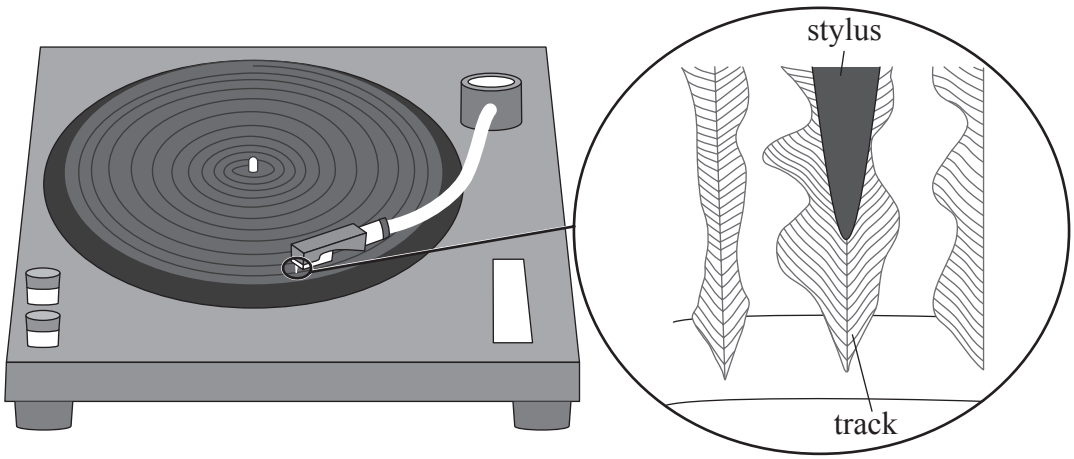
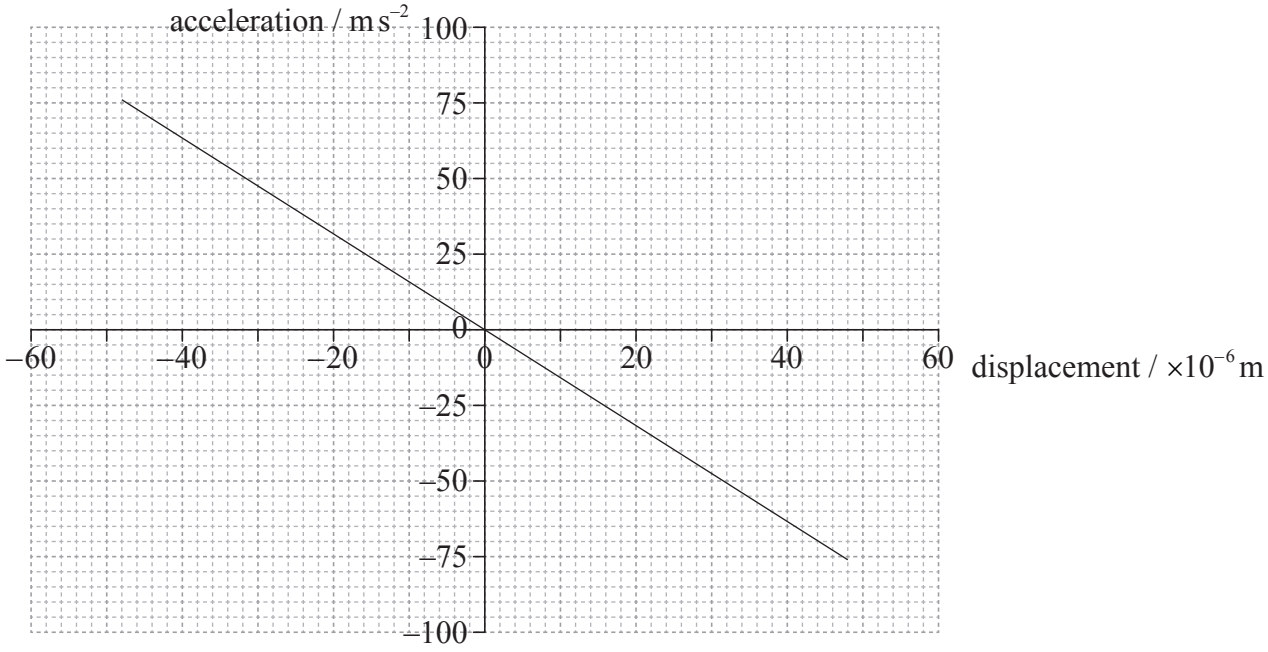
7. This question is about simple harmonic motion (SHM) and sound.

The diagram shows a section of continuous track of a long-playing (LP) record. The stylus (needle) is placed in the track of the record.



As the LP record rotates, the stylus moves because of changes in the width and position of the track. These movements are converted into sound waves by an electrical system and a loudspeaker.

A recording of a single-frequency musical note is played. The graph shows the variation in horizontal acceleration of the stylus with horizontal displacement.



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(Question 7 continued)

(a) Explain why the graph shows that the stylus undergoes simple harmonic motion. *[4]*

In order to have SHM the acceleration should be :

1) Proportional to the displacement from the equilibrium position.

2) Opposite from it, thus pointing always towards the equilibrium position.

The given graph is a straight line through the origin , thus proving the proportionality of the acceleration to the displacement. The gradient of the graph is negative thus when the displacement is positive the acceleration is negative (pointing to equil. point) and when displacement is negative acceleration is positive (pointing to equil. point).

(b) Using the graph on page 20, show that the frequency of the note being played is about 200 Hz. *[4]*

As $a = -\omega^2 x$ from the gradient of the graph $-\omega^2 = -63/(40 \times 10^{-6}) \Rightarrow \omega = 1254.99 = 1250\ rad.s^{-1}$

Thus $f = \omega/2\pi = 199.73 = 200\ Hz$

(c) (i) The mass of the stylus is 5.5×10^{-4} kg. Determine the maximum kinetic energy of the stylus. *[2]*

$E_{kmax} = 1/2 \times m \times v_{max}^2 = 0.5 \times 5.5 \times 10^{-4} \times \omega^2 \times (48 \times 10^{-6})^2 = 9.9 \times 10^{-7} = 1.0 \times 10^{-6}$ J

(ii) On the graph on page 20, identify, with the letter P, the position of the stylus at which the kinetic energy is at a maximum. *[1]*

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