Rewarding Learning

**ADVANCED**
**General Certificate of Education**
**2019**

Centre Number

Candidate Number

# Physics

Assessment Unit A2 1
*assessing*
Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

**[APH11]**

*APH11*

**MONDAY 20 MAY, AFTERNOON**

**TIME**

2 hours.

**INSTRUCTIONS TO CANDIDATES**

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
**You must answer the questions in the spaces provided.**
**Do not write outside the boxed area on each page or on blank pages.**
Complete in black ink only. **Do not write with a gel pen.**
Answer **all nine** questions.

**INFORMATION FOR CANDIDATES**

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part-question.
Quality of written communication will be assessed in Question **9(a)**.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

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**1** A graph showing how the extension of a length of metal wire varies with an applied force is shown in **Fig. 1.1**. The metal wire obeys Hooke's law over the range indicated.

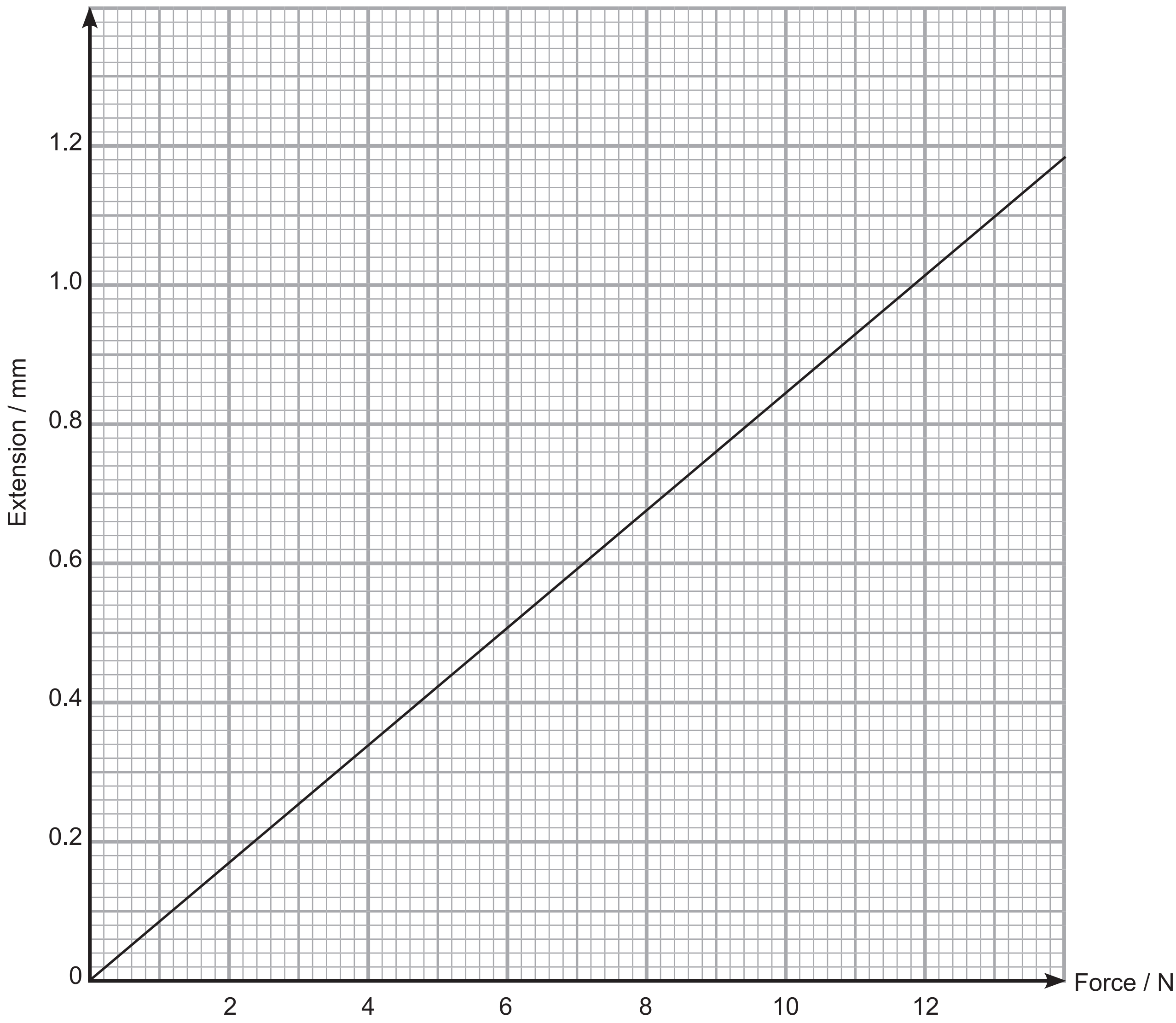


**Fig. 1.1**

**(a)** **(i)** State Hooke's law.

______________________________________________

______________________________________________ [2]

**(ii)** Use the graph in **Fig. 1.1** to determine the force constant k for this sample of wire.
Give your answer in N $mm^{-1}$.

Force constant k = ________________ N $mm^{-1}$ [3]

**(iii)** Draw a labelled diagram of an experimental arrangement which could be used to obtain the results needed to plot the graph in **Fig. 1.1**.

[5]

**(b) (i)** The wire has an unstretched length of 2.0 m and a diameter of 0.40 mm. Calculate the Young modulus of this metal.

Young modulus = ________________ N $m^{-2}$ [4]

**(ii)** State how the electrical resistance of the wire would change after being stretched, explaining your answer with reference to an appropriate mathematical relationship.

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________ [4]

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**(Questions continue overleaf)**

**2** **(a)** A mass m of 0.15 kg rotates clockwise in a horizontal circle of radius 0.80 m with a constant angular velocity of 2.4 rad $s^{-1}$ as shown in **Fig. 2.1**.

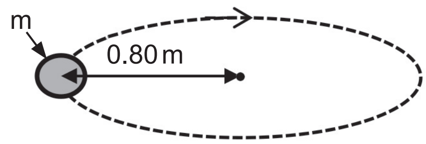



**Fig. 2.1**

**(i)** Calculate how long it takes for the mass to complete one revolution.

Time = ________________ s [2]

**(ii)** Calculate the linear speed of the mass.

Linear speed = ________________ m $s^{-1}$ [3]

**(iii)** Calculate the acceleration of the mass.

Acceleration = ________________ m $s^{-2}$ [3]

**(b)** For the mass to move in the horizontal circle described in **(a)**, it was attached to a string as shown in **Fig. 2.2**.

Determine the value of the tension T in the string.
W is the weight of the mass.

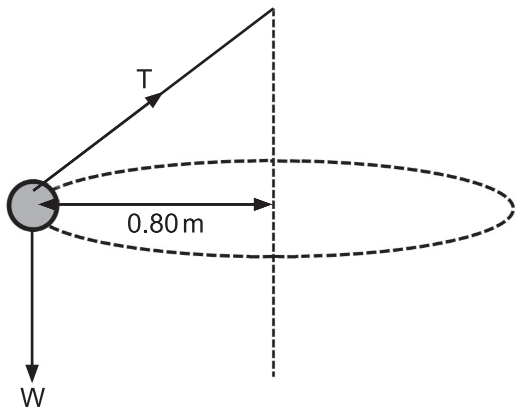



**Fig. 2.2**

T = ________________ N [4]

**3** A metal ruler is clamped to a desk with a load attached to the other end as shown in **Fig. 3.1**. This end is displaced downwards by 5.0 cm and released allowing the system to oscillate with simple harmonic motion.

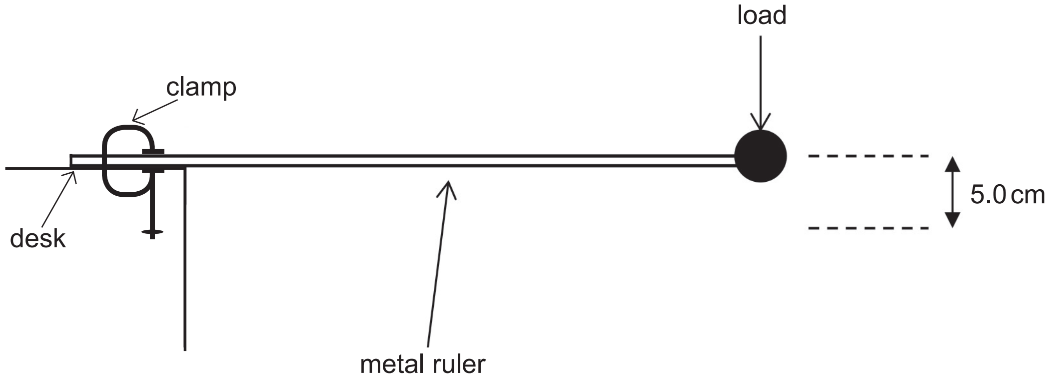



**Fig. 3.1**

**(a) (i)** The displacement x of the load varies with time t according to $x = A \cos \omega t$ and is as shown by the graph in **Fig. 3.2**. Use the information on the graph to determine the value of the constant $\omega$.

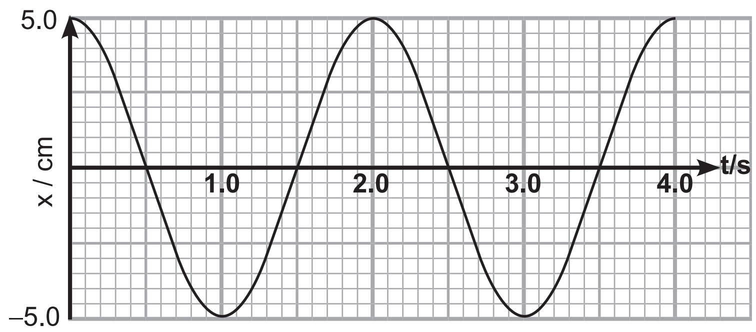


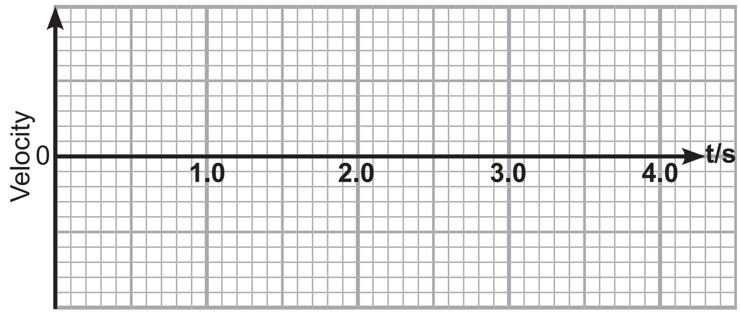

**Fig. 3.2**

$\omega$ = ______________ rad $s^{-1}$ [2]

**(ii)** Determine the value of the maximum velocity of the load from the graph shown in **Fig. 3.2**.

Maximum velocity = _______________ m s$^{-1}$ [3]

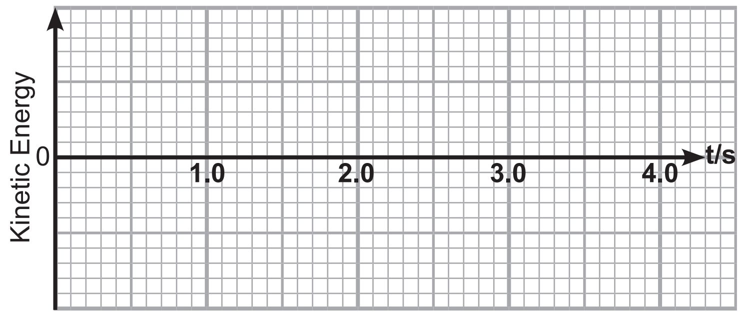
**(b) (i)** On **Fig. 3.3**, sketch a graph to show how the velocity of the load varies with time over the 4.0 seconds. You do not need to insert numerical values on the velocity axis.




[2]

**Fig. 3.3**

**(ii)** On **Fig. 3.4**, sketch a graph to show how the kinetic energy of the load varies with time over the 4.0 seconds. You do not need to insert numerical values on the kinetic energy axis.




[2]

**Fig. 3.4**

**4** A mass is attached to a spring and forced to oscillate with different, known frequencies. The displacement of the mass is observed.

**(a)** What is the name given to describe the condition when the mass oscillates with **maximum** amplitude?

______________________________________________ [1]

**(b)** Sketch a graph on the axes in **Fig. 4.1** to show how the amplitude of the forced oscillations depends on the frequency of the driving force. [1]


**Fig. 4.1**

**(c)** The system is now damped by immersing the mass in water. Sketch a second graph on the axes of **Fig. 4.1** to show how this would affect the amplitude of the forced oscillations. Label this graph **D**. [3]

**5** Einstein stated that mass and energy are equivalent. If an aluminium block of mass 2.50 kg is heated using an element rated at 28 W for 12 minutes then theoretically, according to Einstein's equation, its mass will change.

**(a)** Calculate the maximum theoretical change in mass.

Change in mass ______________ kg [6]

**(b)** State whether the mass increases or decreases. ________________ [1]

.

**6** The ITER Project is a fusion reactor currently under construction in southern France. At temperatures required for fusion, the fuel used is in the form of a plasma. This plasma is contained within a tokamak vacuum vessel at the centre of the reactor where the fusion reactions take place.

**(a) (i)** Describe what a plasma is.

______________________________________________

______________________________________________ [1]

**(ii)** The fuel to be used in the ITER consists of deuterium and tritium. Write down the equation that represents the nuclear fusion of deuterium and tritium.

______________________________________________ [1]

**(iii)** The walls of the tokamak vacuum vessel are lined with a beryllium blanket approximately 0.5 m thick. What is the function of this blanket?

______________________________________________

______________________________________________ [1]

**(iv)** ITER will use three methods to heat the plasma to the very high temperatures required for fusion to occur. One of the methods involves transferring the energy from a high intensity beam of electromagnetic radiation into the plasma. Explain how this is achieved as efficiently as possible.

______________________________________________

______________________________________________

______________________________________________ [2]

**(b)** The plasma in the ITER will be superheated to approximately 150 million kelvin. Calculate the average kinetic energy of the plasma particles at this temperature if nuclear fusion is to occur.

Kinetic energy = ________________ J [2]

**7** The equipment shown in **Fig. 7.1** can be used to investigate the relationship between the volume of a gas and its temperature.

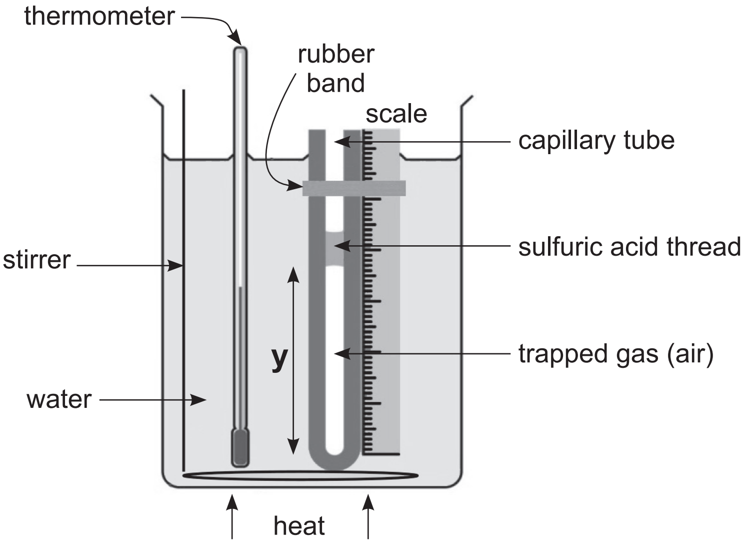





**Fig. 7.1**

**(a) (i)** Using this arrangement, identify the factors that are kept constant in the investigation.

______________________________________________

______________________________________________

______________________________________________ [2]

**(ii)** Explain why the length y of the gas column can be used instead of the volume of the gas when investigating the relationship.

______________________________________________

______________________________________________

______________________________________________ [2]

**(iii)** Complete the labelling of the x-axis in **Fig. 7.2** and sketch the graph that you would expect to obtain from the investigation.

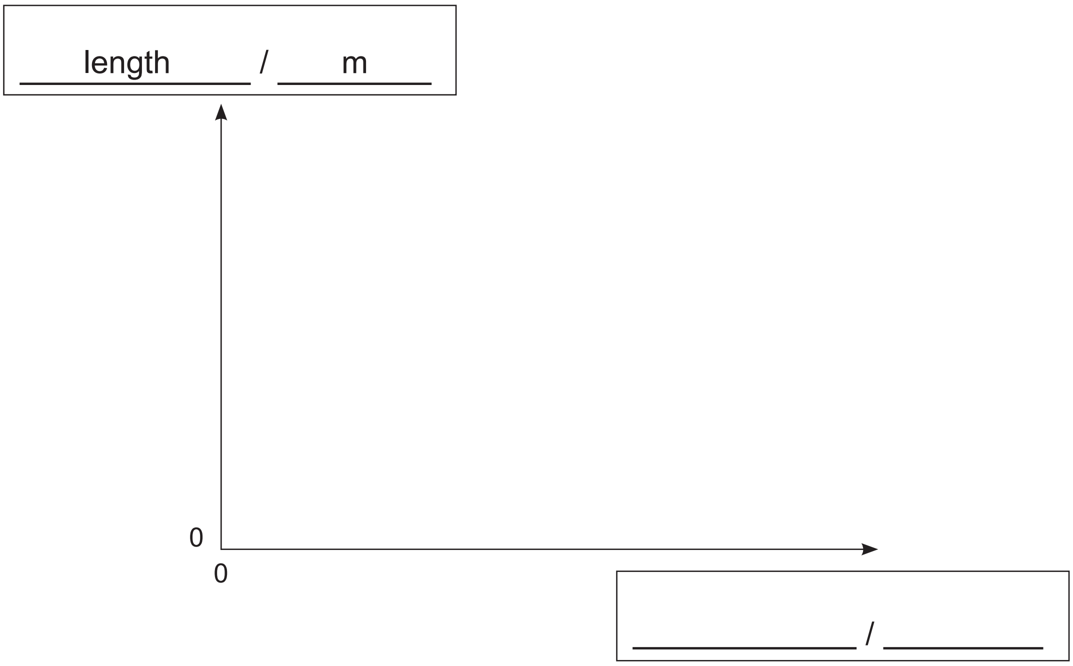



**Fig. 7.2**

[2]

**(b)** A gas has a density $\rho$ of 0.43 kg m$^{-3}$ at a temperature of 12 °C and pressure p of $2.55 \times 10^5$ Pa.

**(i)** Show that $p = \frac{1}{3}\rho \langle c^2 \rangle$ where c is the speed of a molecule.

[2]

**(ii)** Calculate the mean square speed $\langle c^2 \rangle$ of the molecules of the gas.

$\langle c^2 \rangle$ = ____________________ m$^2$ s$^{-2}$ [2]

**(iii)** Calculate the mass of one molecule of the gas.

Mass of one molecule = ____________________ kg [2]

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**(Questions continue overleaf)**

**8** The radius r of a nucleus can be obtained using the following equation.

$$r = r_0 A^{\frac{1}{3}}$$ **Equation 8.1**

**(a) (i)** State what the following terms in **Equation 8.1** represent.

$r_0$ = ______________________________ [1]

A = ______________________________ [1]

**(ii)** A sketch graph of $\log_{10} r$ against $\log_{10} A$ is shown in **Fig. 8.1**.

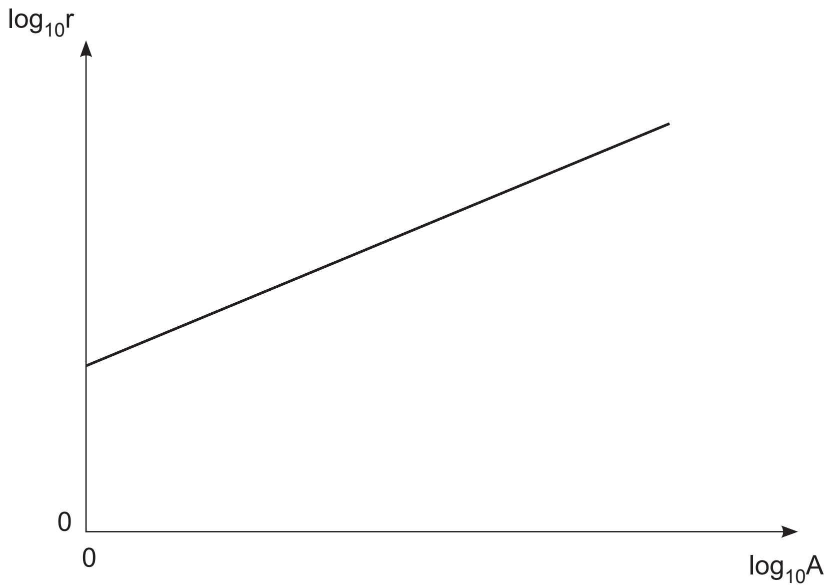


**Fig. 8.1**

1. By mapping to y = mx + c, show how the value of $r_0$ could be determined from the graph.

______________________________

______________________________

2. Determine the numerical value of the gradient.

Gradient = ________________

[3]

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**(b)** Calculate the density of a $^{14}_{6}C$ nucleus.

Take $r_0$ to be equal to 1.2 fm, the average mass of a nucleon to be $1.66 \times 10^{-27}$ kg and the volume of a sphere as $\frac{4}{3}\pi r^3$.

Density = _______________ kg m$^{-3}$ [4]

**9 Quality of written communication will be assessed in this question.**

**(a)** Write an account of the nature of alpha particles and explain how this determines their penetration and range.

[6]

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**(b)** Thulium-170 ($^{170}_{69}Tm$) is a radioisotope commonly used in portable X-ray equipment. Thulium-170 has a half-life of 128 days. It decays by beta minus emission to form an isotope of ytterbium, chemical symbol Yb.

**(i)** Complete equation **Fig. 9.1** to represent this decay by placing the correct number in each box.

$$^{170}_{69}Tm \longrightarrow {}^{\square}_{\square}Yb + {}^{\square}_{\square}\beta$$

**Fig. 9.1**

[2]

**(ii)** Calculate the decay constant λ for this source.

Decay constant λ = ______________ $s^{-1}$ [2]

**(iii)** The source of thulium-170 initially contains $1.60 \times 10^{20}$ radioactive atoms. Calculate the number of radioactive atoms N remaining after 256 days.

Number of radioactive atoms remaining N = ______________ [2]

**(iv)** Use your answers to parts **(ii)** and **(iii)** to calculate the activity of the sample after 256 days.

Activity = ______________ Bq [1]

**(c)** **(i)** Calculate the total energy released by the emission of beta minus radiation during the 256 days if the energy released per disintegration is $1.41 \times 10^{-13}$ J.

Energy released = ________________ J [2]

**(ii)** After emission of beta minus radiation, the thulium nucleus is left in an excited state. Stabilization of this excited state occurs by the emission of gamma radiation of energy 0.084 MeV. Calculate the wavelength of this gamma radiation.

Wavelength = ____________________ m [4]

**(iii)** In 1924, Louis de Broglie suggested that matter could exhibit wave-like properties and could therefore have an associated wavelength. Calculate the de Broglie wavelength $\lambda$ associated with a beta minus particle moving with a velocity of $2.85 \times 10^6$ m $s^{-1}$.

De Broglie wavelength $\lambda$ = _________________ m [2]

**THIS IS THE END OF THE QUESTION PAPER**

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| For Examiner's use only | |
|---|---|
| Question Number | Marks |
| 1 | |
| 2 | |
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| 7 | |
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