1. Illustrate using a sketch, the geometric configuration of the electrodes for the resistivity arrays given below. Be sure to label current and potential electrodes, distances between electrodes, and any restrictions concerning the array. (10 pts)
   
a. Schlumberger
   
   b. Wenner
   
   c. Dipole-Dipole
   
   d. Lee-Partitioning

2. What is the RMS velocity in reflection surveying, and how is it related to interval velocity and to stacking velocity? (10 pts)
3. Interpretation of the seismic data shown below indicates a horizontal interface between the V₁ and V₂ layers but with different depths to the second layer below each shot point. Calculate the depths to the second layer beneath each shot and the dip of the V₁ - V₂ interface connecting the horizontal portions of the interface at each end. Additionally calculate the depth to the V₂ layer directly under the geophone located 240 m from shot point A. Assume a planar interface. (15 pts)
4. What are the factors that control the resistivity of earth materials? (5 pts)

5. Write short concise definitions or answers for five of the following: (15 pts)
   a. bulk modulus
   b. critical distance
   c. acoustic impedance
   d. moveout
   e. P-wave
   f. delay time
   g. causes of seismic wave attenuation
6. 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 4-5 interface, and (b) on the 2-3 interface. For case (a) sketch the proper ray path on the diagram. (10 pts)

\[ V_1 = 500 \text{ m/sec} \]
\[ V_2 = 1500 \text{ m/sec} \]
\[ V_3 = 2000 \text{ m/sec} \]
\[ V_4 = 1500 \text{ m/sec} \]
\[ V_5 = 4000 \text{ m/sec} \]
7. Interpret the refraction and reflection data shown below to include $V_1$, $V_2$, dip angle and direction, and the vertical depth under the shot point ($x = 0$). (10 pts)
8. A $t^2 - x^2$ analysis of the seismic reflection data shown below give RMS velocities for layers 1, 2, and 3 of 1954, 1748, and 2294 m/s, respectively. Calculate layer 2’s interval velocity and thickness. Also what is the time averaged velocity to the layer 2 reflector? (10 pts)
9. Calculate the apparent resistivity for the electrode configuration shown below if the measured ground resistance (R) is 4.5 ohms. Distances are in meters. (5 pts)
10. Draw a sketch of the subsurface structure that is responsible for the time-time curves shown below. (5 pts)
Equations for Exam #3

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

\[ t_2 = x/V_2 + 2z\cos i/V_1 \]
\[ t_3 = x/V_3 + 2z_1\cos i_1/V_1 + 2z_2\cos i_2/V_2 \]
\[ t_N = x/V_N + \sum_{j=1}^{N-1} (2z_j\cos i_j)/V_j \]

where \( i_j = \sin^{-1}(V_j/V_N) \)

\[ \Delta T_D = \frac{1}{2} (t_{D1} + t_{D2} - t_e) \]
\[ z_D = \Delta T_D V_1 / \cos i_c \]

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

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

\[ z_a = V_1 t_{ia}/2\cos i_c \]
\[ h_a = z_a / \cos \gamma \]
\[ z_b = V_1 t_{ib}/2\cos i_c \]
\[ h_b = z_b / \cos \gamma \]

\[ V_N = V_1 t_i + V_2(t_2 - t_1) + V_3(t_3 - t_2) + \cdots + V_N(t_N - t_{N-1}) \]

\[ V_i = \sqrt{\frac{V_{i, \text{rms}}^2 - V_{i-1, \text{rms}}^2}{t_i - t_{i-1}}} \]

\[ z_n = V_n (t_n - t_{n-1})/2 \]

\[ \Delta T_{NMO} = x^2/2t_o V_{rms}^2 \]

\[ t^2 = t_o^2 + x^2/V^2 \]

\[ V_{n, \text{rms}} = \frac{V_{1, \text{rms}}^2 t_1 + V_{2, \text{rms}}^2(t_2 - t_1) + V_{3, \text{rms}}^2(t_3 - t_2) + \cdots + V_{N, \text{rms}}^2(t_N - t_{N-1})}{t_n} \]

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

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

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

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

\[ V = \rho l / 2\pi r \]