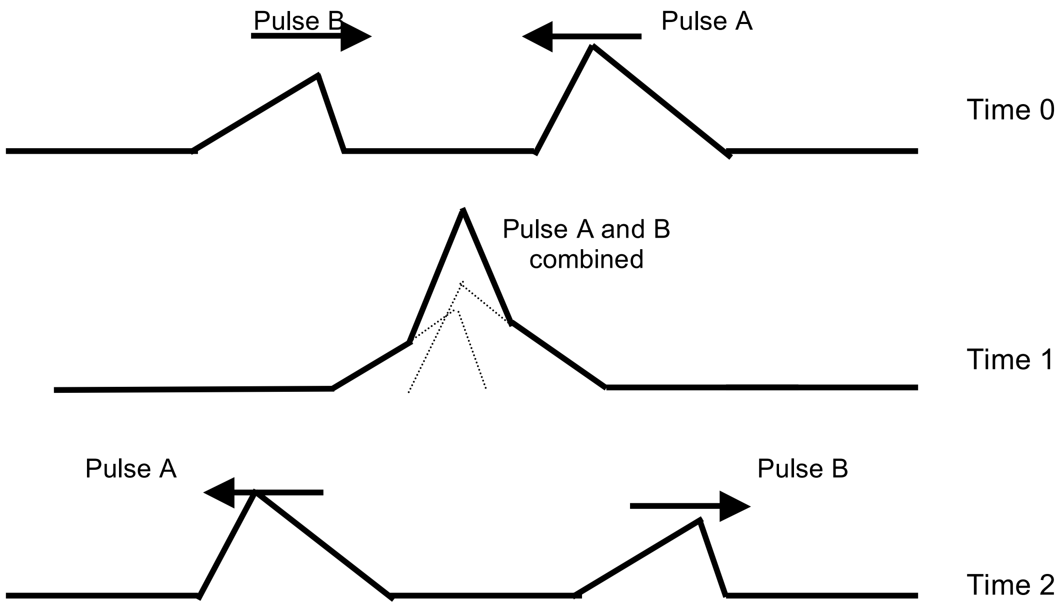
4. Superposition, Reflection and Resonance

Wk	Topic	Heinemann		
		Section	Pages	Qs
	4. Superposition, Reflection and Resonance	Superposition	Pg 21-22	Pg 25 5, 7, 9
		Straight-line propagation Reflection Regular and Diffuse Reflection Reflection, Absorption, Transmission	Pg 28-29 Pg 29-30 Pg 30 Pg 32	Pg 35 1 Pg 35 5, 8 Pg 35 7 Pg 35 3, 6,
		Resonance		

Superposition

Two pulses travelling along a medium will pass through each other without being altered.
To find the total wave disturbance at any time, the individual displacements of each wave are added at each point.
When different waves pass through the same region of space, the individual waves add together to produce the resultant wave. This is called **superposition**.



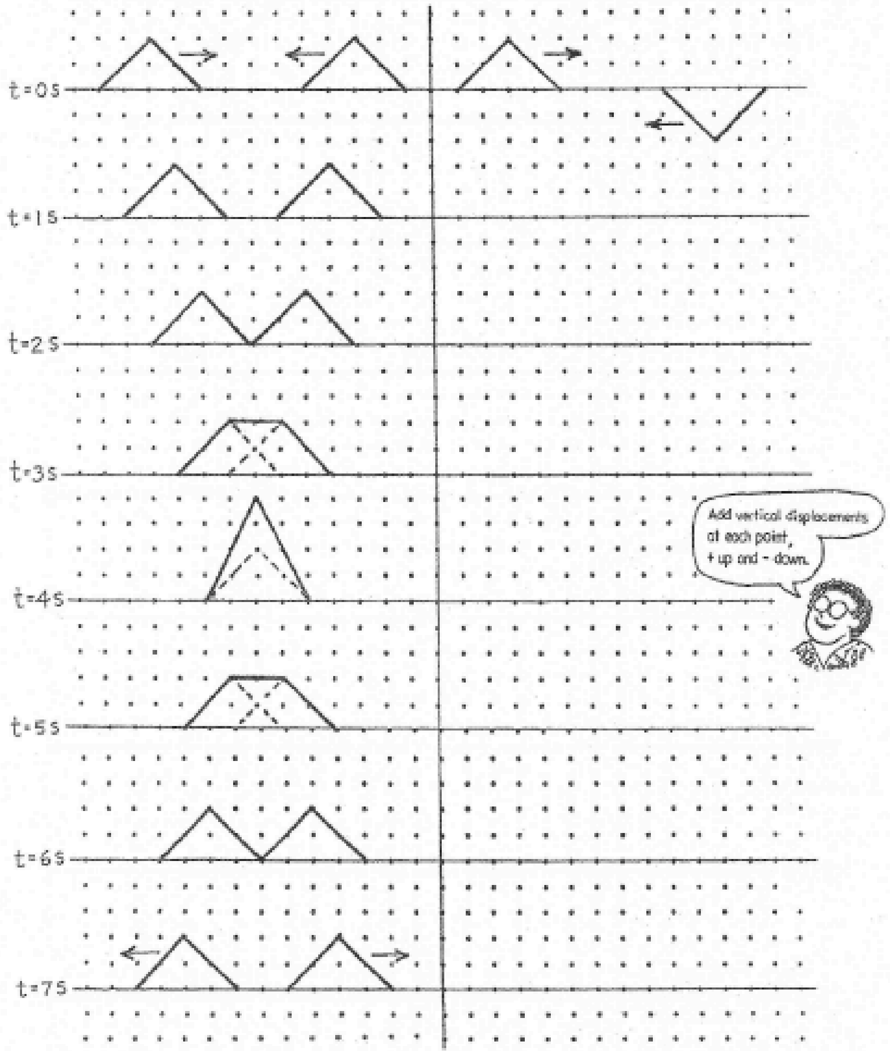
Usually light travels in straight lines, whether it is emitted or reflected, until it meets something that changes its direction. The path of light can be represented by light rays which we draw as straight lines. A set of light rays is called a **light beam.**

CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 20 Sound

Wave Superposition

A pair of pulses travel toward each at equal speeds. The composite waveforms, as they pass through each other and interfere, are shown at 1-second intervals. In the left column note how the pulses interfere to produce the composite waveform (solid line). Make a similar construction for the two wave pulses in the right column. Like the pulses in the first column, they each travel at 1 space per second.



thanx to Marshall Ellenstein

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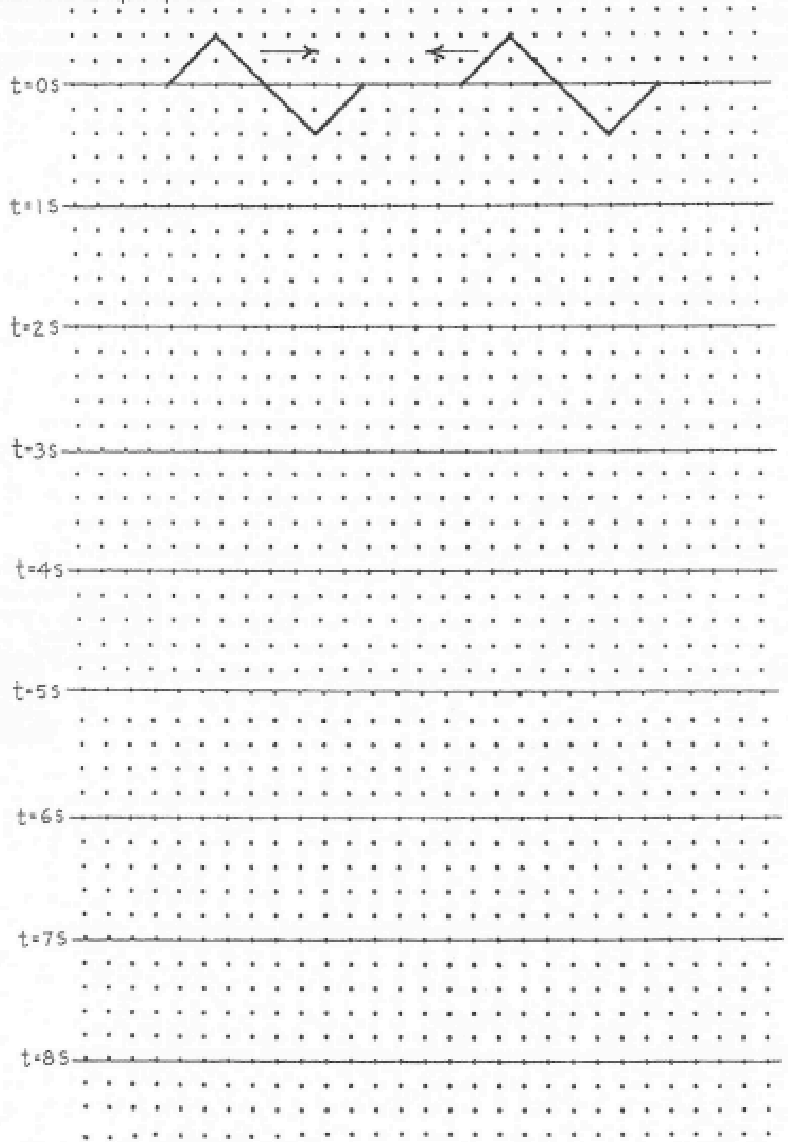
Chapter 20 Sound

Wave Superposition—continued

Construct the composite waveforms at 1-second intervals for the two waves traveling toward each other at equal speed.



On the previous page, the superposition showed examples of constructive and destructive interference.

Constructive Interference

If two pulses pass through each other, and their displacement is in the same direction then the pulses reinforce each other and add together. This is called constructive interference. Constructive interference will result in louder sound or brighter light.

Destructive Interference

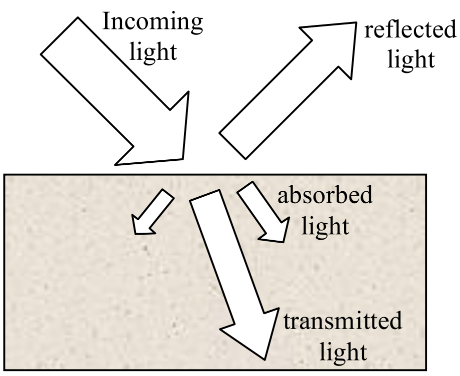
If the displacement of the two pulses is in opposite directions then the two pulses cancel each other out. This is called destructive interference. Destructive interference will result in softer sound or dimmer light.

Examples of Superposition

Superposition will occur whenever two wave sources meet. Examples of this are:

- Reflection (such as a light or sound source reflecting from a surface)
- Two sources (such as two lasers or two speakers)

Reflection, absorption and transmission of light



When light reaches a surface it can interact in three ways. It can be reflected from the surface, absorbed by the material or transmitted through the material. Most of the time light under goes a combination of all three.

We see most objects around us because they reflect light. A plane sheet of paper does not reflect light the same way as a plane mirror. Light reflecting from this page is scattered and the reflection is called **diffuse**. The light is scattered on reflection because this page is not smooth. We can see this page but we cannot see other things reflected in the page. Mirrors are smooth reflectors, so light is reflected in an ordered manner, so we see images. This type of reflection is called **specular.**

Opaque materials

Things we see appear to be different colours because of the way in which they absorb, transmit or reflect different parts of the visible spectrum.
Opaque materials do not transmit any light. They appear coloured because of the light they reflect. Blue surfaces reflect blue light, and absorb the others. Black surfaces absorb all the different colours and white surfaces reflect all the different colours. Paints are examples of opaque material.

Transparent materials

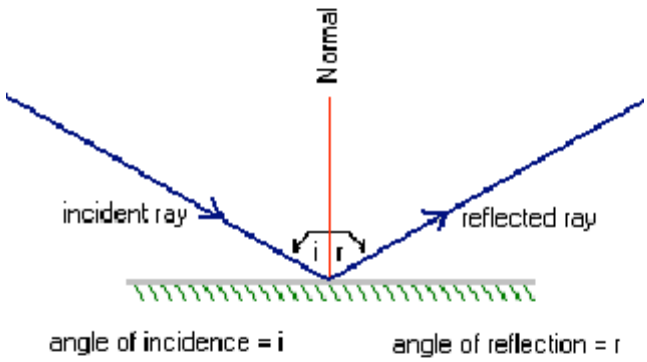
Transparent materials allow light to pass through them. They also absorb all the colours of the visible spectrum except those that give them their colour. Unlike opaque material, transparent materials transmit as well as reflect the parts of the visible spectrum that give them their colour. A piece of red cellophane transmits and partially reflects red light, but absorbs other colours.

Reflection of Light

There are two types of reflection: diffuse and specular. Diffuse reflection is by far the most common. It is what enables us to see object around us. The other type of reflection is specular, which is the kind of reflection that occurs on mirrors. Both types obey the law of reflection.

The Law of Reflection

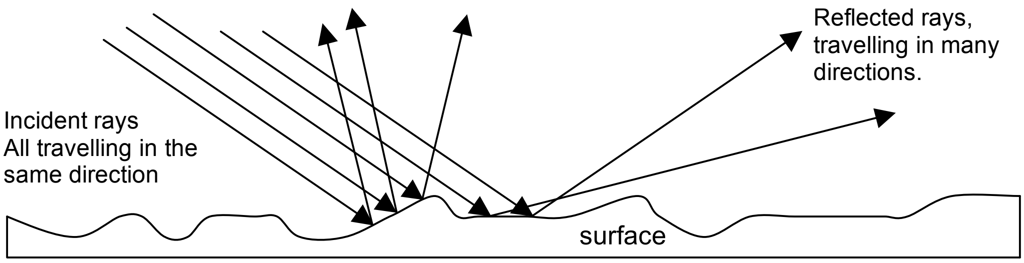
Light will reflect at the same angle as it strikes an object.
The normal is perpendicular to the mirror's surface at the point where the incident (incoming) ray is striking the mirror.
The law of reflection states that the angle of incidence, i, is equal to the angle of reflection, r. Therefore i = r

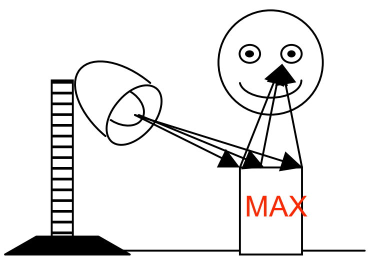


Diffuse Reflection

Diffuse reflection can be thought of as reflection from a rough surface. Light that is hits the surface reflects off at many different angles.

Microscopic View of Diffuse Reflection

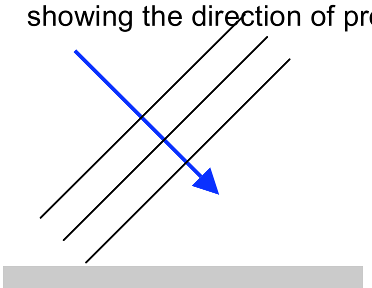


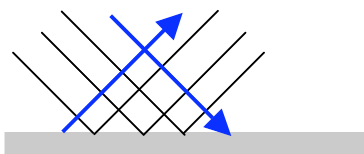


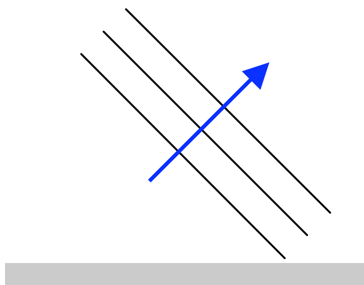
Imagine that you have a can of drink under a lamp on a table. No matter where your head is positioned, you can see the can. This is because light strikes each little area of the can it is reflected in many directions. Some of these rays will travel towards you eye. Hence your eye is detecting light from each area of the can, so you can see the entire can.

Specular Reflection

When light reflects specularly, the reflected wavefronts all travel in the same direction. The diagrams below show wavefronts being specularly reflected from a surface. The arrow is a ray showing the direction of propagation of the light.


Incoming Wavefronts

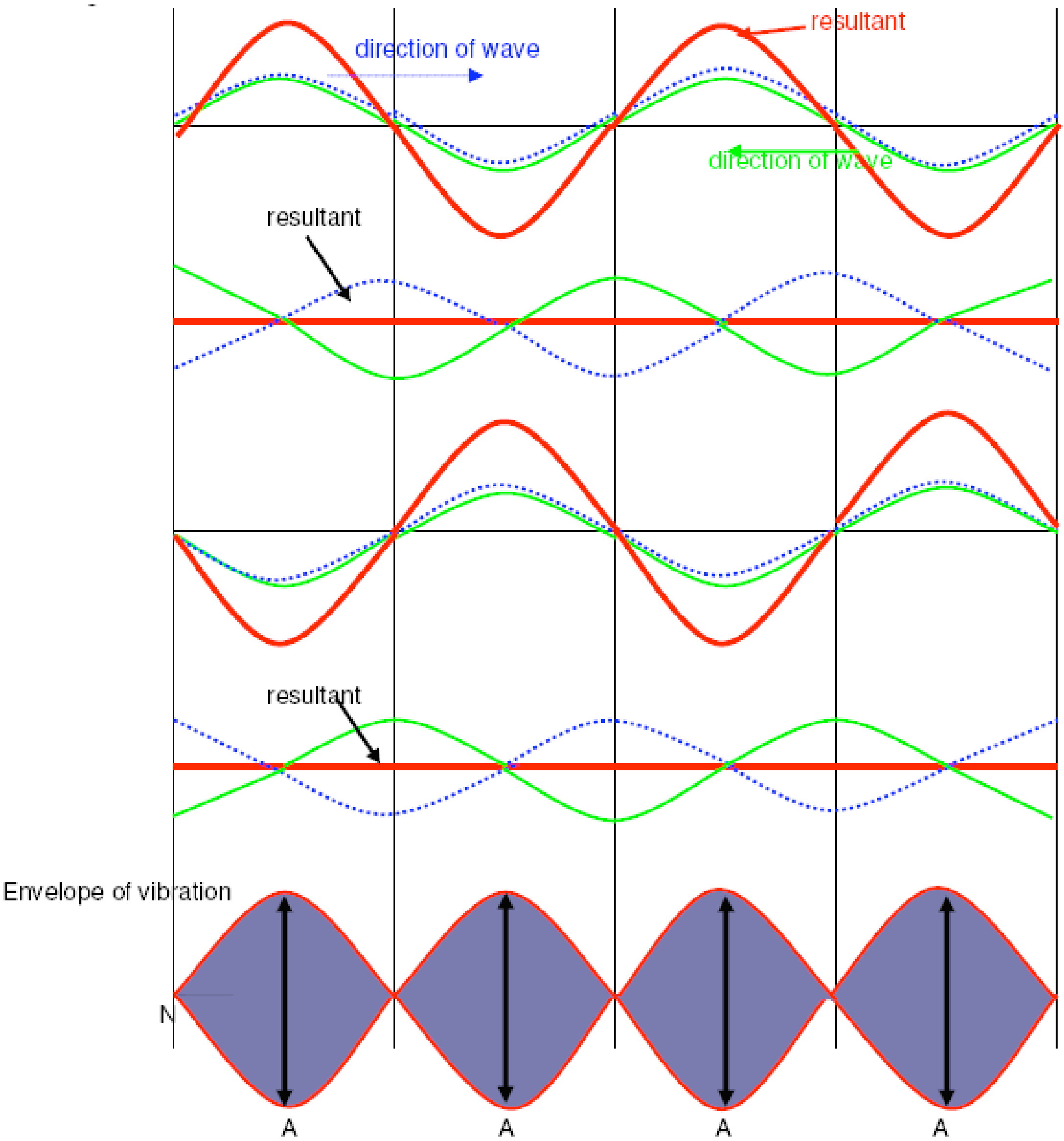

Part of the wave is incoming, part is already reflected


Outgoing Wavefronts

Reflection of Sound

When sound is reflected, the original sound wave will interact with the reflected sound wave. Like all waves, sound haves have the property of superposition. This means that two waves can pass through each other without disturbing each other. The effect of the two waves where they overlap is equal to the sum of the two individual waves.

Resonance



Standing Waves

The diagram above shows what is called a standing wave. The wave is made up of two separate components. These components must have the same amplitude and wavelength. Once of the components is moving to the left and the other is moving to the right (often because it is a reflection of the first wave). These two waves overlap and interfere. The above diagram shows the waves at 4 different times.

Notice that there are some locations where the sum of the two waves is always zero. These are called nodes or nodal points. They would be perceived as quiet points. There are other locations where the two components are always in phase. These are called antinodes

The effect of combining these two waves is that you get a wave that does not seem to move, it just vibrates on the spot. This is a standing wave. Notice that the wavelength of the combined sound is the same as the wavelength of the components, and that the nodes and antinodes are separated by a distance of $\lambda/2$.