OCR
Oxford Cambridge and RSA

Accredited

A Level Physics A
H556/01 Modelling physics
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 2 hours 15 minutes

You must have:
• the Data, Formulae and Relationships Booklet

You may use:
• a scientific or graphical calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **28** pages.

[601/4743/X] DC (…)

SECTION A

You should spend a maximum of 20 minutes on this section.

Answer **all** the questions.

1 A length x is 50 mm ± 2 mm. Length y is 100 mm ± 6 mm. The length z is given by $z = y - x$.

What is the best estimate of the uncertainty in z?

A ± 1 mm

B ± 4 mm

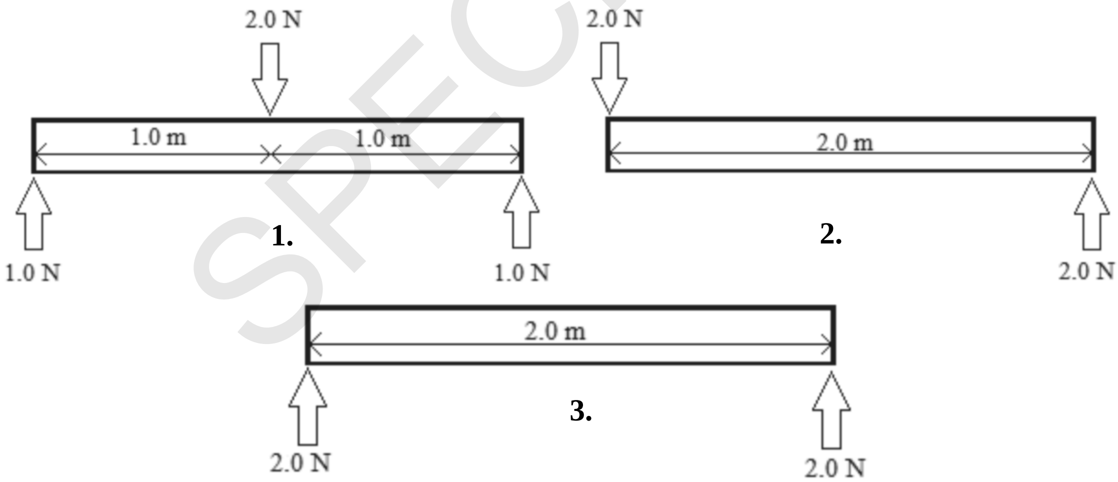
C ± 5 mm

D ± 8 mm

Your answer ☐

[1]

2 A 2.0 m rigid rod with negligible weight is subject to forces in three different ways as shown in diagrams **1-3** below.



For the rod to be in equilibrium which of the diagrams above is/are correct?

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

3 The p.d. across a resistor is 12 V. The power dissipated is 6.0 W.

Which statement is correct?

A The charge passing through the resistor in one second is 2.0 coulomb.

B The resistor transfers 6.0 joule for each coulomb passing through the resistor.

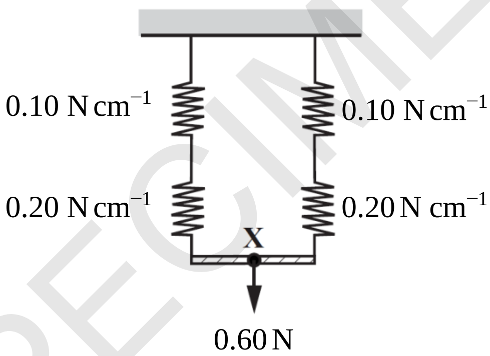
C The resistor transfers 12 joule in 2.0 second.

D The resistor dissipates 6.0 joule when the current is 2.0 ampere.

Your answer ☐

[1]

4 A spring with force constant $0.10\,\mathrm{N\,cm^{-1}}$ is placed in series with one of $0.20\,\mathrm{N\,cm^{-1}}$. These are then placed in parallel with an identical set of springs as shown. A force of 0.60 N is applied.



What distance does the point **X** move down when the 0.60 N force is applied?

A 2.0 cm

B 3.0 cm

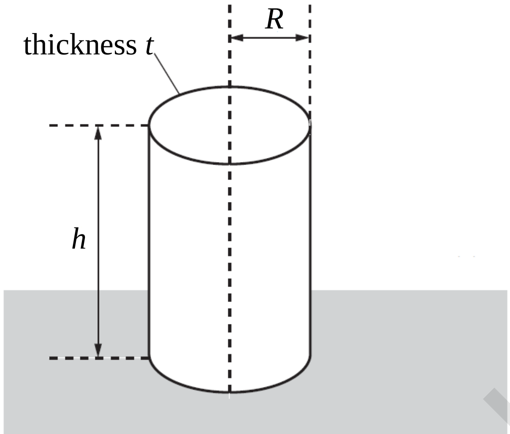
C 4.5 cm

D 9.0 cm

Your answer ☐

[1]

5 A group of civil engineers are assessing whether or not to use solid concrete pillars or hollow metal tubes to support a building. One such tube is shown below. The tube is placed on a horizontal surface. The tube is made of metal of thickness t. The tube has height h and a mean internal radius R. The radius R >> thickness t.



A heavy metal block of mass m is placed on top of the tube.

What is the approximate pressure p acting on the tube?

A $p = \dfrac{mg}{2\pi Rt}$

B $p = \dfrac{mg}{\pi R^2}$

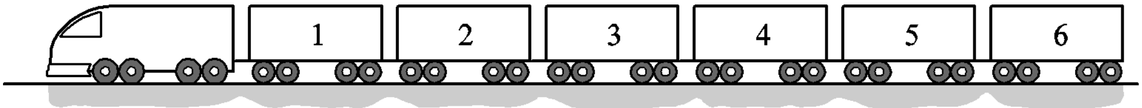
C $p = \dfrac{mg}{\pi R^2 h}$

D $p = \dfrac{mg}{\pi R^2 t}$

Your answer

[1]

6 A train consisting of six trucks each of mass 6.0×10^4 kg is pulled at a constant speed by a locomotive of mass 24×10^4 kg along a straight horizontal track. The horizontal force resisting the motion of each truck is 4000 N.



The coupling between trucks 2 and 3 snaps.

What is the initial acceleration of the locomotive?

A $0.022\,\mathrm{m\,s^{-2}}$

B $0.044\,\mathrm{m\,s^{-2}}$

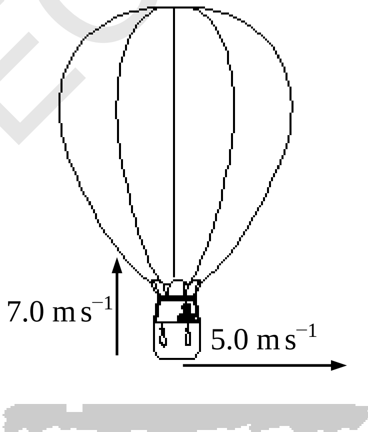
C $0.067\,\mathrm{m\,s^{-2}}$

D $0.133\,\mathrm{m\,s^{-2}}$

Your answer ☐

[1]

7 When a sandbag is dropped from a balloon hovering 1.3 m above the ground, it hits the ground at $5.0\,\mathrm{m\,s^{-1}}$.
On another occasion, the sandbag is released from the balloon which is rising at $7.0\,\mathrm{m\,s^{-1}}$ when 1.3 m above the ground. There is also a crosswind of $5.0\,\mathrm{m\,s^{-1}}$.



At what speed does the sandbag hit the ground?

A $2.0\,\mathrm{m\,s^{-1}}$

B $5.4\,\mathrm{m\,s^{-1}}$

C $10\,\mathrm{m\,s^{-1}}$

D $13\,\mathrm{m\,s^{-1}}$

Your answer ☐

[1]

8 A piece of flat A4 paper is dropped and falls to the floor. The same piece of paper is then collapsed into a ball and dropped again.

Which of the following will change in the second situation?

A the maximum magnitude of the air resistance

B the weight of the paper

C the time taken to reach terminal velocity

D the initial acceleration when dropped

Your answer

[1]

9 A small amount of copper is heated in a container. The copper starts to melt.

Which statement about the melting of copper is correct?

A Temperature is constant and the kinetic energy of the copper atoms increases.

B Temperature increases and the potential energy of the copper atoms increases.

C Temperature is constant and the potential energy of the copper atoms increases.

D Temperature increases and the kinetic energy of the copper atoms increases.

Your answer

[1]

10 What is the correct unit for specific heat capacity?

A $m^2\,s^{-2}\,K^{-1}$

B $m\,s^{-2}\,K^{-1}$

C $m^2\,s^{-1}\,K^{-1}$

D $m^2\,s^{-2}\,K$

Your answer

[1]

11 Betelgeuse is a star in the constellation of Orion which astronomers think could undergo a supernova explosion.

What could Betelgeuse evolve into following the supernova stage?

A main sequence star

B neutron star

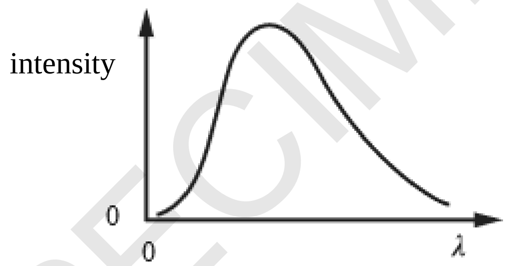
C planetary nebulae

D red giant star

Your answer ☐

[1]

12 Stars emit electromagnetic radiation. A graph of intensity against wavelength λ for a main sequence star is shown.



Which statement is correct as the main sequence star evolves into a red giant?

A the peak wavelength does not change

B the peak wavelength moves towards the origin

C the peak wavelength moves to the left

D the peak wavelength moves to the right

Your answer ☐

[1]

13 When the light from a star is passed through a diffraction grating it forms a spectrum.

Which of the following statements is/are correct?

1 Light emitted from the surface of a star would form a continuous spectrum.

2 Light received from the Sun has dark lines across its spectrum which correspond to the absorption of certain wavelengths by atoms in the Earth's atmosphere.

3 A photon in an emission spectrum occurs when an electron moves from a low to a higher energy level within an atom.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

14 A star has surface temperature 3000 °C and luminosity L. Another star of identical size has a surface temperature of 2500 °C.

What is the luminosity of this second star in terms of L?

A $0.48L$

B $0.52L$

C $0.83L$

D $0.85L$

Your answer ☐

[1]

15 Scientists are planning to launch a rocket from the surface of the Earth into an orbit at a distance of 18000 km above the centre of the Earth. The radius of the Earth is 6400 km and it has mass 6.0×10^{24} kg.

What is the minimum work done to move the 150kg mass of the rocket into this orbit?

A 3.3×10^{9} J

B 7.7×10^{9} J

C 9.4×10^{9} J

D 1.7×10^{10} J

Your answer

[1]

SECTION B

Answer **all** the questions.

16 **(a)** Two cars, **A** and **B**, are travelling clockwise at constant speeds around the track shown in **Fig. 16.1**. The track consists of two straight parallel sections each of length 200 m, the ends being joined by semi-circular sections of diameter 80 m.
The speed of **A** is 20 m s^{-1} and that of **B** is 23 m s^{-1}.

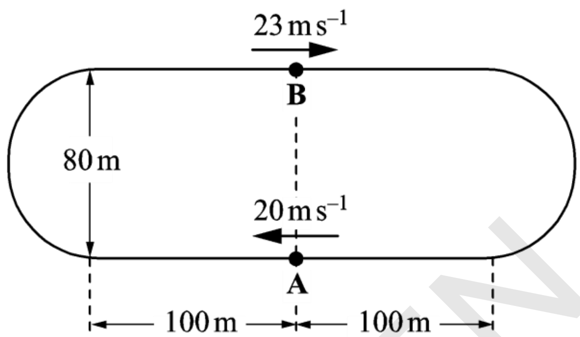


Fig. 16.1

(i) Calculate the time for **A** to complete one lap of the track.

time for one lap = ……………………….. s **[2]**

(ii) Starting from the positions shown in **Fig. 16.1** determine the shorter of the two distances along the track between **A** and **B**, immediately after **A** has completed one lap.

distance = . ……………………….. m **[2]**

(b) Cars **A** and **B** are now on a straight road with car **A** moving at 22 m s^{-1} and car **B** at rest. As car **A** passes car **B**, car **B** accelerates from rest in the same direction at 1.5 m s^{-2} for 16 s. It then moves with constant velocity.

Fig. 16.2 shows the graph of velocity against time for car **A**. The time t = 0 is taken when the cars are alongside.

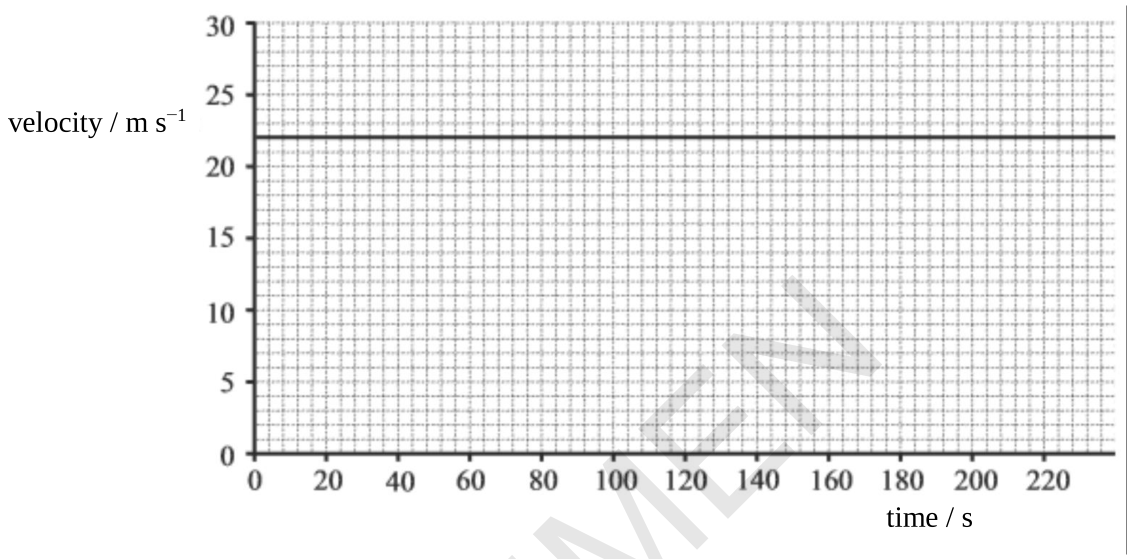


Fig. 16.2

(i) Sketch the graph of velocity against time for car **B** on **Fig. 16.2**. **[2]**

(ii) Determine the time taken for car **B** to be alongside car **A**.

time = …………………….. s **[3]**

17 **(a)** A cyclist moves along a horizontal road. She pushes on the pedals with a constant power of 250 W. The mass of the cyclist and bicycle is 85 kg. The total drag force is $0.4v^2$, where v is the speed of the cyclist.

(i) Calculate the energy provided by the cyclist each minute when the overall efficiency of the cyclist's muscles is 65%.

energy = **……….…………..** J **[2]**

(ii) Calculate the drag force and hence the instantaneous acceleration of the cyclist when the speed is 6.0 m s^{-1}.

acceleration **= ……….…………..** m s^{-2} **[3]**

(b) The cyclist now moves up a slope at a constant speed of 6.0 m s^{-1} and continues to exert a power of 250 W on the pedals.

Fig. 17.1 represents the cyclist and bicycle as a single point **P** on the slope.

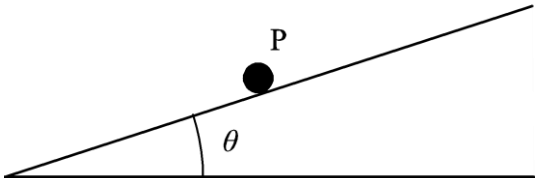


Fig. 17.1

(i) Draw arrows on **Fig. 17.1** to represent the forces acting on **P**. Label each arrow with the force it represents.

[1]

(ii) Calculate the angle θ of the slope to the horizontal.

θ = …………………….. º **[2]**

(c) The cyclist continues to move up the slope at 6.0 m s^{-1} and approaches a gap of width 2.5 m as shown in **Fig. 17.2**.

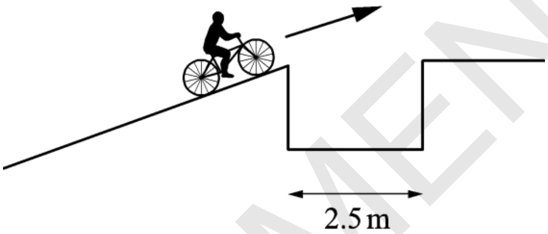


Fig. 17.2

A student has calculated that the cyclist will be able to clear the gap and land on the other side. Another student suggests that this calculation has assumed there is **no** drag and has not accounted for the effect caused by the front wheel losing contact with the slope before the rear wheel.

Without calculation, discuss how drag and the front wheel losing contact with the slope will affect the motion and explain how these might affect the size of the gap that can be crossed successfully.

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18 (a)* A group of scientists have designed an alloy which is less dense than copper but may have similar mechanical properties. A researcher is given the task to determine the Young modulus of this alloy in the form of a wire.

Write a plan of how the researcher could do this in a laboratory to obtain accurate results. Include the equipment used and any safety precautions necessary. **[6]**

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Additional answer space if required.

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(b) **(i)** State the meaning of *elastic* and *plastic* behaviour.

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(ii) Repeatedly stretching and releasing rubber warms it up.
Fig. 18.1 shows a force-extension graph for rubber.

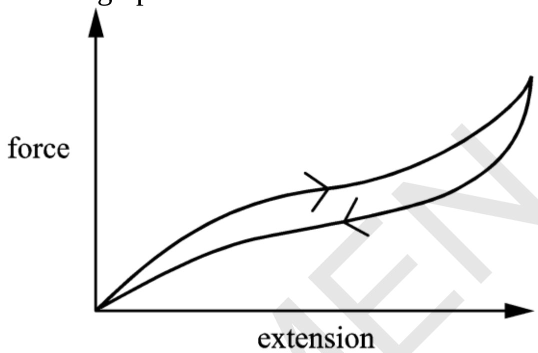

Fig. 18.1

Rubber is an ideal material for aeroplane tyres. Using the information provided, discuss the behaviour and properties of rubber and how its properties minimise the risks when aeroplanes land.

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19 A flat, circular disc moves across a horizontal table with negligible friction.
Fig. 19.1 shows the disc **X** of mass 50 g subject to a force *F*. **Fig. 19.2** shows the variation of the force *F* with time *t*.

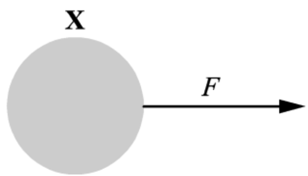

Fig. 19.1

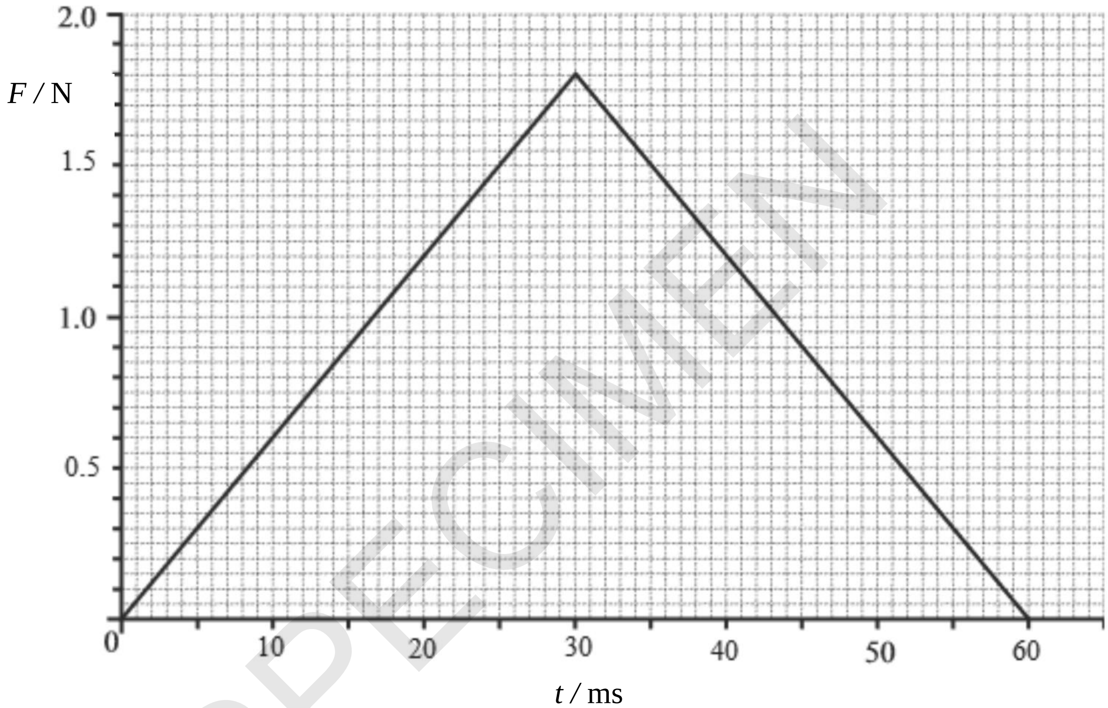

Fig. 19.2

(a) The disc is initially at rest. Calculate the change in velocity of the disc caused by *F*.

change in velocity = **……….…………..** m s^{-1} **[2]**

(b) In a different experiment disc **X** moving at 1.5 m s^{-1} collides elastically with two other discs **Y** and **Z** which are touching and at rest. All the discs are identical. The positions of the discs are shown in **Fig. 19.3**.

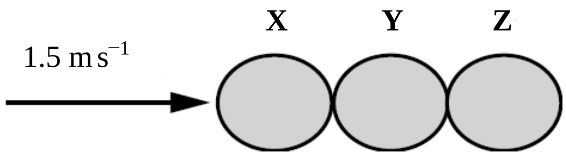

Fig. 19.3

(i) Draw arrows on **Fig. 19.3** to show the relative magnitude and direction of the forces which act on disc **Y** during the collision.

[1]

(ii) State the resultant force on **Y** during the collision.

.... **[1]**

(iii) Show that after the elastic collision **X** is at rest and **Z** moves with a velocity of 1.5 m s^{-1}.

[4]

20 **(a)** The apparatus shown in **Fig. 20.1** is used to investigate the variation of the product PV with temperature in the range 20 °C to 100 °C. The pressure exerted by the air is P and the volume of air inside the flask is V.

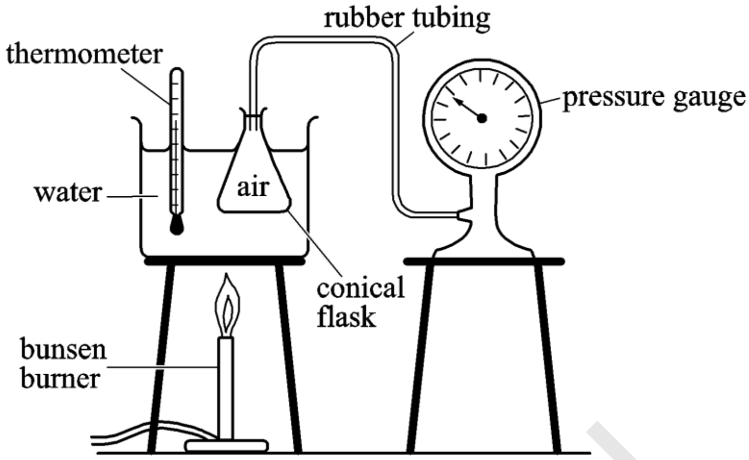

Fig. 20.1

Describe how this apparatus can be set up and used to ensure accurate results.

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.... **[4]**

(b) An investigation similar to that shown in **Fig. 20.1** gives measurements of the pressure P, volume V and temperature θ in degrees Celsius of a fixed mass of gas.

The results are used to plot the graph of PV against θ shown in **Fig. 20.2**.

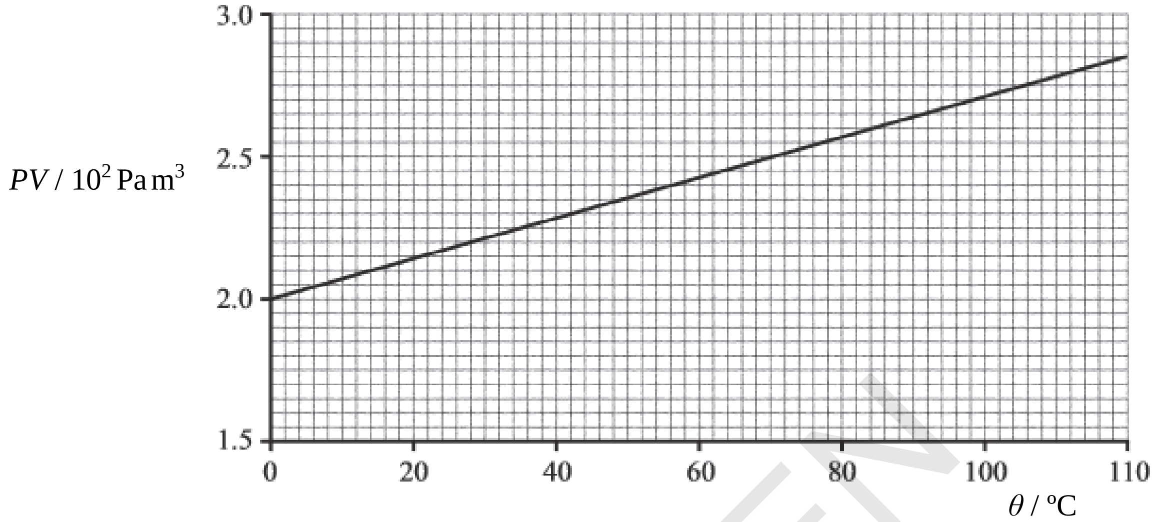

Fig. 20.2

(i) Explain, in terms of the motion of particles, why the graph does **not** go through the origin.

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....

.... **[2]**

(ii) The mass of a gas particle is 4.7×10^{-26} kg. Use the graph in **Fig 20.2** to calculate

1 the mass of the gas

mass = ... kg

2 the internal energy of the gas at a temperature of 100 °C.

internal energy = ... J **[4]**

21 A stabilising mechanism for electrical equipment on board a high-speed train is modelled using a 5.0g mass and two springs, as shown in **Fig. 21.1**. For testing purposes, the springs are horizontal and attached to two fixed supports in a laboratory.

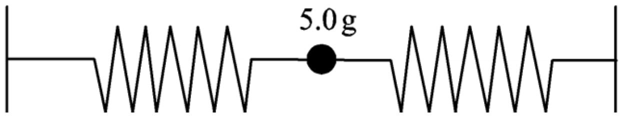

Fig. 21.1

(a) Explain why the mass oscillates with simple harmonic motion when displaced horizontally.

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……………………………………………………………………………………………… **[2]**

(b) **Fig. 21.2** shows the graph of displacement against time for the oscillating mass.

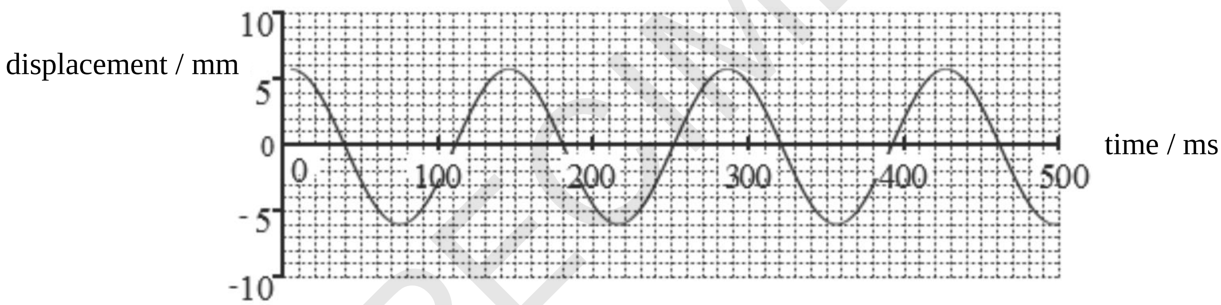

Fig. 21.2

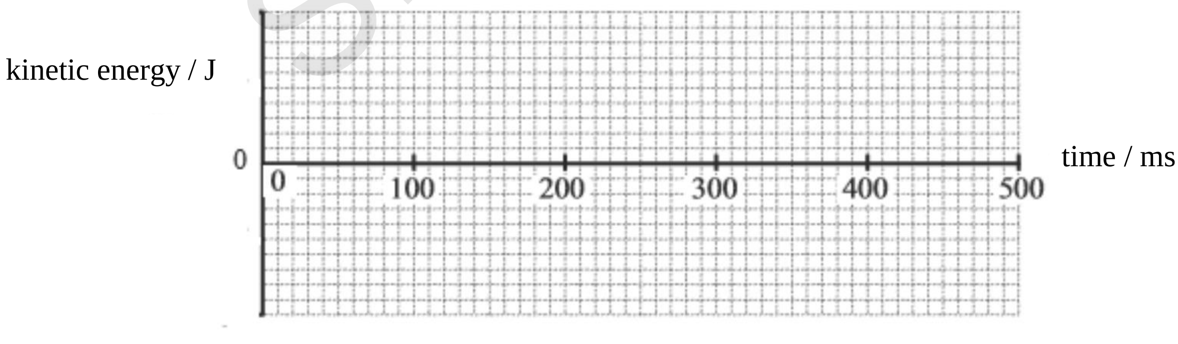

Fig. 21.3

(i) Determine the maximum acceleration of the mass during the oscillations.

maximum acceleration = ... m s^{-2} **[2]**

(ii) Calculate the maximum kinetic energy of the mass during the oscillations.

maximum kinetic energy = ... J **[2]**

(c) On **Fig. 21.3** sketch a graph showing the variation of kinetic energy with time. Add a scale to the kinetic energy axis.

[2]

(d) Plan how you can obtain experimentally the displacement against time graph for the oscillating mass in the laboratory. Include any steps taken to ensure the graph is an accurate representation of the motion.

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.... **[4]**

22 **(a)** Explain how Newton's law of gravitation is applied between two non-spherical asteroids.

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.... **[1]**

(b) A satellite moves in a circular orbit of radius 15 300 km from the centre of the Earth.

(i) State one of the main benefits satellites have on our lives.

....

.... **[1]**

(ii) Calculate the gravitational field strength g at the radius of 15 300 km.

g = ...N kg^{-1} **[2]**

(iii) Calculate the period of the orbiting satellite.

period = ... s **[3]**

(c) Determine the average density of the Earth. The radius of the Earth is 6400 km.

average density = ... kg m^{-3} **[3]**

23 **(a)** State and explain how *stellar parallax* is used to measure distances in space.

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……………………………………………………………………………………..…….......... **[3]**

(b) **Fig. 23.1** gives some data on the wavelength of a hydrogen spectral line for light received from the Andromeda galaxy and the Virgo cluster of galaxies.

	wavelength of hydrogen line from galaxy / nm	wavelength of hydrogen line on Earth / nm
Andromeda galaxy	485.6	486.1
Virgo cluster	489.8	486.1

Fig. 23.1

(i) The Virgo cluster is 16.5 Mpc from the Earth.

Estimate the age of the Universe using data from **Fig. 23.1**.

age = …………….………….. s **[3]**

(ii) Suggest why hydrogen spectral lines might often be used to measure a star's velocity.

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…………………………………………………………………………………………….... **[2]**

(c)* The Big Bang theory is an explanation for the start of the Universe.

Explain how the cosmic microwave background radiation supports the Big Bang theory for the start of the Universe. Comment on the relevance of the data in **Fig. 23.1** concerning the Big Bang theory. **[6]**

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END OF QUESTION PAPER

Oxford Cambridge and RSA

…day June 20XX–Morning/Afternoon

A Level Physics A

H556/01 Modelling physics

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

This document consists of 20 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space

   - OR if there is a comment which does not in any way relate to the question (e.g. ‘can’t do’, ‘don’t know’)

   - OR if there is a mark (e.g. a dash, a question mark) which isn’t an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

- Read through the whole answer from start to finish.

- Decide the level that **best fits** the answer – match the quality of the answer to the closest level descriptor.

- To select a mark within the level, consider the following:

  Higher mark: A good match to main point, including communication statement (in italics), award the higher mark in the level
  Lower mark: Some aspects of level matches but key omissions in main point or communication statement (in italics), award lower mark in the level.

  Level of response questions on this paper are **18a** and **23c**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Additional Guidance.

SECTION A

Question	Answer	Marks	Guidance
1	D	1	
2	D	1	
3	C	1	
4	C	1	
5	A	1	
6	B	1	
7	C	1	
8	C	1	
9	C	1	
10	A	1	
11	B	1	
12	D	1	
13	D	1	
14	B	1	
15	B	1	
	Total	**15**	

SECTION B

Question			Answer	Marks	Guidance
16	(a)	(i)	Circumference = (2 x 200) + (2π x 40) = 651.3 m Time for A to complete one lap = $\frac{651.3}{20}$ = 33 (s)	C1 A1	 accept 32.6
		(ii)	Distance moved by B = 23 x 32.6 = 749.8 m (B has travelled 749.8m – 651.3m more than A) 98.5m to the right from its initial starting point. Distance from A to B = (651.3/2) – 98.5 =227m	C1 A1	Accept calculation of relative speed followed by relative distance. Accept (651.3/2) – 108 using 33s to give 218m
	(b)	(i)	Constant acceleration from 0 shown correctly followed by constant velocity. Constant velocity at 24 m s^{-1} starting at t = 16 s	B1 B1	
		(ii)	Distance moved by B = $(1/2 \times 1.5 \times 16^2) + 24(t - 16)$ $(1/2 \times 1.5 \times 16^2) + 24(t - 16) = 22t$ t = 96 (s)	C1 C1 A1	Alternative method of equating areas. Distance moved by B = (8 x 24) + (24(t – 16)) 22t = (8 x 24) + 24(t – 16) t = 96
			Total	**9**	

Question			Answer	Marks	Guidance
17	(a)	(i)	250 x 60 = 15000 J energy = $\frac{15000}{0.65}$ = 2.3×10^4 (J)	C1 A1	
		(ii)	drag force = 0.4×6.0^2 = 14.4 N forward force = power/velocity = 250/6.0 = 41.7 N acceleration = $\frac{41.7 - 14.4}{85}$ = 0.32 m s^{-2}	C1 C1 A1	
	(b)	(i)	weight; (tractive) force up slope; drag; (normal) reaction. All forces in correct direction and correctly labelled.	B1	
		(ii)	14.4 + (85 x 9.81 x sin θ) = 41.7 θ = 1.9 °	C1 A1	**ecf** from **(a)(ii)**
	(c)		any three from: • drag reduces velocity **or** increases time to cross **or** some kinetic energy of cyclist goes to heat. • longer crossing time results in cyclist at lower point on other side of gap. • moment on bicycle • rotation lowers height of front wheel. Conclusion based on argument(s). The maximum gap width is smaller.	B1 x 3 B1	Allow argument based on: • very short crossing time (< 0.43s at speed of 6ms^{-1} up slope). • energy changed to heat insignificant compared to KE • amount of rotation very small in short time. conclusion based on argument(s). So no change in maximum gap width.
			Total	**12**	

Question			Answer	Marks	Guidance
18	(a)*		**Level 3 (5–6 marks)** All points E1, 2, 3 and 4 for equipment All points M1, 2, 3 and 4 for measurements For calculations expect C1, C2, C3 and C4 Expect at least two points from reliability *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Expect E1 and E2; E3 or E4 for equipment Expect M2 and two from M1, M3, M4 for measurements For calculations expect at least C3 and C4 Expect at least one point from reliability *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Expect at least E1 and E2 for equipment Expect at least two from measurements Expect C5 for the calculation No real ideas for obtaining reliable results *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**B1 x6**	The complete plan consists of four parts: **Equipment used safety (E)** 1. Wire fixed at one end with load added to wire 2. Suitable scale with suitable marker on wire. 3. Micrometer screw-gauge **or** digital**/**vernier callipers for measuring diameter of wire. 4. Reference to safety concerning wire snapping **Measurements (M)** 1. Original length from fixed end to marker on wire. 2. Diameter of wire. 3. Measure load. 4. New length of wire when load increased. **Calculation of Young modulus. (C)** 1. Find extension (for each load) or strain (for each load) 2. Determine cross-sectional area or stress 3. Plot graph of load-extension **or** graph of stress-strain 4. Young modulus = gradient x original length/area **or** Young modulus = gradient 5. Calculate Young modulus from single set of measurements of load, extension, area and length. **Reliability of results (R)** 1. Measure diameter in 3 or more places and take average. 2. Put on initial load to tension wire and take

Question			Answer	Marks	Guidance
					up 'slack' before measuring original length. 3. Take measurements of extension while unloading to check elastic limit has not been exceeded. 4. Use long wire (to give measurable extension) Scale or ruler parallel to wire.
	(b)	**(i)**	Elastic: material returns to original dimensions when load is removed. Plastic: material has permanent change of shape when load is removed.	**B1**	
		(ii)	The material is elastic because the removal of force returns the rubber to its original length. The area under force-extension graph is work done. Repeated stretching and releasing the rubber warms up the rubber because not all the strain energy is returned back. The area enclosed represents the amount of thermal energy. During landing, some of the aeroplane's kinetic energy is transferred to thermal energy and therefore the aeroplane does not "bounce" during landing; hence this minimises the risk to passengers.	**B1** **B1** **B1**	 Mentioning 'hysteresis' is not enough to gain this mark.
			Total	**10**	

Question			Answer	Marks	Guidance
19	(a)		Area under graph = 0.5 x 0.06 x 1.8 = 0.054 (Ns) 0.05 x v = 0.054, therefore v = 1.1 (m s^{-1})	C1 A1	
	(b)	(i)	Both forces shown in correct direction and arrows of same length.	B1	
		(ii)	Zero.	B1	
		(iii)	(Conservation of momentum) $u_X = v_X + v_Z$ (Conservation of kinetic energy) $u^2_X = v^2_X + v^2_Z$ Shows $v_x = 0$ by substitution $v_Z = u_X$ by substitution of $v_x = 0$	C1 C1 C1 A1	
			Total	**8**	

Question			Answer	Marks	Guidance
20	(a)		Ensure largest possible proportion of flask is immersed. Make volume of tubing small compared to volume of flask. Remove heat source and stir water to ensure water at uniform temperature throughout. Allow time for heat energy to conduct through glass to air before reading temperature.	**B1 x 4**	
	(b)	(i)	Pressure is caused by collisions of particles with sides. Velocity of particles (and volume of gas) are not zero at 0°C	**B1** **B1**	
		(ii)	**1:** Gradient of graph $0.75 \times 10^2 / 100 = 0.75$ Number of moles of gas = gradient/R = 0.75/8.31 = 0.09 Mass of gas = $0.09 \times 6.02 \times 10^{23} \times 4.7 \times 10^{-27} = 2.5 \times 10^{-4}$ (kg) **2:** Internal energy = 3/2 x NkT $= 1.5 \times 0.09 \times 6.02 \times 10^{23} \times 1.38 \times 10^{-23} \times (100 + 273)$ = 410 (J)	**C1** **A1** **C1** **A1**	Alternative method Internal energy = 3/2 x p x V At θ = 100°C pV = 2.73×10^2 Internal energy = $1.5 \times 2.73 \times 10^2 = 410$ (J)
			Total	**10**	

Question			Answer	Marks	Guidance
21	(a)		Resultant force from springs is proportional to displacement from centre **or** acceleration (of mass) is proportional to displacement from centre.	B1	
			Directed to centre or fixed point.	B1	
	(b)	(i)	Period from graph = 500/3.5 = 143 ms	C1	
			Acceleration = ω^2 A = $(2\pi/0.143)^2$ x 0.006 = 12 (m s^{-2})	A1	
		(ii)	KE = 0.5 x 0.005 x $(2\pi$ / 0.143 x $0.006)^2$	C1	
			KE = 1.7 x 10^{-4} (J)	A1	
	(c)		Graph correct shape and always positive and suitable scale on kinetic energy axis.	B1	
			Maxima occur at zero displacement times.	B1	

Question			Answer	Marks	Guidance
	(d)		**Accept any sensible and successful method.** **Stroboscope:** Any two from • Use of stroboscope of known frequency or period • Photograph to capture several positions on one picture • Measure displacement from centre using a scale put behind the mass. **or** **Motion sensor:** Any two from • Motion sensor connected to data logger which sends information on displacement and time to computer. • Sensor placed close to moving mass to eliminate reflections from other objects. • Small reflector attached to mass.	**B1 x 2**	Video camera with freeze frame facility, where time between frames is known. Apply marking points as for the stroboscope.
			Safeguards to ensure accuracy **Stroboscope:** Any two from • Use frequency such that positions of mass are close together on photograph. • distance scale close to oscillating mass or camera set back from mass to reduce parallax. • Camera should be directed at equilibrium point or at 90° to oscillation. **or** **Motion sensor:** Any two from • Any attached reflector should not cause damping. • Motion sensor directed along line of oscillation or motion sensor signal blocked by supports so must be as near to line of oscillation as possible. • Use thin supports to reduce reflections.	**B1 x 2**	
			Total	**12**	

Question			Answer	Marks	Guidance
22	(a)		Force is proportional to the product of the mass of each asteroid. **and** the force is inversely proportional to the distance squared between the centres of mass of the asteroids.	B1	
	(b)	(i)	Any sensible suggestion, e.g. Satellites used for global communication, instant access to news, weather forecasting etc.	B1	
		(ii)	$g = (6400/15300)^2 \times 9.81$ $g = 1.72$ (N kg^{-1})	C1 A1	
		(iii)	Acceleration towards centre = 1.72 m s^{-2} or centripetal force = mass of satellite x 1.72 N $T^2 = 4 \times \pi^2 \times 1.53 \times 10^7 / 1.72$ $T = 1.87 \times 10^4$ (s)	C1 C1 A1	ecf (b)(i) Allow 1.9
	(c)		Use of $M = gr^2 / G$ (accept any subject) Density = $3g / 4\pi rG = 3 \times 9.81/4\pi \times 6.4 \times 10^6 \times 6.67 \times 10^{-11}$ $= 5.49 \times 10^3$ (kg m^{-3})	C1 C1 A1	Calculation using g = 1.72 at radius of 15300 km Possible ecf from **(b)(i)** Density = $\dfrac{3 \times 1.72 \times (1.53 \times 10^7)^2}{4\pi \times (6.4 \times 10^6)^3 \times 6.67 \times 10^{-11}}$ $= 5.50 \times 10^3$ kg m^{-3}
			Total	**10**	

Question			Answer	Marks	Guidance
23	(a)		Apparent motion or displacement of a star relative to the position of more distant stars. Caused by the Earth's orbit around the Sun. An angle of parallax of 1 arcsecond when displacement of Earth is 1AU corresponds to distance 1 pc	B1 B1 B1	
	(b)	(i)	$v = \dfrac{(489.8 - 486.1) \times 3 \times 10^8}{486.1}$ $(= 2.28 \times 10^6 \text{ m s}^{-1})$ age $= 1/H_o = \dfrac{16.5 \times 10^6 \times 3.1 \times 10^{16}}{2.28 \times 10^6}$ age $= 2.2 \times 10^{17}$ (s)	C1 C1 A1	
		(ii)	Hydrogen is most common element in stars or Hydrogen has most intense (spectral) lines. Intensity of light from other elements may be too low for accurate measurement.	B1 B1	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>23</td><td>(c)*</td><td></td><td>Level 3 (5–6 marks)
Expect T1 and T2 for the Big Bang Theory
Expect full discussion of red shift points R1, 2, 3 and 4
Expect at least B1 and B2 for the Blue Shift
Expect C1 and any three from C2, C3, C4, C5 for CMBR

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)
Expect T1 and T2 for the Big Bang Theory
Expect R1 and R2; red shift identified but no explanation why it implies an expanding Universe
Expect B1 and B2; blue shift identified with no explanation of cause
Expect any three from C1, 2, 3, 4 and 5; CMBR evidence recalled but linked to the Big Bang

There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</td><td>B1x6</td><td>Big Bang Theory (T)
1. Predicts that all galaxies will be receding.
2. Galaxy velocity proportional to distance from Earth.

Red Shift (R)
1. Radiation from Virgo shows increase in wavelength or red shift
2. Change in wavelength caused by motion of galaxy or reference to Doppler Effect
3. Evidence that Virgo is receding from Earth.
4. Support for Big Bang theory.

Blue Shift (B)
1. Andromeda shows blue shift
2. Andromeda approaching Earth
3. Caused by gravitational attraction.

CMBR (C)
1. Formed as gamma radiation at Big Bang
2. Galactic red shift to microwave wavelength
3. Intensity is uniform in all directions
4. Corresponds to a temperature of 2.7K
5. (Very small) ripples in intensity corresponding to formation of first stars or galaxies.</td></tr>
</table>

Question			Answer	Marks	Guidance
			Level 1 (1–2 marks) Expect T1 or T2 for the Big Bang Theory Expect R1, R2 or B1, B2; red shift or blue shift identified but without explanation or link to Big Bang Theory Expect at least one from C1, 2, 3, 4 and 5; CMBR evidence recalled but not linked to the Big Bang *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.		
			Total	**14**	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions