1. Using the data shown in the time-distance plot below determine the velocities of the two layers and the thickness of layer one using either the cross-over or time-intercept methods. Assume horizontal planar layers. Next, if a hidden layer were present what is the thickness of this layer if the depth to its upper surface is 9000 ft and its velocity is 7500 ft/sec?
2. A split-spread seismic refraction profile with a central shot is established to locate an underlying planar dipping refractor. The resulting time distance curves yield a top layer velocity of 2000 m/s and updip and downdip apparent velocities of 4500 m/s and 3500 m/s, respectively. The common intercept time is 85 ms. Calculate the true velocity and dip of the refractor and its vertical depth beneath the shot point. What would the up and downdip apparent velocities be if the refractor had a dip 10° larger than the one you calculated?

3. From the $x^2$ vs $t^2$ plot shown below, determine the RMS velocities for the two layers, the interval velocity for layer 2, and the 1st and 2nd layer thickness. Also what is the time-averaged velocity to reflector 2? To help in your interpretation of the $x^2$ - $t^2$ plot the equations describing the best-fit lines to the reflection data are also shown.

\begin{align*}
  y &= 9.588E-09x + 1.440E+00 \\
  y &= 2.757E-08x + 1.000E+00
\end{align*}
4. A zero-offset reflection event at 1.000 sec has a normal moveout (NMO) of 0.005 sec at 200 m offset. What is the stacking/RMS velocity?

5. Using the information on the diagram below, what must the angle of incidence of a seismic ray be on the 1-2 interface to cause a critically refracted wave on (a) the 1-2 interface, (b) on the 4-5 interface, and (c) the 3-4 interface. For case (a) sketch the proper ray path on the diagram.

\[ V_1 = 1000 \text{ m/sec} \]
\[ V_2 = 2000 \text{ m/sec} \]
\[ V_3 = 2500 \text{ m/sec} \]
\[ V_4 = 1500 \text{ m/sec} \]
\[ V_5 = 5000 \text{ m/sec} \]
6. What are the four types of seismic waves? Describe each.

7. Using the diagrams below explain why large magnetic anomalies observed over sedimentary basins are generally thought to arise from lithology contrasts within the basement and not from local uplifts on the basement?
8. The diagram below depicts a buried sphere magnetized by induction in the Northern Hemisphere. Inclination of the field is approximately 70°. Indicate clearly on the figure below along horizontal black line (i.e. ground surface) the following:

(a) The North and South directions on this diagram?

(b) The location where the horizontal field (ΔH) anomaly would be zero and where the ΔH anomaly’s positive and negative maximums are.

(c) Draw the vertical field (ΔZ) anomaly on the diagram below using the ground surface for the zero anomaly line.

(d) Which anomaly (ΔZ or ΔH) would look most like the total field anomaly at this location?

(e) If this body were located in the Southern Hemisphere would the anomaly (total field) maximum be located south of the body’s center or north?
9. The total field vector at a given location can be derived by squaring the horizontal and vertical field vectors at that location, summing, and taking the square root of the sum (i.e., \( T = \sqrt{H^2 + Z^2} \)). However, \( \Delta T \) (total field anomaly) at a given location is not equal to the square root of the sum of the squares of the horizontal and vertical field anomalies at that point (i.e., \( \sqrt{\Delta H^2 + \Delta Z^2} \)). Why? In other words, what is a total field magnetic anomaly? What are the assumptions we make in calculating the anomaly?

10. Seismic reflection data undergo many processing steps before the data are ready for interpretation. Discuss two of the many steps used to process the reflection data. Be sure to include the “why” of the processing step.
Equations

\[ B_r = 2\left(\mu_o m/4\pi r^3\right) \cos \rho = 2\left(\mu_o m/4\pi r^3\right) \sin \lambda; \quad B_\theta = \left(\mu_o m/4\pi r^3\right) \sin \rho = \left(\mu_o m/4\pi r^3\right) \cos \lambda \]

\[ |B| = \sqrt{B_r^2 + B_\theta^2} = \left(\mu_o m/4\pi r^3\right)(4 \cos^2 \rho + \sin^2 \rho)^{1/2} \]

\[ \tan I = 2 \cot \rho = 2 \tan \lambda \]

\[ B = \mu_o H + \mu_o J; \quad B = \mu H \quad \mu = \mu_o \mu_r \quad \mu_r = 1 + k \]

\[ \mu_o = 4\pi \times 10^{-7} \text{ webers/Am} \]

\[ X^2 + Y^2 + Z^2 = T^2 \quad X^2 + Y^2 = H^2 \]

\[ H = T \cos I; \quad Z = T \sin I; \quad Z = H \tan I \]

\[ \tan D = Y/X; \quad X = H \cos D; \quad Y = H \sin D \]

2D Dipping Sheet

\[ \Delta H = 2k \sin \delta \left[(Z_o \sin \delta - H_o \sin \alpha \cos \delta) \ln(r_2 r_3/r_1 r_4) - (Z_o \cos \delta + H_o \sin \alpha \sin \delta)(\theta_1 - \theta_2 - \theta_3 + \theta_4)\right] \]

\[ \Delta Z = 2k \sin \delta \left[(H_o \sin \alpha \sin \delta + Z_o \cos \delta) \ln(r_2 r_3/r_1 r_4) - (H_o \sin \alpha \cos \delta - Z_o \sin \delta)(\theta_1 - \theta_2 - \theta_3 + \theta_4)\right] \]

\[ \Delta T = \Delta H \cos \beta \cos I_o + \Delta Z \sin I_o \]

Isolated Pole

\[ \Delta H = -C_m m x / r^3 \]

\[ \Delta Z = C_m m z / r^3 \]

\[ \Delta T = C_m m [z \sin I_o - x \cos I_o] / r^3 \]

Line of Dipoles

\[ \Delta H = 2C_m m [(x^2 - z^2) \cos I_o \sin \alpha - 2xz \sin I_o] / r^4 \]

\[ \Delta Z = 2C_m m [(z^2 - x^2) \sin I_o - 2xz \cos I_o \sin \alpha] / r^4 \]

\[ \Delta T = 2C_m m [(x^2 - z^2)(\cos^2 I_o \sin \alpha \cos \beta - \sin^2 I_o) - 4xz \sin I_o \cos I_o \sin \alpha] / r^4 \]

Isolated Dipole

\[ \Delta H = C_m m [(3x^2 - r^2) \cos I_o - 3xz \sin I_o] / r^5 \]

\[ \Delta Z = C_m m [(3z^2 - r^2) \sin I_o - 3xz \cos I_o] / r^5 \]
\[ \Delta T = C_m \mathbf{m} \left[ 3(x \cos l_o - z \sin l_o)^2 - r^2 \right] / r^5 \]

Half-width Rules - Vertical field

- **Dipole** \( z = 2x_{1/2} \)
- **Pole** \( z = 1.3x_{1/2} \)
- **Line of poles** \( z = x_{1/2} \)
- **Line of dipoles** \( z = 2x_{1/2} \)

Half width rules - Horizontal Field

- **Dipole** \( z = 2.5x_{1/2} \)
- **Pole** \( z = 1.3x_{1/2} \)
- **Line of poles** \( z = x_{1/2} \)
- **Line of dipoles** \( z = 2x_{1/2} \)

\[ V_p = \sqrt{(k+4/3\mu)/\rho} \quad V_s = \sqrt{\mu/\rho} \quad V_R = 0.9V_s \quad V_p/V_s = \sqrt{(2-2\nu)/(1-2\nu)} \]

\[ i = R_p \quad z_1 = (x_{c1}/2)\sqrt{(V_2 - V_1)/(V_2 + V_1)} \]
\[ \sin R_p = (V_{s1}/V_{p1})\sin i \quad z_2 = (x_{c2}/2)\sqrt{(V_3 - V_2)/(V_3 + V_2)} \]
\[ \sin r_s = (V_{s2}/V_{p1})\sin i \quad z_1 = (t_i/2)(V_1V_2)\sqrt{(V_2^2 - V_1^2)} \]
\[ \sin r_p = (V_{p2}/V_{p1})\sin i \quad z_2 = \frac{1}{2}[t_{i3} - 2z_1(V_3^2 - V_1^2)]^{1/2} \quad (V_2V_3) \]
\[ \frac{V_1}{V_3} = (V_{1/3} - V_{1/2})^{1/2} \]

\[ i = R_s \quad \sin R_s = (V_{p1}/V_{s1})\sin i \]
\[ \sin r_s = (V_{s2}/V_{s1})\sin i \]
\[ \sin r_p = (V_{p2}/V_{p1})\sin i \]

\[ t_{i2} = x/V_2 + 2z_2\cos i_c/V_1 \]
\[ t_{i3} = x/V_3 + 2z_1\cos i_1/V_1 + 2z_2\cos i_2/V_2 \]
\[ t_{N} = x/V_{N} + \sum_{j=1}^{N-1} (2z_j\cos i_j)/V_j \quad \text{where } i_j = \sin^{-1}(V_j/V_N) \]

\[ \Delta T_D = \frac{1}{2} (t_{D1} + t_{D2} - t_r) \]
\[ z_D = \Delta T_D V_i / \cos i_c \]

\[ t_{r,downdip} = 2z_a\cos i_c/V_1 + x \sin(i_c + \gamma)/V_1 \]
\[ t_{r,updip} = 2z_b\cos i_c/V_1 + x \sin(i_c - \gamma)/V_1 \]

\[ i_c = \frac{1}{2} [\sin^{-1}(V_1/V_{2a}) + \sin^{-1}(V_1/V_{2d})] \quad \gamma = \frac{1}{2} [\sin^{-1}(V_1/V_{2a}) - \sin^{-1}(V_1/V_{2d})] \]

\[ z_a = V_1t_{ia}/2\cos i_c \quad h_a = z_a/\cos \gamma \]
\[ z_b = V_1t_{ib}/2\cos i_c \quad h_b = z_b/\cos \gamma \]

\[ V_N = \sum_{j=1}^{N} (V_{N,j} - t_{i,j}) \]

\[ V_i = \left[ \frac{V_{i,rms}^2 - V_{i-1,rms}^2}{t_i - t_{i-1}} \right]^{1/2} \]
\[ z_n = V_n (t_n - t_{n-1})/2 \quad \Delta T_{NMO} = x^2/2t_oV^2 \quad t^2 = t^2_o + x^2/V^2 \]

\[ V^2_{n,\text{rms}} = \frac{V^2_1}{t_1} + \frac{V^2_2}{\Delta t_2} + \frac{V^2_3}{\Delta t_3} + \cdots + \frac{V^2_N}{\Delta t_N} (t_N - t_{N-1}) \]

\[ t_x = [2z \cos \gamma/V_1]^2 + [(x + 2z \sin \gamma)/V_1]^2 \]

\[ \cos \gamma = t_{\min}/t_o \]

\[ z = X_{\min}/2\sin \gamma \quad d = (X_{\min}t_o)/(2t_{\min} \sin \gamma) \]

\[ V_1 = (2z \cos \gamma)/t_{\min} \]