Question Number	Answer	Mark
1(a)	(i) Explain how verti distance travelled between 0.5 and 1.0 s can be found Area under graph between 0.5 and 1.0 s / X and Y / these points / Use average velocity between these points x time **(1)** [Accept correct working with or without units, i.e. 0.5 x 4.8 x 0.5, and accept 4.4 instead of 4.8] (ii) Explain how acce tion at Y can be found Gradient of line at Y / of XY / of XZ / of YZ / at 1.0 s **(1)** [Accept correct working with or without units, i.e. (-)4.8/0.5 or 9.6/1 and accept 4.4 instead of 4.8 or 8.8 instead of 9.6] [If candidates give (i) 'area under graph' or 'average velocity' and (ii) 'gradient of graph' without specifying where on graph, allow one mark in total]	**(2)**
1(b)	Explain errors (QWC – Work must be clear and organised in a logical manner using technical wording where appropriate to be eligible for the 4th Physics mark) **Max 2 per error for max 2 errors** Lines not parallel **(1)** Acceleration should be the same/both should have same gradient **(1)** Max +ve and -ve speeds (from 0.5 s) all the same **(1)** There will be some energy losses (bounce, air resistance) so max should have smaller magnitude each time **(1)** Velocity at X/Z greater than that at the start **(1)** Ball cannot gain energy **(1)** Starts with a positive velocity **(1)** but initial movement is down **(1)** Starts with non-zero velocity / graph starts in wrong place **(1)** From photo, it is dropped from rest **(1)** There is a vertical line **(1)** Bounce must take some time / acceleration can't be infinite etc The graph shows a change in direction of velocity between 0 and 0.5 s / release and striking the ground **(1)** It is travelling in one direction / down this whole time **(1)** Graph shows an initial deceleration **(1)** It is actually accelerating downwards **(1)**	**(max 4)**

	[Allow independent mark for second point in a pair if the context is not ambiguous, e.g. can't just say 'it is travelling downwards' without saying when]	
	Total for question	**6**

Question Number	Answer		Mark
2(a)	Use of $F = kx$ $k = 32$ (N m^{-1}) Example of calculation $k = \frac{3.9\ \text{N}}{0.122\ \text{m}} = 32.0$ N m^{-1}	**(1)** **(1)**	**2**
2(b)(i)	Use of $F = kx$ **OR** $F = ma$ $F = 4.1$ (N) (ecf) Example of calculation $F = 31.97$ N m^{-1} × 0.127 m $F = 4.06$ N OR $F = 0.4$ kg x (9.81 m s^{-2} +0.4 m s^{-2}) $F = 4.08$ N	**(1)** **(1)**	**2**
2(b)(ii)	**Max 2** Can be answered using a description: Resultant force = force of spring on mass - weight Substitution of resultant force into $F = ma$ **OR** Could be answered using a calculation e.g. $F = 4.06$ N – 3.9 N $a = \frac{0.16\ \text{N}}{0.4\ \text{m s}^{-2}}$ **OR** clear substitution of any force into this equation.	**(1)** **(1)** **(1)** **(1)**	**2**
2(b)(iii)	Use of $v = u + at$ $v = 0.8$ m s^{-1} (allow ecf) Example of calculation $v = 0 + (0.4 \times 2) = 0.8$ m s^{-1}	**(1)** **(1)**	**2**
2(b)(iv)	Graph correct shape i.e. 1 region of acceleration, 1 region of deceleration Constant velocity between	**(1)** **(1)**	**2**
2(b)(v)	Use of area under graph to find distance **OR** use of appropriate equations of motion Distance = 4.0 m (correct answer only) Example of calculation Area = (½ × 2 s × 0.8 m s^{-1}) + (3 s × 0.8 m s^{-1}) + (½ × 2 s × 0.8 m s^{-1}) Area = 4.0 m	 **(1)** **(1)**	**2**
2(b)(vi)	Spring extended beyond static extension **OR** extension increased at start (So) resultant force upwards	**(1)** **(1)**	**2**
	Total for question		**14**

Question Number	Answer	Mark
3 (a)	Use Newton's laws 1 and 3 to explain motion Uses N3 – force (backward) on air by balloon/car, (so/=) force (forward) on balloon/car by air Uses N1 – resultant force / forces unbalanced / force on balloon > drag, (so) there is an acceleration / moves from rest / <u>starts</u> moving Identifies the <u>use</u> of N1 or N3 (by name or description) correctly, linking it to the context	**(1)** **(1)** **(1)**
3 (b) (i)	Show that maximum speed is between 100 and 150 cm s^{-1} Draw tangent on graph / state use gradient / show use of gradient Identify max speed between 1.2 and 1.4 s (from position of gradient or values used) Correct answer (120 (cm s^{-1})) <u>Example of calculation</u> v = 120 cm – 0 cm / 1.9 s – 0.9 s = 120 cm s^{-1} (allow answers which are in range 100 and 150 cm s^{-1} when rounded to 2 sf)	**(1)** **(1)** **(1)**
3 (b) (ii)	Sketch graph Shows: Speed increasing from 0 and then decreases Max speed at correct time (accept between 1.0 and 1.5 s) OR correct magnitude (must be indicated) Speed decreasing to 0 at between 3.4 and 4.0 s	**(1)** **(1)** **(1)**
	Total for question	**9**

Question Number	Answer	Mark
4(a)	(Use of) acceleration = gradient **Or** $a = \frac{\Delta v}{(\Delta)t}$ stated **Or** use of $a = \frac{v-u}{t}$ with $u > 1$ **(1)** Answers in range 2.0 to 2.8 (m s^{-2}) **(1)** Answers in range 2.1 to 2.5 m s^{-2} **(1)**	**3**
4(b)	**Max 4** changing gradient **Or** graph curves **(1)** The idea of a changing acceleration **(1)** Decreasing acceleration **(1)** Resultant force decreasing **(1)** Drag increases (with speed) **(1)** [Ignore references to initial constant acceleration/straight line initially/(0-3) s]	**4**
4(c)	Zero (no u.e.) **Or** there is no resultant force **(1)**	**1**
4(d)	Attempt to find total distance travelled **(1)** Distance in range 900 (m) to 1100 (m) **(1)** Use of speed = distance / time **(1)** Speed = 20.0 to 21.0 (m s^{-1}) **Or** comparison of their distance with 1100m **(1)** [A number of incorrect methods give the value of 20 – 21 m s^{-1}. Only give final mark if correct method used using total distance and time of 50 s.] **OR** Use of line at 22 m s^{-1} **(1)** Use of area under graph **(1)** Simple comparison of area between graph and line above and below the line (e.g. more below than above) **(1)** Quantitative comparison (e.g. 60 (m) above and 140 (m) below) **(1)**	**4**
	Total for question	**12**