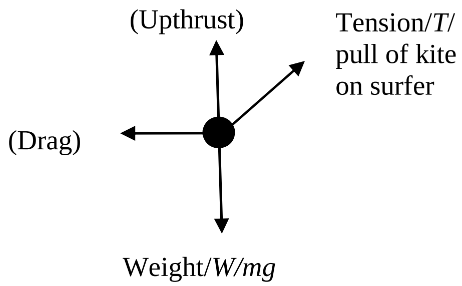
Question Number	Answer		Mark
1(a)(i)	Tension line and arrow correctly drawn and labelled Weight line and arrow correctly drawn and labelled  (Tension can be on either side. If 2 marks have been awarded subtract 1 mark if the drag has been included and is not a horizontal force opposing the tension)	**(1)** **(1)**	**2**
1(a)(ii)	Use of correct trig function to find horizontal component of the tension $T_{horizontal}$ = 840 (N) <u>Example of calculation</u> Horizontal component of tension = $T\cos\theta$ $T_{horizontal}$ = 1100 N × cos 40° $T_{horizontal}$ = 843 N	**(1)** **(1)**	**2**
1(a)(iii)	$T_{vertical}$ = 1100 sin 40° **Or** $T_{vertical}$= 707 (N) seen Use of $W = mg$ Use of $mg = U + T_{vertical}$ with a sensible statement discussing what would happen if $T_{vertical}$ = W **Or** $T_{vertical}$ > weight **Or** $T_{vertical}$ < weight e.g. $T_{vertical}$ = W **Or** mass = 72 kg: Upthrust is zero $T_{vertical}$ > weight **Or** mass < 72 kg: Can't have a negative upthrust $T_{vertical}$ < weight **Or** mass > 72 kg : To provide some upthrust <u>Example of calculation</u> $T_{vertical}$ = T sin 40° (= 707 N) **OR** $mg = U + T_{vertical}$ $mg = U$ + 707 N mass = $\frac{707\ \text{N}}{9.81\ \text{N kg}^{-1}}$ = 72.1 kg	**(1)** **(1)** **(1)**	**3**

*1(b)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** C **Max 3** The horizontal component of the tension in the line produces the forward force acting on the surfer **Or** horizontal component of tension = $T\cos\theta$ (accept $T_{horizontal} = 1100\cos\theta$) As the angle to the horizontal (θ) decreases **Or** As the angle to the vertical (θ) decreases ➔ $T\cos\theta$ increases **Or** the forwards force on the surfer increases **Or** the smallest θ gives the maximum/greatest force Work done increases Power transferred to surfer= $\frac{\text{work done}}{\text{time}}$ has increased hence the power increases **Or** more work done per second on the surfer so the power increases	 **(1)** **(1)** **(1)** **(1)** **(1)**	 **4**
	Total for question		**11**

Question Number	Acceptable Answers	Mark
2(a)(i)	Use of $E_{grav} = mgh$ **(1)** $E_{grav} = 48 \times 10^3$ J **(1)** <u>Example of calculation</u> Work done = 810 kg × 9.81 N kg^{-1} × 6.0 m Work done = 47 700 (J)	**2**

Question Number	Acceptable Answers	Mark
2(a)(ii)	(useful) energy transferred = 0.4 × total energy transferred **(1)** Use of work done against resistive forces of the ground = $F\Delta s$ **(1)** Force = 9.5 / 9.6 × 10^4 N (ecf) (ignore any −) **(1)** (It is possible to calculate *v* from K.E., then *a* and use $F = m\,a$) <u>Example of calculation</u> Useful energy transferred from driver = $\frac{40}{100}$ × 47 700 J = 19 100 J Resistive force = $\frac{19100\text{ J}}{0.20\text{ m}}$ = 9.6 × 10^4 N	**3**

Question Number	Acceptable Answers	Mark
2(b)(i)	Use of Stress = $\frac{\text{force}}{\text{area}}$ **Or** Use of Strain = $\frac{\text{extension}}{\text{original length}}$ **(1)** Correctly use $E = \frac{\text{stress}}{\text{strain}}$ with E = 120 (× 10^6) , F = 7(× 10^5), x = 0.4 correctly substituted **(1)** (Use of $E = (F \times x) / (A \times \Delta x)$ scores MP1 for quoting formula and MP2 for 'use of') Δx = 0.008(3) (m) **(1)** <u>Example of calculation</u> $\sigma = \frac{7.0 \times 10^5\text{ N}}{\pi \times (0.30\text{m})^2} = 2.48 \times 10^6\text{ Pa}$ $\varepsilon = \frac{\Delta x}{0.40\text{ m}}$ $\Delta x = \frac{2.48 \times 10^6\text{ Pa} \times 0.40\text{m}}{120 \times 10^6\text{ Pa}}$ Δx (compression) = 0.0083 (m)	**3**

Question Number	Acceptable Answers	Mark
2(b)(ii)	Use of $E_{el} = ½F\Delta x$ **(1)** Energy stored = 2.8×10^3 J or 2.9×10^3 J (ecf) **(1)** Example of calculation $E_{el} = ½ \times 7.0 \times 10^5$ N $\times$ 0.0083 m $E_{el} = 2.9 \times 10^3$ J	**2**

Question Number	Acceptable Answers	Mark
***2(b)(iii)1.**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** [Only apply if both 1. and 2. get full marks] Graph: Permanent/plastic compression/deformation **Or** does not return to its original length/shape **(1)** Effect: Becomes too thin **Or** will not compress **Or** no longer elastic **Or** becomes brittle **(1)**	**2**

Question Number	Acceptable Answers	Mark
***2(b)(iii)2.**	More work done in loading than unloading the wood **Or** more energy is absorbed/stored than released **Or** the area between the lines shows energy is dissipated **Or** the area while applying the force > the area while releasing **Or** (the area in) the hysteresis loop shows energy is dissipated **(1)** (these should be marked if written in 1. above)	**1**
	Total for question	**13**

Question Number	Answer		Mark
3 (a)	Same (downwards) acceleration **Or** acceleration = *g* (accept constant acceleration)	**(1)**	**1**
3 (b)(i)	The ball is in contact with the floor (accept the ball bounces)	**(1)**	**1**
3 (b) (ii)	Lower gradient **Or** the lines would be not be as steep	**(1)**	**1**
3 (c)	Use of equation(s) of motion to find *s* **Or** use of distance = area under the graph **Or** use of GPE = KE s = 1.1 m – 1.4 m <u>Example of calculation</u> $(4.7 \text{ m s}^{-1})^2 = (0 \text{ m s}^{-1})^2 + (2 \times 9.81 \text{ m s}^{-2} \times s)$ s = 1.13 m	**(1)** **(1)**	**2**
3(d)(i)	Use of KE = ½ mv^2 KE = 1.1 – 1.3 (J) (no ue) <u>Example of calculation</u> KE = ½ × 0.40 kg × $(2.4 \text{ m s}^{-1})^2$ = 1.15 J	**(1)** **(1)**	**2**
3(d)(ii)	Use of GPE = KE h = 0.27 m – 0.32 m (ecf from 16(d)(i)) (If area under graph or an equation of motion is used e.g. $h = \frac{(u+v)t}{2}$ or $v^2 = u^2 + 2as$ only MP2 can be scored) <u>Example of calculation</u> $h = \frac{1.2 \text{ J}}{0.4 \text{ kg} \times 9.81 \text{ N kg}^{-1}}$ h= 0.31 m	**(1)** **(1)**	**2**
3(e)	(Elastic potential) energy transferred to thermal energy **Or** energy dissipated as heat	**(1)**	**1**
	Total for question		**10**

Question Number		Mark
4(a)	(The line) AB (extended)does not pass through the origin /initially **Or** the graph is curved as it passes through the origin **Or** the graph (before A) is not a straight line through the origin. (1) The device does not obey Hooke's law (conditional mark) (1)	**2**
4(b) (i)	Reference to finding area (1) **Detail** count squares **OR** approximate the shape of the graph to a triangle **Or** reference to using a trapezium(could be described as rectangles and triangles) (1)	**2**
4 (b) (ii)	Identifies that force is the problem. (1) Explains why force used is an overestimate e.g. maximum force has been used (each time) **Or** average force was not used (each time) **Or** the force is changing (continuously) **Or** should have used the trapezium rule **Or** area of rectangle has been used (1)	**2**
4(c)	Use of 25% of 540 kJ i.e. find the energy to be used (1) Use of $\frac{\text{total available energy (either 540 000 J or 135 000 J)}}{\text{energy per stretch or energy per unit time}}$ (1) Time = 612 min (1) <u>Example of calculation</u> 540 000 J x 25% = 135 000 J 135 000 J / 14.7 J = 9184 stretches 9184 / 15 stretches per minute = 612 minutes (36 720 s **Or** 10.2 h)	**3**
4(d)	smaller extension **Or** will not stretch as much (1) less work with reference to either same force applied **Or** to work done being force x extension (1) (Do not accept displacement or distance in place of extension for MP1or MP2)	**2**
	Total for question	**11**

Question Number	Answer	Mark
5	See: W = mg **OR** newton unit of force **OR** newton unit of weight **(1)** W = 0.98 N or W = 0.1 (kg) x 9.81 (N kg^{-1}) = 1 N **(1)** See: W = Fs **OR** gpe = Wh **OR** gpe = mgh **OR** joule unit of energy **(1)** Gpe = 0.98 J **(1)** See: P = W/t or variation **OR** watt unit of power **(1)** P = 0.98 W **(1)**	**6**
	Total for question	**6**

Question Number	Answer	Mark
6 (a)	Line not straight **OR** gradient not constant **(1)** Force not proportional to extension **OR** to obey Hooke's Law, force should be proportional to extension **(1)**	**2**
6 (b)	Use of area under graph **(1)** Work done = 2.5 J **(1)** <u>Example of calculation</u> 0.5 x 15 x 0.33 = 2.48 J **OR** 1255 squares × 2 × 10^{-3} J = 2.51 J	**2**
6 (c)	Elastic (tries to) return to a smaller/original length **(1)** (So) will be in <u>tension</u> **OR** applies <u>force /pull</u> **(1)**	**2**
6 (d)	Work done stretching the elastic greater **OR** area under stretching>area under releasing **OR** the area between the two lines represents the energy **(1)** (So) energy must be dissipated (in process) **OR** energy transferred as heat **OR** energy transferred to internal energy **(1)**	**2**
	Total for question	**8**