Name	Date started	Target end date

GCE AS / A LEVEL — WORK, ENERGY & STORED ENERGY QUESTION PACK

Legacy PH1 · New spec Unit 1 Topic 4a · AS unit, 20% of A-level

REVISE
.wales

PHYSICS — UNIT 1 · WORK, ENERGY & STORED ENERGY

PH1.4 Energy — work, kinetic / gravitational PE, and stored / released energy

Defining work and energy, applying $W = Fs\cos\theta$, $KE = \frac{1}{2}mv^2$, $GPE = mgh$ and the principle of conservation of energy, including elastic strain energy and roller-coaster style problems.

NEW 2015 SPEC · UNIT 1 TOPIC 4A

Estimated time for entire question pack: ~2 h 38 min

Derived from the legacy PH1 paper's pace of 80 marks in 1¼ hours.

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH1 papers (2008 modular spec) that maps onto new-spec Unit 1 Topic 4a (1.4).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question. A calculator is required. The Data Booklet is allowed.

For Examiner's use only

Q	Source	Max	Mark
1	PH1 Jun 10 Q7	16	
2	PH1 Jun 14 Q1	9	
3	PH1 Jun 13 Q5	12	
4	PH1 Jun 15 Q5	11	
5	PH1 Jun 09 Q8	11	

Q	Source	Max	Mark
6	PH1 Jan 09 Q5	9	
7	PH1 Jan 12 Q4	11	
8	PH1 Jan 13 Q3	12	
9	PH1 Jan 11 Q7	10	
10	PH1 Jun 12 Q4	12	
	Total	**113**	

Work, Energy & Stored Energy — what the new spec asks

WJEC GCE AS / A Level Physics (from 2015) · Unit 1: Motion, Energy & Matter · Topic 1.4.

Work and energy (A)

- Define work; $W = Fs \cos \theta$.
- State the principle of conservation of energy.

Kinetic and potential energy (A)

- Derive $E_k = \frac{1}{2}mv^2$ from $W = Fs$ and $F = ma$.
- Gravitational PE $E_p = mgh$ near Earth's surface.
- KE / GPE interconversion (drops, swings, hills).

Stored & released energy (B)

- Elastic strain energy from a Hooke's-law extension: $U = \frac{1}{2}Fx$.
- Energy from fuels, springs and capacitors at qualitative level.

Heat & internal energy (B)

- Thermal energy dissipated through friction or drag.
- Mechanical energy converted to internal energy as KE is lost.

Work, Energy & Stored Energy in one page

Quick-reference notes — revisit before each section.

Work

Scalar; units J (= N m).

Only force component *along* displacement does work.

$\theta = 0 \Rightarrow$ max; $\theta = 90° \Rightarrow$ zero.

Energy conservation

Energy cannot be created or destroyed, only transferred.

In mechanics: KE ↔ GPE ↔ Elastic PE ↔ Heat.

Kinetic energy

Scalar; J.

Derive from W = Fs and F = ma.

Work–energy theorem: $W_{net} = \Delta Ek$.

Gravitational PE

Near surface only (constant g).

h = vertical height; choose a reference level.

$\Delta Ep = mg\Delta h$.

Elastic strain energy

For a Hookean spring of stiffness k stretched by x.

Area under F–x graph.

Common problems

Free fall: $\frac{1}{2}mv^2 = mgh \Rightarrow v = \sqrt{(2gh)}$.

Roller-coaster: $\Delta Ek + \Delta Ep + W_{friction} = 0$.

Pulley: tension does +W on one mass, −W on the other.

Section index

Use this index to jump straight to the section you need.

7. *(a)* (i) Define *work*. [2]

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(ii) Hence express the unit of work, J, in terms of the SI base units kg, m and s. [2]

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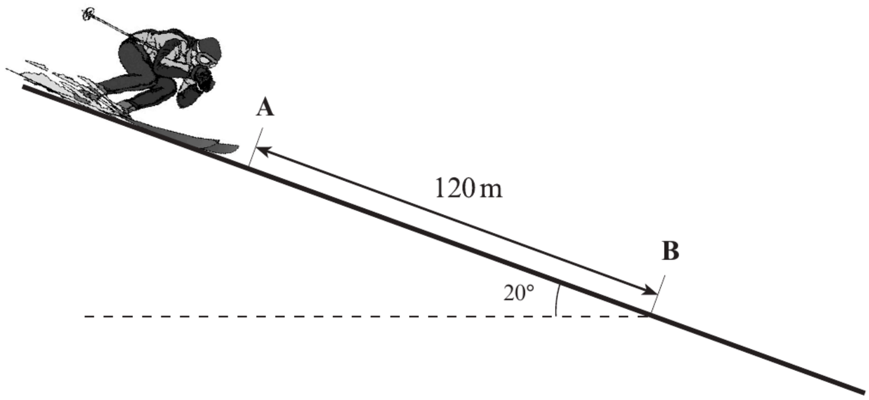
(b)



A skier of mass 70 kg descends a slope inclined at 20° to the horizontal as shown. The skier passes point **A** at a speed of 6 ms^{-1} and a second point **B** at a speed of 21 ms^{-1}. The distance between **A** and **B** is 120 m. Calculate, for the descent from **A** to **B**,

(i) the gravitational potential energy lost by the skier; [2]

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(ii) the kinetic energy gained by the skier. [3]

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

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(ii) Discuss your answers to *(b)* (i) and (ii) in terms of this principle. [2]

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(d) Calculate the mean resistive force experienced by the skier between **A** and **B**. [4]

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QUESTION 8 IS ON PAGE 14

Answer **all** *questions.*

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

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

(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]

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

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

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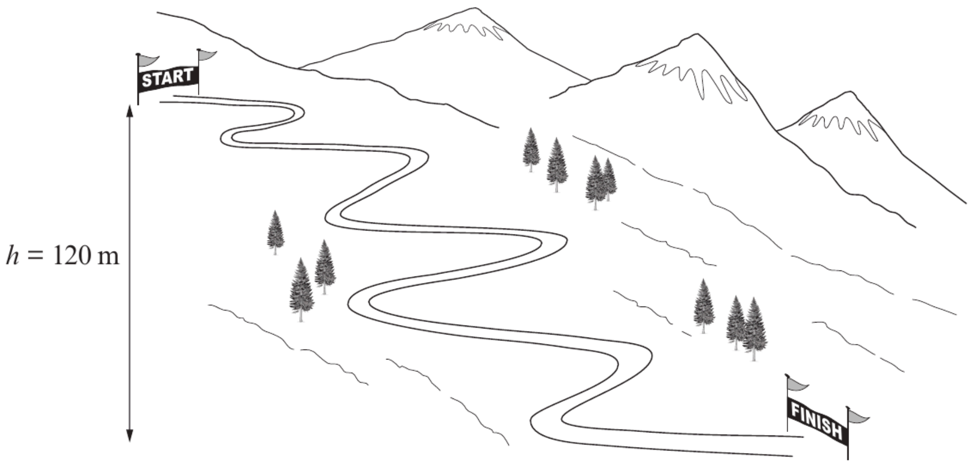
(b) A bobsleigh run in Norway has a curving track of overall length 1.4 km from start to finish. During a run, the bobsleigh starts from rest, and drops through a vertical height, *h*, of 120 m.



(i) Assuming no resistive forces, show that the maximum possible speed, *v*, of a bobsleigh at the finish line is given by [2]

$$v = \sqrt{2gh}$$

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(ii) Hence calculate the maximum possible speed of a bobsleigh at the finishing line. [1]

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(c) (i) Due to resistive forces, the actual speed at the finishing line is **20% less** than the maximum possible speed. Give **two** examples of resistive forces acting on the bobsleigh. [2]

(ii) Taking the resistive forces into account, calculate the kinetic energy of the bobsleigh at the finish. The mass of the bobsleigh and riders = 280 kg. [2]

(iii) Hence, determine the mean resistive force experienced by the bobsleigh from start to finish. [4]

Examiner only

5. *(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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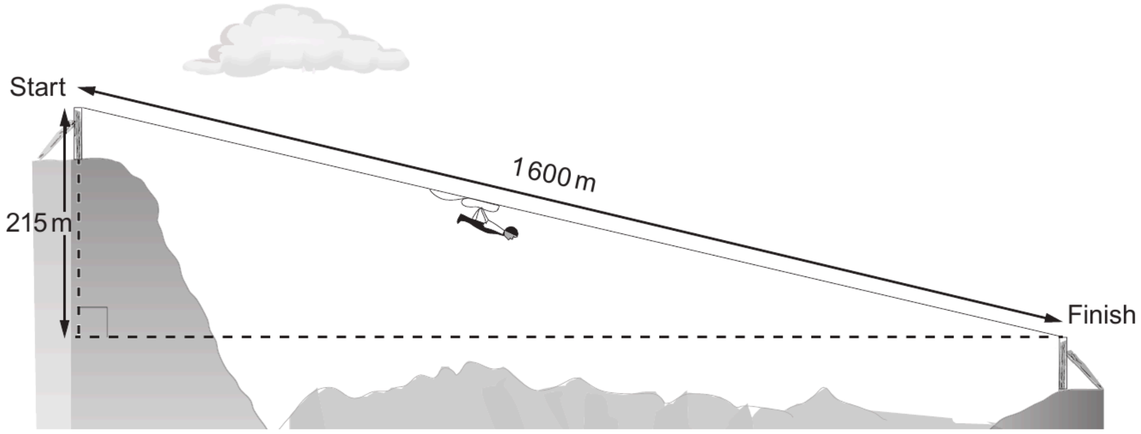
(b) The longest zip-wire ride in the UK is in Snowdonia, North Wales. It is 1600 m long and the vertical drop from start to finish is 215 m as shown. The diagram is not to scale.



(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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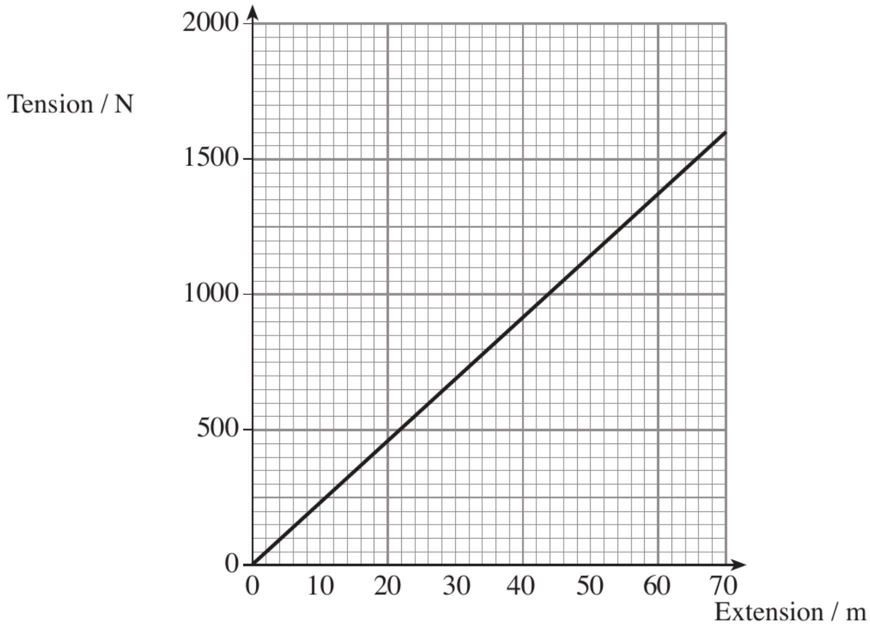
8. (a) State the principle of conservation of energy.

[2]

(b) A 'bungee jumper' standing on a high platform above the ground is attached to a bungee cord of unstretched length 26 m and spring constant k. When she jumps she falls a maximum distance of 96 m where she is momentarily stationary at the lowest point of her jump and about to begin moving upwards. Ignore air resistance.



(i) The graph shows how the tension in the bungee cord varies with extension during the fall. Use the graph to calculate the elastic potential energy stored in the bungee cord when the jumper is at the lowest point.

[3]

(ii) The initial gravitational potential energy (with respect to the ground) possessed by the jumper on the platform is 7.0×10^4 J and her mass is 60 kg. Calculate how high she is above the ground at the bottom of her fall.

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[3]

(iii) After 'bouncing' a few times, the bungee jumper eventually comes to rest hanging a distance, d, below the platform. Calculate the value of d.

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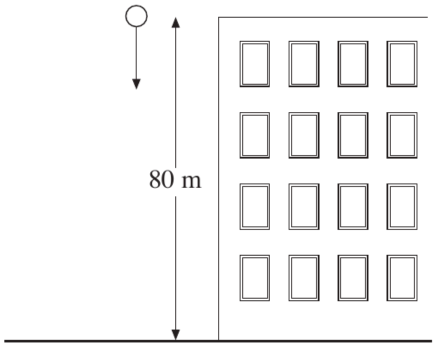
[3]

5. A ball of mass 0·60 kg is dropped from the top of a building 80 m high.



(a) Calculate the initial gravitational potential energy of the ball. [2]

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(b) The ball reaches the ground with a velocity of 30 ms^{-1}. Calculate its kinetic energy. [2]

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(c) (i) Calculate the fraction of the initial gravitational potential energy that is not converted into kinetic energy of the ball during the fall. [1]

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(ii) Explain, referring to molecules, what has happened to this ‘missing’ energy. [2]

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(d) Calculate the mean resistive force acting on the ball during its fall. [2]

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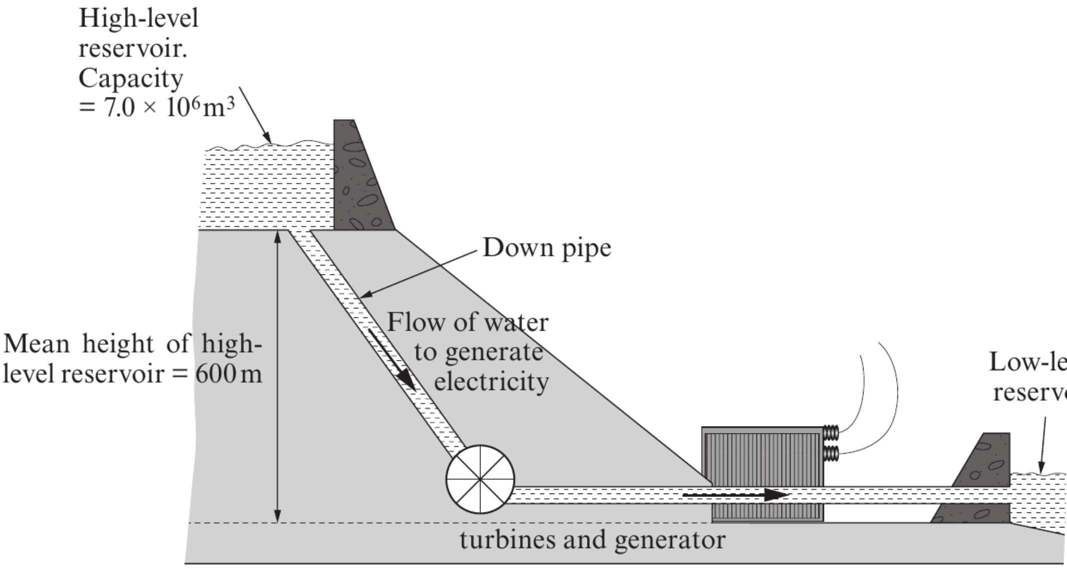
4. The hydroelectric power station at Dinorwig in North Wales is the largest of its kind in Europe. A simplified diagram showing the main features of the plant is shown.



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

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(b) The power plant has six 300 MW 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 $20\,m\,s^{-1}$. 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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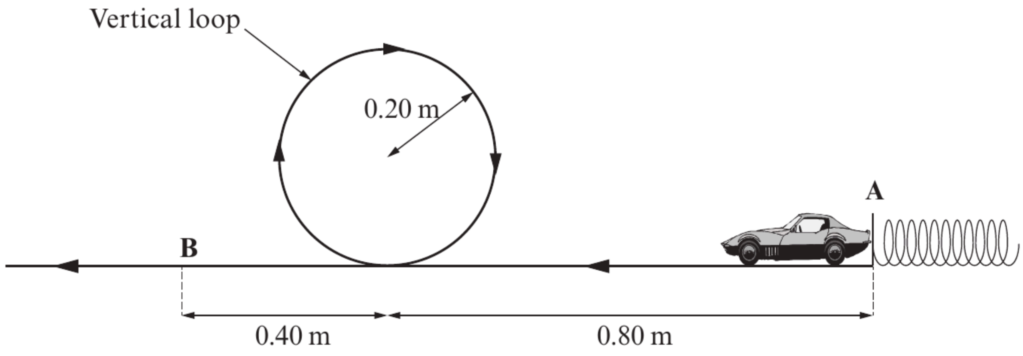
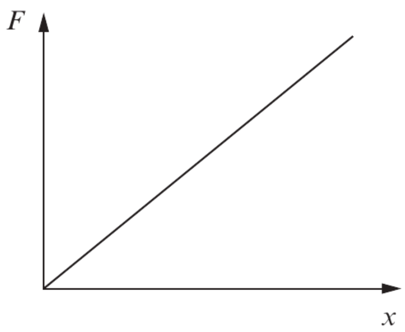
3. A compressed spring is used to shoot a small toy car along a track which contains a circular vertical loop of radius 0.20 m. The spring obeys Hooke's law. Points **A** and **B** are referred to later in the question.



(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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Examiner only

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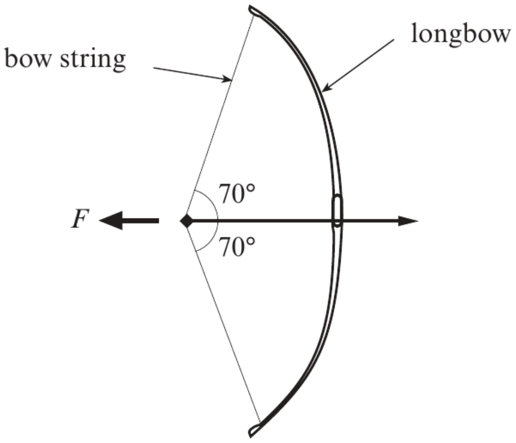
7. *(a)* The medieval longbow was a devastatingly effective weapon. Assuming that a horizontal force F of 800 N is needed to draw back the bow string, show that the tension T in the string is approximately 1170 N. [2]



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(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]

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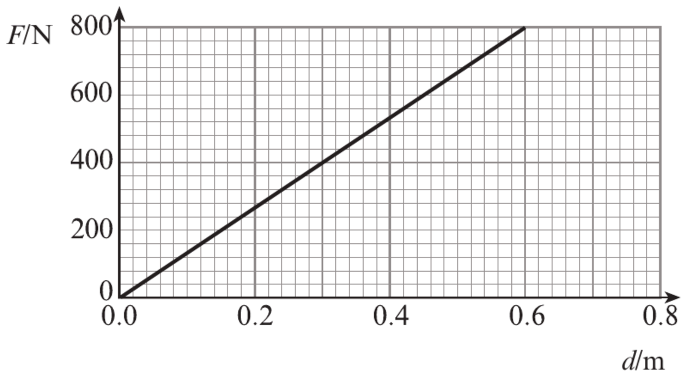

(ii) Hence, **stating any assumptions you make**, show that the speed of the arrow as it leaves the bow is about $100\,\mathrm{m\,s^{-1}}$. Take the mass of the arrow to be 50×10^{-3} kg. [3]

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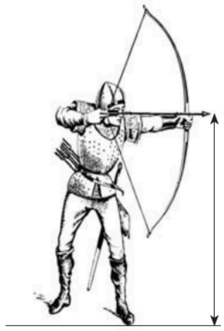
(c) The arrow is released horizontally at this speed from 1.5 m above the ground as shown. The arrow continues its path until it embeds itself into the ground a horizontal distance *D* from the point of release. **Ignoring the effects of air on the arrow**, calculate



(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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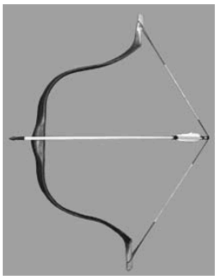
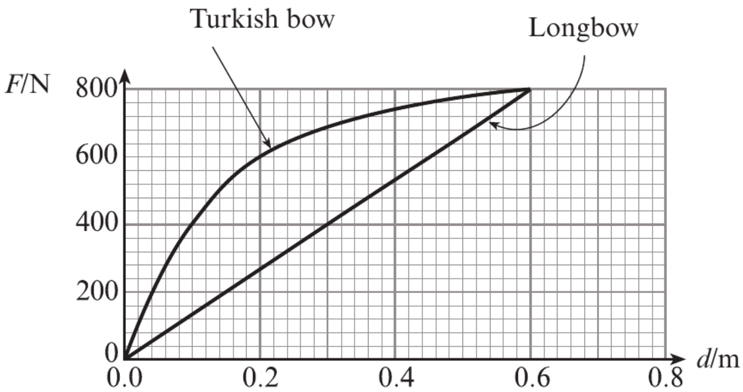
QUESTION 7 CONTINUES ON PAGE 16

(d) The Turkish war-bow of the 15th and 16th centuries (pictured) was also a fearsome weapon, able to shoot lightweight arrows great distances. A copy of the graph on page 14 is shown below which has included on it a curve to represent the draw force versus 'pull back distance' for a typical Turkish bow.





Use the graphs to compare the effectiveness of the Turkish bow in relation to the longbow. Your answer could refer to the ease of use of each bow, the energy stored and the effect this has on motion of an arrow.
Calculations are not required. [4]

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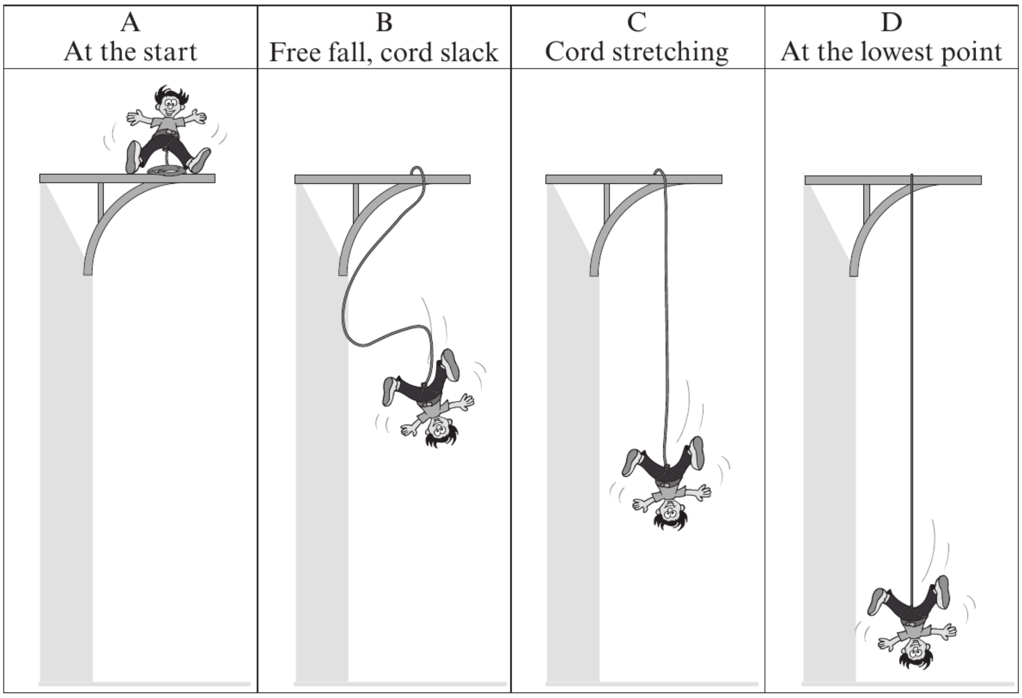
Examiner only

4. *(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]



Examiner only

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

10 questions · 113 marks · ~2 h 38 min

Source: WJEC PH1 (2008 modular spec)

Curated for WJEC Physics 2015 spec AS Unit 1 — Topic 4a (1.4)