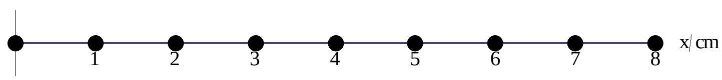
Teacher notes
Topic C

Longitudinal waves

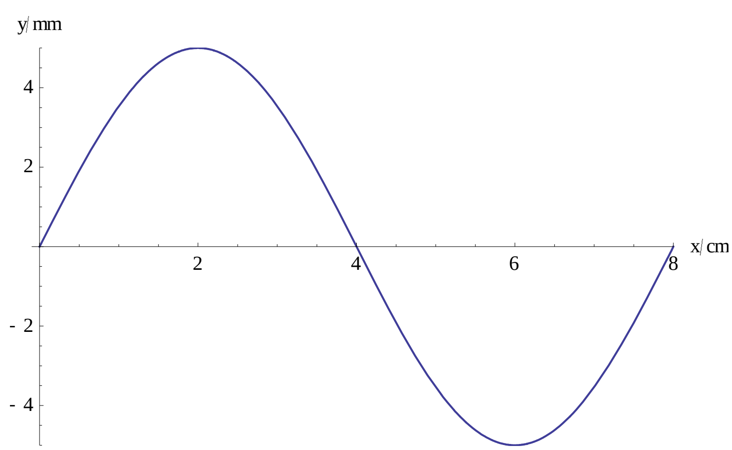
It is very important to make students understand the interpretation of displacement graphs for *longitudinal* waves.

Imagine a solid rod. The dots in the diagram below represent the *equilibrium* positions of 9 molecules in the solid when no wave travels through the rod. The molecules vibrate a bit about these positions because the rod is at some finite temperature but let us ignore this for the moment.



Now suppose that a longitudinal wave travels through this rod (for example by hitting one end of the rod with a hammer in a direction along the length of the rod)

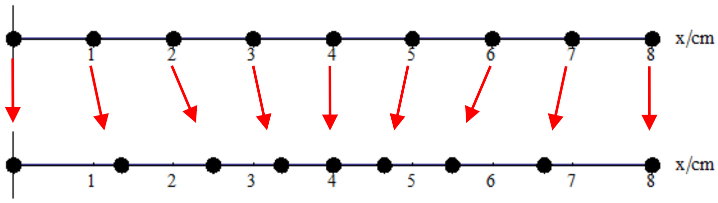
At some instant of time the displacement of the wave varies with distance according to the graph below.



What are the positions of the 9 molecules at this instant?

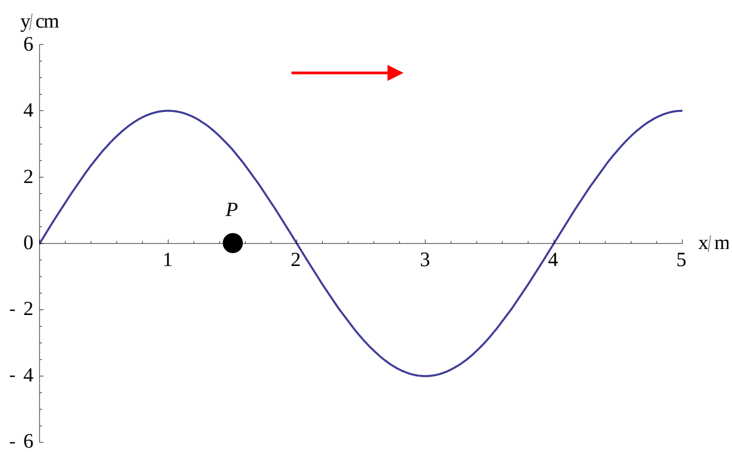
The wave is longitudinal so the molecules will be displaced in the direction of energy transfer or opposite to it, i.e. right or left in this case. We take positive displacements to mean motion to the right. (This is a convention and you must always check the convention of the problem you are given.)

The molecules will be displaced from their equilibrium positions (to the right or left) by an amount given by the displacement graph above. Thus the molecules at x = 0, 4 cm and 8 cm stay in the same place because the displacement at these points is zero. The molecules at x = 1 cm, 2 cm and 3 cm move to the right and those at x = 5 cm, 6 cm and 7 cm to the left.



As time goes by, each molecule executes simple harmonic oscillations about their equilibrium positions with the same amplitude (5 mm) and a frequency equal to that of the wave.

Check yourself: A longitudinal wave travels through a medium directed to the right. The graph shows the displacement of medium particles versus distance at an instant of time. The **equilibrium** position of particle P is at x = 1.50 m. (Positive displacements to mean motion to the right.) Where is the particle at this instant?



The displacement of P is about 2.8 cm so its position is 2.8 cm *to the right* of the equilibrium position. I.e. it is at x = 1.528 m.