Teaching ideas for Topic 4: *Oscillations and waves*, Core

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

- The topic of simple harmonic oscillations contains very many formulae and so can be intimidating to students. It is best to concentrate on just one formula for displacement, say $x = x_0 \cos \omega t$ and try to connect as much as possible with what students have learned in maths and trigonometry. I always find that this is a very useful exercise in that it puts what they have learned in maths in a concrete context and helps them both in maths and physics.
- For example, in maths they learned that the graph of $y = A \cos x$ is obtained from $y = \cos x$ by stretching along the vertical axis by a factor of A. Similarly, they learned that the graph of $y = \cos px$ is obtained form the graph of $y = \cos x$ by stretching horizontally by a factor of $\frac{1}{p}$. Now the period of $y = \cos x$ is 2π, so the period of $y = \cos px$ is therefore $\frac{2\pi}{p}$. This should make clear why in SHM the period is $\frac{2\pi}{\omega}$.
- It is then also a good idea to analyse graphs by concentrating on slopes at various points.
- A good discussion point in the classroom when learning about simple harmonic motion is to ask how astronauts in orbit can 'weigh' themselves. The period formula for a mass at the end of a spring should be of help, as it works in conditions of real or apparent absence of gravity.
- It is important for students to understand that the speed of a wave is determined by the properties of the medium and not by the agent creating the wave. Students can experiment with a long slinky, see practical activities below.
- One of the best ways to introduce the idea of a wave is to give students two graphs of displacement versus distance at two slightly different times. Students must be able to obtain wave characteristics such as amplitude and wavelength right away. Then by seeing how much a peak has moved forward, they can determine the wave speed and then frequency and period.
- It is crucial that the connection between simple harmonic motion and waves is pointed out right away. A good way is to give a graph of displacement versus distance for a transverse wave with given known frequency, f. Then ask for the velocity of a point on the wave. They must then use the SHM equation $v = \omega\sqrt{x_0^2 - x^2}$ and will need to know that $\omega = 2\pi f$ (this is an important point in itself: frequency of SHM is the same as frequency of the wave) and that the amplitude of the wave, x_0, is the same as the amplitude of the SHM oscillations of a point in the medium. Then comes the issue of deciding the direction of motion of the particle. This can be determined by drawing the wave a slightly later time and seeing how the displacement of the given point changes. Spending a good deal of a lesson on such an activity is time very well spent.
- The previous bullet point may now be repeated for a longitudinal wave. Students must appreciate the similarities and differences between the two cases.

Practical activities/ICT

- A simple but nice simulation of simple harmonic oscillations of a mass at the end of a spring, with or without damping, is provided at http://www.myphysicslab.com/spring1.html
- No lesson on resonance can avoid the Takoma bridge (http://www.youtube.com/watch?v=j-zczJXSxnw) but see also the video on the millennium bridge in London (http://www.youtube.com/watch?v=eAXVa__XWZ8). However, a better (but more boring) demonstration of resonance can be found at http://www.youtube.com/watch?v=LV_UuzEznHs&feature=related
- If you use a very long stretched slinky you should be able to see that a series of pulses produced by very frequent shaking of one end of the slinky travel just as fast as pulses produced with much lower frequency. To see a change in speed you must change the tension of the slinky, i.e. the properties of the medium.
- Playing with the circular wavefronts of two coherent point sources (see illustration below) is very useful in determining (i) points that are in phase, (ii) points of constructive interference and points of destructive interference, and (iii) path differences.
- A ripple tank simulator can be found at: http://www.compadre.org/OSP/document/ServeFile.cfm?ID=9989&DocID=1625

Common problems

- Students often think that they can tell whether a wave is transverse or longitudinal by looking a displacement/distance graph, which of course is not true and this has to be pointed out.
- It also has to be pointed out that the speed of a particle executing SHM as a wave passes through the medium has nothing to do with the wave speed.