Question Number	Answer	Mark
1(a)(i)	Horizontal component of velocity = 7.5 cos 50 = 4.8 (m s^{-1}) (1)	**1**
1(a)(ii)	Vertical component of velocity = 7.5 sin 50 = 5.7 (m s^{-1}) (1) May use Pythagoras or tan for second component calculated	**1**
1(a)(iii)	Use of appropriate equation of motion, e.g. $v = u + at$, leading to time of flight (1) Time of flight OR double distance travelled half way (1) Use of velocity = distance / time (1) Distance = 5.6 m to 6.1 m (1) Correct answer from range formula 4/4, incorrect answer from range formula 0/4 <u>Example of calculation</u> $v = u + at$ 0 = 5.7 m s^{-1} + 9.81 m s^{-2} x t t = 0.58 s to max height time of flight = 1.16 s horizontal distance = horizontal component of velocity x time = 4.8 m s^{-1} x 1.16 s = 5.6 m (Using 'show that' values gives 6.12 m)	**4**
1(b)(i)	Use of $E_k = ½ mv^2$ (1) kinetic energy = 41 J (1) <u>Example of calculation</u> $E_k = ½ mv^2$ m = 2.24 kg – 0.79 kg = 1.45 kg E_k = ½ x 1.45 kg x (7.5 m s^{-1})^2 = 40.8 J If answer calculated from difference between 2 kinetic energies, allow first mark only.	**2**
1(b)(ii)	Not all the mass of liquid which left the bottle went that far / 7.5 m s^{-1} is the maximum speed (1)	**1**
1(b)(iii)	Air resistance / friction at neck (1) … could have caused the liquid to lose energy / so the true (initial) velocity is more than the calculated value / so the measured range was less (than it might otherwise have been) (Just 'energy lost' not sufficient – must be linked to some cause) (1)	**2**
	Total for question	**11**

Question Number	Answer	Mark
2(a)(i)	Straight line shown / constant gradient (1) (So) extension or change in length proportional to force (accept Δx or Δl or e proportional to F) / k constant. (NOT Length α force) (1) [Just stating $F = k\Delta x$ does not get the mark] (Yes, because extension or change in length proportional to force gets 2)	**2**
2(a)(ii)	Indication of use of (inverse) gradient, e.g. $k = F/\Delta x$ or with values obtainable from graph (accept extension/force for first mark) (1) Substitution of values as force/extension (1) Stiffness = 0.66 to 0.80 (N m^{-1}) [no ue] (1) Range is due to tolerance of + or – half a square on reading graph. [Allow answers of 0.7 N m^{-1} or 0.8 N m^{-1} without extra sig fig if that is the exact value produced from their figures, e.g. from F = 0.7 N, where length = 260 cm] <u>Example of calculation</u> $k = F/\Delta x$ k = 0.8 N / (2.7 m – 1.6 m) k = 0.8 N / 1.1 m = 0.73 N m^{-1} (Read graph to half a square)	**3**
2(a)(iii)	Use of $E = \frac{1}{2} F\Delta x = \frac{1}{2} k(\Delta x)^2$ OR Use of an area between a line and an axis (allow line shown and force axis) (1) Identify correct extension OR correct area (1) E = 0.31 J to 0.35 J from $E = \frac{1}{2} F\Delta x$ E = 0.27 J to 0.40 J from $\frac{1}{2} k(\Delta x)^2$ if k in range [allow ecf for k] (1) <u>Example of calculation</u> $E = 1/2\ F\Delta x$ = 0.5 x 0.7 N x (2.55 m – 1.6 m) = 0.33 J	**3**
2(b)(i)	Coils at top support coils below (1) (So) a greater force acts (on top coils) (1) Coils at the top support the weight of the coils below as well = 2 marks	**2**
2 (b)(ii)	Clearly below centre and above bottom – accept if no label (1)	**1**
2 (b)(iii) (1)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Ball acted on by its weight (alone) / by gravity (alone) (1) Top coils acted on by their weight and/also acted on by elastic/tension force / force due to extension of coils (1) So the acceleration is greater (1) Energy explanation – max 2 for ball, transfer to ke from gpe alone - 1 mark for top coils, transfer to ke from gpe and elastic pe – 1 mark (allow 'has' energy instead of transfer to ke)	**3**
2(b)(iii) (2)	They are acted on by weight downwards and (elastic) force upwards/ the forces on them are/remain balanced (1)	**1**
	Total for question	**15**

Question Number	Answer	Mark
3 (a)	Explain whether the band obeys Hooke's law. States: Line not straight / line curves / gradient not constant / k not constant **(1)** (But) Hooke's law states extension or change in length is proportional to force **(1)** [Allow both marks for: No, because extension is not proportional to force] [Accept coherent references to 'the variables' for force and extension]	**(2)**
3(b)	Show that energy stored is below 0.8 J Indication of use of area (could be marks on graph) / use of ½ Fx **(1)** Calculation of value as good as triangle approximation (0.6 J) **(1)** More detailed, e.g. counting squares, for correct answer (0.76 J) **(1)** (accept answers above from 0.7 J to just below 0.8 J) [If a candidate shows it is less than 0.8 J by drawing a shape with area of 0.8 J, 1st mark as above, 2nd mark for correct 0.8 J shape, 3rd for making comparison.]	**(3)**
3(c)	Calculate of initial speed of aeroplane Equates stored energy with initial kinetic energy of aeroplane **(1)** Use of ke = 1/2 mv^2 **(1)** Correct answer (7.5 m s^{-1}) **(1)** *Example of calculation* 0.76 J = 1/2 mv^2 v = √(2 x 0.76 J / 0.027 kg) = 7.5 m s^{-1} [Allow use of 0.8 J for energy instead of ecf from 19 (b), or allow an obvious 'less than 0.8 J' if a candidate hasn't got their own value and is attempting to continue, but it must not be less than 0.6 J] [Use of 0.6 J gives 6.7 m s^{-1}; use of 0.8 J gives 7.7 m s^{-1}]	**(3)**
3(d) (i)	Describe energy transfers energy transferred to (elastic) strain energy / elastic potential energy of band (and some heat) **(1)** (elastic) strain energy / elastic potential energy / this energy decreases and some energy transferred to heat **(1)** [Ignore references to sound]	**(2)**

3(d) (ii)	Explain effect on initial speed (QWC – Work must be clear and organised in a logical manner using technical wording where appropriate to be eligible for the 3rd Physics mark) Area under graph for increasing force > area for decreasing force / one line higher than the other / gap between lines **(1)** Work done by band less than calculated energy stored / energy stored > energy retrieved / area between lines is energy transferred to heat/ area between lines is energy dissipated **(1)** not all energy is transferred to kinetic energy **(1)**	**(3)**
	Total for question	**13**

Question Number	Answer	Mark
4(a) (i)	Explain the shape of the graph in the part labelled AB Force proportional to extension / obeys Hooke's law (1)	**1**
4(a) (ii)	Explain what is happening in the part of the graph labelled CD. Fully compressed / coils closed (accept cup/bug/toy touches base) (1)	**1**
4(b)	Show that the stiffness of the spring is about 1000 N m^{-1}. State k = 1/gradient or use of values in $k = F / x$ (1) Correct answer to at least 2 s.f. [1100 N m^{-1}] (1) (Values from graph must be within half a square) (Accept 1000 N m^{-1} to only 1 s.f. if the answer given by the values used from the graph is 1.0×10^3 N m^{-1} to 2 s.f.) **Example of calculation** $k = F / x$ = 20 N / 0.019 m = 1050 N m^{-1}	**2**
4(c) (i)	Calculate the energy stored in the spring at this stage State area under graph or use of energy = 1/2 $F\Delta x$ or state energy = 1/2 kx^2 (1) correct answer [0.17 J] (1) [ecf for k] (Values from graph must be within half a square) **Example of calculation** energy = 1/2 $F\Delta x$ = 1/2 x 19.2 N x 0.018 m = 0.17 J	**2**

4(c)(ii)	Calculate the maximum height reached by the bug. Use of gpe = *mgh* (1) correct answer [2.4 m] (1) [ecf] **Example of calculation** 0.17 J = *mgh* *h* = 0.17 m / 7.3 x 10^{-3} kg x 9.81 N kg^{-1} = 2.4 m	**2**
4(c)(iii)	State an assumption made in your calculation all elastic pe → ke of bug → gpe of bug (2 out of 3) / all stored energy (of the spring) transferred to the 'toy' / no energy lost due to air resistance (1)	**1**
4(d)	Explain the advantage of using the video camera improves accuracy/reliability/precision (1) eliminate reaction time in looking / can slow down and stop (to take reading) etc (1)	**2**
4(e)	Comment on this data Has not included 0.36 / has not included the anomalous result / 0.36 is anomalous/outlier etc (1)	**1**
	Total for question	**12**

Question Number	Answer	Mark
5	Use of $E_k = ½mv^2$ **(1)** Use of 25% **(1)** Use of $\Delta E = mc\Delta\theta$ **(1)** $\Delta\theta$ = 39 K [accept 39°C] **(1)** Example of calculation: $E_k = \frac{1}{2}mv^2 = 0.5 \times 1200\,\text{kg} \times (25\,\text{m s}^{-1})^2 = 3.75 \times 10^5\,\text{J}$ $\Delta\theta = \frac{\Delta E}{mc} = \frac{0.25 \times 3.75 \times 10^5\,\text{J}}{5.3\,\text{kg} \times 450\,\text{J kg}^{-1}\,\text{K}^{-1}} = 39.3\text{K}$	**4**
	Total for Question	**4**