Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A Level

2420U10-1 – **NEW AS**

S16-2420U10-1

PHYSICS – Unit 1
Motion, Energy and Matter

A.M. TUESDAY, 24 May 2016

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**10**	
3.	**13**	
4.	**12**	
5.	**11**	
6.	**12**	
7.	**14**	
Total	**80**	

2420U101 01

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use pencil or gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space use the continuation pages at the back of the booklet taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

The assessment of the quality of extended response (QER) will take place in **Q5*(a)***.

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Answer **all** *questions.*

1. *(a)* A student wishes to determine the material from which a metal ball bearing is made. He obtains the following values and uses them to determine the density of the metal in the ball bearing.

Volume of ball bearing = 5.6 ± 0.2 cm^3
Mass of ball bearing = 45.4 ± 0.5 g

(i) Calculate the density of the ball bearing (in g cm^{-3}) and show that its **percentage** uncertainty is approximately 5%. [3]

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(ii) Determine the **absolute** uncertainty in the density. [1]

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(b) The table gives the density of some common metals and alloys.

Metal	**Density / g cm^{-3}**
Tin	7.3
Stainless steel	7.5
Iron	7.9
Brass	8.2
Nichrome	8.3
Copper	8.9

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(i) Write down possible materials from which the ball bearing is made and explain why it is not possible to determine the exact material. [2]

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(ii) Identifying the correct material from which the ball bearing is made depends on reducing the uncertainty in density. Explain which of the two values (volume or mass) contributes more to this uncertainty. [2]

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2. *(a)* State the difference between *baryons* and *mesons* in terms of quark make-up. [2]

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(b) When two protons collide, the following interaction may occur, where x is an unknown particle:

$$p + p \longrightarrow p + x + \pi^0$$

(i) The π^0 is a meson which carries no charge. State its quark make-up. [1]

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(ii) Identify particle x, explaining how you use the law of conservation of baryon number and one other conservation law. [3]

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(iii) State how lepton number is conserved in the above interaction. [1]

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(c) A π^0 decays in a typical time of 8×10^{-17} s into two photons as shown. State which force is involved in this interaction, giving **two** reasons for your answer. [3]

$$\pi^0 \longrightarrow \gamma + \gamma$$

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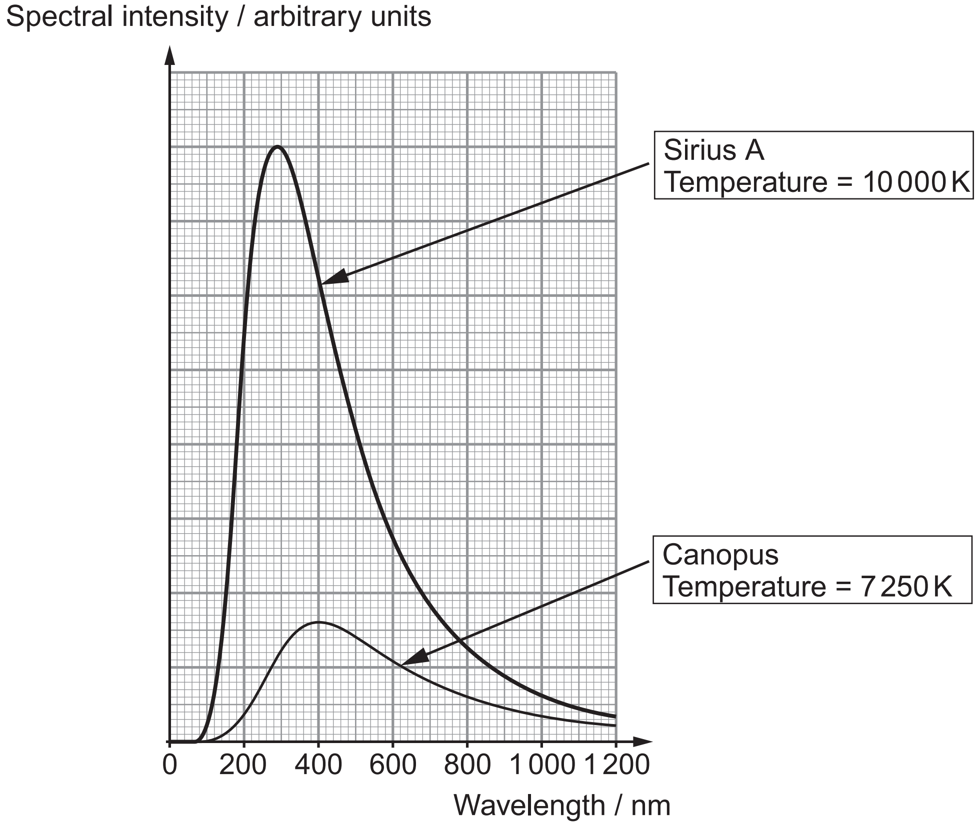
3. *(a)* Two of the brightest stars in the night sky are Sirius A and Canopus. The graph shows the continuous black body spectra for these two stars.



(i) Confirm that Wien's displacement law is valid for the stars. [3]

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(ii) Astronomers state that one of the stars appears 'bluer' than the other. Explain how the spectra support this statement and state which star would appear bluer. [2]

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(b) (i) The radius of Canopus is 4.97×10^{10} m and that of Sirius A is 1.19×10^{9} m. Show that the luminosity of Canopus is approximately 500 times the luminosity of Sirius A. [4]

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(ii) Calculate the intensity of the radiation reaching the surface of the Earth from Sirius A. (Distance between Sirius A and Earth = 8.15×10^{16} m.) [2]

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(iii) The intensity of the radiation reaching the Earth's surface from Canopus is **less than** that from Sirius A, even though Canopus has a **greater** luminosity than Sirius A. Explain this apparent contradiction. [2]

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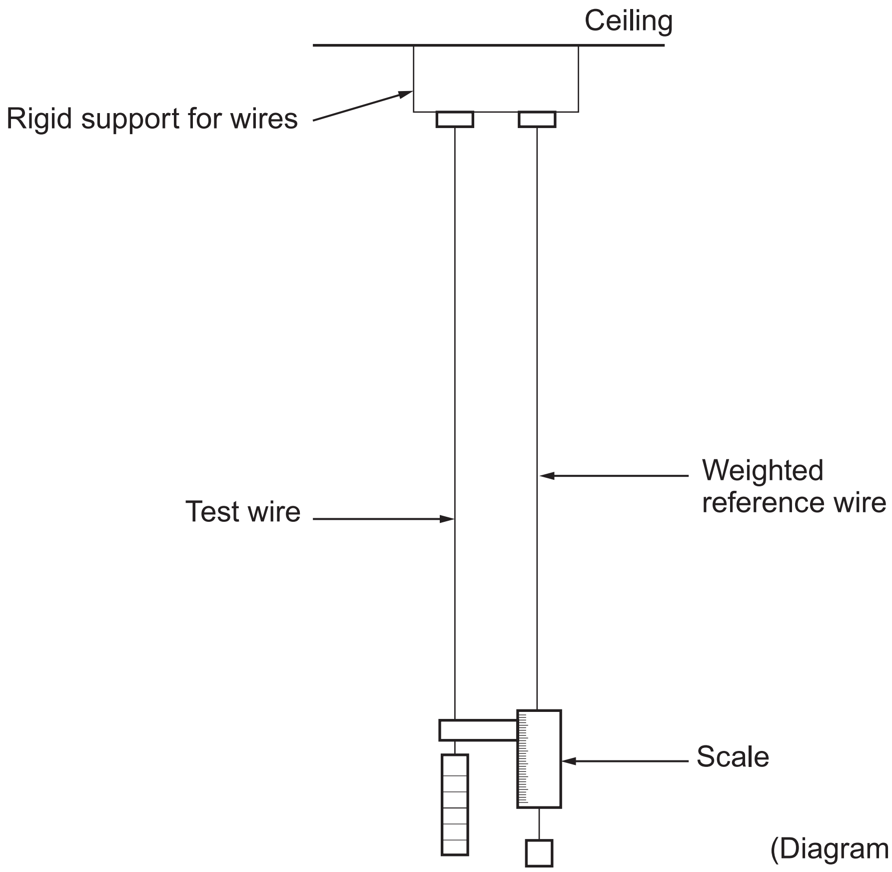
4. The following extract from a Physics text book describes a method for determining the Young modulus of a metal in the form of a wire.

Apparatus

A long test wire and a reference wire of the same length and material are suspended from a common rigid support. This minimises the effect of temperature and the movement of the support. The scale for measuring extensions is on the reference wire and a weight is placed on it to keep it taut and kink free. This way if the test wire pulls the support downwards, the reference wire and scale move with it. The scale will therefore read only the extension of the test wire.



(Diagram not to scale)

Method

Measure the extension for increasing loads ensuring that the wire remains within its *elastic limit.* Take repeat readings during the removal of the load to provide a mean value for the extension. Measure the diameter of the test wire at several different places using a micrometer. Measure the length of the test wire with a ruler.

(a) (i) Explain how the effect of a change in temperature on the wire is minimised. [2]

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(ii) State what is meant by the term *elastic limit* **and** explain how an experimenter would know whether or not the test wire has extended beyond its elastic limit. [2]

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(iii) The text book also states:

'The apparatus and procedures are designed carefully to minimise uncertainties when taking measurements.'

I. State why a long wire is used rather than a short one. [1]

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II. Why is the diameter of the wire measured at several different places? [1]

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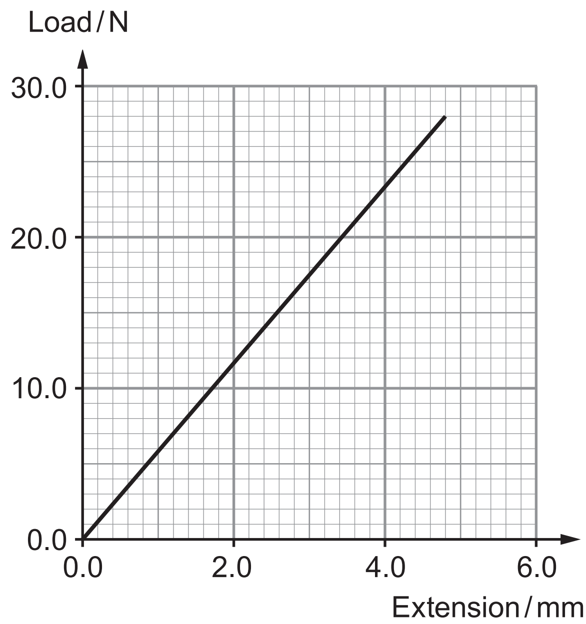
(b) A typical graph showing the results of such an experiment is given below. The original length of the wire is 2.40 m and the mean value of its **diameter** is 0.32 mm.



(i) Use the graph and the measurements given to determine the Young modulus of the material of the wire. Give your answer to an appropriate number of significant figures. [4]

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(ii) Calculate the energy stored in the wire when it is extended by 2.4 mm. [2]

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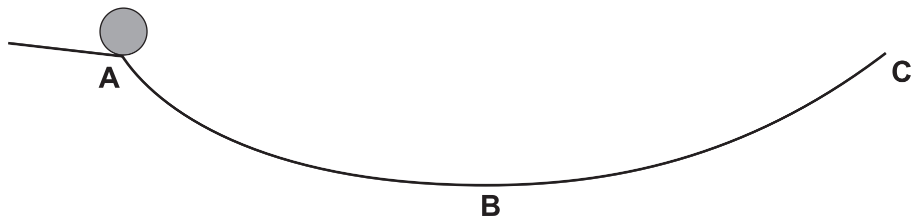
5. *(a)* The diagram shows a marble about to be released at **A** on a curved ramp.



Explain the energy transfers that take place from the moment the marble is released to the moment it finally comes to rest. [6 QER]

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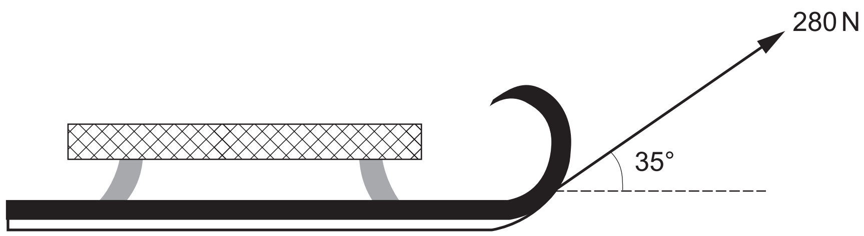
(b) A heavy sled moves with **constant velocity** when it is pulled by a force of 280 N acting as shown.



(i) State why the work done in pulling the sled **cannot** be calculated by simply multiplying 280 N by the distance the sled is pulled. [1]

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(ii) It takes 20 minutes to pull the sled a distance of 3.0 km over level ground. Calculate the mean power needed. [4]

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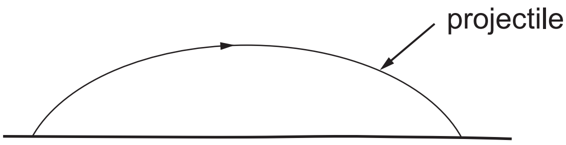
6. *(a)* A projectile is fired from the Earth's surface and follows a curved path as shown.



Describe and explain how, if at all, the vertical and the horizontal components of velocity of the projectile change during the flight. Ignore the effects of air resistance. [3]

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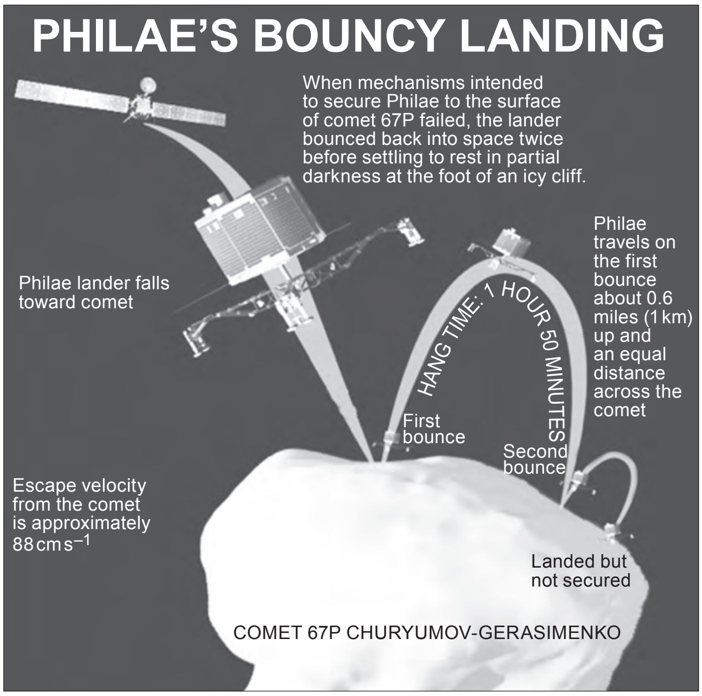
(b) In November 2014 the space probe 'Philae' was dropped onto comet 67P. Philae bounced twice before coming to rest. A national newspaper used the following image to describe the landing.



(i) Use information from the image to calculate the horizontal velocity of the lander between the first and second bounce. [1]

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(ii) By considering the first bounce, show that the value of the acceleration due to gravity on the comet is approximately 0.0002 $m s^{-2}$. [2]

(iii) Show that the vertical velocity of the lander immediately after the first bounce was greater than 60% of the escape velocity. [3]

(c) By considering the following facts discuss whether or not the mission was justified. [3]

- Cost of developing and sending the spacecraft to the comet: £1 billion over 10 years.
- Around 2 000 people involved in the development of the spacecraft and its instruments.
- Advanced solar cell technology developed.
- 28 000 landing announcement 're-tweets' in the first hour.
- Organic molecules detected on comet surface.

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7. *(a)* Momentum is a *vector.* State what is meant by a vector. [1]

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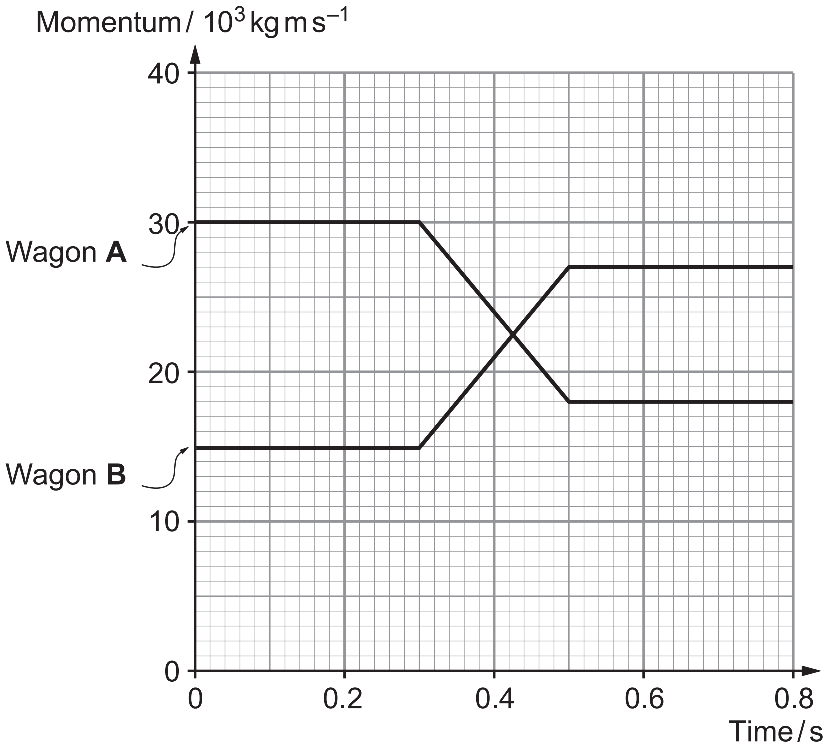
(b) The graph shows how the momentum of two colliding railway wagons (**A** and **B**) varies with time. The collision takes place between 0.30 s and 0.50 s as shown. The wagons remain joined together after impact.



(i) Explain with suitable calculations how the graphs show that external forces on the system are negligible. [3]

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(ii) Calculate the final velocity of the two wagons given that the total mass of wagon **A** and wagon **B** is 25 000 kg. [3]

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(c) (i) State Newton's Second Law of motion in terms of momentum. [2]

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(ii) Determine from the graph the resultant force on wagon **A** during the collision. [3]

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(iii) The force experienced by wagon **B** during the collision is equal and opposite to the force experienced by wagon **A**. State which law of motion this is an example of **and** explain how the graph confirms this law. [2]

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