**Physics: 7. Sound**

***Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier***

**Syllabus**

**OP40** Show that sound is a form of energy, and explain that sound is produced by vibrations

**OP41** Show that sound transmission requires a medium and that echoes are reflected sound

**OP42** Appreciate that the ear detects sound vibrations and that exposure to very loud sounds can cause damage to hearing

**OP43** Recall that the speed of sound is less than the speed of light

**OP44** Explain the time lag between seeing and hearing the same event

**Student Notes**

**Sound is a form of energy**

To show that sound is a form of energy you must be able to show that it can do work (because energy is the ability to do work). Work is done when an object is being moved. So we need to show that sound can move something.

**Demonstration**

Hang a balloon in front of a speaker; note that when the speaker is turned on the balloon moves.

**Sound is produced by vibrations**

**Demonstration**

Feel the speaker vibrate by putting your hand on it. Notice that as the sound gets louder the vibrations get bigger.

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**Sound requires a medium**

**Demonstration**

Notice that you can see and hear the bell ringing before the vacuum pump is switched on.

After pumping the air out you can still see the bell ringing but can no longer hear it.



**Echoes are reflected sound**

Echoes occur when sound reflects from a surface back into your ears.

Sonar makes use of reflected sound waves to find shoals of fish or even to map the ocean floor – can you figure out how it works?

**The ear detects sound vibrations**

There are tiny hairs in your ear which vibrate when they detect sound and this then gets converted to electrical signals which travel to the brain.

**Exposure to very loud sounds can cause damage to hearing**

This is why people who work with loud machinery need to wear ear protectors.

**The speed of sound is less than the speed of light**

The speed of sound is about 340 m/s while the speed of light is about one million times faster. This is why when something far away makes a sound we can see it before we hear it, e.g. in an electrical storm we see the lightning before we hear the thunder.

Maths problems: Speed = Distance ÷ Time

Note that if we are dealing with echoes from a wall, the distance the sound travels will be twice the distance between the source of the sound and the wall.

**Ultrasound is a high-pitched sound beyond the range of the human ear**

**Exam Questions**

1. [2011]

Describe a simple experiment to show that sound is a form of energy.

1. [2007 OL][2009 OL]

A student set up the following experiment to investigate how sound travels through air.

An electric bell was placed inside a bell-jar as shown in the diagram.

The bell rang and it could be heard clearly.

When the pump was switched on it started to pump the air out of the bell-jar and a vacuum was created.

At that stage the bell could no longer be heard but it could still be seen ringing.

1. What conclusion could be drawn from this investigation?
2. When the air was pumped out, the bell could still be seen even though it could not be heard. What difference between light and sound does this show?
3. During an electric storm lightning is usually seen before thunder is heard.

What does this tell us about light and sound?

1. [2007]

Describe, using a labelled diagram in the box, an investigation you could carry out to show that *sound requires a medium* in which to travel.

1. [2007][2008 OL][2010][2012 OL]

The picture shows a flash of lightning.

* + 1. Which is detected first, the flash of lightning or the clap of thunder?
    2. What does this tell us about the speed of light?

|  |
| --- |
| Energy |
| Electricity |
| Noise |
| Echo |
| Vibrations |

1. [2010 OL]

Copy the sentences below into your copy and complete them using words from the list on the right.

1. Sound is a form of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. A reflected sound is called an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
3. Sound is produced by \_\_\_\_\_\_\_\_\_\_\_\_\_\_.
4. [2006] [2009]

How are *echoes* produced?





1. [2009 OL]
2. The soldier in the diagram has safety goggles on his hat.

Give one reason why safety goggles should be used in the laboratory.

1. The sign on the right is found displayed at shooting ranges and in many factories. What instruction does this sign give?
2. Why is it important to obey the instruction given by this sign?

**Exam Solutions**

1. Use a speaker which is emitting sound

Suspend a table tennis ball by a thread in front of the speaker.

Result: the table tennis ball moves.

1. Sound will not travel through a vacuum / sound needs a medium to travel.
2. Light can travel through a vacuum / light doesn’t need a medium.
3. Light travels faster than sound
4. Set up the apparatus as shown with the bell ringing.

Turn on the vacuum pump; as the air gets pumped out the sound gradually fades

1. Flash of lightning
2. Light travels faster than sound
3. Energy
4. Echo
5. Vibrations
6. Echoes are produced when sound reflects off a surface.
7. Eye protection
8. Ear protection must be worn to protect your ears.
9. To prevent damage to hearing

**Other Test Questions**

1. How is sound produced?
2. Draw a labelled diagram of an apparatus used to show that sound is a form of energy.
3. Why is the moon sometimes referred to as “the silent planet”?
4. Draw a diagram and write a brief note to demonstrate that sound is caused by vibrations.
5. What is ultrasound?
6. What is the speed of sound in air?
7. Give two differences between sound and light waves.
8. Give two applications of reflected sound.
9. If the time-lag between seeing lightning and hearing thunder is 5 seconds, how far away is the storm?
10. When a girl was a certain distance from a high cliff she shouted loudly. One and a half seconds later the echo returned from the cliff. How far was the girl from the cliff? (take the speed of sound to be 340 m/s).
11. A guitar string is plucked. The sound is heard. It seems simple, but there are a few stages in between. Can you put the following stages in the correct order?

vibrating eardrum, brain, vibrating source, vibrating air, nerve

Make sure to check out Audacity.

**Teaching *Sound***

**Syllabus**

**OP40** Show that sound is a form of energy, and understand that sound is produced by vibrations.

**OP41** Show that sound transmission requires a medium and that echoes are reflected sound.

**OP42** Understand that the ear detects sound vibrations and that exposure to very loud sounds can cause damage to hearing.

**OP43** Recall that the speed of sound is less than the speed of light.

**OP44** Explain the time lag between seeing and hearing the same event.

**Teaching the concepts**

**OP40: Show that sound is a form of energy, and understand that sound is produced by vibrations.**

**OP40.1 To Show Sound is a form of Energy**

Use a large speaker (there is one in the resource box) connected up to a power supply.

The textbooks usually use a table-tennis ball as the object which moves, but it can be difficult to achieve this so a candle-flame will suffice.

If using the tennis ball it is important to remind students that the ball should not be touching the speaker directly; otherwise it would just be mechanical energy being transferred caused by the speaker banging off of the ball.

Alternatively try a balloon.

This is perfectly legitimate and is much more likely to work – students have even been known to be impressed.

**OP40.2 Understand that sound is produced by vibrations**

Get the students to feel the vibrations of the speaker-cone itself.

Start at a low voltage and increase gradually. They should notice that a louder volume is caused by greater amplitude of vibration.

Throw some ‘spit-balls’ on the speaker and note how they react to an increase in voltage which in turn causes an increase in amplitude.

This can also be used as a (partial) analogy for kinetic theory.

Follow the link for Junior Cert Physics on thephysicsteacher.ie for clips of vocal chords in action to see them vibrate.

* **Tuning Forks**

Allow the students to play with the tuning forks provided. Dip them in a beaker of water to generate an unexpected splash.

If the tuning fork is set vibrating and held in the air the sound is very quiet, this is because the forks are only in contact with a small amount of air.

When the end of the fork is set down on the table it causes the closely-packed molecules to vibrate over much of the area of the table.

This in turn causes a much larger amount of air to vibrate, and so the sound appears much louder.

You can also test this on different materials.

Those that allow the vibrations to propagate along the material will as a result give the loudest sounds.

The logic is similar in principle to the conduction of heat in a metal, although as the textbook suggests the materials being tested should have the same area for it to be a fair test, although this is a little impractical.

**OP41: Show that sound transmission requires a medium and that echoes are reflected sound**

**OP41.1 Show that sound requires a medium**

This experiment is not as impressive in practice as it promises in theory; it’s very difficult to achieve even a decent partial vacuum.

The air can enter the bell-jar much more quickly than when pumping it out so it’s best to hear the sound before and after letting the air back in.

The other problem is that some sound will travel along the electrical leads.

The ideal would be little wind up drummer or some variation on same, so if you come across anything close …

So this is why in space no-one can hear you scream.

Apparently the first Star Trek tried to be ‘true-to-life’ and all explosions were silent, but the audiences complained so sound was put in (mind you in ‘real-life’ you can’t see laser beams either).

It’s also advisable to use the PHET interactive applet (follow the link from the Junior Physics page of thephysicsteacher.ie).

Click on the tab labelled *Listen with varying air pressure*.

Ensure a sound is playing and *Remove air from box*. What happens to the sound?

Note the behaviour of the loudspeaker.

*Let air into the box.* What happens to the sound?

**OP41.2 Show that** **echoes are reflected sound**

The standard demo here is to use a sound source such as a watch, two cardboard tubes and a hard surface.

I find that it doesn’t work well (for me at least) so I just tell students what is supposed to happen.

**OP42: Understand that the ear detects sound vibrations and that exposure to very loud sounds can cause damage to hearing**

**OP42.1 Sound Detection**

A diagram of the ear is useful here showing the hairs which vibrate in sympathy with the air.

**OP42.2 Exposure to very loud sounds can cause damage to hearing**

Sound level indicators are now available on iphones.

**OP43: Recall that the speed of sound is less than the speed of light.**

**OP44: Explain the time lag between seeing and hearing the same event.**

**Activities**

* **Make a ‘mobile phone’**

For years I never bothered with this because I thought you would just hear the other person speak via the medium of air, and that the string wouldn’t add anything noticeable. But now that I know differently I do it every time.

The only problem is keeping all the cord from going back into the box as one big ball!

An extension to this experiment is to have many connections coming off the main ‘trunk’ line.

Bear in mind that the cords have to be tight, and cups should be firmly over ear or mouth.

* Tie a metal object, e.g. a spatula, to a piece of string and hold the other end of the string against your ear.

Now tip the metal object with another metal; the transmission of sound along the string is impressive, but like the one above, it can only be heard by one person at a time.