21. Gravitational acceleration, *g*, at the surface of the earth can be formulated as $g = G\frac{M}{r^2}$ where G = 6.673 x 10^{-11} N.m^2/kg^2, M = 5.98 x 10^{24} kg and r = the distance from the Earth's surface to its centre. If the gravity, *g*, at the mean sea level (R = 6371 km) is 9.83 m/s^2 and the gravity value depends on elevation, *h*, gravity value decreases with increasing elevation as per the formula _____ . (Note: 1 cm/s^2 = 1 gal). Write the calculation procedure. (2 points)

22. The mathematical formula for seismic refraction in 2-layer systems shows that the travel time of seismic waves, *t*, is dependant on its propagation distance, *x*.

$$t = \frac{2h_1 (V_2^2 - V_1^2)^{1/2}}{V_2 V_1} + \frac{x}{V_2}$$

where t is the travel time of seismic waves (second)

h_1 is the thickness of 1st layer

x is the distance of seismic wave propagation

V_1 is the seismic velocity in 1st layer

V_2 is the seismic velocity in 2nd layer

The seismic velocity of layers, V_1 and V_2, and the thickness of layer, *h*, are constant. The seismic refraction data are given in Table 1. Determine the seismic velocity of the 1st and 2nd layers, V_1 and V_2, respectively (2 points)

Table 1. Seismic Refraction Data

x (m)	*t* (ms)
2	4
4	10
6	12
8	19
10	24
12	27
14	30
16	31
18	32
20	34
22	36
24	39

- Write the calculation procedure. (2 points)
- Calculate h_1 (1 point)

23. Tthe number of earthquake events (N) and their magnitude (M) are related as follows:

$$\log N = a - b\,M$$

The graph associated with the above equation is shown in Figure 1 for such an earthquake which occurred at Padang, West Sumatra. The parameter a is a constant representing the number of earthquakes which have magnitude higher than 1 on the Richter scale. Similarly, b is a value that represents the ratio of the number of small to big eartquakes. If the value of b is 1, determine the ratio of the number of earthquakes (with magnitude 5) to the number of earthquakes (with magnitude 7) on the Richter scale (2 points).

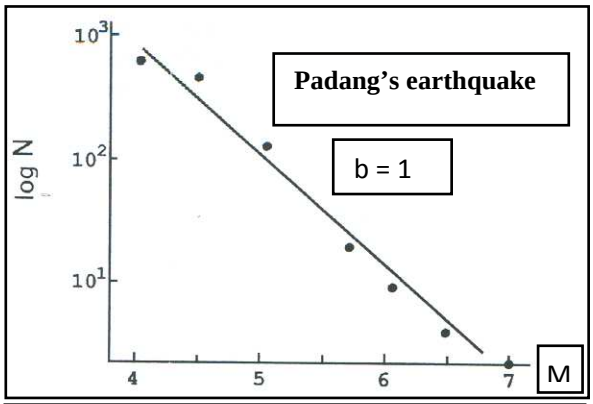

Figure 1. The graph of number (N) of earthquakes versus its magnitude (M) of Padang's event.

24. An earthquake was recorded at four seismic stations in Central Java, Indonesia. Figure 2 shows the locations of the seismic stations: AE2 (7.7 S; 109.5 E), AG2 (7.6 S; 110.0 E), BH2 (7.5 S; 110.4 E), and AK4 (8.2 S; 110.9 E). Figure 3 displays the seismograms recorded at the seismic stations. If the average longitudinal (P) wave velocity, V_p, is 6.4 km/s and the average transversal (S) wave velocity, V_s, is 3.7 km/s, determine the epicenter of the earthquake. Write the calculation procedure and draw your graphical solution in Figure 2. (1 degree = 111 km). (5 points)

Figure 2. Location of the seismic stations AE2, AG2, BH2, and AK4 which recorded the earthquake.

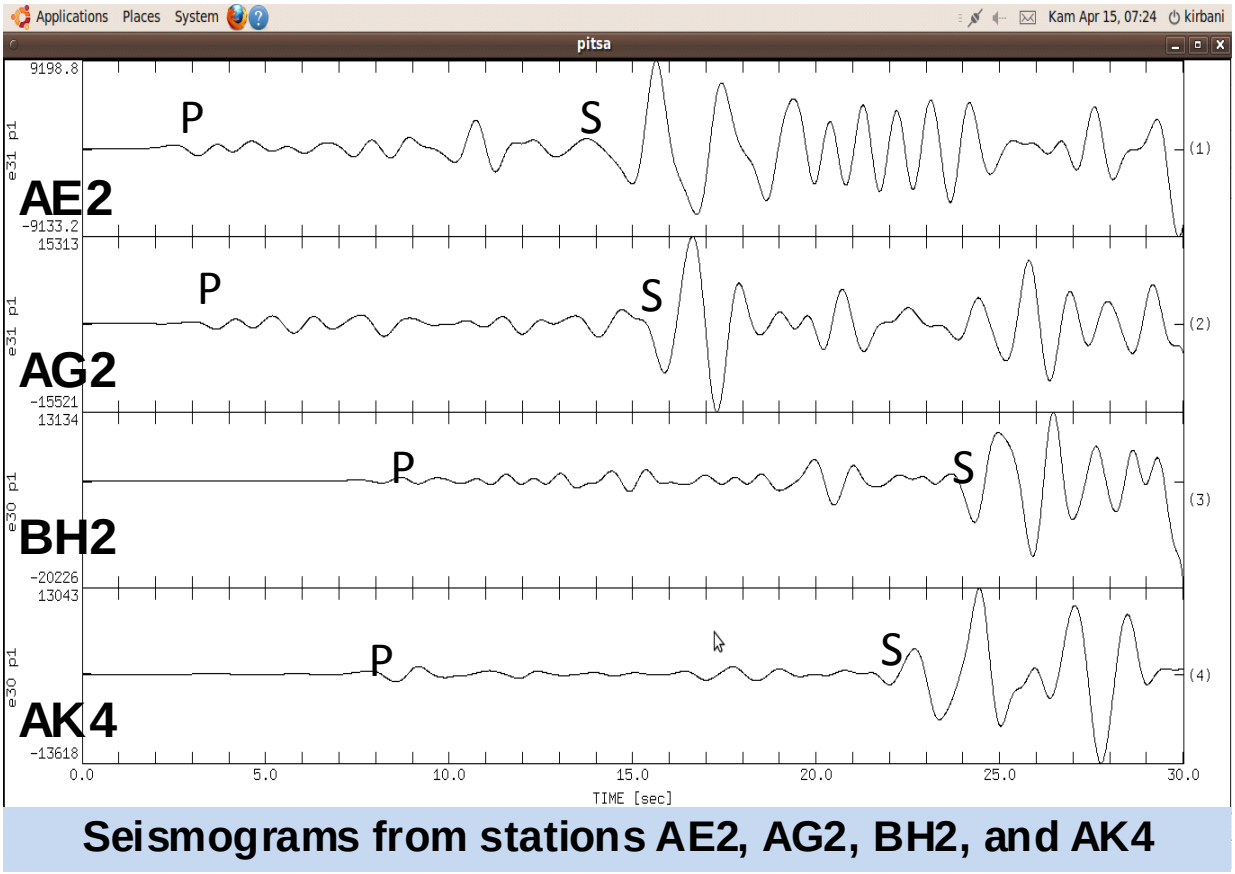

Figure 3. Seismograms of the earthquake recorded at seismic stations AE2, AG2, BH2, and AK4.