17. Oscillations

17.2 Energy in simple harmonic motion

Paper 4

Marking Scheme

Q1.

(b)(iii)	$E = \frac{1}{2} m\omega^2 x_0^2$	**C1**
	$= \frac{1}{2} m \times (2A / 3Y) \times (3Y)^2$ $= 3mAY$	**A1**

Q2.

(b)(iii)	total energy $= \frac{1}{2}m\omega^2 x_0^2$	**C1**
	$= \frac{1}{2} \times 0.15 \times 15.7^2 \times 0.016^2$ $= 4.7 \times 10^{-3}$ J	**A1**
(c)	dome-shaped curve starting and ending on the x-axis, with peak at $x = 0$	**B1**
	maximum E_K shown as 4.7×10^{-3} J	**B1**
	minimum x shown as –0.016 m and maximum x shown as +0.016 m at the ends of the line	**B1**

Q3.

(c)	sum of potential energy and kinetic energy is constant	**B1**
	at maximum displacement, kinetic energy is zero **or** at maximum displacement, potential energy is maximum	**B1**
	at zero displacement, kinetic energy is maximum **or** at zero displacement, potential energy is minimum	**B1**

Q4.

(b)(ii)	$E = \frac{1}{2}m\omega^2 x_0^2$	**C1**
	$= \frac{1}{2} \times 0.81 \times 2.1^2 \times 0.036^2$ $= 2.3 \times 10^{-3}$ J	**A1**

Q5.

(c)	(increasing L causes) ω to decrease **or** energy ($= \frac{1}{2} m\omega^2 x_0^2$) $= \frac{1}{2} mkx_0^2 / L$ (and L increases)	**M1**
	so amplitude increases	**A1**

Q6.

(b)(iii)	$E = \frac{1}{2}M\omega^2 x_0^2$	**C1**
	$0.050 = \frac{1}{2} \times M \times 1.67^2 \times 0.12^2$ $M = 2.5$ kg	**A1**
	or	
	$(E_K)_{max} = \frac{1}{2}Mv_0^2$	**(C1)**
	$0.050 = \frac{1}{2} M \times 0.20^2$ $M = 2.5$ kg	**(A1)**

Q7.

(a)(iii)	$E = \frac{1}{2}m\omega^2 x_0^2$	**C1**
	$= \frac{1}{2} \times 36 \times 1.6^2 \times 0.080^2$	**C1**
	$= 0.29$ J	**A1**
(b)	dome-shaped curve, starting and ending at $E_K = 0$	**B1**
	maximum E_K shown as 0.29 J	**B1**
	position of peak shown at $h = 10.0$ cm	**B1**
	line intercepts h-axis at $h = 2.0$ cm and at $h = 18.0$ cm	**B1**

Q8.

(c)	energy $\propto x_0^2$	**C1**
	(after 3 cycles,) amplitude $= (0.94)^3 x_0$ $= 0.83x_0$	**C1**
	ratio final energy / initial energy $= 0.83^2$ $= 0.69$	**A1**

Q9.

(b)(i)	zero	**B1**
(b)(ii)	E_T is maximum potential energy $= mgh$ $E_T = 94 \times 10^{-3} \times 9.81 \times 0.90 \times 10^{-2}$	**C1**
	$= 8.3 \times 10^{-3}$ J	**A1**
(b)(iii)	$E_{MAX} = \frac{1}{2} mv_0^2$ **and** $v_0 = \omega x_0$ **or** $E_{MAX} = \frac{1}{2}m(\omega x_0)^2$	**C1**
	$8.3 \times 10^{-3} = \frac{1}{2} \times 94 \times 10^{-3} \times \omega^2 \times (12.7 \times 10^{-2})^2$ …leading to $\omega = 3.3$ rad s^{-1}	**A1**

Q10.

(b)(ii)	(maximum) KE $= \frac{1}{2}mv_0^2$ **and** $v_0 = \omega x_0$ **or** energy $= \frac{1}{2}m\omega^2 x_0^2$	**C1**
	change $= \frac{1}{2} \times 18 \times 10^{-3} \times 103 \times [(2.0 \times 10^{-2})^2 - (0.95 \times 10^{-2})^2]$	**C1**
	$= 2.9 \times 10^{-4}$ J	**A1**

Q11.

(c)(ii)	(maximum) KE $= \frac{1}{2}mv_0^2$ **and** $v_0 = \omega x_0$ **or** energy $= \frac{1}{2}m\omega^2 x_0^2$	**C1**
	ratio $= (1.3/2.0)^2$ $= 0.42$	**A1**