

**MATHEMATICS METHODS 4**

**SEMESTER 2 2018**

**INVESTIGATION 2**

**Earthquakes**

**Marks: 44 Time: 50 minutes**

**In this Investigation, any answer without sufficient reasoning will not be awarded full marks.**

We know the Richter scale reading, R, is a measure of the magnitude of seismic waves from an earthquake. It was devised in 1935 by the seismologist Charles F. Richter (1900–1985) and technically known as the local magnitude scale, such that

R =

Where is the minimum intensity used for comparison.

1. a) What is the value of R for an earthquake of intensity 50?

[1]

b) An earthquake measures 5.5 on the Richter scale. Write the intensity in terms of .

[2]

c) An earthquake measuring 6.1 on the Richter scale is how many times as intense as one that measures 4.7 on the Richter scale?

[2]

d) Based on your answer to c), write a formula or rule that could be used to determine how many times more intense R1 on the Richter scale is than R2.

[3]

e) A new age seismologist, Solanderi, thought that since earthquakes were a naturally occurring phenomena then the formula should use natural logarithms.

i.e. S = *ln*

i) Using this scale, an earthquake measuring 7.2 on the Solanderi scale is how many times as intense as that of one measuring 5.2 on the Solanderi scale?

[2]

ii) If an earthquake measures 4 on the Solanderi scale, what is the value of S for an earthquake 20 times stronger? [3]

f) A particularly strong earthquake of R = 7.5 is measured in Japan. What is S?

[4]

The moment magnitude scale is used by seismologists to measure the size of earthquakes in terms of the energy released. It was developed to succeed the 1930's-era Richter magnitude scale.

The moment magnitude has no units and is defined as

where is the total amount of energy that is transformed during an earthquake, measured in dyncm.

2. a) On 28 June 2016, an estimated dyn∙cm of energy was transformed during an earthquake near Norseman, WA. Calculate the moment magnitude for this earthquake.

[2]

b) A few days later, on 8 July 2016, there was another earthquake with moment magnitude 5.2 just north of Norseman. Calculate how much energy was transformed during this earthquake.

[3]

c) Had this been 5.3 rather than 5.2, how many times more energy would have been transformed?

[3]

(d) Show that an increase of 2 on the moment magnitude scale corresponds to the transformation of 1000 times more energy during an earthquake.

[Hint: let the total amount of energy transformed be *x* before the increase and *y* after.]

[6]

Worldwide there are far more low magnitude than high magnitude earthquakes. The table below shows how the average annual frequency of earthquakes varies with magnitude. These figures are based on observations since 1900.

|  |  |  |
| --- | --- | --- |
| **Description** | **Magnitude** | **Average Annual Frequency** |
| Great Earthquakes | 8 or more | 1 |
| Major Earthquakes | 7 – 7.9 | 18 |
| Strong Earthquakes | 6 – 6.9 | 120 |
| Moderate Earthquakes | 5 – 5.9 | 800 |
| Light Earthquakes | 4 – 4.9 | 6 200 (estimated) |
| Minor Earthquakes | 3 – 3.9 | 49 000 (estimated) |
| Very Minor Earthquakes | 2 – 2.9 | approx 1 000 per day |
| 1 – 1.9 | approx 8 000 per day |

Data Source: US National Earthquake Information Centre

A relationship has been discovered between the magnitude of earthquakes and their frequency of occurrence.

3. a) Complete the following table where *N* denotes the number of earthquakes per year with magnitude greater than or equal to *M*.

|  |  |  |
| --- | --- | --- |
| ***M*** | ***N*** | **log10 *N*** |
| 8 |  |  |
| 7 |  |  |
| 6 |  |  |
| 5 |  |  |
| 4 |  |  |
| 3 |  |  |
| 2 |  |  |
| 1 |  |  |

[4]

b) Draw a graph of log10 *N* against *M*.

[4]



c) Use your graph to find the relationship between *N* and *M*.

[5]