Question	Answer	Marks
1 (a) (i)	weight = 0.500 × 9.81 = 4.91 N Triangle of forces drawn, see below. Using sine rule: $\frac{\sin 30°}{T} = \frac{\sin 110°}{4.91}$ T = 2.61 N	1 1 1 1
1 (a) (ii)	Tie one end of a newtonmeter to the string and the other upper end of the newtonmeter to a rod in a clamp. The reading on the newtonmeter will be equal to the tension *T.* The axis/length of the newtonmeter may not be in line with the string because of its mass.	1 1
1 (b) (i)	The ball gas GPE <u>before</u> it is ejected by the spring. It then gains kinetic energy from the stored energy of the spring. As it leaves the bench, its KE increases and its potential energy decreases. Just before **G** its energy is entirely KE.	1 1 1 1
1 (b) (ii)	Vertical motion of the ball: s = ? $u = 0$ a = 9.81 m s^{-2} t = 0.42 s $s = \frac{1}{2}at^2 = \frac{1}{2} \times 9.81 \times 0.42^2$ height = 0.87 m	1 1 1
2 (a)	By principle of conservation of energy, initial GPE = final KE. $mgs = \frac{1}{2}mv^2$ The mass m cancels, therefore $v^2 = 2gs$.	1 1 1
2 (b)	Place a light gate connected to a timer at the position of the lowest swing. Hold the ball at a given height and release it so that it passes through the light gate. Record the time t on the timer. $v = \frac{\text{diameter of ball}}{t}$ Limitation: Getting the position of the light gate correct so that the entire diameter of the ball passes through the beam of the light gate.	1 1 1 1
2 (c) (i)	$v^2 = 2.54^2 = 6.45$ m^2 s^{-2} % uncertainty in $v^2 = 2 \times \left(\frac{0.18}{2.54}\right) \times 100 = 14.2$ % absolute uncertainty = 0.142 × 6.45 = 0.91 m^2 s^{-2} Therefore, the answer is: 6.45 ± 0.91 m^2 s^{-2}	 1 1 1
2 (c) (ii)	Determine the gradient of the graph and gradient = 2g. Therefore, acceleration of free fall $g = \frac{\text{gradient}}{2}$.	1 1
3 (a) (i)	Ammeter in series Voltmeter in parallel with LED	1
3 (a) (ii)	at 20 mA, V_{led} = 4.0 V V_R = 0.020 × 100 = 2.0 V so p.d. = 6.0 V	1 1 1
3 (b) (i)	energy in eV = $\frac{4.1 \times 10^{-19}}{1.6 \times 10^{-19}}$ = 2.6 eV	1
3 (b) (ii)	LED only conducts above 2.6 V. An electron must pass through a p.d. of 2.6 V to lose energy as a photon of blue light.	1 1
3 (c) (i)	$n = \frac{I}{e} = \frac{0.02}{1.6 \times 10^{-19}}$ $n = 1.3 \times 10^{17}$	1 1
3 (c) (ii)	energy per second = 1.25 × 10^{17} × 4.1 × 10^{-19} or 2.6 V × 0.020 A energy per second = allow 0.051 to 0.053 J s^{-1}	1 1
3 (c) (iii)	efficiency = $\frac{0.052}{4.0 \times 20 \times 10^{-3}}$ efficiency = 0.64	1 1
3 (d)	A shape similar to that in figure 3a, leaving the x-axis at close to 2.0 V and passing through (3.4, 20).	1 1
4 (a) (i)	When two waves combine at a point there is a change in overall intensity.	1 1

Question	Answer	Marks
4 (a) (ii)	Constant phase difference between the waves.	1
4 (b) (i)	Path difference of $n\lambda$ for constructive interference produces either maximum amplitude/intensity. Path difference of $\frac{(2n+1)\lambda}{2}$ for destructive interference produces either minimum amplitude/intensity.	 1 1 1
4 (b) (ii)	$x = \frac{\lambda D}{a} = \frac{0.030 \times 5.0}{0.20}$ $x = 0.75$ m	1 1
4 (b) (iii) (1)	intensity increases by a factor of 4 position unchanged	1 1
4 (b) (iii) (2)	intensity unchanged distance apart of maxima is doubled	1 1
4 (b) (iii) (3)	intensity unchanged maxima move to positions of minima and vice versa	1 1
5 (a) (i)	Two vertical arrows of equal length (by eye) and opposite direction in the same vertical line passing through the ball; weight of 0.49 N and normal reaction/string tension of 0.49 N.	1 1
5 (a) (ii)	resultant force = ma = 0.05 × 2 = 0.1 N	2
5 (b) (i)	$v^2 = u^2 + 2gh$ and $\frac{1}{2}mv^2 = mgh$ to give $v^2 = 2gh$ $v^2 = 2 \times 9.8 \times 0.8$ to give $v = 3.96$ m s^{-1}	1 1
5 (b) (ii)	$mv = 0.198$ kg m s^{-1}	1
5 (b) (iii)	$2mv = 0.396$ kg m s^{-1}	1
5 (b) (iv)	$\frac{2mv}{t} = 7.92$ N	1
5 (c)	gravity; acts on ball and Earth reaction forces; between ball and strings/racket	2 2
6 (a)	kinetic energy $E = \frac{1}{2}mv^2$ and $p = mv$ Therefore $E = \frac{p^2}{2m}$ $p^2 = 2mE$, hence $p = \sqrt{2Em}$	1 1 1
6 (b) (i)	$p = \sqrt{2Em} = \sqrt{2 \times 6.2 \times 10^{-21} \times 1.7 \times 10^{-27}}$ $p = 4.59 \times 10^{-24}$ kg m s^{-1} $\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{4.59 \times 10^{-24}}$ wavelength = 1.44×10^{-10} m	1 1 1 1
6 (b) (ii)	The de Broglie wavelength of the neutrons is similar to the gaps between the atoms of the DNA molecules.	1
6 (c)	$\lambda = \frac{h}{p}$ and $p = \sqrt{2Em}$ Therefore $\lambda^2 = \frac{h^2}{2Em}$ gradient of line = $\frac{2.4 \times 10^{-21}}{1.0 \times 10^{16}} = 2.4 \times 10^{-37}$ (allow ± 5%) gradient = $\frac{h^2}{2m}$ $m = \frac{h^2}{2 \times \text{gradient}} = \frac{(6.63 \times 10^{-34})^2}{2 \times 2.4 \times 10^{-37}}$ $m = 9.2 \times 10^{-31}$ kg	 1 1 1 1