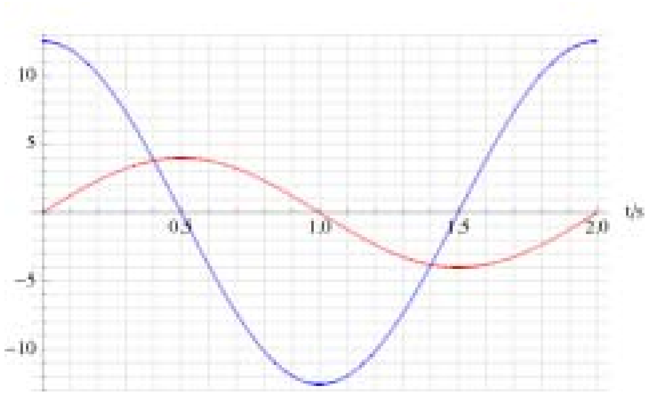
Mark scheme for Extension Worksheet – Topic 4, Worksheet 1

1 **a** Since $v_{max} = \omega x_0 = \frac{2\pi}{T} x_0$ we have that $4.0 = \frac{2\pi}{2.0} x_0$; hence

$x_0 = \frac{4}{\pi} = 1.2732 \approx 1.3\ \text{m}$ [2]

b the area represents twice the amplitude and so it equals
$2x_0 = 2 \times 1.2732 \approx 2.5\ \text{m}$ [1]

c See graph in blue (cosine curve). Original graph is in red.



[2]

2 **a** Conservation of energy states that the ball will move to the same height on either side so it will oscillate back and forth. [1]

b Since the sides are essentially straight the acceleration is $a = g\sin\theta$; and so does not satisfy the condition of SHM where the acceleration is proportional to the displacement. [2]

3 **a** The loss of mechanical energy during an oscillation; [1]

b $kx = mg \Rightarrow x = \frac{mg}{k} = \frac{1.2 \times 9.8}{240}$; $x = 0.049\ \text{m}$ [2]

c the period is $T = 2\pi\sqrt{\frac{1.2}{240}} = 0.4443\ \text{s}$; and so the frequency is

$f = \frac{1}{T} = \frac{1}{0.4443} = 2.25\ \text{Hz}$ [2]

d The extension is 4.9 + 5.1 = 10 cm; and so the net force is
$T - mg = 240 \times 0.10 - 1.2 \times 9.8 = 12.24 \approx 12\ \text{N}$ [2]

e The maximum acceleration is $\frac{T_{max} - mg}{m} = \frac{12.24}{1.2}$; $= 10.2 \approx 10\ \text{m s}^{-2}$ [2]

or you can apply the formula from SHM that $a_{max} = \omega^2 x_0$ but you must remember that x_0 is the maximum displacement from equilibrium, i.e. 5.1 cm; then

$$a_{max} = \left(\frac{2\pi}{0.4443}\right)^2 \times 0.051 = 10.19 \approx 10 \text{ m s}^{-2}$$

[2]

f Similarly, $$v_{max} = \left(\frac{2\pi}{0.4443}\right) \times 0.051 = 0.72 \text{ m s}^{-1}$$ [1]

g The frequency matches the natural frequency of the oscillations of the mass at the end of the spring, i.e. we have resonance; and so the amplitude of oscillations will be large. [2]

4 The speed of the wave will remain the same; and so doubling the frequency will halve the wavelength. [2]

