This lesson introduces students to how Earthquakes are used as imaging tools to see inside the Earth and introduces them to the concept of P and S wave seismic wave shadow zones caused by the presence of the liquid outer core. Pupils then apply basic geometry and speed, distance, time equations to real world examples using earthquake waves to learn about Earth structure. An accompanying powerpoint presentation, pupil worksheet (and answers) are included in the lesson 3 resource pack.

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| **Cycle** | **Aims** | **Teacher instructions** | **Pupil focus** | **Timing/ mins** |
| Starter | - Get a sense of the scale of the Earth, and why we need seismology to look inside it | The second slide asks how deep we have drilled into the Earth. Get students to guess, perhaps voting for the guess they think is closest. Reveal the answer, give information from the slide about the borehole and show the scale images of the Earth. The next slide says that to look deeper, we need seismology. | Estimating depth, visualising scale of the earth, understanding the need for seismology to study the deep Earth | 5 |
| Introducing new information: seismic shadow zones and waves through the Earth | - Know what a seismic shadow zone is and why they exist  - Getting an idea of waves travelling through the Earth from an earthquake | Show the video that explains seismic shadow zones. It is quite high level, but students do not need to understand every detail. Go through the questions on the next slide. All the answers are in the video. It is worth watching it yourself first because it is more complicated than previous content. Then the slide ‘Waves through the Earth’ has a link to a simulation. Here you can see seismic waves travelling through the Earth after the 2004 Sumatra earthquake. You can drag the Earth to rotate the view. Note that the seismic waves pick up extra letters in their names to describe their journey depending on which parts of the Earth they travel through. This makes referring to a specific wave easier. | Being introduced to new information via a video and via a simulation. Participating by answering questions on the video. | 15 |
| Activity: Worksheet | - Problem solving using geometry and the speed, distance, time equation in the context of Earth structure | A worksheet and answers are provided. You could go through the answers with the students or collect in their work. The worksheet involves: calculating the radius of the core using trigonometry (set up for them using the idea of the S wave shadow zone); considering the effect of real wave paths being curved on their answer; comparing two paths of P waves through the Earth to calculate P wave speed in the inner core; an extension question sketching the wave paths from the previous question as displacement-time graphs; an extension question drawing the Earth to scale. | Problem solving | 20 |
| Summarising | - Showing a graph which brings together knowledge of the deep Earth from seismic studies.  - Getting students to reflect on their understanding | The slide showing the real velocity and density profile of the Earth can be presented as the result of the seismic study of the inner Earth. CMB stands for core-mantle boundary, and ICB stands for inner core boundary. The crust is too thin to be seen clearly, the mantle has some interal structure shown as irregularities in the graph, but the boundaries of all major earth layers (mantle, outer and inner core) show clear jumps in velocity and density (up or down). The graph shows P wave velocity Vp, S wave velocity Vs and density (rho). Note that the S wave velocity in the outer core is zero. The next slide introduces the next lesson, where you can can say we will go beyond the simple layered structure. The final slide requires them to write a summary of what they know about the inner Earth structure. They could take this home with them or give it to you. | Bringing together what they have learned, summarising their understanding of Earth’s structure so far | 10 |