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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**				

SPECIMEN

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.

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

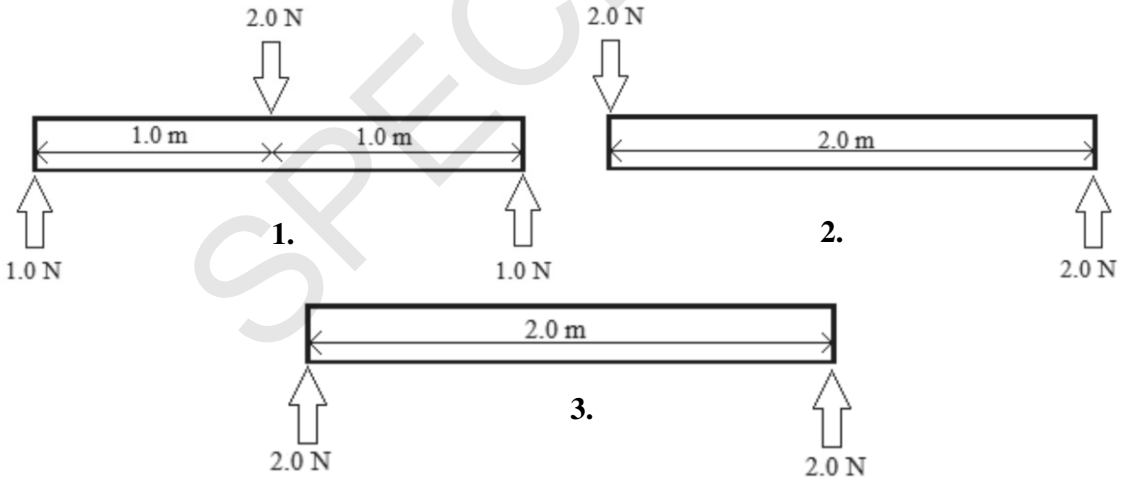
C ± 5 mm

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]

SPECIMEN

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.

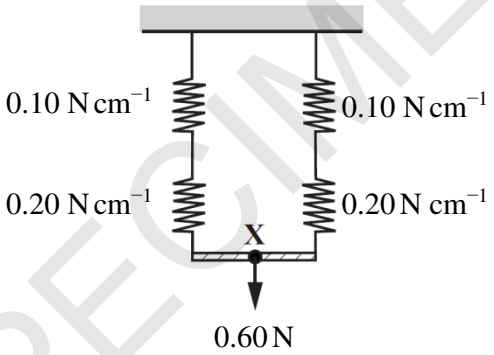
C The resistor transfers 12 joule in 2.0 second.

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 N cm^{-1} is placed in series with one of 0.20 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

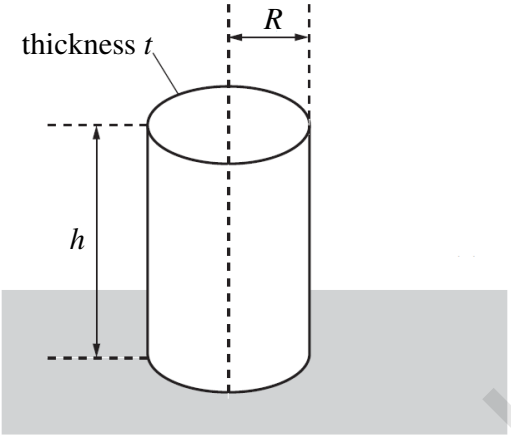
D 9.0 cm

Your answer ☐

[1]

SPECIMEN

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

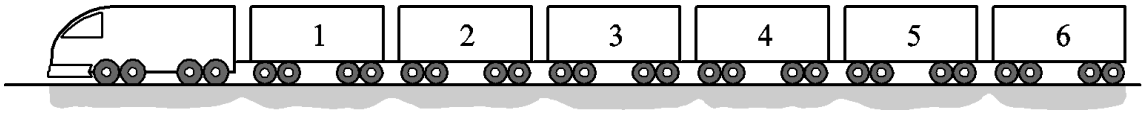
D $p = \dfrac{mg}{\pi R^2 t}$

Your answer ☐

[1]

SPECIMEN

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 $0.022\,\text{m s}^{-2}$

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

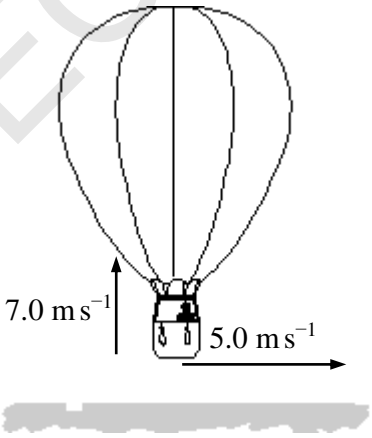
C $0.067\,\text{m s}^{-2}$

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

Your answer ☐

[1]

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



At what speed does the sandbag hit the ground?

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

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

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

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

Your answer ☐

[1]

SPECIMEN

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]

SPECIMEN

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

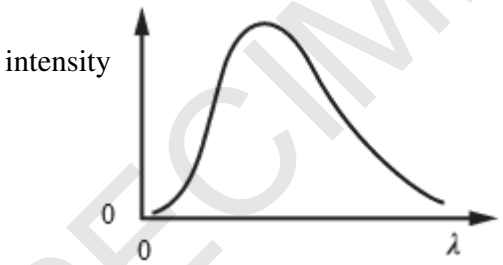
C planetary nebulae

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]

SPECIMEN

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 0.48*L*

B 0.52*L*

C 0.83*L*

D 0.85*L*

Your answer ☐

[1]

SPECIMEN

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]

SPECIMEN

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}.

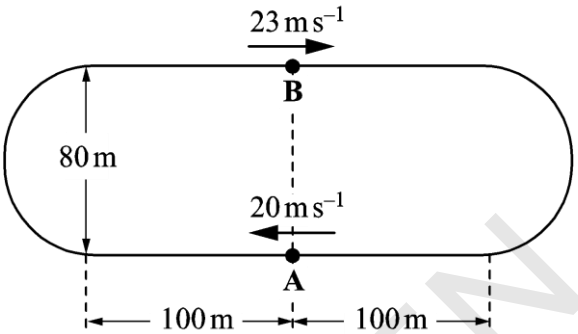


Fig. 16.1

(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]**

SPECIMEN

(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.

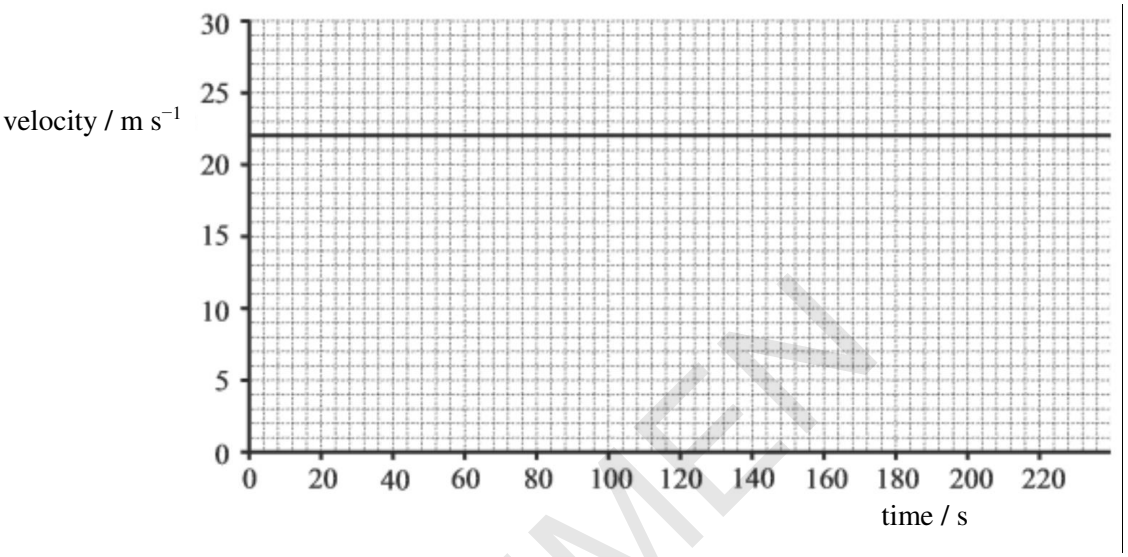


Fig. 16.2

(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]**

SPECIMEN

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.

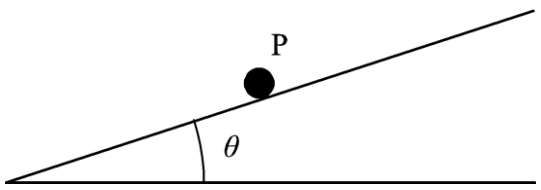


Fig. 17.1

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

[1]

SPECIMEN

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

θ = …….. ° **[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**.

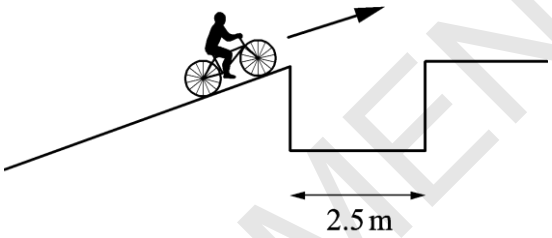


Fig. 17.2

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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…… **[4]**

SPECIMEN

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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SPECIMEN

Additional answer space if required.

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SPECIMEN

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

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…… **[1]**

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

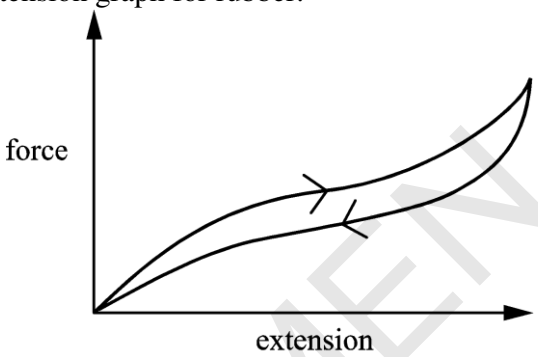

Fig. 18.1

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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…… **[3]**

SPECIMEN

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SPECIMEN

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*.

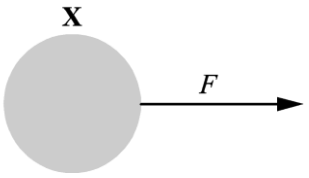

Fig. 19.1

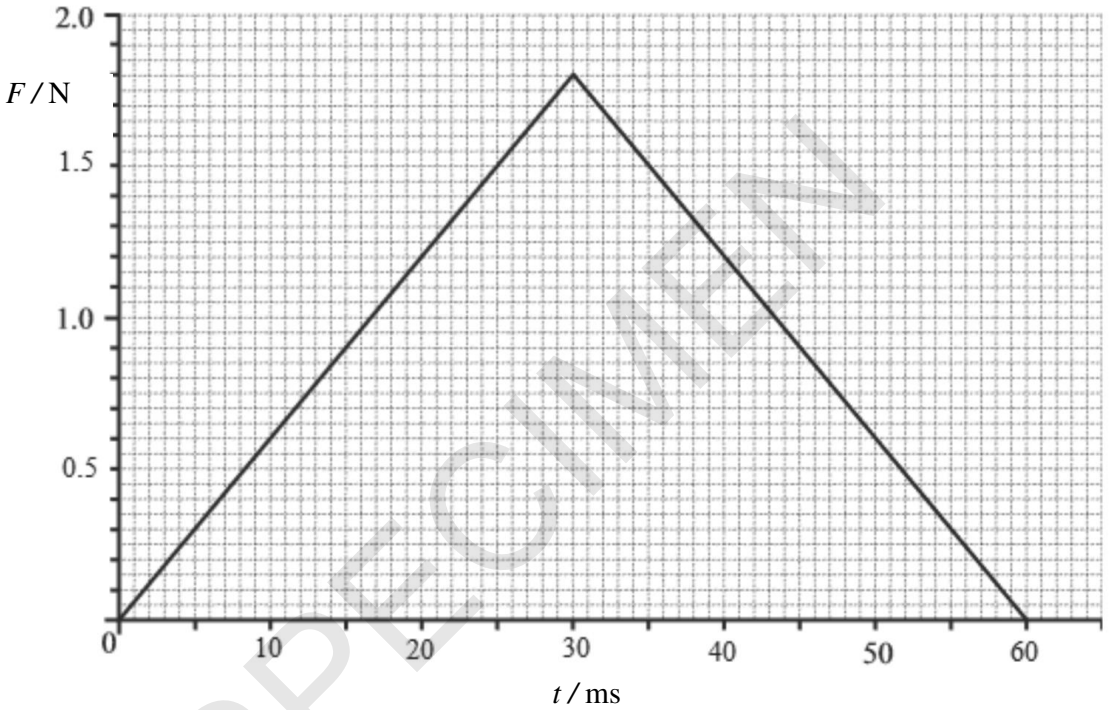

Fig. 19.2

(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]**

SPECIMEN

(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**.

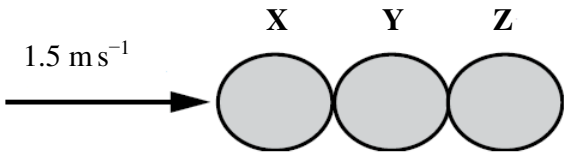

Fig. 19.3

(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]

SPECIMEN

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*.

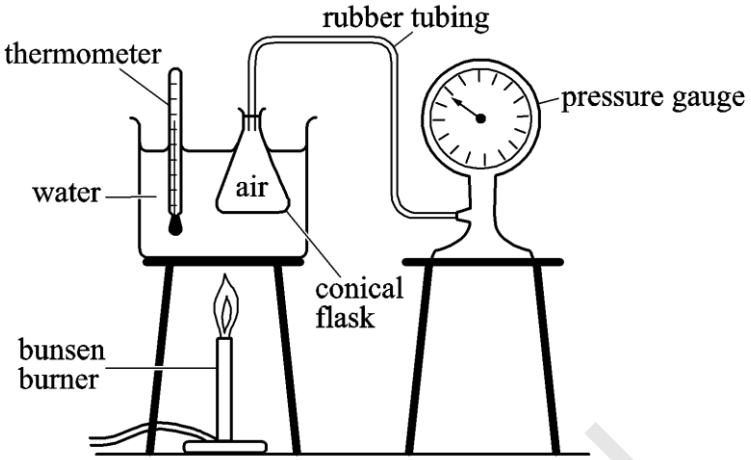

Fig. 20.1

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

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..... **[4]**

SPECIMEN

(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**.

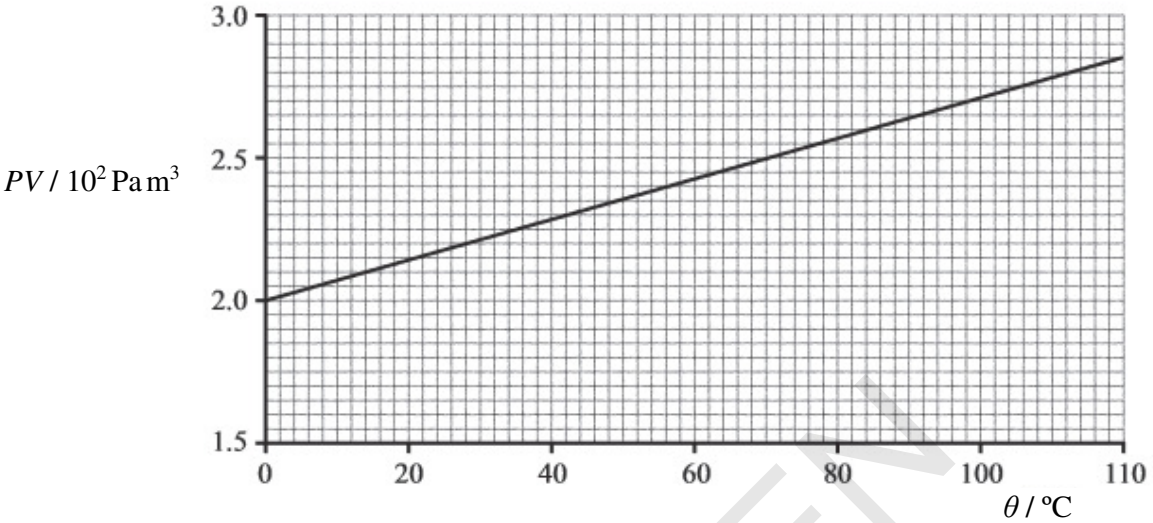

Fig. 20.2

(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 x 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]**

SPECIMEN

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.

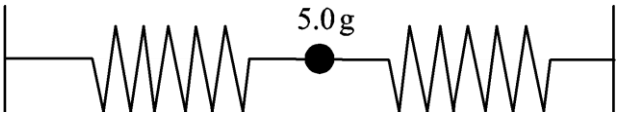

Fig. 21.1

(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.

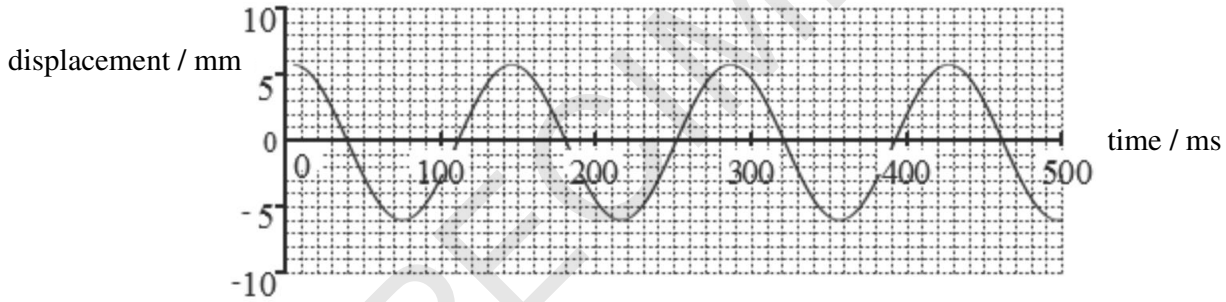

Fig. 21.2

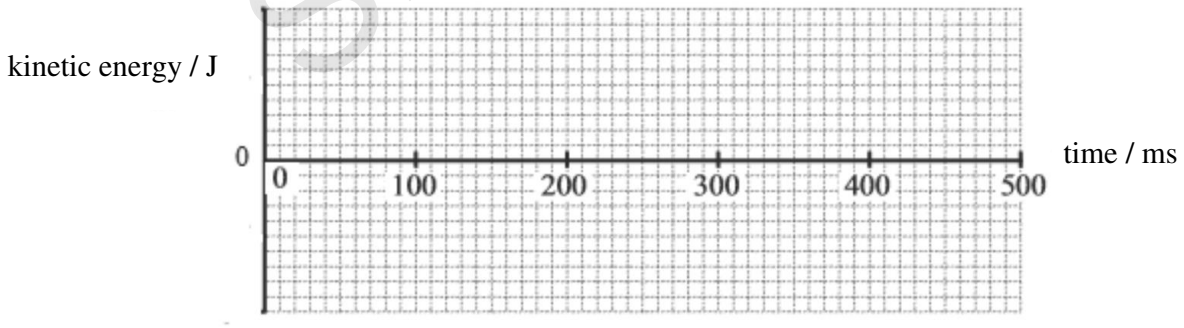

Fig. 21.3

SPECIMEN

(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.

SPECIMEN

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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.

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..... **[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]**

SPECIMEN

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]**

SPECIMEN

(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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Additional answer space if required.

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END OF QUESTION PAPER

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