Progressive Waves

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Lesson Objectives

1. To revise wave properties from GCSE.
2. To fully understand wave definitions and the wave equation.
3. To practise using the concepts on questions.

REMINDER: Office hours are week 2 Tuesdays 3.45–5.0 p.m. in room 19.
Next office hours: Tuesday 31 January 2012

Specification Requirement

Progressive waves
Oscillation of the particles in a medium; amplitude, frequency, wavelength, speed, . . .
$c = f\lambda$
Longitudinal and transverse waves
Characteristics and examples, including sound and electromagnetic waves

[AQA GCE AS and A Level Specification Physics A, 2009/10 onwards]

Reading memos...

By 9.30 last night, I had 2 paper reading memos (perfect), and 1 online (who had the wrong idea...)
Hopefully at the start of the lesson I now have the other 11 memos!
Remember:

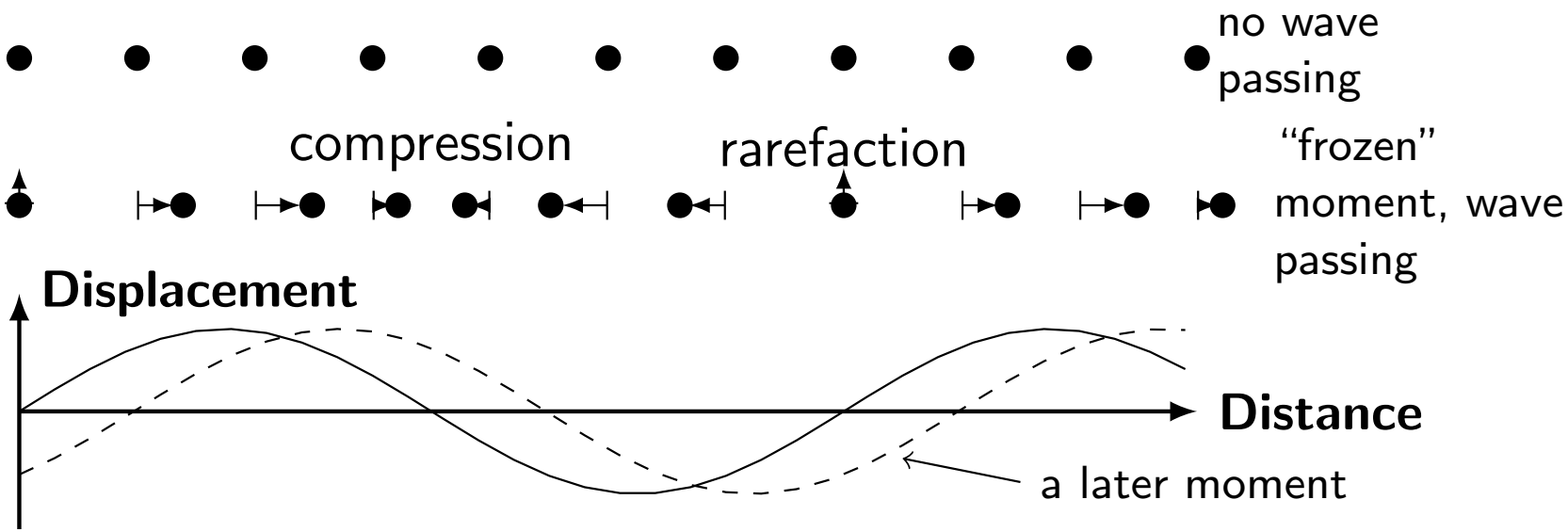
- You **must** make at least 1 comment (1 is not really enough).
- Make sure you write down any difficulties you had in understanding (even if you puzzle it out later).

Reading memos. . .

Definitions: **superimposed**, **propagation**
Wave equation: $v = f\lambda$: doesn't v always equal c?
Medium for waves
Compression / rarefaction diagram

Mean position

Compression / Rarefaction diagram



a longitudinal wave at two instants

Anything else from memos. . .

Waves I

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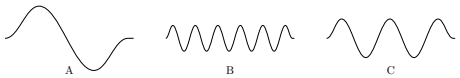
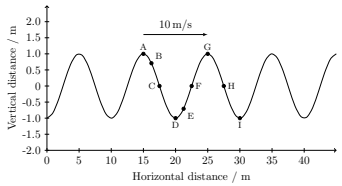
1. Copy out and complete the following sentences:
   (a) A wave is a motion which transfers ....
   (b) The maximum distance of a particle on a wave from its resting position is called the ....
   (c) The distance between two adjacent crests is called the ....
2. The diagram below shows three waves:



   (a) Which wave has the shortest wavelength?
   (b) Which wave has the largest amplitude?
3. The diagram below shows a piece of string with a wave travelling along it. There are beads attached in positions A to I.



   (a) Which beads are
      i. at crests?
      ii. at troughs?
   (b) What is the
      i. amplitude of the wave?
      ii. wavelength of the wave?
   (c) Which beads will move up as the wave moves to the right?

Waves II

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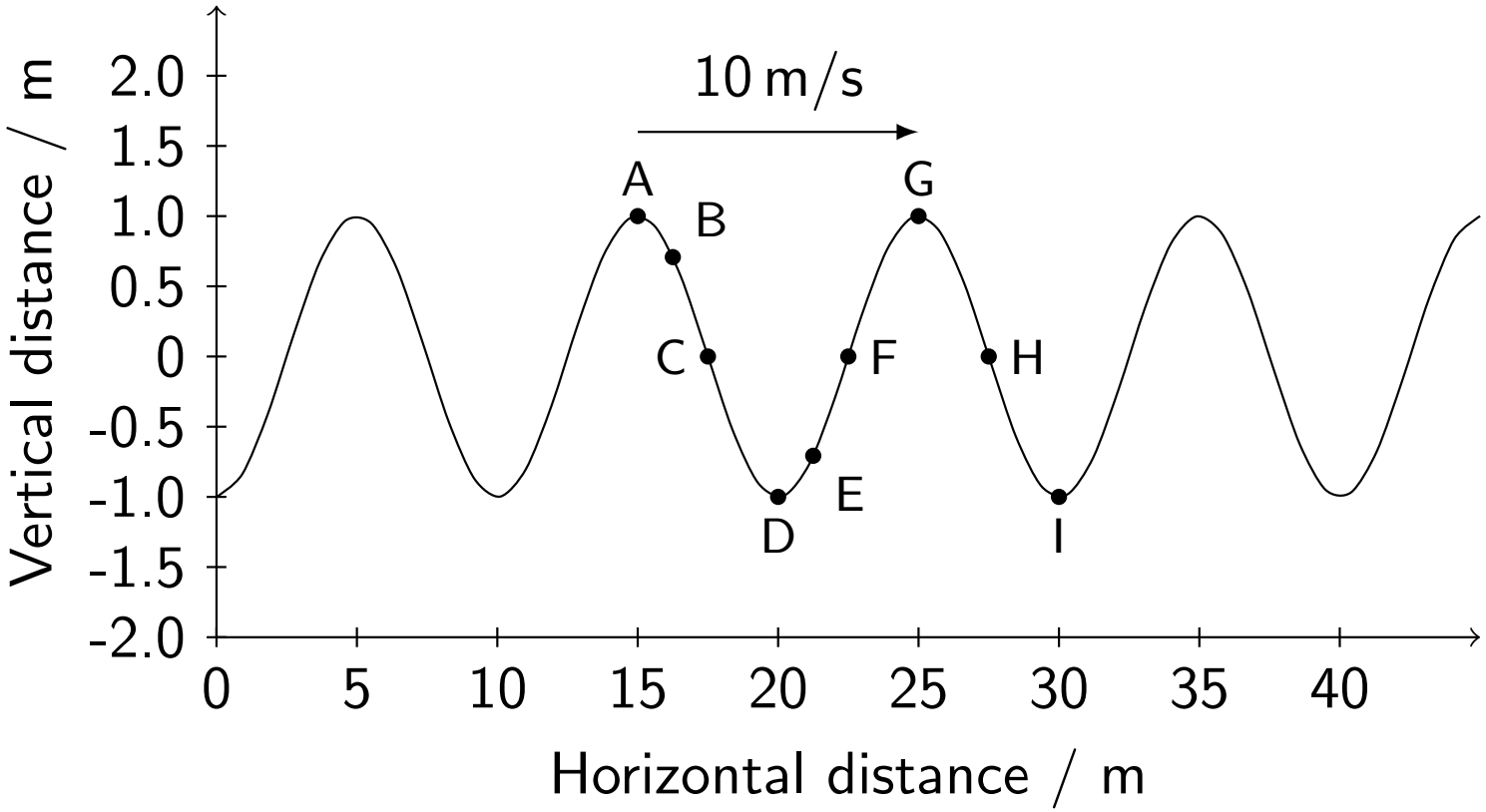
1. (a) Write out the wave equation in symbols.
   (b) Say what each symbol stands for.
   (c) What units are each quantity in?
2. Use the wave equation to complete the table.

Wave speed / m/s	Frequency / Hz	Wavelength / m
	10	2.5
	50	0.02
340	170	
2.4	0.5	
310		0.5

3. What is the wavelength of a 200 Hz sound wave in air if the speed of sound in air is 340 m/s.
4. Sound waves travel at 1500 m/s in water. Calculate the wavelength of 300 Hz sound wave in water.
5. How many waves are made in 3 minutes by a swimming pool's wave machine if its frequency is 0.25 Hz.
6. A tuning fork vibrates at
7. 256Hz. How many times does one of its prongs vibrate back and forth in 5 s.
8. A water wave travels 10 m in 5 s. Calculate...
   (a) ... the speed of the wave.
   (b) ... the frequency of the wave if its wavelength is 1.5 m.
9. A man fires a gun and hears an echo from the cliff after 4 s. The cliff is 600 m away.
   (a) How long did the sound wave take to travel to the cliff?
   (b) Use speed = $\frac{\text{distance}}{\text{time}}$ to work out the speed of sound.
10. A sonar pulse is sent out from a boat and arrives back after 3 s. If the speed of sound in water is 1500 m/s, how deep is the water?

The hardest problem (I think!)



Some extra problems

Questions adapted from CK-12 Curriculum Material at `http://www.ck12.org/flexbook/chapter/14517`, published under a CC BY-NC-SA license.

1. 'Round the room' on the difference between transverse and longitudinal waves. For each of the following types of waves, tell the class what type it is and why and draw a diagram on the board (depends on where you're sitting!
   - sound waves
   - water waves in the wake of a boat
   - a vibrating string on a guitar
   - a swinging jump rope
   - the vibrating surface of a drum
   - the 'wave' done by spectators at a sports event
   - slowly moving traffic jams

Some extra problems

2. If you tap your toe into a calm swimming pool, circular waves result.
   (a) What does the fact that those waves are circular tell you about the speed of the wave in different directions?
   (b) If you tap your toe more frequently, what happens to the wavelength of those waves? What happens to the period of the waves?
3. Blue light has a shorter wavelength than red light. Which color has the higher frequency? Which moves faster in a vacuum?
4. If the frequency of a sound wave is tripled, what happens to its speed and wavelength? Explain briefly.

Some extra problems

5 Describe the pressure changes in the air as a sound wave passes a given point, then explain why a very loud sound can damage your tympanic membrane (ear drum).

6 Bored in class, you start tapping your finger on the table. Your friend, sitting right next to you also starts tapping away. But while you are tapping once every second, your friend taps twice for every one tap of yours.

(a) (i) What is the period and frequency of your tapping?
(ii) What is the period and frequency of your friend's tapping?

(b) Your tapping starts small waves going down the desk (a bit like hitting a bell with a hammer). The frequency of the sound you hear is 1200 Hz. You know the wave speed in wood is about 3600 m/s. Find the wavelengths generated by your tapping.

Some extra problems

7 The speed of light c is $3 \times 10^8\,\mathrm{m/s}$.

(a) What is the frequency in Hz of a wave of red light ($\lambda = 0.7 \times 10^{-6}\,\mathrm{m}$)?

(b) What is the period T of oscillation (in seconds) of an electron that is bouncing up and down in response to the passage of a packet of red light? Is the electron moving rapidly or slowly?

8 The speed of sound v in air is approximately $331.4\,\mathrm{m/s} \pm (0.6\,\mathrm{m/s\,^\circ C} \times T)$, where T is the temperature of the air in Celsius. The speed of light c is $300\,000\,\mathrm{km/s}$, which means it travels from one place to another on Earth more or less instantaneously. Let's say on a cool night (air temperature $10\,^\circ\mathrm{C}$) you see lightning flash and then hear the thunder rumble five seconds later. How far away (in km) did the lightning strike?