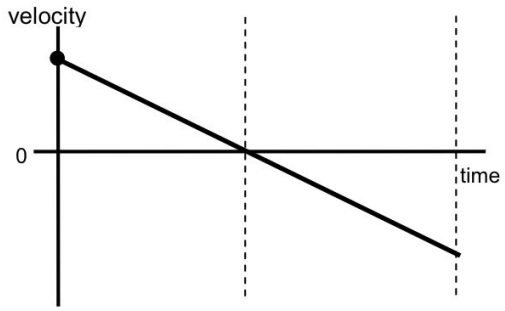
Question 1			
a	i	gradient (allow 'slope'/'**steepness of the line**') ✓	**1**
a	ii	 single straight line sloping down from X to t_2 ✓ passes through zero at t_1 ✓ increases to a maximum negative value at t_2 (ignore all lines beyond t_2) **or** allow line from zero at t_1 to a positive velocity at t_2 greater than the initial velocity ✓	**3**
b	i	**ball** exerts **force on ground and** ground exerts force (on ball)/reaction ✓ and **these** forces are **equal** and **opposite** ✓	**2**
(b)	ii	recognise that the downward force is the weight of the ball (accept gravity) ✓ recognition that the upward/reaction force (on the ball) is greater than the downward force on the ball ✓	**2**
		Total	**8**

Question Number	Answer	Mark
13(a) (i)	Show that the initial horizontal component of velocity for the drop is about 1 m s^{-1}. Shows a correct, relevant trigonometrical relationship Correct answer for horizontal component (1.2 (m s^{-1})) Example of calculation $v_h = v \cos\theta$ = 3.5 m s^{-1} x cos70° = 1.2 m s^{-1}	 **(1)** **(1)**
13(a)(ii)	Calculate the vertical distance to the insect if the shot is successful. Use of equation of motion suitable for time Calculates time (allow 1/3) Use of trigonometry or Pythagoras suitable to find vertical component of speed Use of equation of motion suitable to find distance Correct answer (0.55 m) If using $v^2 = u^2 + 2as$: Use of trigonometry or Pythagoras suitable to find vertical component of speed(1) Use of equation of motion suitable to find distance (1) Substitute $v = 0$ (1) Substitute g negative (1) Correct answer (1) Answers based on $mgh = 1/2\ mv^2$ coincidentally giving correct answer are not credited as $v^2 = u^2 + 2as$ unless conservation of energy fully described, i.e. ke at bottom using u = 3.5 m s^{-1} and ke at top due to only horizontal motion accounted for Example of calculation $t = s/v$ = 0.4 m / 1.2 m s^{-1} = 0.33 s $v_v = v \sin\theta$ = 3.5 m s^{-1} x sin 70° = 3.3 m s^{-1} $s = ut + 1/2\ at^2$ = 3.3 m s^{-1} x 0.33 s - 1/2 x 9.81 m s^{-2} x $(0.33\ s)^2$ = 0.55 m	 **(1)** **(1)** **(1)** **(1)** **(1)**
13(b)	Sketch the path of the water droplet Any section of an approximate parabolic path	 **(1)**
	Total for question 13	**8**

Question Number	Answer		Mark
17(a)	(Use of) acceleration = gradient **Or** $a = \frac{\Delta v}{(\Delta)t}$ stated **Or** use of $a = \frac{v-u}{t}$ with $u > 10$	**(1)**	
	Answers in range 2.0 to 2.8 (m s^{-2}) Answers in range 2.1 to 2.5 m s^{-2}	**(1)** **(1)**	**3**
17(b)	**Max 4** changing gradient **Or** graph curves The idea of a changing acceleration Decreasing acceleration Resultant force decreasing Drag increases (with speed) [Ignore references to initial constant acceleration/straight line initially/(0-3) s]	**(1)** **(1)** **(1)** **(1)** **(1)**	**4**
17(c)	Zero (no u.e.) **Or** there is no resultant force	**(1)**	**1**
17(d)	Attempt to find total distance travelled Distance in range 900 (m) to 1100 (m) Use of speed = distance / time Speed = 20.0 to 21.0 (m s^{-1}) **Or** comparison of their distance with 1100m [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} Use of area under graph Simple comparison of area between graph and line above and below the line (e.g. more below than above) Quantitative comparison (e.g. 60 (m) above and 140 (m) below)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**12**

Question Number	Answer		Mark
16(a)(i)	Use of $v = s/t$ Velocity = 2.1 (m s^{-1}) (No ue) Example of calculation $v = \frac{1.83\ m}{0.88\ s}$ = 2.14 m s^{-1}	**(1)** **(1)**	**2**
16(a)(ii)	Use of appropriate equation(s) to calculate velocity Velocity = 4.3 (m s^{-1}) (No ue) (if $v = 0$ and $g = -9.81$ have not been used only award the first mark) Example of calculation $v = u + at$ $0 = u + (-9.81\ ms^{-2}) \times 0.44\ s$ $u = 9.81\ m\ s^{-2} \times 0.44\ s$ = 4.3 m s^{-1} **OR** $s = ut + \frac{1}{2}at^2$ $0 = (u \times 0.88\ s) + (\frac{1}{2} \times (-9.81\ ms^{-2}) \times (0.88\ s)^2)$ u = 4.3 m s^{-1}	**(1)** **(1)**	**2**
16(a)(iii)	Correct use of Pythagoras/trig function to find the velocity. Magnitude = 4.8 m s^{-1} Correct use of trig function Angle = 64° (ecf from parts (i) and (ii)) Example of calculation velocity^2 = (2.1 m s^{-1})^2 + (4.3 m s^{-1})^2 velocity = 4.8 m s^{-1} tan of angle = $\frac{4.3\ m\ s^{-1}}{2.1\ m\ s^{-1}}$ angle = 63.9°	**(1)** **(1)** **(1)** **(1)**	**4**
16(b)(i)	Air resistance has not been taken into account **OR** air resistance acts on the rocket **OR** friction of the rocket on the stand has not been taken into account **OR** energy dissipated/transferred due to air resistance (just 'air resistance' does not gain credit)	**(1)**	**1**
16(b)(ii)	**Max 2** Can watch again Can slow down /watch frame by frame/stop at maximum height Too fast for humans to see Does not involve reaction time Can zoom in (to see height reached)	**(1)** **(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 16		**11**

Question Number	Acceptable Answers	Mark
16(a)	Use of an equation of motion involving $a = g$ *or* $-g$ **(1)** $v = u + at$ with v or $u = 0$ and double t **Or** Use of $s = ut + \frac{1}{2}at^2$ with $s = 0$ **Or** Use of $a = \frac{v-u}{t}$ with $v = -u$ **Or** Find max $s = 0.40$ m then use $s = \frac{1}{2}(v + u)\,t$ and double t **(1)** (do not award MP2 if 8 m s^{-1} used) Time = 0.57 or 0.58(s) **(1)** (Do not award 3rd mark if negatives have been ignored.) Example of calculation: using $a = \frac{v-u}{t}$ $t = \frac{0 - 2.8\,\text{m s}^{-1}}{-9.81\,\text{m s}^{-2}} = 0.285\,\text{s}$ to reach top of jump $t = 0.57$ (s)	**3**

Question Number	Acceptable Answers	Mark
16(b)	Use of distance = 8 m s^{-1} × time (either their time or 0.6 s) **(1)** Distance = 4.6 m (ecf (a)) **(1)** (If show that value of 0.6 s used then $d = 4.8$ m) Example of calculation Distance = 8.0 m s^{-1} × 0.57 s Distance = 4.6 m	**2**

Question Number	Acceptable Answers	Mark
16(c)	Attempt to calculate total / extra time using correct equations with correct vertical values **(1)** t = 0.14 s or 1/7 s extra time for additional drop assuming u = 2.8 m s^{-1} t =0.43 s or 3/7 s time from calculation of maximum height using u = 0 t = 0.71 s or 5/7s time for whole trajectory using s = − 0.5 m **(1)** Distance = 8.0 m s^{-1} × time **(1)** Extra horizontal distance travelled = 1.1m to 1.2m **(1)** Example of calculation $v^2 = (2.8\ \text{m s}^{-1})^2 + (2 \times 9.81\ \text{m s}^{-2} \times 0.50\ \text{m})$ $v = 4.2\ \text{m s}^{-1}$ $t = \frac{4.2\,\text{m s}^{-1} - 2.8\,\text{m s}^{-1}}{9.81\,\text{m s}^{-2}}$ $t = 0.14$ s Distance = 8.0 m s^{-1} × 0.14 s Distance = 1.1 m	**4**
	Total for question 16	**9**

Question Number	Answer		Mark
17(a)(i)	Convex curve drawn from the box to the drop zone	**(1)**	**1**
17(a)(ii)	Use of $s = ut + \frac{1}{2}at^2$ t = 3.6 (s) Example of calculation 63 m = 0 + (½ × 9.81 m s^{-2} × t^2) t = 3.6 s	**(1)** **(1)**	**2**
17(a)(iii)	Use of speed = $\frac{\text{distance}}{\text{time}}$ Distance = 270 m (ecf) [300 m using the show that value] Example of calculation 75 m s^{-1} = $\frac{\text{distance}}{3.6\text{ s}}$ Distance = 270 m	**(1)** **(1)**	**2**
17(b)(i)	Use of GPE = mgh GPE = 6.2 (kJ) (A unit is required for an answer in J to score MP2) Example of calculation GPE = 10.0 kg × 9.81 N kg^{-1} × 63 m GPE = 6180 J	**(1)** **(1)**	**2**
17(b)(ii)	Use of KE = ½ mv^2 KE = 28.1 (kJ) (A unit is required for an answer in J to score MP2) Example of calculation KE = ½ × 10.0 kg × (75 m s^{-1})^2 KE = 28 125 J	**(1)** **(1)**	**2**
17(b)(iii)	KE at bottom = 34.3 kJ (ecf) Example of calculation KE at bottom = 6180 J + 28 125 J = 34 305 J	**(1)**	**1**
17(b)(iv)	Work is done against air resistance **Or** energy transferred due to air resistance	**(1)**	**1**
17(c)	Reduces the acceleration of the package **Or** reduces the speed on impact of the package **Or** has a lower terminal velocity **Or** less (resultant) force on the package	**(1)**	**1**
	Total for question 17		**12**