Marking Scheme

1.

(a)		**All 4 positions considered, 2 relevant statements per position**	
		At start (A): E_{Grav} – max; E_k – zero; $E_{Elastic}$ – zero (1)	
		Free fall, Cord slack(B): E_{Grav} – decreasing; E_k – increasing; $E_{Elastic}$ – zero (1)	
		Cord stretching (C): E_{Grav} – decreasing; E_k – increasing or decreasing; $E_{Elastic}$ – increasing (1)	
		At lowest point (D): E_{Grav} – minimum (accept zero if explained); E_k – zero; $E_{Elastic}$ – maximum (1)	
		5th mark available for other general comment e.g. Some of initial energy lost due to air resistance / rope gets hot (1) Don't accept statement of the conservation of energy on its own.	5
(b)	(i)	$E_{p\ loss}$ = 70 x 9.8[1] x 130 (1) substitution (not $g = 10$ m s^{-2})	
		= 89 271 [J] (1) (accept 89 300 or 89 000)	2
	(ii)	89271 = ½ $k(50)^2$ (2) [1 mark for $E_{p\ loss} = \frac{1}{2}kx^2$; 1 mark for 50 [m]]	
		k = 71.4 [N m^{-1}] (1) ecf from (b)(i)	3
	(iii)	$mg = kx$ (1) $= \frac{70 \times 9.81}{71.4}$ = 9.6 [m] (1) ecf on k from (b)(ii) N.B. Only penalise once for use of g = 10 m s^{-2}	2

2.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Energy cannot be created or destroyed only changed from one form to another	1			1		
	(b)	(i)	Length from top of pendulum = 2 cos 48° = 1.34 [m] (1) Height pendulum rises = 2.00 – 1.34 = 0.66 [m] (1)		2		2	2	
		(ii)	$\frac{1}{2}mv^2 = mgh$ (1) v = 3.60 [m s^{-1}] (1)		2		2	2	
	(c)	(i)	The vector sum of momentum before a collision equals the vector sum of momentum after collision / Accept total for vector sum of (1) provided no external forces act (1)	2			2		
		(ii)	$m_b v_b$ = 1.91 × 3.6 ecf (1) v = 687(.6) or 688 [m s^{-1}] (1)		2		2	2	
	(d)		**Any 2 × (1) from:** - Students over the age of sixteen - Legitimate reason for scientific learning - Needs to be transported through school play ground -Possible dangers in transporting - Risk assessment made			2	2		
			Question 2 total	**3**	**6**	**2**	**11**	**6**	**0**

3.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Use of $s = \frac{1}{2}(u+v)t$ (1) t = 14.6 [s] (1)	1	1		2	2	
	(b)		Gain in KE = 4 020 – 962 = 3 058 [J] (1) Gain in PE = 95 × 9.8 × 4 = 3 728 [J] (1) Total = 3 058 + 3 728 = 6 786 [J] ecf (1)		3		3	3	
	(c)	(i)	Use of $E = VIt$ (1) 3 679 or 3 680 [J] ecf (1)	1	1		2	2	
		(ii)	Useful energy of motor = *(b)* – 6 500 = 1 286 [J] (1) Efficiency $= \frac{1286}{3679} \times 100 = 35$ [%] (1) ecf from (c)(i)		2		2	2	
		(iii)	Friction within motor / between front tyre and road (not just 'friction') (1) Air resistance on bike and Helen (1) Do not accept just heat / sound loss	2			2		
	(d)		Yes compared to petrol vehicles no [direct] emissions (1) ..and power station emissions [of CO_2, PM2s etc] much less than petrol vehicles			2	2		
			Question 3 total	**4**	**7**	**2**	**13**	**9**	**0**

4.

Question				Marking details	AO1	AO2	AO3	Total	Maths	Prac
4	(a)			Total energy [of a closed system] stays constant [or equivalent] (1) but energy can be stored [or calculated] in different ways [accept can be converted from one form to another or equivalent] (1).	2			2		
	(b)	(i)	I	Substitution of data from one point on the curved graph or by implication (1) Re-arrangement at any stage of $E = \frac{1}{2}kx^2$ (1) k = 40 N m^{-1} **unit** Accept equivalent unit such as J m^{-2} (1)	1	1 1		3	2	
			II	Substitution of data from one point on straight line or by implication (1) 0.20 kg (1)	1	1		2	1	
			III	Total energy (including at x = 0.050 m) is zero or by implication (1) KE = 0.050 J (1) 'Correct' answer from $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \rightarrow$ 0 marks		2		2	1	
		(ii)		Graph passes through (0, 0), (0.05, 0.05), (0.1, 0) [1] rises and falls smoothly [1]		2		2	2	
	(c)			Attach **different** masses, m, drop, and measure x_{max} each time (1) Any one relevant experimental detail (e.g. measure x_{max} with metre rule or repeat readings or take precautions against parallax). (1) Plot x_{max} against m [or m against x_{max}] or for each pair of readings calculate $\frac{x_{max}}{m}$ [or $\frac{m}{x_{max}}$] (1) Straight line through origin or constancy of calculated quotient will verify relationship. (1)			4	4	2	4
				Question 4 total	4	7	4	15	8	4

5.

(a)		$E_P = (7.0 \times 10^6 \times 1000)(1) \times 9.81 \times 600$ (1) [$= 4.1 \times 10^{13}$] 1st mark – use of density equation to get 7.0 x 10^9 kg 2nd mark – use of mgh	2
(b)		Energy available per second = $0.9 \times 4.1 \times 10^{13}$ [$= 3.6 \times 10^{13}$] J (1) allow e.c.f. from (a) Time = $\frac{3.6\times10^{13}}{6\times300\times10^6 (1)}$ [$= 2 \times 10^4$ [s] / 5.6 [hour]] (1)	3
(c)	(i)	$\frac{7.0\times10^9}{2\times10^4 \text{e.c.f.}} = 3.5 \times 10^5$ [kg s^{-1}] allow e.c.f from (a) and (b)	1
	(ii)	E_k per second [$= ½ \times 3.5 \times 10^5 \times 20^2$] $= 7 \times 10^7$ [J s^{-1}] allow e.c.f from (c)(i)	1
	(iii)	Energy wasted per second = $\frac{10\%\times4\times10^{13}\text{ J}}{2\times10^4\text{s}}$ (1) allow e.c.f. from (a) and (b) [or equiv, or by impl.] $= 2 \times 10^8$ [W] (1)	2
	(iv)	% lost in $E_k = \frac{7\times10^7}{2\times10^8}$ [e.c.f. on (ii) and (iii)] = 35%	1
	(v)	Any sensible answer, e.g. [k.e. in] water turbulence, [work against] friction in turbines, drag/friction between water and pipes not just heat or sound or refilling the high level reservoir.	1

6. (a)		Use of cos 70° (1) $2T \cos 70° = 800$ (1) [$\rightarrow T = 1170$ N] [Accept mysterious division by 2 (b.o.d.)]	2
(b)	(i)	Area under graph attempted or ½ Fx or ½ kx^2 (1) 240 J (1)	2
	(ii)	Initial energy stored in bow converted entirely to E_k of arrow (1) 240 e.c.f. = ½ 50 × 10^{-3} v^2 (1) [subst] manipulation leading to $v = 98$ m s^{-1} shown. (1) [Final mark not available if incorrect E_k used]	3
(c)	(i)	$x = ut + ½ at^2$ (1); $u = 0$ (1) $t = 0.55$ s [accept 0.6 s] (1)	2
	(ii)	$D = V_H t$ [or by imp.] (1) e.c.f. of t $D = 98$ [or 100] × 0.55 [or 0.6] [e.c.f.] ∴ $D = 54$ m (1)	3
	(iii)	$v_{vertical} = u + at$ and $u = 0$ (1) [or equiv or by impl.] $v_v = 5.4$ m s^{-1} (1) $v_{resultant} = \sqrt{5.4^2 + 98.0^2}$ (1) or $v^2 = 5.4^2 + 98.0^2$ $v_{resultant} = 98.1$ m s^{-1} (1) Angle to horizontal [clearly identified] = $\sin^{-1} \frac{5.4}{98.1} = 3°$ (1) [Or equivalent correct application of other trig function]	5
(d)		Greater [initial] force [or equiv.] required to pull the Turkish bow string [through a given distance] (1) [or more work / energy needed] Greater area under the Turkish bow curve (1) [leading to] more [elastic] potential energy stored (1). Arrows will leave Turkish bow with a greater speed / velocity (1) [Accept converse arguments]. [Alt to 2nd marking point: linking to 1st marking point …. because gradient of graph greater for Turkish bow]	4
			[21]

7.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	Work done = 65 000 × 32 = 2.08 × 10^6 J		1		1	1	
		(ii)	Energy at B = 2 600 × 9.81 × 42 (1) or 1.07 × 10^6 seen Substitution into % efficiency = $\frac{1.07 \times 10^6 \times 100\%}{2.08 \times 10^6}$ (1) (no ecf) % efficiency = 51.5% (1) [accept 51% – 55%, or 0.51 – 0.55]	1	1 1		3	3	
	(b)		Work against resistive forces = 2 800 × 36 (1) or 101 kJ seen ΔE_p using 30 m drop = -765 kJ (1) Substitution into work-energy theorem: KE gain = 765 kJ – 101 kJ = 664 kJ (1) 664 000 = ½ × 2 600 × v^2 (1) [allow use of 765 kJ] v = 22.6 m s^{-1} (1) [765 kJ → 24.3 m s^{-1}] Additional marking guidance • Whole drop (42 m) with resistive forces → 27.3 m s^{-1} → 4 marks • 30 m drop without resistive forces → 24.3 m s^{-1} → 3 marks • Whole drop without resistive forces → 28.7 m s^{-1} → 2 marks • Mixing force and energy → 0 • Use of $v^2 = u^2 + 2ax$ →0 • Dissipate energy =	1	1 1 1 1		5	5	
			Question 7 total	2	7	0	9	9	0

8.

(a)	(i)	Energy cannot be created or destroyed; it can only change from one form to another. Don't accept can only be conserved.	[1]
	(ii)	$E_p \rightarrow E_k$ (1) can be implied Some energy lost as heat or due to air resistance or due to friction with air - general statement (1) Air molecules gain E_k and/or molecules of object gain E_k - **specific** statement (1)	[3]
(b)	(i)	mgh calculated correctly = 376.7 [J] (1) accept g as 9.8 or 9.81 but not 10 ½ mv^2 calculated correctly = 288 [J] (1) $E_p - E_k$ = 88.7 [J] [ecf from calculated values of E_p and/or E_k] (1)	[3]
	(ii)	Correct substitution into $W = Fd$ i.e. 88.7 (ecf) = F × 4.0 (1) F = 22[.2N] (1) If either E_p or E_k substituted in for W then award 1 mark only **Alternative Solution:** Force down slope = $16 \times 9.81 \times \frac{2.4}{4}$ [$F=mg\sin\theta$] = 94.2 [N] Resultant Force $\Sigma F = 16 \times \left(\frac{6^2}{8}\right)$ = 72 [N] Mean Frictional Force = 94.2 – 72 = 22[.2N] Award 1 mark for **either** force values correct (or both) Award 2 marks for correct solution	[2]

9.

(i)	Straight line through origin. Accept $F \alpha x$.	[1]
(ii)	Area = ½ Fx (1); $F = kx$ and clear substitution/manipulation (1)	[2]
(i)	$F = 8.0$ [N] (1) or $k = 100$ [N m^{-1}] (1) Use of ½ Fx (i.e ½ x 8.0 x 80 x 10^{-3}) (1) = 0.32[J] (1) (ecf for F) or Use of ½ kx^2 (i.e ½ x 100 x $(80 \times 10^{-3})^2$) (1) = 0.32[J] (1) (ecf for derived value of k)	[3]
(ii)	$0.32 = ½ mv^2$ (ecf) (1); $v = 4.0$ [m s^{-1}] (1)	[2]
	$\Delta E_k = Fd$ understood (1) $d = (0.8 + 0.4 + (2\pi(0.2)))$ or 2.46 [m] (1) $\Delta E_k = 0.03$[J] or (½ x 0.04 x $(4^2 - 3.8^2)$) (1) (ecf from *(b)* (ii)) $F = 0.013$ [N] (1) (ecf for d) Alternative method using equations of motion and $F = ma$ acceptable.	[4]

10.

Question				Marking details	Marks Available
5	*(a)*	(i)		$\text{power} = \dfrac{\text{work done or energy transferred}}{\text{time}}$ [Accept rate of doing work/ rate of energy transfer]	1
		(ii)		kg m s^{-2} × m × s^{-1} (1) [Evidence of full correct methodology] kg m^2 s^{-3} (1)	2
	(b)	(i)		$E_p = 70 \times 9.81 \times 215$ (1) [= 147 641 J] $E_k = ½ (70)(35)^2$ (1) [= 42 875 J] $E_{lost} = 147641 - 42875$ (1) [= 104 766](**ecf** on both E_p and E_k) $F = \dfrac{104766}{1600} = 65.5$ [N] (1) (**ecf** on E_{lost}) **Alternative solution:** using $v^2 = u^2 + 2ax$	4
		(ii)		$P = \dfrac{104766}{46}$ **ecf** (1) = 2 277 J s^{-1} or W (1) **UNIT mark**	2
				Question 5 total	[9]

Examiner's Comments

1. (a) The majority of candidates were able to make reasonable attempts at explaining the energy changes in the bungee cord. Some common misconceptions included stating that the cord possessed elastic potential energy at the start; stating that the bungee jumper had maximum kinetic energy at the lowest point and/or stating that all three forms of energy were at a maximum at the lowest point. Few candidates mentioned the possible effects of air resistance on the conservation of energy in the bungee jump.

(b) *(i)* The majority of candidates calculated the loss in gravitational potential energy correctly although a small number failed to pick up marks for using an incorrect value for Δh.

(ii) Few candidates were successful in calculating the stiffness constant. The majority of candidates realised the need to equate their answer in (b)*(i)* to ½ kx2. Many, however, chose wrong values for x or were unable to manipulate the equation mathematically to find k.

(iii) This was poorly answered. Few candidates understood the concepts required to find the final extension in the cord. In many scripts, this question was left unanswered.

*This comment originally referred to question **4** on paper **1321/01 (17/05/2012)***

2. There are no examiner comments available for this question

3. There are no examiner comments available for this question

4. There are no examiner comments available for this question

5. Mean Mark: 4.8/11 = 53%

(a) The vast majority of candidates were able to show that the gravitational potential energy stored in the high-level reservoir was about 4 x 1013 J.

(b) The majority of candidates gained at least one mark (from 3) here. Forgetting to multiply by 6 and/or not calculating 90% of the available energy were common mistakes.

(c) *(i)* Many candidates were able to calculate the ratio of the mass of water in the upper reservoir to the time taken calculated in part (b). Candidates could achieve full credit here even if their answer to part (b) was incorrect, by the error carried forward (ecf) principle.

(ii) The kinetic energy per second of the water was usually calculated correctly. Occasionally errors were made because candidates neglected to square the velocity, even though they had written down the correct formula.

(iii) This proved to be difficult for many candidates. However, the question was structured in such a way that those candidates who followed the sequence of events and the order in which the calculations were set, scored full marks without too much difficulty.

(iv) Candidates were able to obtain full credit here, even if answers to previous parts of the question were incorrect. There was evidence of candidates attempting to manipulate figures incorrectly to achieve an answer within the limits stated in the question.

(v) GCSE-type answers such as heat, sound or friction (without qualification) did not score. The examiners were looking for sensible answers which demonstrated more than a superficial knowledge of basic energy forms e.g. friction in the turbines/friction between the water and the pipe.

*This comment originally referred to question **4** on paper **1321/01 (12/01/2012)***

6. (a) Candidates found this problem difficult. Many were unable to resolve two forces and equate the sum of the horizontal components to the given force. The fact that there was a tension in both halves of the bow string was ignored and the factor of 2 often appeared from nowhere in order to obtain the required tension. Correct, unambiguous, well set out answers were rare.

(b) *(i)* The link between the 1170N tension in the bow string and the 800N force on the given graph was only appreciated by the more able candidates. Many candidates did not realise that the area under the graph was equal to the energy stored and often attempted to calculate the gradient of the graph as being the energy stored. Some of the more able candidates did use the gradient and the formula $\frac{1}{2}kx^2$ to calculate the energy stored.

(ii) Although many candidates equated the energy stored in the bow to the kinetic energy of the arrow, only a minority stated this assumption- as required in the question. To obtain credit here, candidates were required to state that the initial energy stored was converted (entirely) to the kinetic energy of the arrow.

(c) *(i)* Most candidates did not separate the vertical and horizontal motions of the arrow. In many cases candidates used the initial horizontal velocity provided (100ms-1) to represent the initial vertical velocity of the arrow.

(ii) Many candidates did not appreciate the constancy of the horizontal motion and applied the equations of accelerated motion in an attempt to calculate D.

(iii) This part proved to be most discriminating with only the very best candidates achieving full credit. As stated earlier, the attempt to find the vertical speed on hitting the ground was often spoiled by candidates assuming that the arrow had an initial vertical velocity of 100 m/s. Many candidates realised that the vertical and horizontal velocities had to be added vectorially to give the resultant velocity, and many creditable attempts were seen. Only the most able went on to compute the direction of the resultant velocity to score the final mark.

(d) Most candidates were able to make some headway here, but few were able to score all the available marks. Most answers lacked structure, and candidates merely listed points randomly and often in contradiction to points made earlier in their answer. Many candidates correctly stated that the Turkish bow would require a greater initial force to pull it back, and it would therefore store more energy. Very few candidates went on to qualify this by stating that there was a larger area under the graph for the Turkish bow.

The most common misconception, even among the more able candidates, was to state (correctly) that the Turkish bow stored more energy, but then to go on to state that because the force required for each bow to be stretched to 0.6 m was the same, the energy stored at 0.6 m was also the same.

*This comment originally referred to question **7** on paper **1321/01 (12/01/2011)***

7. There are no examiner comments available for this question

8. (a) *(i)* Nearly all candidates were able to state the principle of conservation of energy correctly.

(ii) The majority of candidates gained 2 out of 3 marks here for identifying the energy conversion from gravitational potential energy to kinetic energy and also that some energy is converted due to work done against friction. Only a small minority provided the extra detail needed to gain the third mark i.e. that the work done against friction resulted in an increase in molecular kinetic energy of the air particles and/or the particles of the falling object.

(b) *(i)* A significant number of the more able candidates had little difficulty in calculating the work done against friction. However, many candidates calculated either the change in gravitational potential energy or the increase in kinetic energy of the child. They then took these answers to be the work done against friction.

(ii) The majority of candidates were able to calculate the mean frictional force acting on the child, in many cases as 'error carried forward' (ecf) from (b)*(i)* .

*This comment originally referred to question **1** on paper **1321/01 (20/05/2014)***

9. Mean Mark: 5.3/12 = 44%

(a) *(i)* Merely stating that the given graph was a straight line was not sufficient to show that the spring obeyed Hooke's law, candidates were also required to state that the graph passed through the origin.

(ii) The derivation of the formula for the potential energy stored in the spring was poorly answered. Many candidates failed to link the area under the graph to the energy stored. Also, many answers lacked clarity, especially in showing the substitution of *kx* into ½ *Fx* to give the required expression.

(b) *(i)* Candidates who attempted to calculate the elastic potential energy stored using the equation ½kx2 met with more success than those who used the ½ Fx method. The careless conversion of units from mm to m was often carried out incorrectly.

(ii) Most candidates used the law of conservation of energy correctly (though in some cases as 'error carried forward' from*(i)*) to calculate the speed with which the car left the spring.

(c) Most candidates did understand the physical principles involved and made some reasonable attempts at a solution. Most solutions used the work done / change in energy principle, but correct solutions which calculated the mean deceleration of the car and then ΣF = ma, were also seen.

*This comment originally referred to question **3** on paper **1321/01 (11/01/2013)***

10. Q.5 (a)*(i)* The majority of candidates gave a correct definition for power. However, a small number defined it as the work done 'over' (a period of) time, as opposed to work done per unit of time.

(ii) Many candidates misread the question and attempted to determine the SI unit of work (as opposed to the Watt). Some candidates incorrectly simplified the following: kg m s-2 ´ m /s = kg m2 s-1.

(b) *(i)* Almost all candidates who were able to identify that GPE - KE = Work done were successful in gaining full marks here. Some neglected to divide by the distance, thus giving an answer of 104 kN. Candidates who attempted to resolve forces along the zipwire were generally unsuccessful in doing so.

(ii) Most candidates who correctly calculated the force in part*(i)* were able to calculate the power here. A small number of candidates lost the 'unit' mark here.

*This comment originally referred to question **5** on paper **1321/01 (19/05/2015)***