

5(a)(i)	straight line through the origin shows that a is proportional to x
	negative gradient shows that a is always in the opposite direction to x
5(a)(ii)	$a_0 = \omega^2 x_0$
	$\omega = 2\pi / T$
	$T = 2\pi \sqrt{(x_0 / a_0)}$
	$= 2\pi \sqrt{(1.2 / 13)}$ $= 1.9 \text{ s}$
5(b)(i)	loss of energy of oscillations
	due to <u>resistive</u> force(s)
5(b)(ii)	line starting from $x = \pm 1.2 \text{ cm}$ at $t = 0$
	line starting from non-zero value of x from $t = 0$ to $t = 2T$ that is entirely either above or below the t -axis
	curve from $t = 0$ starting from non-zero x value, with both magnitude of x value and magnitude of gradient continuously decreasing

4(a)	<u>number</u> of oscillations per unit time
4(b)(i)	kinetic energy (of object) reaches maximum / minimum / zero twice in a cycle
4(b)(ii)	$\omega = 2\pi / T$
	$= 2\pi / 0.80$
	or
	$a_0 = \omega^2 x_0$ $\omega = \sqrt{(1.0 / 0.016)}$ $\omega = 7.9 \text{ rad s}^{-1}$
4(b)(iii)	Any three points from: - oscillations are simple harmonic <u>amplitude</u> = 0.016 m - maximum speed = 0.13 m s⁻¹ - total energy of oscillations = 7.0 × 10⁻⁴ J - mass of object = 0.087 kg - maximum momentum = 0.011 kg m s⁻¹ or 0.011 N s
4(b)(iv)	Any two points from: - kinetic energy is a maximum at zero displacement or kinetic energy is zero at maximum displacement - potential energy is zero at zero displacement or potential energy is a maximum at maximum displacement - kinetic energy is maximum when the potential energy is zero or potential energy is a maximum when the kinetic energy is zero
	kinetic energy + potential energy is constant

5(a)	(motion in which) acceleration is (directly) proportional to displacement
	(motion in which) acceleration is (always) in the opposite <u>direction</u> to displacement or acceleration is (always) directed towards a fixed point
5(b)(i)	period = $2\pi / 16$ $= 0.39 \text{ s}$
5(b)(ii)	$v_0 = \omega x_0$ or $v_0 = \omega \sqrt{(x_0^2 - 0^2)}$
	$x_0 = 0.56 / 16$ $= 0.035 \text{ m}$
5(b)(iii)	$v = \pm 16 \sqrt{(0.0352 - x^2)}$
5(b)(iv)	closed loop surrounding the origin
	loop crosses $v = 0$ at maximum values of x at $x = \pm 3.5 \text{ cm}$
	loop crosses $x = 0$ at maximum values of v at $v = \pm 0.56 \text{ m s}^{-1}$

5(a)(i)	amplitude = 0.60 m
5(a)(ii)	oscillations are simple harmonic
5(b)	Any three points from: - mean / equilibrium position is at $h = 1.4 \text{ m}$ - total energy of oscillations = 9.0 J - angular frequency of oscillations = 1.2 rad s⁻¹ or period of oscillations = 5.1 s or frequency of oscillation = 0.19 Hz - maximum speed of block = 0.73 m s⁻¹ - mass of block = 33 kg
5(c)	U-shaped curve resting on h axis (with minimum at $E_P = 0$)
	curve from $h = 0.8 \text{ m}$ to $h = 2.0 \text{ m}$, with minimum E_P shown at $h = 1.4 \text{ m}$
	both end-points of curve shown at $E_P = 9.0 \text{ J}$

4(a)	(motion in which) acceleration is (directly) proportional to displacement
	(motion in which) acceleration is (always) in the opposite <u>direction</u> to displacement or acceleration is (always) directed towards a fixed point
4(b)(i)	t_1 and t_5 or t_3 and t_7
4(b)(ii)	$f = 1 / T$
	period = $2.2 / 1.25$
	$f = 1.25 / 2.2$ = 0.57 Hz
4(c)	$v_0 = \omega x_0$ and $\omega = 2\pi f$
	$0.080 = 2\pi \times 0.57 \times x_0$
	$x_0 = 0.022 \text{ m}$

4(a)	$\omega = 2\pi / T$
	$= 2\pi / (0.15 \times 10^{-6}) = 4.2 \times 10^7 \text{ rads}^{-1}$
4(b)	$a_0 = \omega^2 x_0$
	$= (4.2 \times 10^7)^2 \times 40 \times 10^{-6}$
	$= 7.1 \times 10^{10} \text{ ms}^{-2}$
4(c)	$E = \frac{1}{2} m \omega^2 x_0^2$
	$= \frac{1}{2} \times 2.4 \times 10^{-4} \times (4.2 \times 10^7)^2 \times (40 \times 10^{-6})^2$
	= 340 J
4(d)(i)	apply alternating p.d. (to / across crystal)
	applying p.d. to / across crystal causes it to distort
4(d)(ii)	$Z = \rho c$
	$Z_m = 1100 \times 1600 (= 1.76 \times 10^6)$ $Z_b = 1900 \times 4100 (= 7.79 \times 10^6)$
	intensity reflection co-efficient = $[(7.79 - 1.76) / (7.79 + 1.76)]^2$ = 0.40 or 40%
	percentage transmitted = 60%