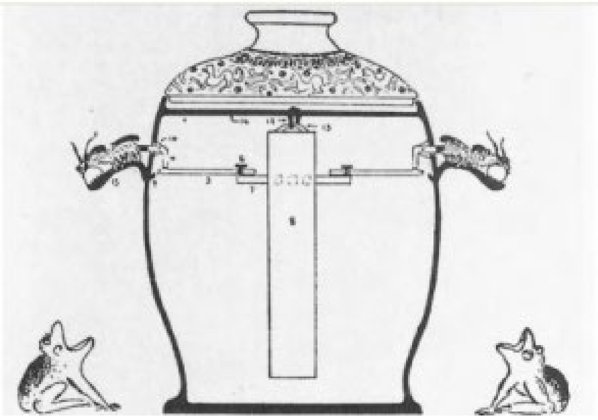
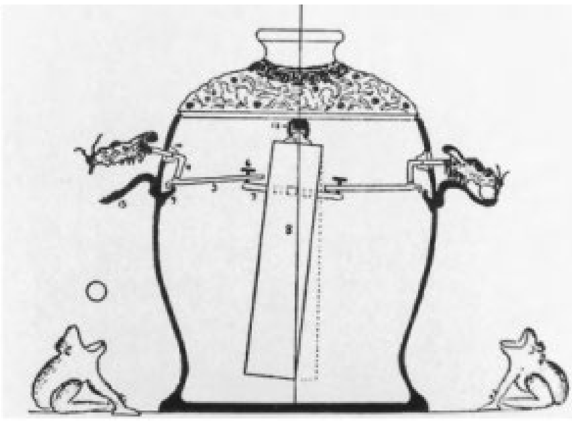
Shaky Science – Teacher Notes

In AD 132, Chinese scholar Zhang Heng designed an instrument he called the seismoscope. It was a vessel with 8 dragon heads holding balls in their mouths. Below each dragon was a toad with an open mouth ready to catch a falling ball. A pendulum inside the vessel caused a dragon's mouth to open in response to seismic waves. The direction of the earthquake was shown by which ball was released.





Later, scientists built earthquake detectors with large pendulums that swung in response to movement but were of little practical use. The first modern seismograph was built by Filippo Cecchi in 1875 using an inertial pendulum. In the 1880s, British scientists working in Japan developed more refined instruments and showed their value in understanding earthquakes.

Seismic scales

Earthquakes can be measured in different ways. Commonly used scales include the Modified Mercalli, Richter and Moment Magnitude scales.

The Modified Mercalli Earthquake Scale

1. Not felt by humans unless in tall buildings but noticed by some animals.
2. Felt indoors by a few people, especially on upper floors. Doors may swing.
3. Felt by many people indoors. Vibration like a lightly loaded truck passing. Hanging objects may swing.
4. Most people indoors and some outdoors feel vibrations like a heavy truck passing. Dishes rattle, hanging objects swing and parked cars rock slightly.
5. All indoor and many outdoor people feel shaking, with some frightened. Buildings tremble and windows may crack. Small objects may fall and hanging objects swing.
6. Everyone feels shaking. Many are frightened and unsteady during shaking. Bells may ring and some damage of poorly built buildings, cracked plaster is more common. Many broken dishes and windows.
7. General alarm as people run outdoors, finding it difficult to stand. Waves appear on bodies of water and more buildings are damaged, including internal plaster falling and many windows breaking.
8. Alarm approaches panic. Trees shaken so much that branches break off. Strong buildings are damaged and ordinary ones partially collapsed. Water and mud may be ejected from ground.
9. General panic. Ground is cracked and even strong buildings are badly damaged. Buildings shift from foundations and underground pipes may be broken.

10. Large cracks in the ground, landslides and changed water level in wells. Severe damage to wooden structures, while most brick buildings are destroyed. Underground pipes torn apart.
11. Great damage to dams and wooden structures. Bridges fall down. Large landslides and possible tsunami (depending on location of earthquake focus).
12. Total destruction. Land and rockslides, waterways changed and objects thrown up into the air.

Can you think of any advantages of using this scale? This method requires no instruments or infrastructure. It is easy to ask people about their experiences and damage around them. Results are meaningful for real life.

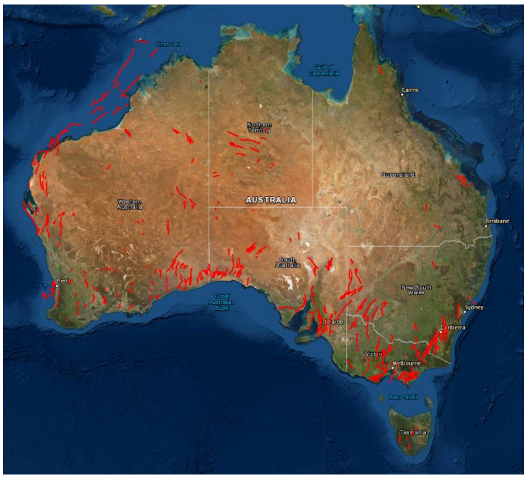
Can you think of any disadvantages of using this scale? It is a subjective scale and different people will report it differently. People who are prone to alarm or experiencing their first earthquake may rate the quake higher on the scale than others. If the earthquake occurs in an unpopulated area, it cannot be rated.

The **RICHTER SCALE** was developed in the 1930s. It measures the largest amplitude of seismic waves on a recording. This was most effective for regional earthquakes with a magnitude of M5 or less. Seismologists now use the **MOMENT MAGNITUDE SCALE** (MMS). The MMS uses more information to calculate the energy released during an earthquake. It considers the physical properties of the underlying rock as well as the movement caused by seismic waves. The logarithmic scale means that for every unit increase in magnitude, 31 times more energy is released by the earthquake.

Australian earthquakes

Australia's largest recorded onshore earthquake occurred in 1988 at Tennant Creek in the Northern Territory. It was an estimated magnitude of 6.6 and damaged a major gas pipeline. Meckering in Western Australia was hit by a 6.5 magnitude earthquake in 1968 that caused extensive damage to buildings and roads over much of southwest Australia. Australia's most deadly earthquake was a magnitude 5.6 event that devastated Newcastle, New South Wales in 1989. Thirteen people died, 50,000 buildings were damaged, and the cost was over $4 billion.

An earthquake is sudden movement of rock along faults within the Earth. The place where the rocks move is known as the focus and the point directly above it at Earth's surface is the **epicentre.** Earthquakes are most common along plate boundaries where there is a great deal of movement but can also occur along smaller faults within a continent. Faults across Australia are shown below.



Neotectonic features (Geoscience Australia, accessed 8 Dec 2021 from https://neotectonics.ga.gov.au/?execution=e1s1 CC 4.0)

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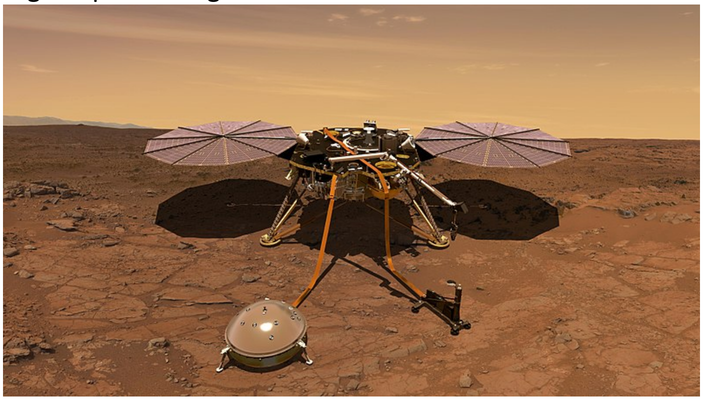
The Australian Seismometers in Schools (AuSIS) program allows schools to get involved in seismic monitoring, accessing data from 42 seismometers in schools. For more information and resources, visit http://ausis.edu.au/.

Extraterrestrial quakes

Other bodies in the solar system also experience seismic activity. Apollo astronauts installed a seismometer network on the moon that is still monitoring seismic events. Deep moonquakes on the near lunar side are most common and triggered by tidal deformations. Other moonquakes appear to be caused by gradual shrinking as the moon's interior cools.

NASA's InSight mission landed in 2018 and has recorded hundreds of Marsquakes, including several of magnitude 4. The largest quakes originate from the Cerberus Fossae.



NASA's InSight lander detects frequent seismic activity on Mars (NASA 2018, public domain)

Inertia

We use pendulums to detect earthquakes because their relatively large mass makes them reluctant to move. This phenomenon is known as **inertia**. Students may have felt the effect of inertia when a car suddenly accelerates and their heavy head is pressed back into the seat because it does not move as fast as their body, which is more firmly attached to the car by a seatbelt. Whiplash injuries occur when a car decelerates suddenly, usually in a crash, and the head keeps going forward until it is 'whipped' back on the neck.

The teacher demonstration **Inertia** can be used to demonstrate this phenomenon. Students can see that the heavy pendulum moves less than the water. The contents of the container (water and pendulum) remain in their original position longer. The less massive water develops waves, while the more massive pendulum remains in its original position longer.

Inertia Demonstration

Materials

- A clear plastic container
- A pendulum or heavy weight tied with string
- A pencil or wooden ruler
- A smooth surface
- Water

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Method

1. Place container on smooth surface.
2. Three quarters fill the container with water. (It will spill if the container is filled to the top).
3. Tie the pendulum or weight to the pencil and suspend in the centre of the container.
4. Observe the behaviour of the pendulum when the container suddenly moves.

Observations

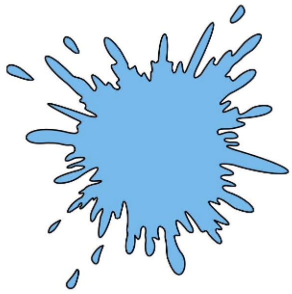
The pendulum and water appear to move opposite the container at the start of movement because of inertia.

The water sloshes back and forth but the pendulum moves very little. The pendulum has more inertia than the water.

Seismic Splash

Materials

- A small paper or plastic cup, bottom of a cool drink bottle
- A plastic container for water
- A pencil
- An outside cemented area
- Water



Method

1. Place container on cemented area.
2. Fill container to the brim with water.
3. Sharply tap the bottom of the container with the blunt end of the pencil.
4. Observe what happens and the splash pattern.
5. Repeat to ensure reliability.

Observations

What happened after the container was tapped? The container moved forwards and the water appeared to move in the other direction. Then the water moved back and forward, eventually stopping.

What happened when you repeated the activity? The same result.

Which variable or variables did you change? The position of the container.

Which variable or variables did you keep the same? All other variables: same container, same amount of water and same process.

Discussion

Could you use a container of water to find the direction of the epicentre of an earthquake? Yes. The splashed water falls in the opposite direction to the epicentre (this might be quite inaccurate, however).

How could you estimate the energy released by the earthquake using this equipment? You could measure the amount of water lost from the container and/or the maximum splash distance. The larger the earthquake, the more water spilled and the further the splash.

Vocabulary	Earthquake, seismic energy, epicentre, seismic scale