# Teaching ideas for Topic 4: *Wave phenomena*, AHL

## Questions

A number of worksheets are provided for this Topic:

- support questions examine the very basic concepts of the syllabus
- extended questions delve deeper and are equivalent to exam level questions.

## Teaching ideas

- Standing waves do not transfer energy: students who have been at water parks know this since even large waves in the pool do not throw you down (which they would if they transferred energy to you) – they just make you go up and down!
- What is the meaning of wave speed for a standing wave? It is the speed of the travelling waves making up the standing wave.
- The big difference between diagrams showing transverse and longitudinal standing waves must be pointed out: the diagram for a transverse waves is what you would see with your eyes, for example when looking at an oscillating string. However, a diagram for a longitudinal sound standing wave in a pipe is just a representation of how the molecules of air move!
- Visit the site for information on tall buildings' response to earthquakes, http://mceer.buffalo.edu/infoservice/reference_services/EQaffectBuilding.asp. It shows that 20-storey buildings have a natural frequency of around 0.5 Hz. This explains why buildings taller or shorter than 20-storey buildings were not damaged in the Mexico City earthquake of 1985, whereas very many 20-storey buildings collapsed.
- See the comments on the Doppler effect under 'Problems' below.
- The proof of the formula for diffraction by a single rectangular slit must be learned because it can be asked for in an exam – the proof itself is not particularly illuminating.
- A student must be able to draw the single slit intensity pattern fairly accurately.
- The factor of 1.22 in the circular slit diffraction angle formula comes from the first zero of a Bessel function – that should stop any further interest into this number!
- It must be understood that the Rayleigh criterion is an arbitrary criterion of what might be called the limit of resolution: its states that the first minimum of the diffraction pattern of one source coincides with the central maximum of the other source's diffraction pattern. This is equivalent to seeing a 'dip' at the centre of the combined diffraction pattern of the two sources. Other schemes have been proposed (and appear to be more realistic), for example having a flat section in-between the two separate peaks of the two diffraction patterns.

## Practical activities/ICT

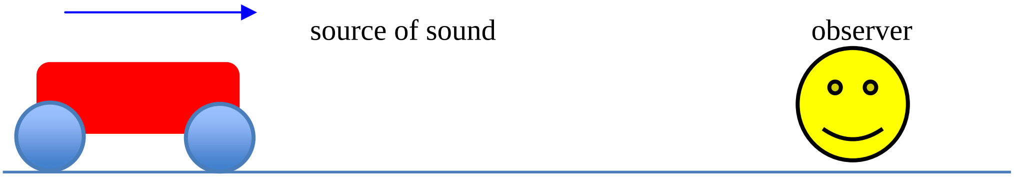
- Use of two polarising sheets are a must. Students can learn a lot just by playing with these. The darkening of crossed polarisers is impressive. You can view horizontal surfaces such as glass or plastic through a polarizer as it is rotated and describe what is being observed. You can also hold partially crossed polarisers (one vertical and one horizontal) against the sky and notice that one of the polarizers is darker than the other. The darker polariser has its transmission axis vertical, most of the reflected light is mainly horizontally polarised so it does not get transmitted through that polariser.

- Another demonstration is to put ordinary kitchen wax paper in-between crossed polarisers. There will now be light transmitted through the wax paper and the two polarisers, presumably because the light in the paper undergoes multiple scatterings and reflections that effectively ruin the polarisation of light achieved by the first polariser.
- A quick and easy demonstration of the Rayleigh criterion in class is to make two small dots with red ink on white paper, a distance of about 1.5 mm apart, and place it far away from students. As you bring it closer the students must say when they first see two separate dots. Check if this agrees with the standard theory.

## Common problems

- An extremely common problem with students' understanding of the Doppler effect is that they often confuse frequency of sound with intensity. This often occurs in the classic exam question where a source of sound approaches and then moves away from a stationary observer. When asked to graph the variation of the frequency heard by the observer with time, students frequently draw a graph that increases to a maximum (at the position of the observer) and then decreases to zero as the source recedes.




- Another problem with the Doppler effect is whether the speed of the wave changes when the source of sound moves relative to an observer. When the wave is an electromagnetic wave, we know from the theory of relativity that the speed must stay the same for all observers (the ones moving with the source as well as the others 'at rest' on the ground). But what about sound? The speed of sound depends on the medium properties, air in this case. Thus in the case of the moving source and a stationary observer there is no change in speed. The observer will measure a different frequency, and so a different wavelength as well since the speed is constant. This is seen also from a wavefront diagram. If the observer moves and the source is stationary the situation is different: the (moving) observer is perfectly entitled to consider herself to be at rest in which case the source moves *plus* the air moves. This is a case of a medium with a wind and this is a different medium than still air. The observer will measure a different frequency and, as it turns out, because the speed is different, will measure the same wavelength. (But this is for mechanical waves only – light is different – and beyond our syllabus.)