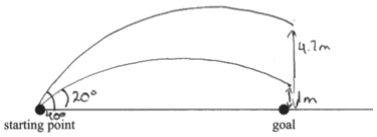
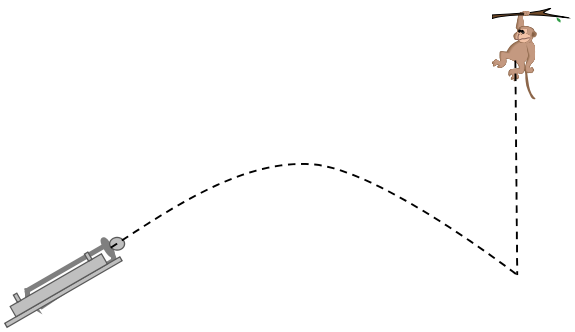
Question Number	Answer		Mark
1(a)(i)	Convex curve drawn from the box to the drop zone	**(1)**	**1**
1(a)(ii)	Use of $s = ut + ½ at^2$ t = 3.6 (s) Example of calculation 63 m = 0 + (½ × 9.81 m s^{-2} × t^2) t = 3.6 s	**(1)** **(1)**	**2**
1(a)(iii)	Use of speed = $\frac{\text{distance}}{\text{time}}$ 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**
1(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**
1(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**
1(b)(iv)	Work is done against air resistance **Or** energy transferred due to air resistance	**(1)**	**1**
1(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**

Question Number	Acceptable Answers	Mark
2(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.) <u>Example of calculation:</u> 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
2(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) <u>Example of calculation</u> Distance = 8.0 m s^{-1} × 0.57 s Distance = 4.6 m	**2**

Question Number	Acceptable Answers	Mark
2(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)** <u>Example of calculation</u> $v^2 = (2.8\ \text{m s}^{-1})^2 + (2 \times 9.81\ \text{m s}^{-2} \times 0.50\ \text{m})$ $v = 4.2\ \text{m s}^{-1}$ $t = \frac{4.2\,\text{m s}^{-1} - 2.8\,\text{m s}^{-1}}{9.81\,\text{m s}^{-2}}$ 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
3(a)(i)	The ball has bounced **Or** the ball would be below initial height **Or** the ball has landed before reaching the goal **Or** the ball has hit the ground **(1)**	**1**
3(a)(ii)	Correct shape of at least one trajectory, starting at the kick and ending at/beyond the goal **(1)** Range/position of the higher angle > range/position of lower angle ball seen with paths labelled **(1)** Example of response scoring 2 marks  	**2**
3(b)(i)	Use of (u_H) = u cos15 **Or** u sin75 **Or** see 25(.1) m s^{-1} **(1)** Use of $u = s/t$ to calculate the time to the goal **Or** see 0.44 s **(1)** Use of (u_V) = u sin15 **Or** u cos75 **Or** see 6.7 m s^{-1} **(1)** Use of $s = ut + ½ at^2$ (a must be negative) **(1)** s = 2.0 m **(1)** Use of (value obtained + the 0.22 m (or 0.11 m)) to make a sensible statement as to whether or not the goal will be scored e.g. the top of the ball on reaching the goal 2.23 m. (This is less than 2.4 m and) the goal will be scored **(1)** (Answer must be consistent with calculated distance. For calculated heights greater than 2.4 m, candidates do not need to refer to radius /diameter but a comparison of heights is needed.) <u>Example of calculation</u> $t = \frac{11\text{ m}}{26\text{ ms}^{-1} \times \cos 15°} = 0.44$ s s = (26 m s^{-1} × sin 15°)(0.44 s) + (½) (–9.81 N kg^{-1})(0.44 s)^2 s = 2.01 m Height of the top of the ball on reaching the goal = 2.01 m + 0.22 m = 2.23 m	**6**
3(b)(ii)	Air resistance is in the opposite direction to the ball's motion **Or** air resistance adds a backwards force **Or** work is done against air resistance **(1)** The ball will decelerate (horizontally) **Or** the ball will have a decreas**ing** velocity/speed **Or** the ball will not travel as far **Or** this reduces the maximum height the ball reaches **Or** the ball is in the air for less time **Or** the ball will take longer to reach the goal **(1)**	**2**
	Total for question 18	**11**

Question Number	Answer		Mark
4(a) (i)	Use of correct equation(s) of motion to be able to find t t = 0.23 (s) (no ue) Example of calculation 0.25 m = (0 × t) + ½ × 9.81 m s^{-2}× t^2 t = 0.23 s	**(1)** **(1)**	**2**
4(a) (ii)	Use of $\text{speed} = \frac{\text{distance}}{\text{time}}$ Distance = 0.59 m - 0.60 m (ecf) (show that value gives d = 0.52 m) Example of calculation d = 2.6 m s^{-1} × 0.23s d = 0.60 m	**(1)** **(1)**	**2**
4(b)(i)	 Ball has a curved path with a decreasing gradient and the monkey' path is downwards Initial path of ball parallel to launcher and monkey approximately vertical with paths intersecting below initial position of monkey (Allow a small gap between the paths approximately the width of monkey)	**(1)** **(1)**	**2**
4(b)(ii)	Use of $\text{speed} = \frac{\text{distance}}{\text{time}}$ with cos 20° to find the time of the drop Use of $s = ut + ½ at^2$ with u = 0 Distance fallen = 0.15 m – 0.16 m Example of calculation $t = \frac{0.50\text{ m}}{3\cos 20°} = 0.177\text{ s}$ s = ½ × 9.81 m s^{-2} × (0.177 s)^2 s = 0.154 m	**(1)** **(1)** **(1)**	**3**
	Total for question 18		**9**

Question Number		Mark
5(a) (i)	Use of equation of motion suitable for a, e.g. $v = u + at$ (1) a = 16.3 m s^{-2} (2.1×10^5 km h^{-2} or 58.7 km h^{-1} s^{-1}) (1) Example of calculation $a = \frac{37.5 \text{ m s}^{-1} - 0}{2.3 \text{ s}}$ a = 16.3 m s^{-2}	**2**
5(a) (ii)	Use of $E_k = ½ mv^2$ (1) Use of $P = E/t$ (1) Power = 3.1×10^6 W (1) **Or** Use of $F = ma$ (must be a from (i)) **and** Use of equation to find distance **and** use of work done = Fd (1) Use of $P = E/t$ (1) Power = 3.1×10^6 W (1) (distance = 43 m) Examples of calculations $E_k = ½ \times 10\,000 \text{ kg} \times (37.5 \text{ m s}^{-1})^2 = 7.03 \times 10^6$ J Power = 7.03×10^6 J / 2.3 s = 3.1×10^6 W	**3**
5(a) (iii)	Energy transferred by heating **Or** energy transferred due to friction **Or** work done against friction **Or** idea that more energy required (due to energy transfer) due to friction. (1) (do not accept 'lost' but accept air resistance as an alternative to friction)	**1**
***5(b**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) larger force is needed **Or** the (same) force is insufficient (1) need same acceleration/ (max) velocity **OR** acceleration/(max) velocity is too small (1) more energy needed (to reach top) **Or** insufficient energy (to reach top) (1)	**3**
5 (c)	Viscosity of oil decreases (with increasing temperature) **Or** the (warm) oil is less viscous (1) (accept a reverse argument e.g. when cold oil is more viscous) Lower frictional/resistive force **Or** less viscous drag (1)	**2**
	Total for question 16	**11**

Question Number	Answer		Mark
6(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**
6(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}) × 0.44 s u = 9.81 m s^{-2} × 0.44 s = 4.3 m s^{-1} **OR** $s = ut + ½at^2$ 0 = (u × 0.88 s) + (½×(-9.81 ms^{-2}) × (0.88 s)^2) u = 4.3 m s^{-1}	**(1)** **(1)**	**2**
6(a)(iii)	Correct use of Pythagoras/trig function to find the velocity. Magnitude = 4.8 m s^{-1} Correct use of trig function Angle = 64º (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 = 63.9º	**(1)** **(1)** **(1)** **(1)**	**4**
6(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**
6(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**