1	**(a)**	energy or W: kg m^2 s^{-2} **or** power or P: kg m^2 s^{-3}	M1	
		intensity or I: kg m^2 s^{-2} m^{-2} s^{-1} (from use of energy expression) **or** kg m^2 s^{-3} m^{-2} (from use of power expression)		
		indication of simplification to kg s^{-3}	A1	[2]
	(b) (i)	ρ: kg m^{-3}, c: m s^{-1}, f: s^{-1}, x_0: m	M1	
		substitution of terms in an appropriate equation and simplification to show K has no units	A1	[2]
	(ii)	$I = 20 \times 1.2 \times 330 \times (260)^2 \times (0.24 \times 10^{-9})^2$	C1	
		$= 3.1 \times 10^{-11}$ (W m^{-2})	C1	
		= 31 (30.8) pW m^{-2}	A1	[3]
2	**(a) (i)**	(the loudspeakers) are connected to the same signal generator	B1	[1]
	(ii) 1.	the waves (that overlap) have phase difference of zero or path difference of zero and so *either* constructive interference *or* displacement larger	B1	[1]
	2.	the waves (that overlap) have phase difference of (n + ½) × 360° or (n + ½) × 2π rad or path difference of (n + ½)λ and so *either* destructive interference *or* displacements cancel/smaller	B1	[1]
	3.	the waves (that overlap) are in phase or have phase difference of n360° or 2πn rad or path difference of $n\lambda$ and so *either* constructive interference *or* displacement larger	B1	[1]
	(b)	time period = 0.002 s or 2 ms	C1	
		wave drawn is half time period	B1	
		amplitude 1.0 cm (same as Fig. 2.2)	B1	[3]

3 (a) (i) 1.	$s = ut + ½at^2$		
	$192 = ½ \times 9.81 \times t^2$	C1	
	t = 6.3 (6.26) s	A1	[2]
2.	max E_k (= mgh) = 0.27 × 9.81 × 192	C1	
	or		
	calculation of v (= 61.4) and use of E_K (= ½ mv^2) = ½ × 0.27 × $(61.4)^2$	(C1)	
	max E_k = 510 (509) J	A1	[2]
(ii)	velocity is proportional to time **or** velocity increases at a constant rate		
	as acceleration is constant or resultant force is constant	B1	[1]
(iii)	use of $v = at$ or $v^2 = 2as$ or $E = ½mv^2$ to give v = 61(.4) m s^{-1}	B1	[1]
(b) (i)	R increases with velocity	B1	
	resultant force is $mg - R$ **or** resultant force decreases	B1	
	acceleration decreases	B1	[3]
(ii)	at v = 40 m s^{-1}, R = 0.6 (N)	C1	
	0.27 × 9.8 – 0.6 = 0.27 × a		
	a = 7.6 (7.58) m s^{-2}	A1	[2]
(iii)	R = weight for terminal velocity	B1	
	either weight requires velocity to be about 80 m s^{-1} *or* at 60 m s^{-1}, R is less than weight		
	so does not reach terminal velocity	B1	[2]
4 (a) (i)	reaction/vertical force = weight – P cos 60°	C1	
	= 180 – 35 cos 60°		
	= 160 (163) N	A1	[2]
(ii)	work done = 35 sin 60° × 20	C1	
	= 610 (606) J	A1	[2]

	(b)	**(i)**	work done by force P = work done against frictional force	B1	[1]
		(ii)	horizontal component of P is equal and opposite to frictional force	B1	
			vertical component of P + normal reaction force equal and opposite to weight	B1	[2]
5	**(a)**	**(i)**	resistance = V/I	B1	
			very high/infinite resistance at low voltages	B1	
			resistance decreases as V increases	B1	[3]
		(ii)	p.d. from graph 0.50 (V)	C1	
			resistance = $0.5/(4.4 \times 10^{-3})$		
			= 110 (114) Ω	A1	[2]
	(b)	**(i)**	current (= 1.2 / 375) = 3.2×10^{-3} A	A1	[1]
		(ii)	current in diode = 4.4×10^{-3} (A) total resistance = $1.2/4.4 \times 10^{-3} = 272.7$ (Ω)	C1	
			resistance of R_1 = 272.7 – 113.6 = 160 (159) Ω	A1	
			or		
			p.d. across diode = 0.5 V and p.d. across R_1 = 0.7 V	(C1)	
			resistance of R_1 = $0.7/4.4 \times 10^{-3}$ = 160 (159) Ω	(A1)	[2]
		(iii)	power = IV **or** I^2R **or** V^2/R	C1	
			ratio = $(4.4 \times 0.5)/(3.2 \times 1.2)$ **or** $[(4.4)^2 \times 114]/[(3.2)^2 \times 375]$ **or** $[(0.5)^2 \times 375]/[114 \times (1.2)^2]$ = 0.57	A1	[2]
6	**(a)**		waves from loudspeaker (travel down tube and) are reflected at closed end	B1	
			two waves (travelling) in opposite directions with same frequency/wavelength overlap	B1	[2]
	(b)	**(i)**	0.51 m 0.85 m	A1 A1	[2]
		(ii)	A at open end, N at closed end, with an N and A in between, equally spaced (by eye)	B1	[1]

7 **(a)** stress or $\sigma = F/A$ C1

max. tension = UTS × A = $4.5 \times 10^8 \times 15 \times 10^{-6}$ = 6800 (6750) N A1 [2]

(b) $\rho = m/V$ C1

weight = $mg = \rho Vg = \rho ALg$
$6750 = 7.8 \times 10^3 \times 15 \times 10^{-6} \times L \times 9.81$ C1

$L = 5.9\ (5.88) \times 10^3$ m A1

or

maximum mass = 6750/9.81 = 688 kg (C1)
mass per unit length = ρA = 0.117 kg m^{-1} (C1)
$L = 688/0.117 = 5.9 \times 10^3$ m (A1)

or

maximum mass = 6750/9.81 = 688 kg (C1)
volume = m/ρ = 0.0882 m^3 = LA (C1)
$L = 0.0882/15 \times 10^{-6} = 5.9 \times 10^3$ m (A1) [3]

8 **(a)** mass-energy
proton number or charge
nucleon number B2 [2]

(b) **(i)** $E_k = ½ mv^2$ and $p = mv$ with working leading to

[via $E_k = ½m^2v^2/m$ or $½m(p/m)^2$]
to $E_k = \dfrac{p^2}{2m}$ B1 [1]

(ii) $p = (2E_km)^{½}$ hence $(2[E_km]_\alpha)^{½} = (2[E_km]_{Th})^{½}$ C1

$2 \times [E_k]_{Th} \times 234 = 2 \times 6.69 \times 10^{-13} \times 4$ C1

$[E_k]_{Th} = 1.14 \times 10^{-14}$ J
= 71(.5) keV A1

or

calculation of speed of α-particle = 1.42×10^7 m s^{-1}
calculation of momentum of α-particle/nucleus = 9.43×10^{-20} N s (C1)

$[E_k]_{Th}$ = 1.14×10^{-14} J (C1)
= 71(.5) keV (A1) [3]