

WJEC A-LEVEL PHYSICS • UNIT 1

PHYSICS



EXAM QUESTION PACK

1.4 ENERGY CONCEPTS

SCORE

/

PERCENTAGE

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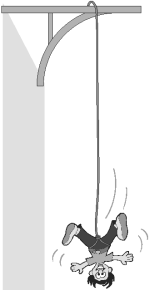
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1.

- (a) By referring to the diagrams, discuss some of the energy changes involved in a bungee jump. You should make reference to *gravitational potential energy*, *kinetic energy* and *elastic potential energy* in your answer. [5]

A	B	C	D
At the start	Free fall, cord slack	Cord stretching	At the lowest point
			

This image shows a single sheet of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting or typing. There are no margins, text, or other markings on the paper.

(b) A bungee jumper of mass 70 kg jumps from a high bridge using a bungee cord of natural length 80m. When he reaches the lowest point for the first time the length of the cord is 130m. Calculate

- (i) the loss of gravitational potential energy from his position on the bridge to the lowest point for the first time, [2]

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- (ii) the stiffness constant (k) of the bungee cord assuming the cord obeys Hooke's law and that there are no losses due to air resistance, [3]

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- (iii) the extension of the cord when he finally comes to rest (after having 'bounced' a few times). [2]

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2. A wooden block on a string (ballistic pendulum) is a device that can be found at well equipped shooting ranges. It is used to find the speed of a bullet. To calculate the speed it is necessary to use both the principles of conservation of energy and momentum.

(a) State the principle of conservation of energy.

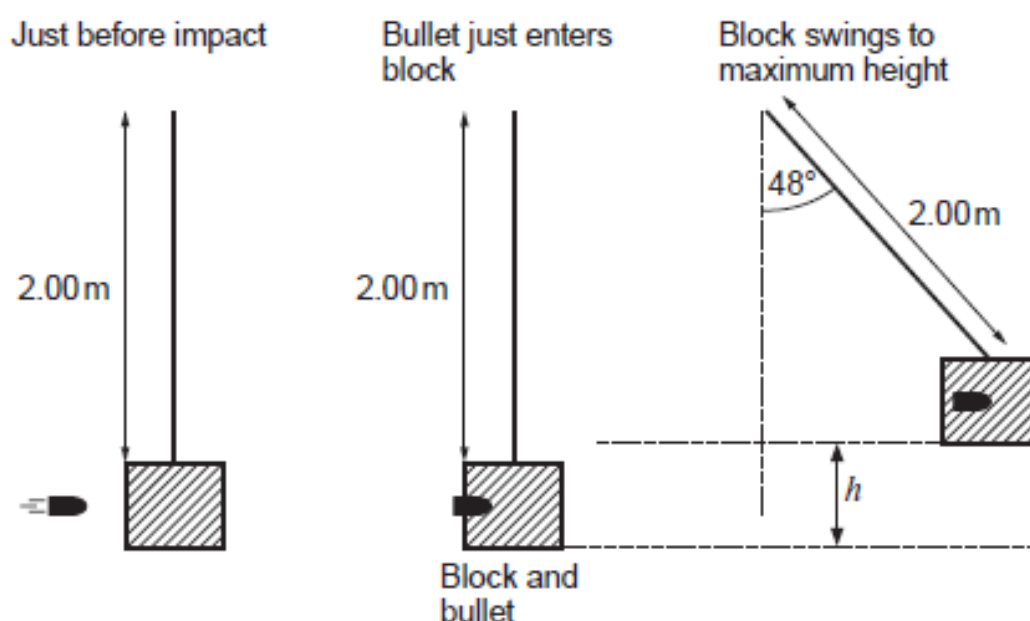
[1]

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- (b) When a bullet of mass 10.0 g is fired horizontally into a pendulum of mass 1.90 kg , the block rises through an angle of 48° as shown. The pendulum string is 2.00 metres long.



- (i) Show that the height, h , the block rises is approximately 0.70 m .

[2]

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- (ii) Using the principle of conservation of energy, determine the velocity of the block and the bullet just after the bullet has embedded itself in the block.

[2]

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(c) (i) State the principle of conservation of momentum. [2]

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(ii) Determine the speed of the bullet just before it enters the block. [2]

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(d) Discuss whether you feel it would be appropriate for a Physics teacher to carry out this experiment in school with a group of sixth form students. [2]

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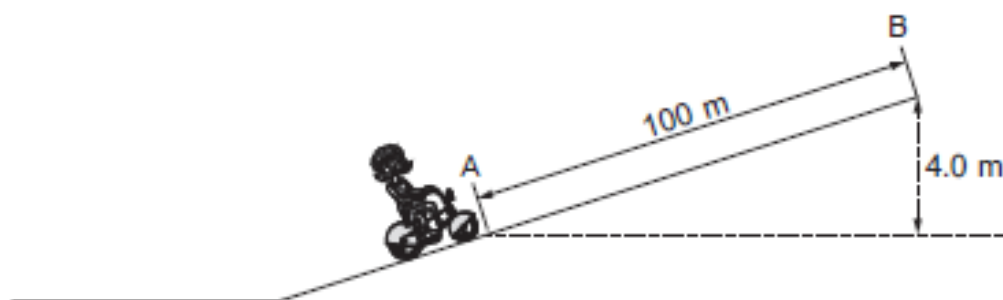
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3.

3. Helen is riding an electric bike (a bike that is assisted by an electric motor) up a hill at a speed of 4.5 m s^{-1} . At point A she starts the electric motor and accelerates uniformly reaching a speed of 9.2 m s^{-1} at B. Whilst accelerating she also gains a height of 4.0 m as shown in the diagram below.



- (a) Show that the time taken for Helen's journey between A and B is approximately 15 s. [2]

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- (b) Helen and the bike have a combined mass of 95 kg. Determine the gain in total energy between A and B. [3]

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- (c) (i) If the bike's electric motor operates at 36 V and 7.0 A calculate the electrical energy used by the motor between A and B. [2]

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- (ii) Helen, by pedalling, also provides 5 500 J of work between A and B. Determine the efficiency of the electric motor. *Ignore all resistive forces on Helen and the bike.* [2]

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- (iii) In practice resistive forces will act. Identify these forces and where they act. [2]

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- (d) Helen believes that by riding an electrically powered bike to the shops rather than using her car she is benefiting the environment. Explain whether or not Helen is correct. [2]

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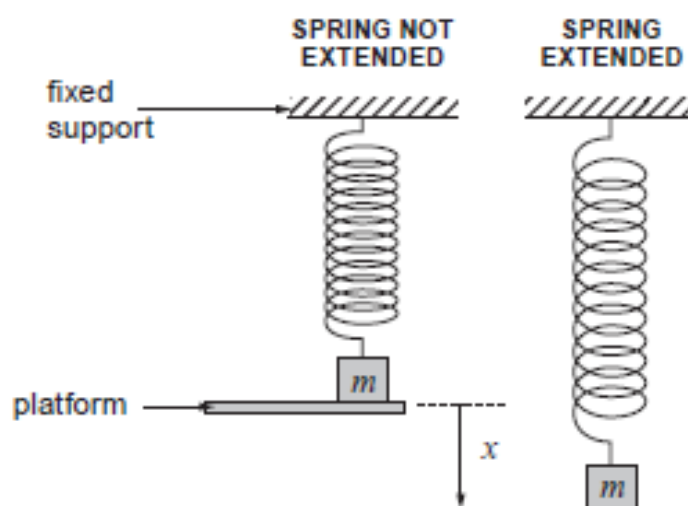
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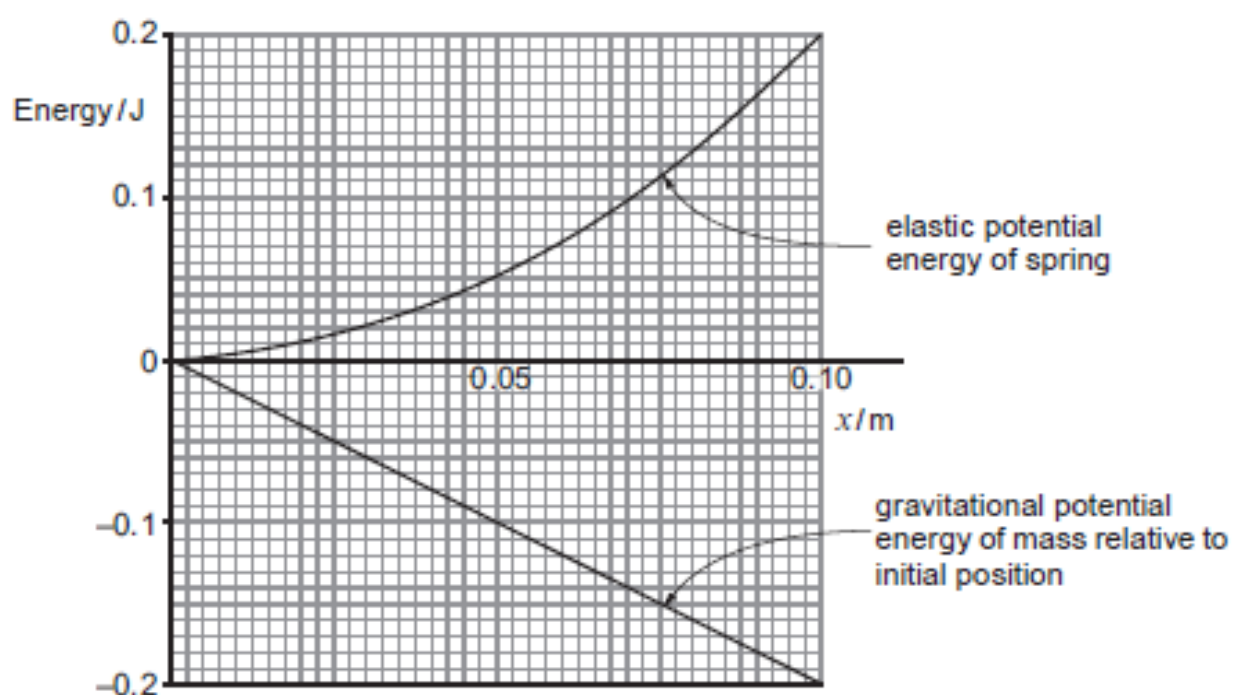
4. (a) State the *principle of conservation of energy*.

[2]

- (b) A mass, m , is attached to a light spring whose top end is held firmly. Initially the mass is supported by a platform with the spring unextended. The platform is suddenly removed so the mass falls.

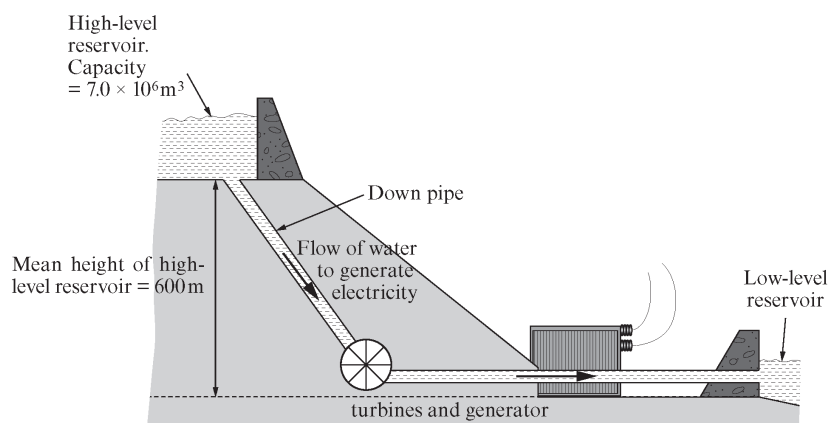


The graphs show how the elastic potential energy of the spring and the gravitational potential energy of the mass vary with the distance, x , of the mass below the platform (see diagrams).



5.

The hydroelectric power station at Dinorwig in North Wales is the largest of its kind in Europe. A simplified diagram showing the main features of the plant is shown.



- (a) Use the information in the diagram to show that the gravitational potential energy stored in the high-level reservoir is approximately $4 \times 10^{13} \text{ J}$.
[Density of water = 1000 kg m^{-3}]. [2]

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- (b) The power plant has six 300MW generators. Calculate the longest time for which the stored energy could provide power at maximum output given that the generation process is 90% efficient [i.e. 10% of the gravitational potential energy stored in the high level reservoir is wasted]. [3]

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- (c) (i) Calculate the mean rate of flow of water (in kg s^{-1}) through the turbines of the power station when it is operating at full power. [1]

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- (ii) After passing through the turbines the water enters the lower lake at a speed of 20ms^{-1} . Use your answer to (c)(i) to calculate the kinetic energy per second [power] of this water. [1]

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- (iii) Calculate the **wasted energy per second** (power lost) during the generation process. [2]

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- (iv) Hence show that your answer to (c)(ii) represents between 30% and 40% of the wasted power. [1]

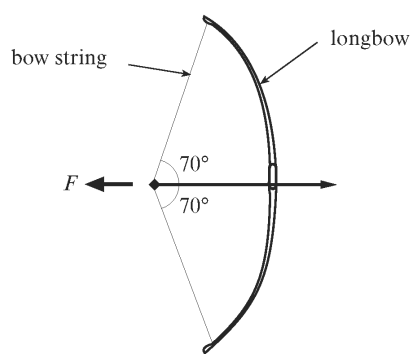
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- (v) Where else would energy be wasted during the generating process? [1]

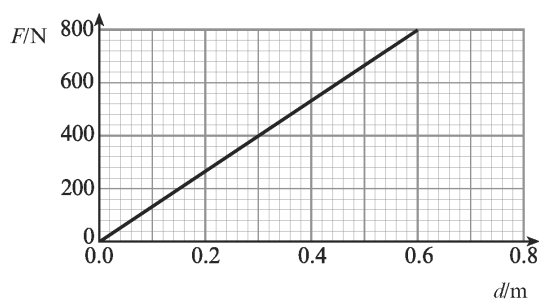
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6.

- (a) The medieval longbow was a devastatingly effective weapon. Assuming that a horizontal force F of 800 N is needed to draw back the bow string, show that the tension T in the string is approximately 1170 N. [2]

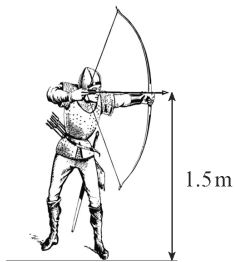


- (b) (i) The graph shows the variation of F with d for the longbow, where d is the distance the centre of the string is pulled back. Calculate the energy stored in the bow when the tension in the string is 1170 N. [2]



- (ii) Hence, **stating any assumptions you make**, show that the speed of the arrow as it leaves the bow is about 100 m s^{-1} . Take the mass of the arrow to be $50 \times 10^{-3} \text{ kg}$. [3]

- (c) The arrow is released horizontally at this speed from 1.5 m above the ground as shown. The arrow continues its path until it embeds itself into the ground a horizontal distance D from the point of release. **Ignoring the effects of air on the arrow**, calculate



- (i) the time taken for the arrow to reach the ground, [3]

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- (ii) the horizontal distance D , [2]

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- (iii) the **resultant velocity** of the arrow when it hits the ground. [5]

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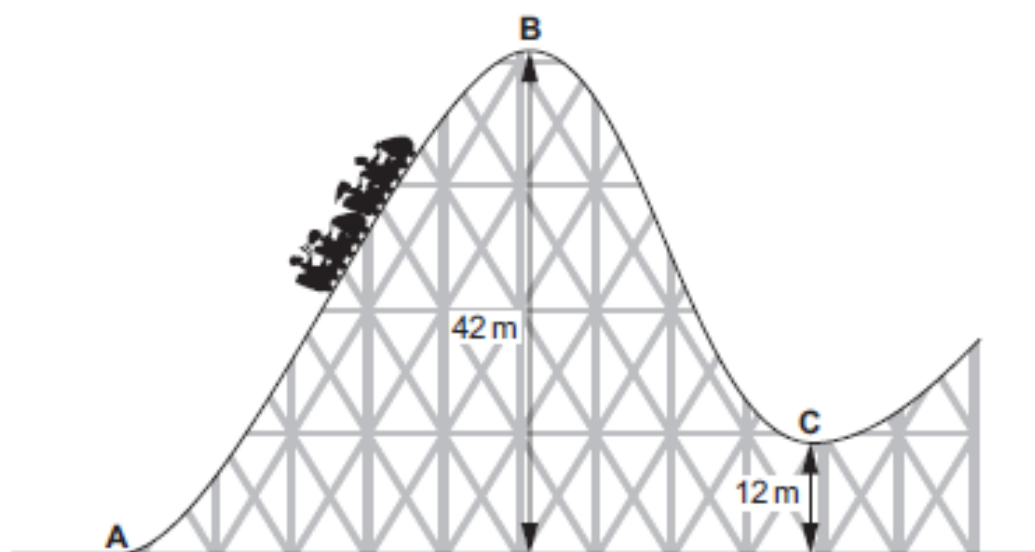
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7. The diagram shows part of a rollercoaster ride at a theme park.



- (a) A motor with a power output of 65 kW and a chain mechanism pulls the carriages of mass $2\,600\text{ kg}$ from A to B in a time of 32 s .

- (i) Show that the work done by the motor in 32 seconds is approximately 2 MJ . [1]

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- (ii) Hence calculate the efficiency of the mechanism, assuming the carriages are momentarily at rest at B. [3]

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- (b) At B, the carriages become disconnected from the motor and the carriages move under the influence of gravity for the rest of the ride. In moving from B to C, a distance along the track of 36 m, the carriages experience a mean resistive force of 2.8 kN. Calculate the speed of the carriages at C. [5]

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1. (a) (i) State the principle of conservation of energy. [1]

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- (ii) Explain how the principle applies to an object falling from rest **through the air**. [3]

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- (b) A child of mass 16 kg starts from rest at the top of a playground slide and reaches the bottom of the slide with a speed of 6.0 m s^{-1} . The slide is 4.0 m long and there is a difference in height of 2.4 m between the top and the bottom.

- (i) Calculate the work done against friction. [3]

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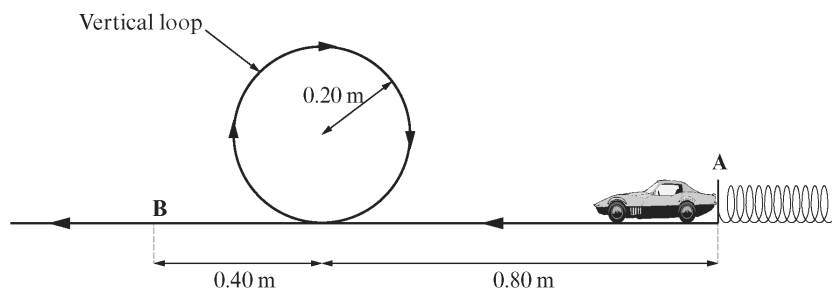
- (ii) Use your answer to (b)(i) to calculate the mean frictional force acting on the child. [2]

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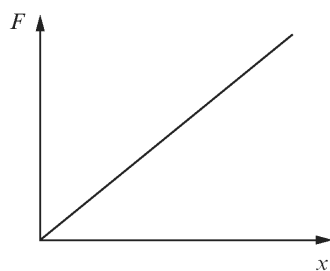
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9. A compressed spring is used to shoot a small toy car along a track which contains a circular vertical loop of radius 0.20 m. The spring obeys Hooke's law. Points **A** and **B** are referred to later in the question.



- (a) The sketch graph shows how the extension, x , of the spring varies with the force, F , applied to it.



- (i) Explain how the graph shows that the spring obeys Hooke's law. [1]

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- (ii) Use the graph to show that the elastic potential energy stored in the spring $= \frac{1}{2} kx^2$, where k is the spring constant. [2]

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(b) The spring requires a force of 0.10 N to compress it 1.0 mm.

- (i) Calculate the elastic potential energy stored in it when it is compressed by 80 mm. [3]

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- (ii) A small car of mass 0.04 kg is placed at point A, against the end of the spring, which is then released. Using your answer to (b)(i), calculate the speed with which the car leaves the spring. [2]

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- (c) The speed of the car at point B (after it has completed the loop) is 0.2 m s^{-1} less than its speed at A. Determine the mean frictional force on the car during its motion from A to B. [4]

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- (a) (i) Define *power*.

[1]

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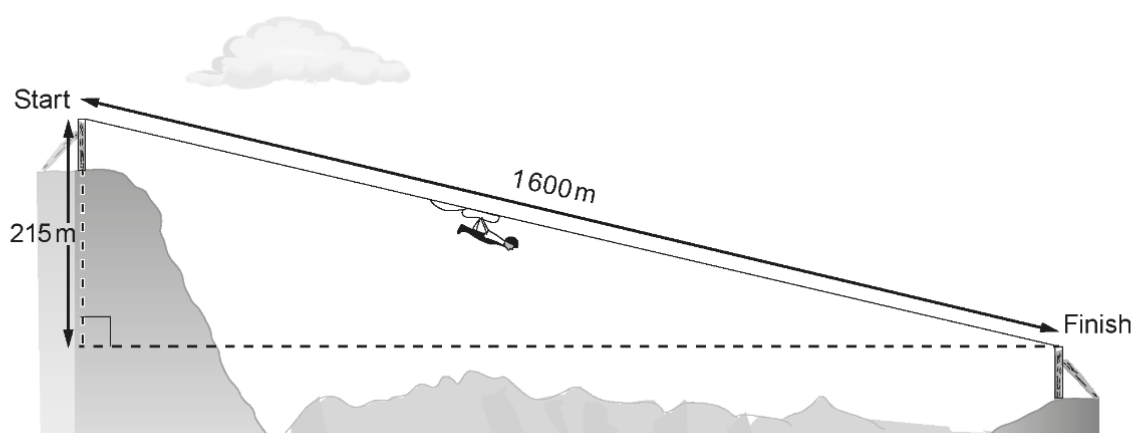
- (ii) Show how the unit **W** can be expressed in terms of the SI base units **kg**, **m** and **s**. [2]

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- (b) The longest zip-wire ride in the UK is in Snowdonia, North Wales. It is 1600 m long and the vertical drop from start to finish is 215 m as shown. The diagram is not to scale.



- (i) A person of mass 70 kg arrives at the finish travelling at 35 m s^{-1} , having started from rest. Use this data and information from the diagram opposite to determine the mean force opposing the motion of the person. [4]

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- (ii) The time taken to travel from start to finish is 46 s. Calculate the mean rate at which energy is transferred to the surroundings during the journey. [2]

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1.

(a)	<u>All 4 positions considered, 2 relevant statements per position</u>	
	<u>At start (A)</u> E_{Grav} – max E_k – zero E_{Elastic} – zero (1)	
	<u>Free fall, Cord slack(B)</u> E_{Grav} – decreasing E_k – increasing (1) E_{Elastic} – zero	
	<u>Cord stretching (C)</u> E_{Grav} – decreasing E_k – increasing or decreasing (1) E_{Elastic} – increasing	
	<u>At lowest point (D)</u> E_{Grav} – minimum (accept zero if explained) E_k – zero E_{Elastic} – maximum (1)	
	5 th 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) $E_{p \text{ loss}} = 70 \times 9.8[1] \times 130$ (1) substitution (not $g = 10 \text{ m s}^{-2}$) $= 89\,271 \text{ [J]}$ (1) (accept 89 300 or 89 000)	2
	(ii) $89271 = \frac{1}{2} k (50)^2$ (2) [1 mark for $E_{p \text{ loss}} = \frac{1}{2} kx^2$; 1 mark for 50 [m]] $k = 71.4 \text{ [N m}^{-1}\text{]}$ (1) ecf from (b)(i)	3
	(iii) $mg = kx$ (1) $= \frac{70 \times 9.81}{71.4} = 9.6 \text{ [m]}$ (1) ecf on k from (b)(ii) N.B. Only penalise once for use of $g = 10 \text{ m s}^{-2}$	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 = $2 \cos 48^\circ = 1.34$ [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)	$m_b v_b = 1.91 \times 3.6$ 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 = $95 \times 9.8 \times 4 = 3\,728$ [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 , PM _{2.5} etc] much less than petrol vehicles			2	2		
			Question 3 total	4	7	2	13	9	0

4.	Question			Marking details	Marks available					Prac
					AO1	AO2	AO3	Total	Maths	
	(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) $k = 40 \text{ N m}^{-1}$ 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 $x = 0.050 \text{ m}$) 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 $\frac{x_{\text{max}}}{m}$ [or $\frac{m}{x_{\text{max}}}$] (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) [= 4.1×10^{13}] 1 st mark – use of density equation to get $7.0 \times 10^9 \text{ kg}$ 2 nd mark – use of mgh	2
	(b)	Energy available per second = $0.9 \times 4.1 \times 10^{13}$ [= 3.6×10^{13}] J (1) allow e.c.f. from (a) Time = $\frac{3.6 \times 10^{13}}{6 \times 300 \times 10^6}$ (1) [= 2×10^4 [s] / 5.6 [hour]] (1)	3
	(c) (i)	$\frac{7.0 \times 10^9}{2 \times 10^4 \text{ e.c.f.}} = 3.5 \times 10^5 \text{ [kg s}^{-1}\text{]}$ allow e.c.f. from (a) and (b)	1
	(ii)	E_k per second [= $\frac{1}{2} \times 3.5 \times 10^5 \times 20^2$] = $7 \times 10^7 \text{ [J s}^{-1}\text{]}$ allow e.c.f. from (c)(i)	1
	(iii)	Energy wasted per second = $\frac{10\% \times 4 \times 10^{13} \text{ J}}{2 \times 10^4 \text{ s}}$ (1) allow e.c.f. from (a) and (b) [or equiv, or by impl.] = $2 \times 10^8 \text{ [W]}$ (1)	2
	(iv)	% lost in $E_k = \frac{7 \times 10^7}{2 \times 10^8}$ [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 $\cos 70^\circ$ (1) $2T \cos 70^\circ = 800$ (1) [$\rightarrow T = 1170$ N] [Accept mysterious division by 2 (b.o.d.)]	2
	(b)	(i) Area under graph attempted or $\frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ (1) 240 J (1)	2
		(ii) Initial energy stored in bow converted entirely to E_k of arrow (1) 240 e.c.f. = $\frac{1}{2} 50 \times 10^{-3} v^2$ (1) [subst] manipulation leading to $v = 98 \text{ m s}^{-1}$ shown. (1) [Final mark not available if incorrect E_k used]	3
			2
	(c)	(i) $x = ut + \frac{1}{2}at^2$ (1); $u = 0$ (1) $t = 0.55 \text{ s}$ [accept 0.6 s] (1)	3
		(ii) $D = V_H t$ [or by imp.] (1) e.c.f. of t $D = 98$ [or 100] $\times 0.55$ [or 0.6] [e.c.f.] $\therefore D = 54 \text{ m}$ (1)	
		(iii) $v_{\text{vertical}} = u + at$ and $u = 0$ (1) [or equiv or by impl.] $v_v = 5.4 \text{ m s}^{-1}$ (1) $v_{\text{resultant}} = \sqrt{5.4^2 + 98.0^2}$ (1) or $v^2 = 5.4^2 + 98.0^2$ $v_{\text{resultant}} = 98.1 \text{ m s}^{-1}$ (1) Angle to horizontal [clearly identified] = $\sin^{-1} \frac{5.4}{98.1} = 3^\circ$ (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 2 nd marking point: linking to 1 st marking point because gradient of graph greater for Turkish bow]	4
			[21]

7.

Question	Marking details		Marks available				Maths	Prac
			AO1	AO2	AO3	Total		
7	(a)	(i)	Work done = $65\,000 \times 32 = 2.08 \times 10^6 \text{ J}$		1		1	
		(ii)	Energy at B = $2\,600 \times 9.81 \times 42$ (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 = $2\,800 \times 36$ (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) $664\,000 = \frac{1}{2} \times 2\,600 \times v^2$ (1) [allow use of 765 kJ] $v = 22.6 \text{ m s}^{-1}$ (1) [765 kJ $\rightarrow$ 24.3 m s ⁻¹] Additional marking guidance - Whole drop (42 m) with resistive forces $\rightarrow 27.3 \text{ m s}^{-1} \rightarrow 4$ marks 30 m drop without resistive forces $\rightarrow 24.3 \text{ m s}^{-1} \rightarrow 3$ marks - Whole drop without resistive forces $\rightarrow 28.7 \text{ m s}^{-1} \rightarrow 2$ marks - Mixing force and energy $\rightarrow 0$ - Use of $v^2 = u^2 + 2ax \rightarrow 0$ - Dissipate energy =	1	1 1 1 1		5	5
			Question 7 total	2	7	0	9	0

8.

(a)	(i)	<u>Energy cannot be created or destroyed; it can only change from one form to another.</u> 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 $\frac{1}{2}mv^2$ 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)	<u>Correct substitution</u> into $W = Fd$ i.e. 88.7 (ecf) = $F \times 4.0$ (1) $F = 22[.2 \text{ N}]$ (1) If either E_p or E_k substituted in for W then award 1 mark only <u>Alternative Solution:</u> Force down slope = $16 \times 9.81 \times \frac{2.4}{4}$ [$F = mgsin\theta$] = 94.2 [N] Resultant Force $\Sigma F = 16 \times \left(\frac{6^2}{8}\right) = 72$ [N] Mean Frictional Force = $94.2 - 72 = 22[.2 \text{ N}]$ Award 1 mark for either force values correct (or both) Award 2 marks for correct solution	[2]

9.

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

10.

Question				Marking details	Marks Available
5	(a)	(i)		power = $\frac{\text{work done or energy transferred}}{\text{time}}$ [Accept rate of doing work/ rate of energy transfer]	1
		(ii)		$\text{kg ms}^{-2} \times \text{m} \times \text{s}^{-1}$ (1) [Evidence of full correct methodology] $\text{kg m}^2 \text{s}^{-3}$ (1)	2
	(b)	(i)		$E_p = 70 \times 9.81 \times 215$ (1) [= 147 641 J] $E_k = \frac{1}{2}(70)(35)^2$ (1) [= 42 875 J] $E_{\text{lost}} = 147 641 - 42 875$ (1) [= 104 766] (ecf on both E_p and E_k) $F = \frac{104766}{1600} = 65.5 \text{ [N]}$ (1) (ecf on E_{lost}) Alternative solution: using $v^2 = u^2 + 2ax$	4
		(ii)		$P = \frac{104766}{46}$ 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 $\frac{1}{2} kx^2$. 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 4×10^{13} 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 $\frac{1}{2}Fx$ to give the required expression.

(b) (i) Candidates who attempted to calculate the elastic potential energy stored using the equation $\frac{1}{2}kx^2$ met with more success than those who used the $\frac{1}{2}Fx$ 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 $\Sigma F = ma$, 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: $\text{kg m s}^{-2} \cdot \text{m/s} = \text{kg m}^2 \text{s}^{-1}$.

(b) (i) Almost all candidates who were able to identify that $\text{GPE} - \text{KE} = \text{Work done}$ 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)