Body Waves (S&P) - Teacher Notes

Seismic waves are energy waves released during earthquakes. Stress built up during tectonic movement builds up until it overcomes limiting friction and is released as a seismic wave. When seismic waves pass through rock, particles are moved to release stress. These shock waves travel in all directions away from the source and are impeded and deflected by the materials they travel through. A background to wave movement is provided in the "Wave Energy Transfer" activities. Their point of origin within the Earth is called the focus. The point on the surface directly above this is called the epicentre. In general, the shallower the earthquake the more damaging it is liable to be. The worldwide distribution of earthquakes is remarkably similar to the location of constructive and destructive plate boundaries.

There are two kinds of seismic waves: body waves and surface waves.

BODY WAVES (S&P) are waves that travel through the body of the Earth.

> **P waves** are compressions that pulse through rock. The compressive wave of energy moves on but molecules return to their original position. Because the waves are affected by density, they are slowed and deflected by the Earth's dense core. This results in a donut shaped shadow zone formed on the other side of the planet where no p waves are registered.
> In most earthquakes the P waves are the first to be felt. Often there is an accompanying sonic boom. Sound is the result of compression and refraction of air molecules when p wave energy is transmitted across the rock-air interface at the surface.
>
> **S waves** are also known as secondary, shake or transverse waves. These are transmitted by a sideways or up and down movement. These cannot travel through liquids and have a shadow zone directly on the other side of the planet where no seismicity is felt. This characteristic was used to infer that the outer core of the Earth was liquid. These can be demonstrated by moving a rope from side to side. The S waves usually arrive a few seconds later than the P waves. They rattle and shake the ground vertically and horizontally.
> http://www.pbs.org/wnet/savageearth/animations/earthquakes/main.html

(There are also surface waves (Love waves (L) and Rayleigh (R)). These travel across the surface of the planet lifting and dropping the earth like ripples across a pond and cause major damage to humans and their property)

For animations of these wave forms visit:
http://www.pbs.org/wnet/savageearth/animations/earthquakes/main.html

Name	Travels	Passes through	
P	Compression longitudinal movement	Solid and molten rock, liquids and air.	Fastest wave (speed of sound)
S	Transverse (shearing) movement	Solid rock only	Slower than P but more damaging
L & R	At right angles to S & P on surface in a rolling motion	Surface rock	Devastating

More resources available at: http://www.iris.edu/hq/retm teachable earthquake moments

Body Waves (S&P) - Teacher Notes

AIM **To demonstrate the difference between S and P body waves**

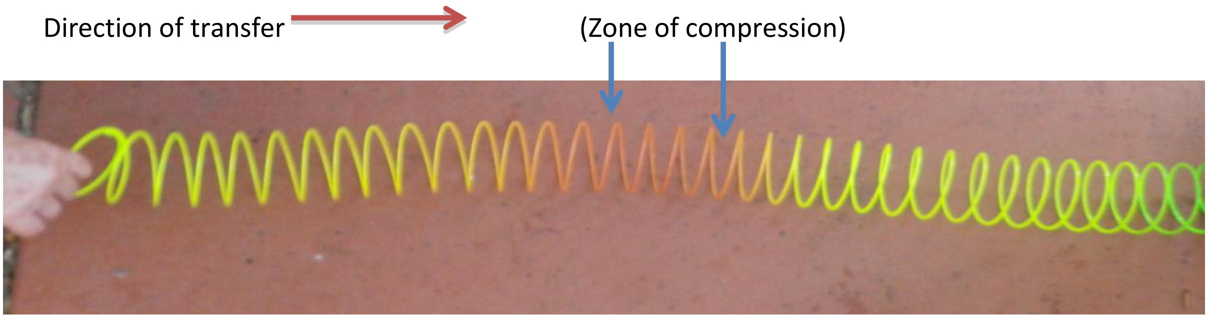
This activity needs room and if students are performing it is best done outside on a smooth surface such as a concrete veranda or pathway.

Materials

- Three students or two students and a teacher
- A piece of chalk or masking tape to mark positions
- A measuring tape of metre ruler
- A long slinkie
- A piece of rope or cord the same length as the partially extended slinkie
- A stopwatch or accurate timepiece

Part A The P wave. COMPRESSION OR PRIMARY WAVES

P waves are compressions that are transmitted through solids, liquids and gasses. P waves are the result of a zone of compressed waves being transferred along the direction of wave travel.
P waves are called primary waves because they are the first to arrive after an earthquake.



A scientist often trials experiments before formal testing to find out which variables have not been controlled and to work out how the experiment can be improved. These are sometimes called "trial" or "dummy" runs.

Trial Run – (groups of three)

Method

1. Bunch a few coils of the slinkie in one student's hand at one end and let another student extend the slinky.
2. Mark the position of the ends with chalk or masking tape.
3. Measure the length of the slinky
4. Release the bunched coils and observe.
5. Measure the time taken for the compression wave to travel along your slinky

How can this experiment be improved?
Share ideas with your group to control variables and make sure the results are accurate and precise.
All slinkies should be in the same condition, of the same length and used over the same surface.
The length of the extended slinky should be adjusted to best observe the movement of the compression wave.
All experimenters should have exactly the same number of coils bunched in their hands.

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Body Waves (S&P) - Teacher Notes

The experiment should be repeated and the results averaged.
Accuracy and precision requires the use of an accurate timepiece that has sufficient discrimination to be precise and a user that observes and responds quickly.

Write your improved experiment below. Carry it out and list your observations

AIM ____

Materials

Method

Observations

Speed = Distance / Time

Conclusion The speed of the wave was ____________**Units are essential (m/s)**_____________
The speed of the P wave will depend on the material of the slinky and friction with the surface you are working on.

P wave - Student Activity 2

Rules

1. Each student only takes four steps, two to the right and then two to the left to return to their original position.

2. There are never more than three students bunched up at any time.

Method

1. Students stand about 1 step (30 cm) apart.
2. Someone loudly counts the seconds.
3. On the first second the first student takes one step to their right to join the second student.
4. On the second count both these students take one step to the right to join the third student. This group of three is the compression wave.
5. On the third second the first student starts their return to their original position at one step per second while the remaining pair move one step to the right to join the next student and maintain the compression of three.
6. This pattern continues to the end of the line.
7. Each student returns to their original position after the wave moved on.
8. It is easiest to start with 8 students in a line. Place another line behind the first line to pick up the pattern of movement.
9. Finally place students in a circle and send a series of waves through them.

Body Waves (S&P) - Teacher Notes

Direction of wave transmission

1	2	3	4	5	6	7	8
	1+2	3	4	5	6	7	8
		1+2+3	4	5	6	7	8
	1		**2+3+4**	5	6	7	8
1		2		**3+4+5**	6	7	8
1	2		3		**4+5+6**	7	8
1	2	3		4		**5+6+7**	8
1	2	3	4		5		**6+7+8**
1	2	3	4	5		6	7+8
1	2	3	4	5	6	7	8

P wave - Student Activity 3

To demonstrate that compression waves in air can create a sonic boom clap hands together to cause compressed air and noise.

Part B The S wave. Secondary or Shear wave

S waves are slower than P waves and only travel through solids. When an S wave passes, particles move at right angles to the direction of transmission. S waves only travel through solids so cannot be transmitted through the molten outer core. This means there is a “shadow zone” where no secondary waves are felt on the other side of the Earth from the focus.

AIM To replicate an S wave and measure its speed of transmission.

Materials

- Two students
- A piece of rope or cord as long as the extended slinky in the previous experiment
- Something to tie one end of the rope to e.g. a door handle, seat back or fence line

Method

1. Lay the rope straight between the markings of the previous experiment
2. Two students hold the ends firmly
3. One of these students briskly flicks a single vertical wave of rope towards the other end
4. The second student measures time taken for the transmitted S wave to travel the length of the rope
5. Repeat measurements and find the average speed of transmission of S waves.
6. Compare these results with those from the previous (p wave) experiment

Body Waves (S&P) - Teacher Notes

Observations on S wave motion

Trial	Time (s)	Distance (m)	Speed (m/s)
1			
2			
3			
		Average	

Discussion

Which waveform is transmitted faster? P waves

S waves can be twice as slow as P waves. This may not be obvious over a short distance with inaccurate timekeeping.

Describe the difference in mode of transmission between P and S waves that you could see.

P waves travelled as compressions along the same direction as the wave front. S waves moved as displacement at perpendicular/at right angles to the direction of movement

What should you do if you feel a P wave arrive? Take cover under a table or in the toilet and wait for the arrival of the S wave and more destructive surface waves which follow them

Average speed of teenager running	about 10 to 15km/hour	3-4m/s
Average speed of P wave	330 m/s in air	
	450m/s in water	
	500m/s in rock (granite)	
Average speed of S wave	about 60% of P wave	2-3m/s
	S waves cannot travel through liquids or gasses they rely on resistance to shear the medium they pass through.	
Average speed of Stealth bomber	1,010km per hour	280.5m/s

It can however fly "through the sound barrier" causing a sonic boom

Speed of sound	343.2m/s

Materials

Students will have to convert the data above to uniform units for comparison. Scrap paper and calculators may be necessary.

If you realise a particularly devastating earthquake was about to strike, could you outrun or fly away from it? No. Running would be at least one hundred times too slow. Even the fast Stealth bomber could not consistently outrun the waves.

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Why do P waves travel faster in rock than in air (HINT kinetic energy)
In solids molecules are closer together and it is easier to pass on energy from molecule to molecule.

S wave - Student Activity 2

Students can either perform the “Mexican wave” movement beloved by soccer fans by standing up and sitting down one second after the student on their left starts moving. The wave rolls along the line of students. Seated students can just raise and lower their arms with a similar one-second delay.

Many simple animations of P and S waves can be found on the Internet

Extension

Students can lay both P and S wave experiments side by side. They can estimate which form of wave transmission looks faster by observing which reached the other end first.

Why is this experiment scientifically flawed?
This experiment is inaccurate because it relies on the reaction rates of four different people.

Information about seismic monitoring in Australia can be found at:
http://www.ga.gov.au/hazards/our-capabilities/monitoring/earthquake-monitoring.html

Seismometers in Schools project at: https://www.facebook.com/ausisnetwork

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