Problem 1

The historical seismic data for a region are: Richter’s local magnitude 6.0, 6.5, 5.5, 5.2, 7.0. These data were recorded between 1960 and 1979 (20 years) taking into account only earthquakes of magnitude greater or equal to 5.0.

a) Using only these data, compute the number of earthquakes per year with a magnitude greater than or equal to 5.0? What is the corresponding return period?

b) Construct and plot a recurrence relation of the type \( \log_{10} = A - bM \), where \( N \) is the number of earthquakes per year with a magnitude greater or equal to \( M \), \( M \) is Richter’s local magnitude and \( A \) and \( b \) are constants to be determined by regression.

c) Using the recurrence relation constructed in b), estimate the number of earthquakes per year having a magnitude greater or equal to 5.0. Compare your result with the one obtained in a).

d) Using the recurrence relation constructed in b), estimate the number of earthquakes per year having a magnitude greater or equal to 7.5. Why is it hazardous, but also necessary, to extrapolate beyond the historical seismic data.

Problem 2

The Gutenberg-Richter model best representing the seismicity of the entire world has the following parameters: \( A = 7.7, b=0.9 \) and \( \log = \log_e = \ln \).

a) Compute the return period of an earthquake with a magnitude greater or equal than 6.

b) Based on Poisson’s probabilistic model, what is the probability of having three earthquakes with magnitude greater or equal than 8 next year?

c) What is the return period of an earthquake having a magnitude between seven and 8?
**Problem 3**

Figure 1 shows a site located symmetrically from a known fault. This fault can be considered a linear seismogenic fault on which shallow earthquakes occur in any location with equal probability. The following equation defines the magnitude-recurrence relation for this fault.

\[
\ln N = A - bM_L
\]

where \( A = 2.00; \ b = 1.74; \ M_L \) is Richter’s local magnitude and \( N \) is the number of earthquakes per year and per unit length with a magnitude greater or equal than \( M_L \).

Figure 1 – Site located symmetrically from a known fault.

The attenuation relation for the peak ground horizontal acceleration in the region is given by:

\[
a_{\text{max}} = ce^{dM_L}R^{-f}
\]

where \( a_{\text{max}} \) is the peak ground horizontal acceleration in g; \( M_L \) is Richter’s local magnitude; \( R \) is the epicentral distance in km; \( c = 0.01; \ d = 1.305; \ f = 1.5 \).

a) Derive a general expression for the number of earthquakes, \( N \), per year producing a peak ground acceleration at the site greater than or equal to \( a_{\text{max}} \). Neglect the uncertainties associated with the attenuation relation in your derivation.

b) If the length of the fault \( L = 10 \) km, plot a graph showing the variation of \( a_{\text{max}} \) having a 475-year return period with the distance \( d_o \). Consider values of \( d_o \) between 10 and 100 km.

c) Describe (without calculation) how you would incorporate the uncertainties associated with the attenuation relation in your derivations in a).
Problem 4

Figure 2 illustrates the seismicity of the San Francisco bay area in the last 163 years. It is assumed that the seismicity of the region can be modeled by two rectangular seismogenic source zones. The first zone is associated with the San Andreas fault. The second source zone combines the Hayward and Calaveras faults.

![Figure 2 – Seismicity of the San Francisco bay region.](image)

a) Construct a magnitude-recurrence relation, lnN vs M, for each seismogenic source zone.

b) Using the attenuation relation constructed in Problem 4 of Assignment No. 1, plot a graph showing the variation of the peak ground horizontal acceleration with the return period for the cities of San Jose, San Francisco, and Santa Rosa. Use only one sector per source zone and a constant focal depth of 15 km for the region. Neglect the uncertainties associated with the attenuation relation in your calculations.

c) For each city, estimate the peak ground horizontal acceleration having a 100-year return period.
Problem 5

A nuclear power plant must be located in a region influenced by three distinct seismotectonic source zones capable of producing shallow earthquakes. These source zones are small and can be considered point sources. Figure 3 shows two possible sites for the power plant.

The maximum earthquake local magnitudes that can be generated by each source are:

- Source 1: \( M_L = 6.9 \)
- Source 2: \( M_L = 7.6 \)
- Source 3: \( M_L = 7.1 \)

The attenuation relation for the region is given by:

\[
a_{\text{max}} = 0.01 e^{1.3M_L} d^{-1.5}
\]

Where \( a_{\text{max}} \) is the peak ground horizontal acceleration in g, \( M_L \) is Richter’s local magnitude and \( d \) is the hypocentral distance (km).

Based on a Deterministic Seismic Hazard Analysis (DSHA):

a) Which site should be selected for the nuclear power plant?
b) What is the design peak ground acceleration for the nuclear power plant at the selected site in a)?