^	Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.
SEEN	Indicates that a page has been seen.

Question	Answer	Marks
1(a)	force acting between two masses **or** force on mass due to another mass **or** force on mass in a gravitational field	**B1**
1(b)	arc length = $r\theta$ $d = 1.5 \times 10^{17} \times 1.2 \times 10^{-5} = 1.8 \times 10^{12}$ m	**A1**
1(c)(i)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / (44.2 \times 365 \times 24 \times 3600)$ $= 4.5 \times 10^{-9}$ rad s^{-1}	**A1**
1(c)(ii)	gravitational forces are equal **or** centripetal force about P is the same	**C1**
	$M_1 x\omega^2 = M_2(d - x)\omega^2$ so $M_1 / M_2 = (d - x) / x$	**A1**
1(c)(iii)	$x = 0.4d$	**C1**
	$6.67 \times 10^{-11} \times M_1 = (1.0 - 0.4) \times (1.8 \times 10^{12})^3 \times (4.5 \times 10^{-9})^2$	**C1**
	$M_1 = 1.1 \times 10^{30}$ kg	**A1**

Question	Answer	Marks
2(a)	total potential energy and kinetic energy (of molecules/atoms)	**M1**
	reference to random motion of molecules/atoms	**A1**
2(b)	(in ideal gas,) no intermolecular forces	**B1**
	no potential energy (so change in kinetic energy is change in internal energy)	**B1**
2(c)	(random) potential energy of molecules does not change	**M1**
	(random) kinetic energy of molecules does not change	**M1**
	so internal energy does not change	**A1**
	or	
	decrease in total potential energy = gain in total kinetic energy	**(M1)**
	no external energy supplied	**(M1)**
	so internal energy does not change	**(A1)**
	or	
	no compression (of ball) so no work done on the ball	**(M1)**
	no resistive forces so no heating of the ball	**(M1)**
	so internal energy does not change	**(A1)**

Question	Answer	Marks
2(c)	**or**	
	no change of state so potential energy (of molecules) unchanged	**(M1)**
	no temperature rise so kinetic energy (of molecules) unchanged	**(M1)**
	so internal energy does not change	**(A1)**

Question	Answer	Marks
3(a)(i)	amplitude = 4.9 cm	**A1**
3(a)(ii)	frequency = 2700 / 60 = 45 Hz	**A1**
3(a)(iii)	$v_0 = x_0\omega$ **and** $\omega = 2\pi f$	**C1**
	$v_0 = 4.9 \times 10^{-2} \times 2\pi \times 45$ $= 14\ \text{m s}^{-1}$	**A1**
3(a)(iv)	$v = \omega (x_0^2 - x^2)^{½}$ $= 2\pi \times 45 \times [(4.9 \times 10^{-2})^2 - (2.6 \times 10^{-2})^2]^{½}$	**C1**
	$= 12\ \text{m s}^{-1}$	**A1**

Question	Answer	Marks
3(b)	$F = ma$ **and** $a_0 = v_0\omega$ **or** $a_0 = x_0\omega^2$	**C1**
	$F = 0.64 \times 13.9 \times 2\pi \times 45$ **or** $0.64 \times 4.9 \times (2\pi \times 45)^2$	**C1**
	$= 2500$ N	**A1**

Question	Answer	Marks
4(a)(i)	product of density and speed	**M1**
	speed of ultrasound in medium	**A1**
4(a)(ii)	the greater the difference between Z_1 and Z_2, the closer the ratio is to 1 **or** if difference between Z_1 and Z_2 large, ratio is close to 1	**B1**
	the closer together Z_1 and Z_2, the closer the ratio is to 0 **or** if difference between Z_1 and Z_2 small, ratio close to 0	**B1**
4(b)(i)	loss of intensity/amplitude/power (of the wave)	**B1**
4(b)(ii)	$I = I_0 e^{-\mu x}$	**C1**
	$0.35 = e^{-0.046\mu}$ $\mu = 23\ m^{-1}$	**A1**

Question	Answer	Marks
5(a)	similarity: both are radial **or** both have inverse square (variations)	**B1**
	difference: direction is always/only towards the mass **or** direction can be towards or away from charge	**B1**
5(b)	field strength = $Q / 4\pi\varepsilon_0 x^2$	**C1**
	$E = Q / 36\pi\varepsilon_0 R^2$	**A1**
5(c)(i)	fields (due to each sphere) are in same direction	**B1**
5(c)(ii)	charges on spheres attract/affect each other **or** charge distribution on each sphere distorted by the other sphere **or** charges on the surface of the spheres move	**B1**
	spheres are not point charges (at their centres)	**B1**

Question	Answer	Marks
6(a)(i)	greater information carrying capacity	**B1**
6(a)(ii)	power/energy is radiated	**B1**
	signal picked up by adjacent fibre/wire	**B1**
6(b)	ratio / dB = 10 lg(P_2 / P_1)	**C1**
	13 = 10 lg [P / (1.0 $\times$ 10^{-3})] and so P = 20 mW	**A1**
6(c)	45 $\times$ 0.18 = 10 lg (20 / P)	**C1**
	P = 3.1 mW	**A1**

Question	Answer	Marks
7(a)	output signal proportional to input signal	**B1**
	output signal has same sign/polarity as input signal	**B1**
7(b)(i)	gain = V_{OUT} / V_{IN} = 2.6 / 0.084 = 31	**A1**
7(b)(ii)	$31 = 1 + (15 \times 10^3) / R$	**C1**
	$R = 500\ \Omega$	**A1**
7(c)(i)	e.g. cathode-ray oscilloscope/CRO	**B1**
7(c)(ii)	gain is reduced	**B1**
	(so) V_{OUT} is smaller	**B1**

Question	Answer	Marks
8(a)	magnetic field normal to current	**B1**
	newton per ampere	**B1**
	newton per metre	**B1**
8(b)(i)	current in wire QL gives rise to a force **or** wire QL is perpendicular to the magnetic field	**B1**
	force on wire QL is vertical	**B1**
	force does not act through the pivot	**B1**
8(b)(ii)	forces act through the same line **or** forces are horizontal	**B1**
	forces are equal (in magnitude) and opposite (in direction)	**B1**
8(c)(i)	change $= mg \times (\Delta)L$	**C1**
	$= 1.3 \times 10^{-4} \times 9.81 \times 2.6 \times 10^{-2} = 3.3 \times 10^{-5}$ N m^{-1}	**A1**
8(c)(ii)	change $= B \times (\Delta)I \times L \times x$	**C1**
	$3.3 \times 10^{-5} = B \times 1.2 \times 0.85 \times 10^{-2} \times 5.6 \times 10^{-2}$	**C1**
	$B = 0.058$ T	**A1**

Question	Answer	Marks
9(a)(i)	e.m.f. $= (\Delta)BA \times N / t$	**C1**
	$= 45 \times 10^{-3} \times \pi \times (1.8 \times 10^{-2})^2 \times 350 / 0.20 = 0.080$ V	**A1**
9(a)(ii)	0 to 0.2 s: straight horizontal line at 0.080 V or –0.080 V	**B1**
	0.2 s to 0.4 s: zero	**B1**
	0.4 s to 0.8 s: straight horizontal line at 0.040 V or –0.040 V	**B1**
	opposite polarity to 0 to 0.2 s line	**B1**
9(b)	either disc cuts flux lines (of the magnet) **or** there is a changing flux in the disc	**B1**
	(by Faraday's law) e.m.f. is induced in the disc	**B1**
	e.m.f. causes (eddy) currents in the disc	**B1**
	current in the magnetic field (of the magnet) causes force on disc	**B1**

Question	Answer	Marks
10(a)	• photon gives energy to electron (in an inner shell) **or** electron (in an inner shell) absorbs a photon • electron moves (from lower) to higher energy level • energy (of photon) is equal to difference in energy levels • electron de-excites giving off photon (of same energy) • photons emitted in all directions *Any four points, 1 mark each*	**B4**
10(b)	(in light) photons gives energy to electrons in VB **or** (in light) electrons in VB absorb photons	**B1**
	electron crosses FB/jumps to CB	**B1**
	(positive) holes left/created in VB	**B1**
	low intensity: few electrons in CB/most electrons in VB **or** high intensity: more photons so more electrons in CB **or** electron-hole pairs are charge carriers	**B1**
	more charge carriers results in lower resistance	**B1**

Question	Answer	Marks
11(a)(i)	$E = mc^2$	**C1**
	$= 9.11 \times 10^{-31} \times (3.0 \times 10^8)^2$ $= 8.2 \times 10^{-14}$ J	**A1**
11(a)(ii)	$p = h / \lambda$ **and** $E = hc / \lambda$ **or** $E = pc$	**C1**
	$p = (8.2 \times 10^{-14}) / (3.0 \times 10^8)$ $= 2.7 \times 10^{-22}$ N s	**A1**
11(b)	total momentum (before and after interaction) is zero **or** momentum must be conserved (in the interaction) **or** momentum of the photons must be equal and opposite	**B1**
	(photons emitted in) opposite directions	**B1**

Question	Answer	Marks
12(a)(i)	time at which a nucleus will decay cannot be predicted **or** constant probability of decay of a nucleus	**B1**
12(a)(ii)	decay (of a nucleus) not affected by environmental factors	**B1**
12(b)	$A = A_0 e^{-\lambda t}$ **and** $\lambda = \ln 2 / t_{½}$	**C1**
	$= 3.6 \times 10^5 \times \exp [-(2 \times \ln 2) / 1.4]$	**C1**
	or	
	$A = A_0 \times 0.5^N$	**(C1)**
	$= 3.6 \times 10^5 \times 0.5^N$ where $N = 2 / 1.4$	**(C1)**
	$A = 1.3 \times 10^5$ Bq	**A1**
12(c)(i)	smooth curve, starting at $(0, 3.6 \times 10^5)$ and passing through $(1.4, 1.8 \times 10^5)$ and $(2.0, 1.3 \times 10^5)$	**B1**
12(c)(ii)	(activity of sample is greater than activity of X so) there must be an additional source of activity	**C1**
	the decay product (of isotope X) is radioactive	**A1**

