Mark scheme for Topic 4

1 The acceleration is proportional to and opposite to displacement and so we must have a straight line through the origin with a negative gradient, **A**.

2 The period is independent of amplitude. The energy is proportional to amplitude squared, and so **D**.

3 Draw an identical graph but shifted slightly to the right. The marked point is now lower, hence **C**.

4 Draw an identical graph but shifted slightly to the right. The marked point is now lower, i.e. the point has a smaller positive displacement than before. Hence it is moving to the left, **B**.

Exam tip: make sure you understand the last 2 questions.

5 All waves will diffract but appreciable diffraction takes place only for waves whose wavelength is comparable to the size of the opening, hence only sound, **B**.

6 All quantities will change except for frequency, hence **B**.

7 a i The maximum kinetic energy is given by $E_{max} = \frac{1}{2}m\omega^2 A^2$.

$0.60 = \frac{1}{2} \times 0.25 \times \omega^2 \times 0.15^2$, giving $\omega = 14.6\ \mathrm{s^{-1}}$

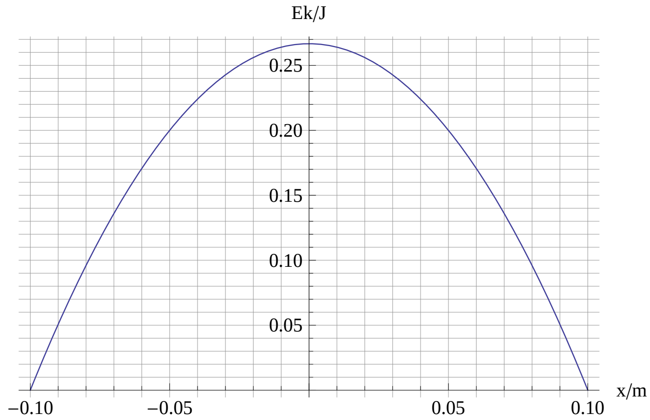
$\omega = \frac{2\pi}{T}$, $T = \frac{2\pi}{14.6} = 0.43\ \mathrm{s}$ **[3]**

ii $a_{max} = -\omega^2 A = -14.6^2 \times 0.15$

$a_{max} = 31.97 \approx 32\ \mathrm{m\,s^{-2}}$ (for the magnitude). **[2]**

b Correct amplitude.

Correct maximum.



[2]

c i $T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$f = \frac{1}{2\pi}\sqrt{\frac{6.0 \times 10^4}{1200}} = 1.1\,\mathrm{Hz}$; **[2]**

ii The car hits the bumps every $\frac{d}{v} = \frac{15}{16} = 0.9375\,\mathrm{s}$,

i.e. with a frequency of $\frac{1}{0.9375} = 1.1\,\mathrm{Hz}$.

Therefore at this speed we will have **resonance** and the amplitude of oscillations will be large. **[3]**

8 **a** **i** The acceleration is proportional to

and opposite to displacement, and this is what this equation is stating. **[2]**

Exam tip: do not forget that there are **2 statements** to be made.

ii $a = -\omega^2 x$ and so $\omega^2 = 39 \Rightarrow \omega = 6.245\,\mathrm{s}^{-1}$.

From $\omega = 2\pi f \Rightarrow f = \dfrac{6.245}{2\pi} = 0.99\,\mathrm{Hz}$. **[2]**

b **i** $E_{max} = \dfrac{1}{2} m\omega^2 A^2$

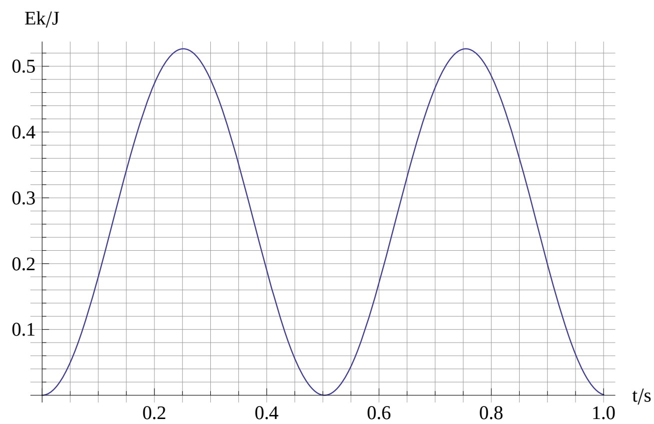
$E_{max} = \dfrac{1}{2} \times 1.2 \times 39 \times 0.15^2$

$E_{max} = 0.53\ \mathrm{J}$ **[3]**

ii Overall shape and beginning at origin.

Correct maximum.

Correct period.



[3]

Exam tip: students often make a mistake with period here.

iii Any peak. **[1]**

c **i** The period would be very slightly larger,

and the peaks of the curve would be decreasing. **[2]**

ii The period would stay the same.

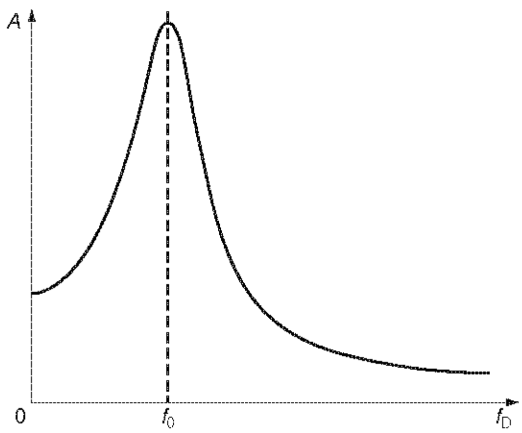
The energy is proportional to the square of the amplitude, and so the increase from 0.15 m to 0.21 m implies an increase in maximum energy by a factor of $\left(\frac{0.21}{0.15}\right)^2 \approx 2$. **[2]**

d Peak at/close to natural frequency.

Amplitude going to constant value as $f \to 0$.

Amplitude going to zero as $f \to \infty$. **[3]**

Exam tip: you need detail, quantitative whenever possible.



9 **a** In a transverse wave the displacement of the medium particles is at right angles to the direction of energy transfer of the wave,

whereas in a longitudinal wave the displacement is parallel to the direction of energy transfer. **[2]**

b **i** 4.0 cm. **[1]**

ii 0.65 m. **[1]**

iii In 92 ms the crest moved forward 0.15 m,

and so $v = \frac{0.15}{92 \times 10^{-3}} = 1.63 \approx 1.6\,\mathrm{m\,s^{-1}}$. **[2]**

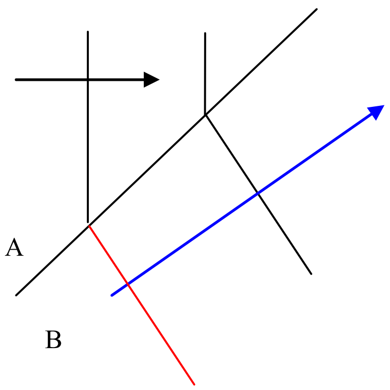
iv From $v = f\lambda$ we get $f = \frac{1.63}{0.65}$.

$f = 2.51 \approx 2.5\,\mathrm{m\,s^{-1}}$ **[2]**

10 **a** A surface at right angles to the direction of energy transfer,

where all its points are in phase. **[2]**

b



i Red line in diagram. **[1]**

ii Blue line in diagram. **[1]**

iii Measuring the distance between successive wavefronts in each medium

to get a ratio of about 1.3. **[2]**

11 **a** When two similar waves meet, the resulting displacement is the algebraic sum of the individual displacements. **[1]**

b **i** The difference in the length of the paths followed by the two waves from their source to point P. **[1]**

ii Assuming zero phase difference initially, we will have constructive/destructive interference.

If the path difference is an integral / half integral multiple of the wavelength. **[2]**

c No interference pattern will be observed.

Because the phase difference between the two lasers is constantly changing, and so at point P we sometimes have constructive interference and sometimes destructive in very short succession (of the order of nanoseconds),

and so no pattern will be observable. **[3]**

