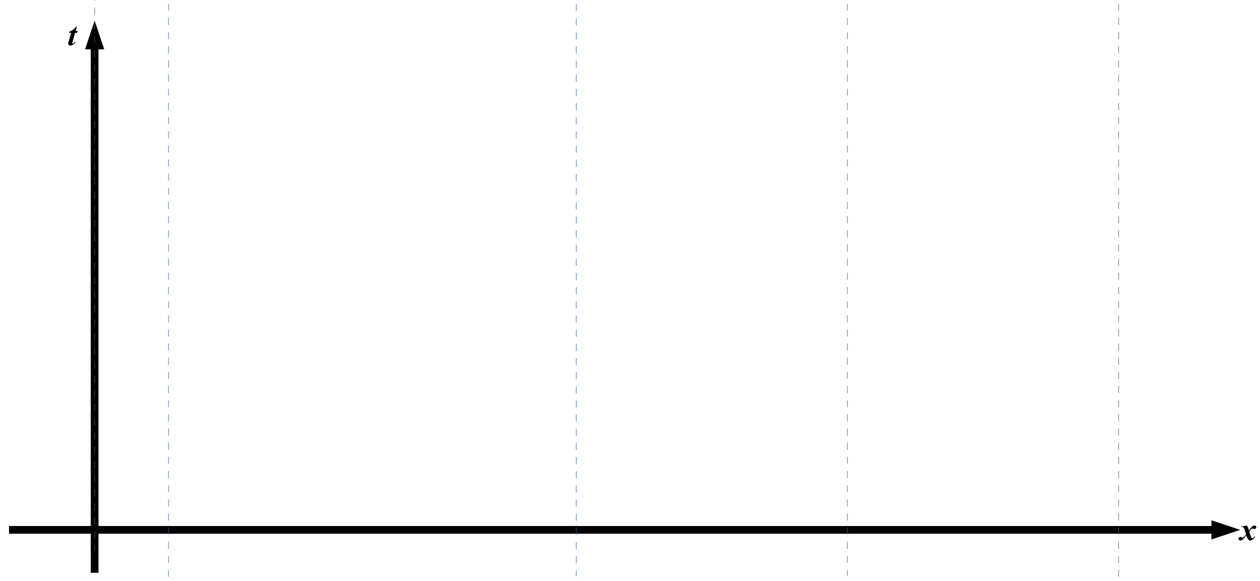
3. You are preparing to shoot a crustal seismic refraction survey crossing the transition from the Basin-Range province to the Colorado Plateau. One possible crustal model of the transition is shown below.

(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}? 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. **NOTE:** Horizontal and vertical distances are not to the same scale!



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



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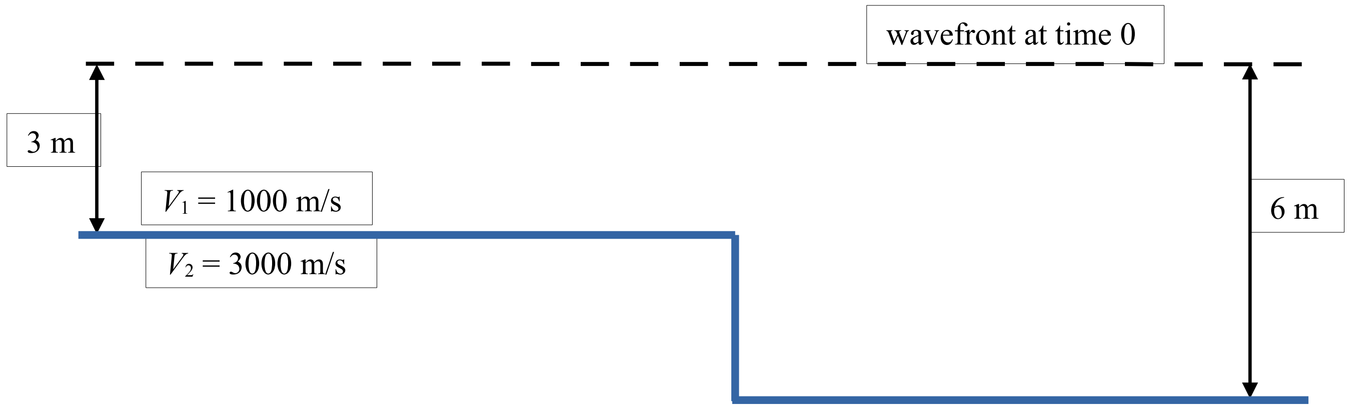
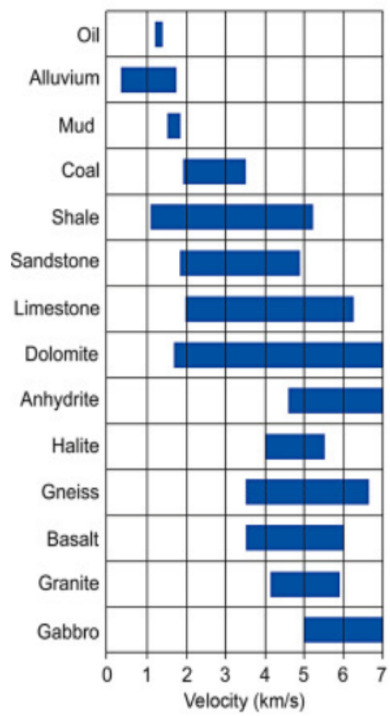
4. Use Huygen's principle to determine wavefronts at 1 millisecond intervals for downward propagation of the planar wavefront (dashed line) shown. Sketch in the next five wavefronts.



RELEVANT DATA/EXPRESSIONS

I. P-Velocities in common crustal rocks/materials:



II. Snell's Law:

$$\frac{V_1}{V_2}=\frac{\sin(\theta_1)}{\sin(\theta_2)}$$

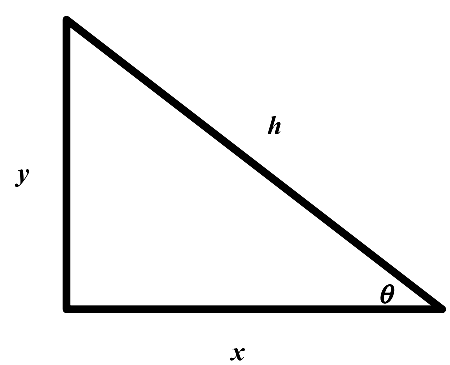
III. Basic Trigonometric relations:

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

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

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

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



IV. Refraction – *n* horizontal layers:

$$t = \frac{x}{V_n} + \sum_{i=1}^{n-1} \frac{2h_i\cos(\theta_i)}{V_i}, \quad n=2,3, \ldots ; \qquad Snell's\ Law: \ \sin(\theta_i) = \frac{V_i}{V_n}$$

where, x is the distance to each geophone from the shot-point, $\{V_i, h_i, \theta_i\}$ are the seismic velocity, depth, and angle for the first refracted arrival within each layer, and V_n, the velocity of the lower-most layer.

V. Reflection – *n* horizontal layers:

$$t = \sqrt{\frac{x^2 + 4h_i^2}{V_{i,rms}^2}}; \qquad V_{n,rms} = \sqrt{\frac{\sum_{i=1}^{n-1} V_i h_i}{\sum_{i=1}^{n-1} \frac{h_i}{V_i}}}$$

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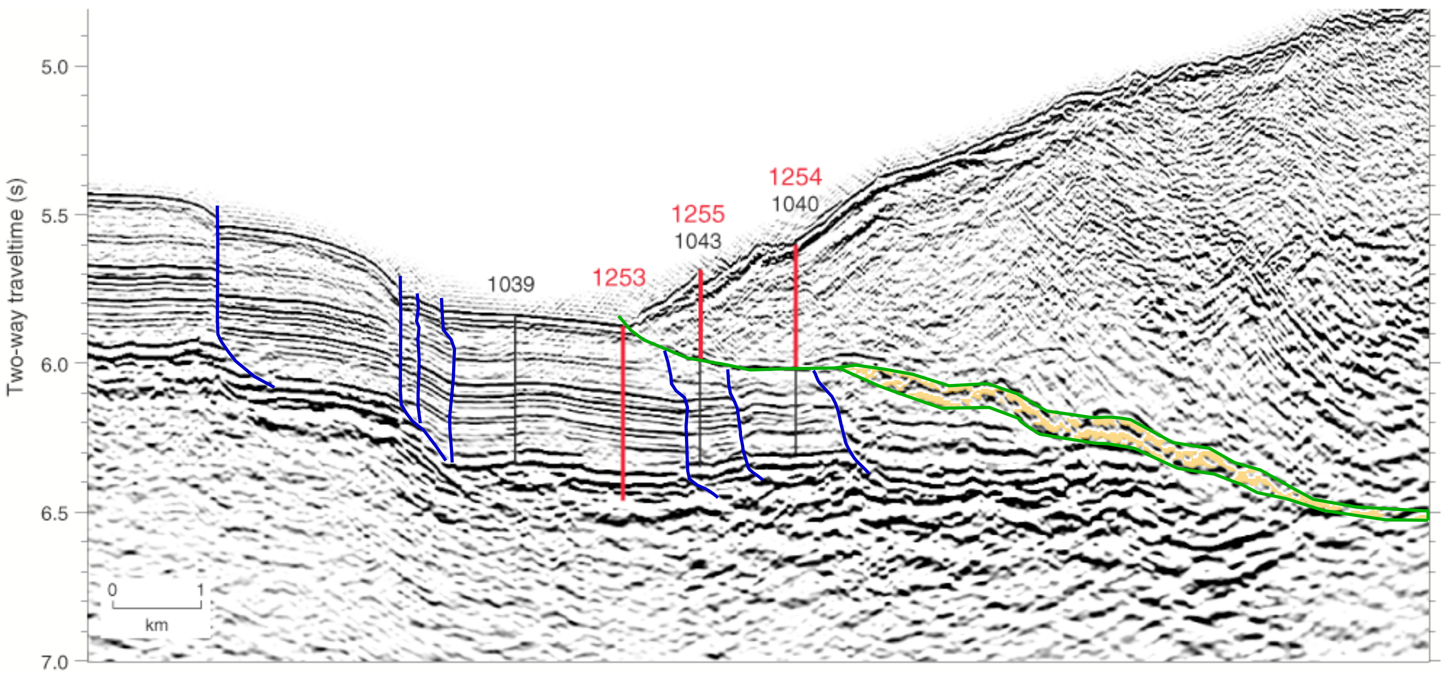
Name: Ravi Kanda Solutions

1. The seismic section below is a pre-migration common-midpoint stack.

(a) Interpret it by line tracing and labeling major structures and/or other features (note that the vertical lines – black & red – are drill-holes).



(b) What is the tectonic environment of the region?

A subduction zone

(c) Based on your assessment of the tectonic setting and plausible rock-type(s), **approximately** how deep below the ocean bottom was well #1253 drilled? What kind of rocks can we expect to find at the bottom of this well?

1. Two -way travel time (TWTT) from the seismic section,

$$\Delta t \approx 6.5 - 5.8 \text{ s} = 0.7 \text{ s}$$

2. Assuming bulk composition of basalt/gabbro for the oceanic crust, from table provided: $V \approx 5$ km/s. Thus,

$$h = V\,(\Delta t/2) \approx (5 \times 0.7/2) = 1.75 \text{ km}$$

3. Rocks at the bottom are most likely to be pillow basalts.

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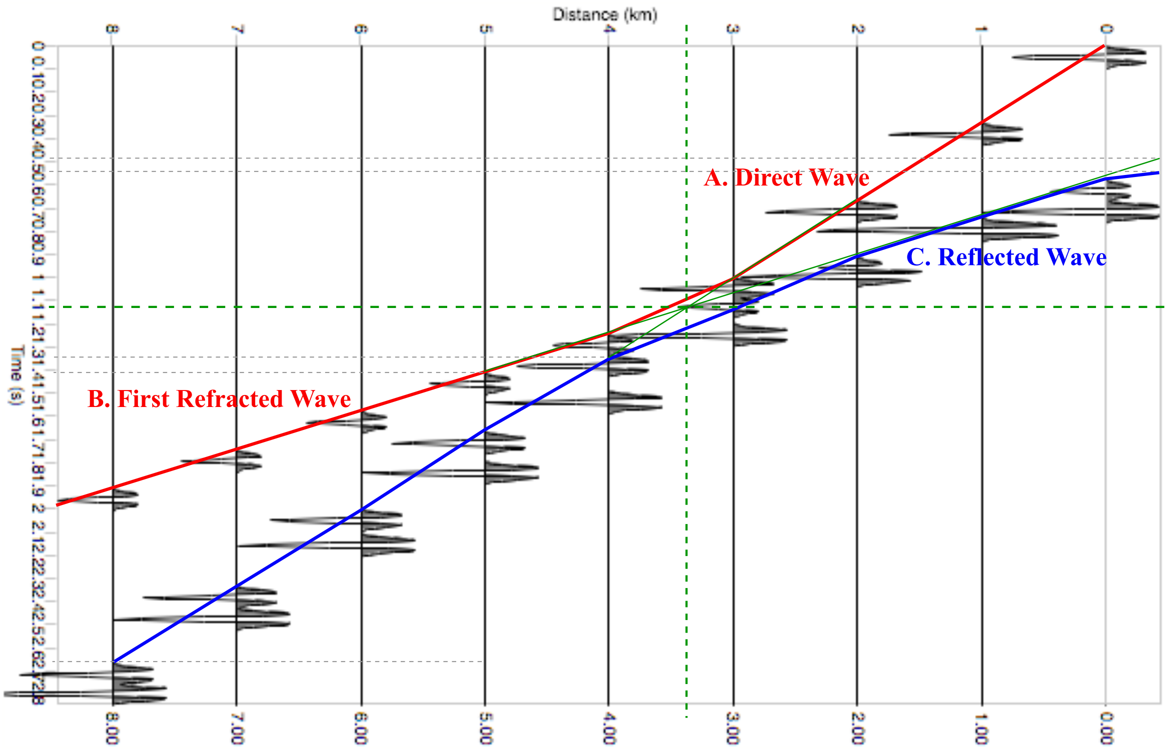

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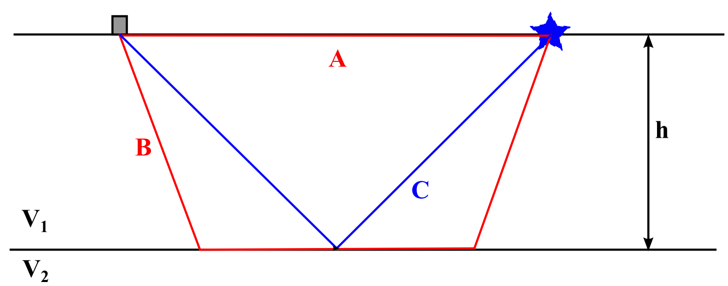

(c) Determine the layer velocities and thicknesses associated with your simple model ***using first arrivals (refraction method) as well as the reflection method***. Show all work.

1. Refraction Analysis: Use provided eqns to solve for slopes/intercepts, for $n = 2$, *i.e.*, (V_1, h_1) & (V_2, ∞)

$m_A = (1.35 - 0.00)$ s / (4 km) = 0.3375 s/km $\Rightarrow$ $V_1 = 1/m_A = 2.96$ km/s *(3 km/s OK)*

$m_B = (2.00 - 1.40)$ s / (8.5-5) km = 0.1714 s/km $\Rightarrow$ $V_2 = 1/m_B = 5.83$ km/s *(6 km/s OK)*

$t_0 = 0.49$ s $= 2h_1 \sqrt{\{(V_2^2 - V_1^2)/(V_1V_2)\}}$ $\Rightarrow$ $h_1 = t_0V_1V_2/\{2\sqrt{(V_2^2 - V_1^2)}\} \approx 0.85$ km *(0.83-0.88 km OK)*

II. Reflection Analysis: Use provided eqns to solve for slopes/intercepts, for $n = 2$, i.e., (V_1, h_1) & (V_2, ∞)

At $x = 8$ km, $t \approx 2.65$ s; at $x = 0$ km, $t_0 = 2h_1/V_1 \approx 0.55$ s

$t^2 = t_0^2 + (1/V_1^2)x^2$ $\Rightarrow$ $V_1 = x/\sqrt{(t^2 - t_0^2)} = 8/\sqrt{\{(2.65)^2 - (0.55)^2\}} = 3.086$ km/s *(3 km/s OK)*

$t_0 = 2h_1/V_1$ $\Rightarrow$ $h = V_1t_0/2 = 0.849$ km ≈ 0.85 km

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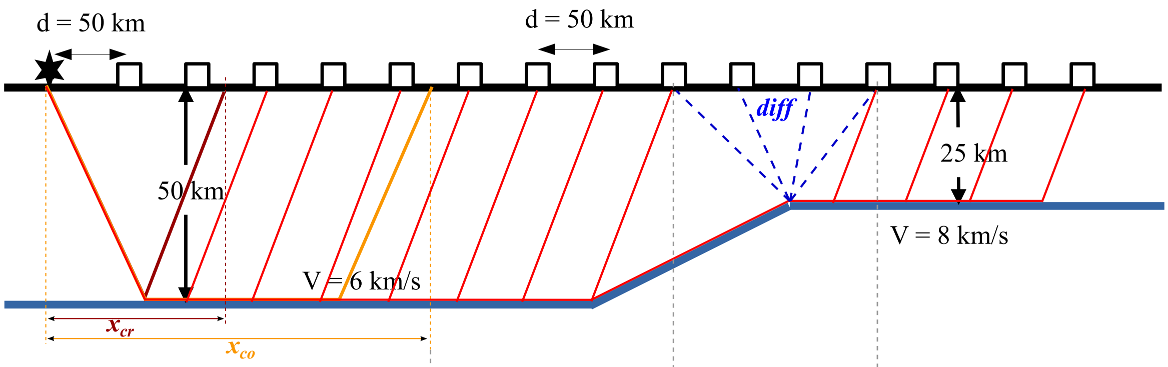

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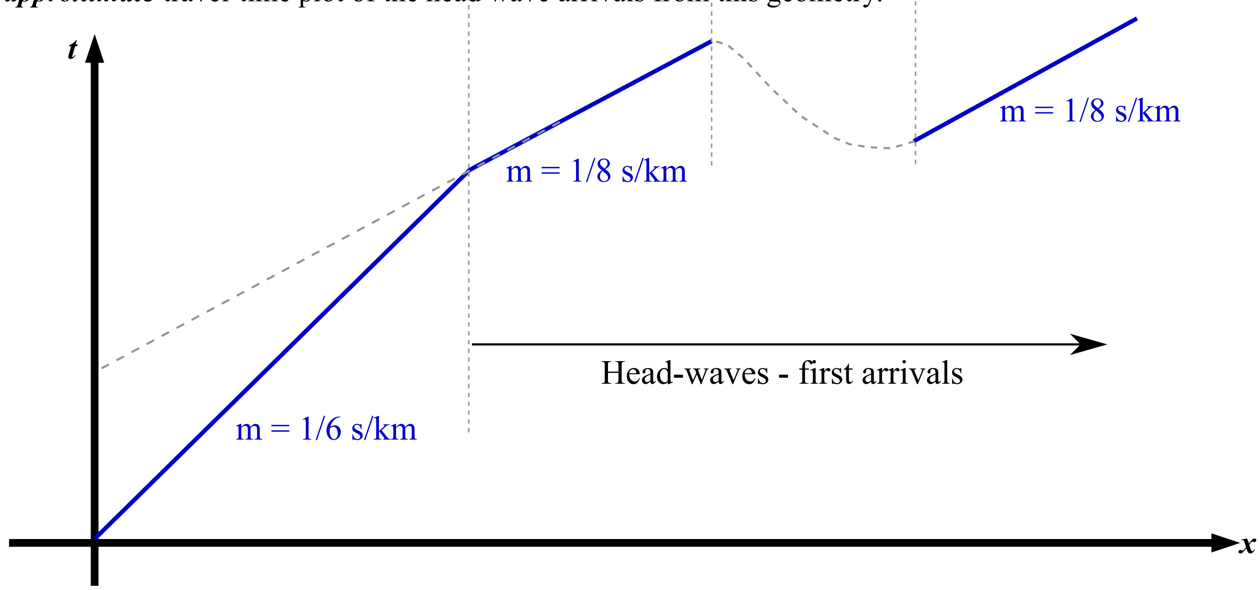

$$x_{cr} = 2hV_1 / \sqrt{(V_2^2 - V_1^2)} = 2(50)(6)/\sqrt{(64 - 36)} \approx 113 \text{ km}$$

$$x_{co} = 2h \sqrt{\{(V_2 + V_1)/(V_2 - V_1)\}} = 2(50) \sqrt{\{14/2\}} \approx 265 \text{ km}$$

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