Simple Harmonic Motion – 2 - Answers

1.

a		acceleration ∝ displacement/distance from a fixed point;	**1**	
		directed towards that point/indication acc. and displ. in opp. direction	**1**	
		for symbols without explanation ($a = -\omega^2 x$ or $a \propto -x$) max 1 mark		**2**
b		arrow downwards through centre of bob, labelled weight/gravity/mg;	**1**	
		upward arrow on string, labelled tension	**1**	**2**
c	**i**	reading T = 1.6 s ; *2 marks for correct f without working*	**1**	
		f = 1/T = 0.625 to 0.632 ; Hz or s^{-1}	**2**	**3**
	ii	tangent to graph at displacement = 0; gradient = 0.20 ± 0.03 ($m\ s^{-1}$)		
		or $v = 2\pi fA$; = 2 x 3.14 x 0.625 x 0.05 = 0.20 ($m\ s^{-1}$)		**2**
d	**i**	none ; as period independent of amplitude		**2**
	ii	doubled; as twice the distance covered in the same time/ from c(ii) *or*	**1**	
		$v \propto -A$ /AW *possible ecf from d(i)*	**1**	
		increased because the gradient is steeper/greater distance in same time		
		worth 1 mark only		**2**

2.

a	**i**	acceleration ∝ displacement; indication of restoring force by negative	**1**	
		sign/acc. in opp. direction to displacement/acc. towards origin/AW	**1**	
	ii	linear graph through origin; negative gradient	**2**	**4**
b	**i**	0.05 (m)	**1**	
	ii	$4\pi^2f^2 = a/A$; = 12.5/0.05 = 250 so f = 2.5(1) Hz; T = 1/f (= 0.4 s)	**3**	**4**
c	**i**	cosine wave; correct period of 0.4 s; correct amplitude of 0.05 m	**3**	**3**
	ii	0; 0.1/0.3/0.5/0.7/0.9 (s)	**2**	**2**

3.

a	**i**	cosine curve;	**1**	
		sensible (exponential) decay of amplitude with time;	**1**	
		correct period	**1**	
	ii	amplitude will decay more rapidly; greater damping/air resistance on wings **or** greater damping; air resistance on wings **or** oscillation will effectively cease in shorter time; greater energy/amplitude loss per cycle **or** AW	**2**	
		frequency will decrease/period increase; greater mass/inertia of system	**2**	**7**

(P.T.O)

b	•	resonance occurs at /close to the natural frequency of an oscillating object/system	**1**	
		caused by driving force (at this frequency)	**1**	
		when maximum energy transfer between driver and driven/maximum amplitude achieved *max 2 marks*	**1**	
	•	small amplitude (≈ that of driver) at low frequencies/less than 1.0 Hz; *driver and driven in phase*	**1**	
		amplitude rises to maximum; at 1.0 Hz *driver and driven 90° out of phase*	**2**	
		(very) small amplitude at high frequencies/greater than 1.0 Hz	**1**	
		driver and driven (180°) out of phase (up to 2 marks can be credited for accurate reference to phase shifts as shown in italics) but max 3 marks	**2**	**5**

4.

a	**i**	Fig. 2.1 : x and a in opposite directions/acceleration towards equilibrium	**1**	
		point/AW; Fig. 2.2 : proportional graph between x and a/AW	**1**	
		Figures not identified max. of 1 mark		
	ii	$a = 4\pi^2 f^2 x$; $50 = 4\pi^2 f^2 .50 \times 10^{-3}$; giving $f^2 = 25$ and $f = 5.0$ Hz	**3**	
	iii	cosine wave with initial amplitude 25 mm; decreasing amplitude;	**2**	
		correct period of 0.2 s (for minimum of 2.5 periods);	**1**	**8**
b	**i**	the acceleration towards A/centripetal acceleration or force; is constant	**2**	
	ii	$a = v^2/r$; so $50 = v^2/10$; $v^2 = 500$ giving $v = 22.4$ m s^{-1}	**3**	**5**

5.

(a)		A motion in which the acceleration/force is proportional to the displacement; directed towards the centre of oscillation/equilibrium position/AW	2	**[2]**
		or $a \propto -x$ or $a = -\omega^2 x$; symbols must be identified		
(b)		**(i) 1** 0.025 (m)/2.5 (cm)/25 (mm) tolerance ± 1 mm; *2 marks if correct answer without working; 1 mark for correct method shown but arithmetic error*	2	
		2 T = 0.4 s or f = 1/T	1	
		f = 2.5 (Hz)	1	
		(ii) $a = -4\pi^2 f^2 A$ or $\omega^2 A$ where meaning of ω given in answer;	1	
		= 6.2 (m s^{-2}); ecf; *2 marks if correct answer without working*	1	
		(iii) 1 0.1/0.3/0.5 (s), etc	1	
		2 0/0.2/0.4 (s), etc	1	**[8]**
(c)		Inverted/180° phase shift graph of Fig.3.2	1	
		Correct/same period *full marks not possible if curve is not a sinusoid*	1	
		Scale matched to amplitude value of **b(ii)** ecf labelled on y-axis	1	**[3]**

6.

(a)	**(i)**	120 (mJ)	**1**	**1**
	(ii)	120 - 70 ; = 50 (mJ) *give 2 marks for correct answer without working*	**2**	**2**
(b)	**(i)**	k.e. = ½ mv^2 = 50 x 10^{-3} = 0.2 v^2 ecf from a(ii)	**1**	
		v^2 = 0.25; v = 0.5 (m s^{-1})	**1**	**2**
	(ii)	Reasoning, e.g. max energy = ½ mv_m^2 = ½ kA^2 so A ∝ v_m/AW;	**1**	
		or max ke = 12.5 mJ so total energy = 82.5 mJ, read x from graph;		
		giving A = 0.025 (m)	**1**	**2**
(c)	**(i)**	$a = -4\pi^2f^2x$;	**1**	
		$f^2 = 110/4\pi^2 = 2.786$ / $f = 10.5/2\pi = 1.67$ so f = 1/T = 0.6 (s)	**1**	**2**
	(ii)	sinusoidal wave with correct period; correct amplitude	**2**	
		correct phase accept A or –A at 0.15 s	**1**	**3**