CAMBRIDGE
OCR

Wednesday 20 May 2026 – Afternoon

A Level Physics A

H556/01 Modelling physics

Time allowed: 2 hours 15 minutes

You must have:
• theData, Formulae and Relationships Booklet

You can use:
• a scientific orgraphical calculator

• a ruler (cm/mm)

* H 5 5 6 0 1 *

* 2 6 7 7 7 4 3 3 1 6 *

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **36** pages.

ADVICE
- Read each question carefully before you start your answer.

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Section A

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

Write your answer to each question in the box provided.

1 Which option has the same unit as **kg m s^{-2}**?

A Force constant × extension

B Force × distance

C Force × time

D Force × velocity

Your answer ☐ **[1]**

2 A football is kicked at 30° above the horizontal. Air resistance is negligible.

Which measurement changes while the ball is in the air?

A Horizontal component of velocity

B Mass of the ball

C Total energy store of the ball and Earth

D Total momentum of the ball

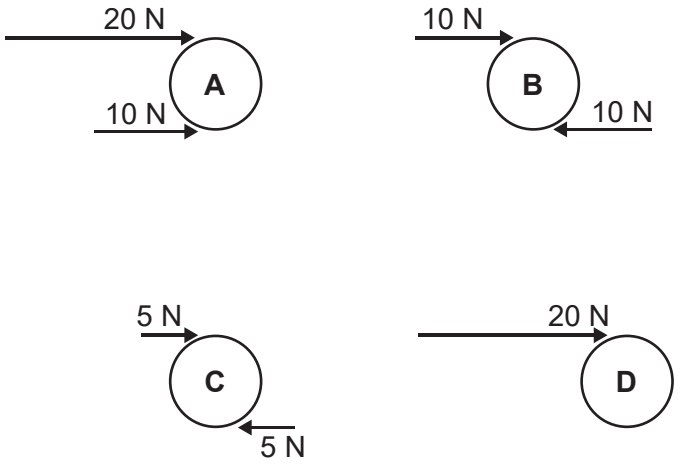
Your answer ☐ **[1]**

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3 Which object has a couple with a torque of 10 Nm?

The diameter of each spherical object is 1.0 m.

Each diagram shows forces acting tangentially at the rim.

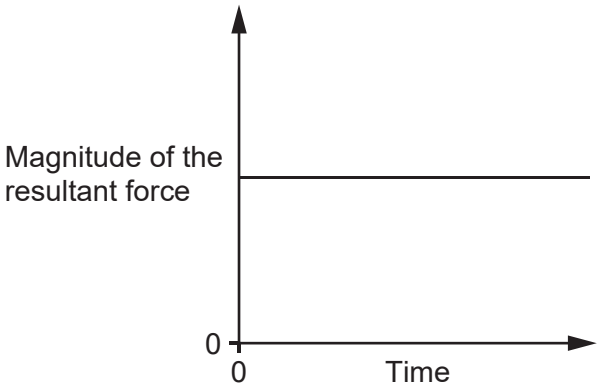


Your answer ☐ **[1]**

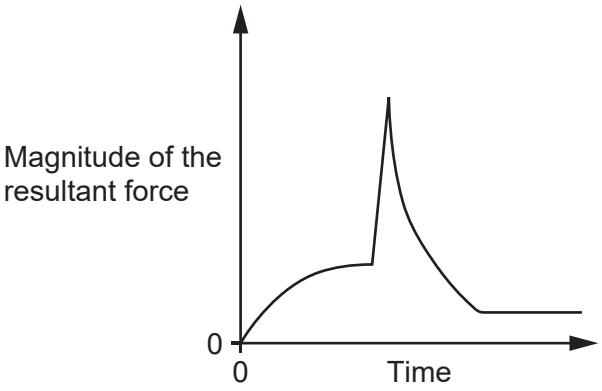
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4 A parachutist jumps from an aeroplane. They accelerate until they reach terminal velocity. They then open the parachute.

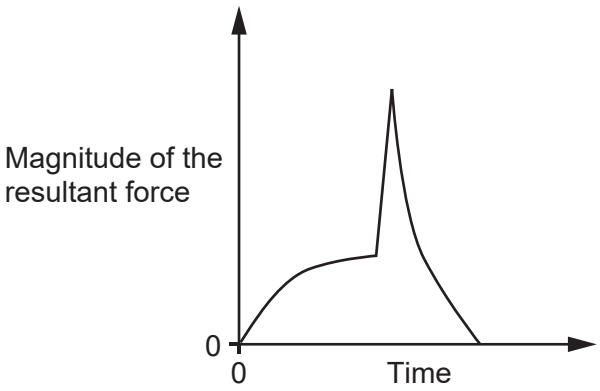
Which graph shows how the magnitude of the resultant force on the parachutist changes with time from the start of the jump?



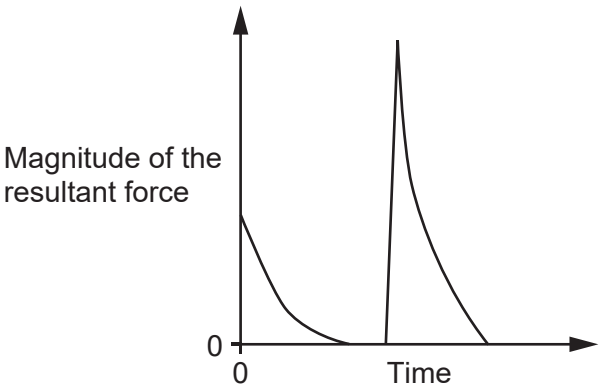
A



B



C



D

Your answer ☐ **[1]**

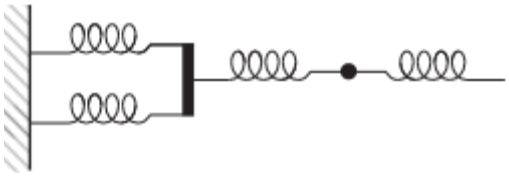
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5 Identical springs are connected to a fixed wall in different ways as shown.

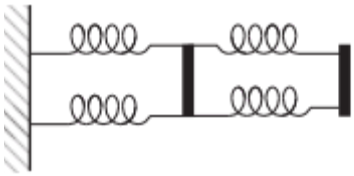
The black blocks are rigid connectors. A dot shows where springs are joined end to end.

Which combination has the **largest** force constant?

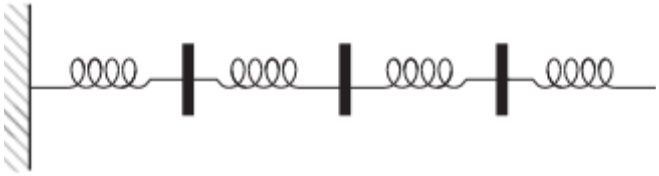
A



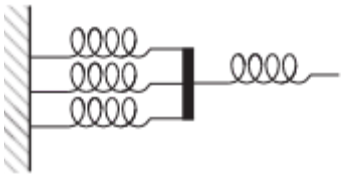
B



C



D



Your answer ☐ **[1]**

6 Brownian motion is named after Robert Brown who observed pollen grains moving randomly in water.

Which conclusion(s) can be drawn from Brown's observations?

1 The pollen grains are experiencing collisions.
2 The water particles cannot be seen using a microscope.
3 The water particles all move at the same speed.

A 1 only

B 1 and 2

C 3 only

D 1, 2 and 3

Your answer ☐ **[1]**

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7 Water of mass m_0 kg boils in a kettle of power P watts.
The kettle stays on for 600 s.
The mass falls to m_1 kg.

Which expression gives the specific latent heat of vaporisation of water?

Assume the kettle and water are in thermal equilibrium while the water is boiling.
All expressions are in J kg^{-1}.

A $\frac{600P}{m_0 - m_1}$

B $\frac{10P}{m_0 - m_1}$

C $\frac{600P}{m_1}$

D $\frac{600P}{m_0}$

Your answer ☐ **[1]**

8 An object of mass 1.4 kg is in simple harmonic motion. The maximum displacement is 57 cm. The maximum kinetic energy is 20 J.

What is the angular frequency?

Use the formula: $v_{max} = \omega A$

A 0.066 rad s^{-}

B ^{1} 0.094 rad

C s^{-1} 6.6 rad s^{-}

D ^{1} 9.4 rad s^{-1}

Your answer ☐ **[1]**

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9 The period T of a simple pendulum of length l is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

The pendulum has a natural frequency of f_0 on Earth.

What would be the natural frequency of this pendulum on a planet where the gravitational field strength is **four** times greater than on Earth?

A $0.5\,f_0$

B $\frac{f_0}{2}$

C $2\,f_0$

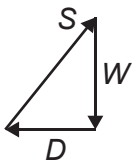
D $4\,f_0$

Your answer ☐ **[1]**

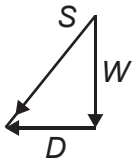
10 A helicopter of weight W flies horizontally at a constant velocity.
The rotor blades produce a thrust S.
The drag force D acts opposite to the velocity.

Which free-body diagram is correct?

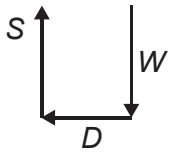
A



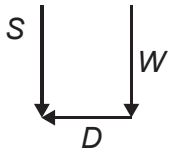
B



C



D



Your answer ☐ **[1]**

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11 The pressure of a fixed mass of gas is measured at different temperatures using a pressure gauge. A graph of pressure against temperature is then plotted to estimate absolute zero.

The pressure gauge has a zero error and gives readings higher than the true value.

What effect does this zero error have on this value of absolute zero?

A It would be higher than the true value

B It would be lower than the true value

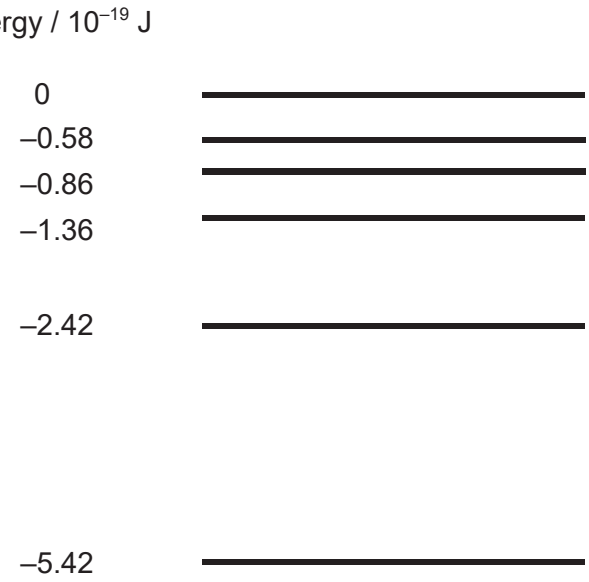
C It would have a random error

D It would have no effect

Your answer ☐ **[1]**

12 The diagram shows the electron energy levels in an atom.

What is the longest wavelength of light absorbed to cause an electron transition in this atom?



A 1.2×10^{-6} m

B 3.4×10^{-6} m

C 7.1×10^{-6} m

D 1.4×10^{-5} m

Your answer ☐ **[1]**

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13 A star has a surface temperature of 5500 K. Light from the star has a wavelength of maximum intensity, λ_{max}, of 527 nm.

What is λ_{max} for a star with a surface temperature of 2000 K?

A 150 nm

B 180 nm

C 1400

D 1700 nm

Your answer [ ] **[1]**

14 T is the surface temperature of the Sun in kelvin. The surface area of the Sun is A.

What is the surface area of a star with the same luminosity and a surface temperature of $2T$?

A A /

B 16 A

C / 4 A

D / 2 16 A

Your answer [ ] **[1]**

15 Two observations of a star from Earth are made 6 months apart. The parallax angle of the star is 2×10^{-4} degrees.

What is the distance of the star from Earth?

A 1.4 parsecs

B 2.8 parsecs

C 83 parsecs

D 170 parsecs

Your answer [ ] **[1]**

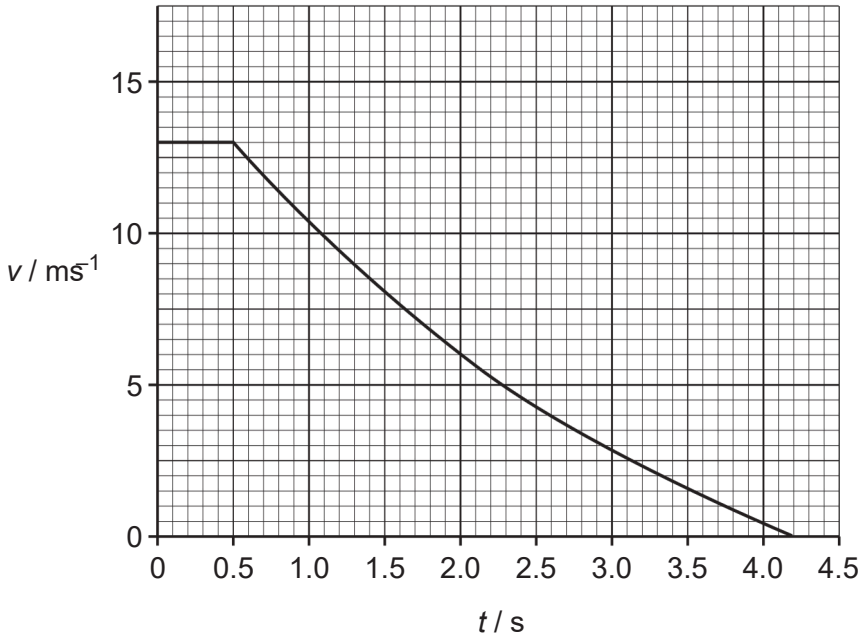
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Section B

16

(a) **Figure 16.1** shows the graph of velocity *v* against time *t* for a car being driven along a straight road.
At time *t* = 0 the driver sees an obstruction and brakes hard to make an emergency stop.

Figure 16.1



(i) Use **Figure 16.1** to find the reaction time.

Reaction time = ... s **[1]**

(ii) Show that the **maximum** deceleration of the car is about 6 ms^{-2}.

[2]

(iii) Describe the changes in the braking force over the time shown in **Figure 16.1**.

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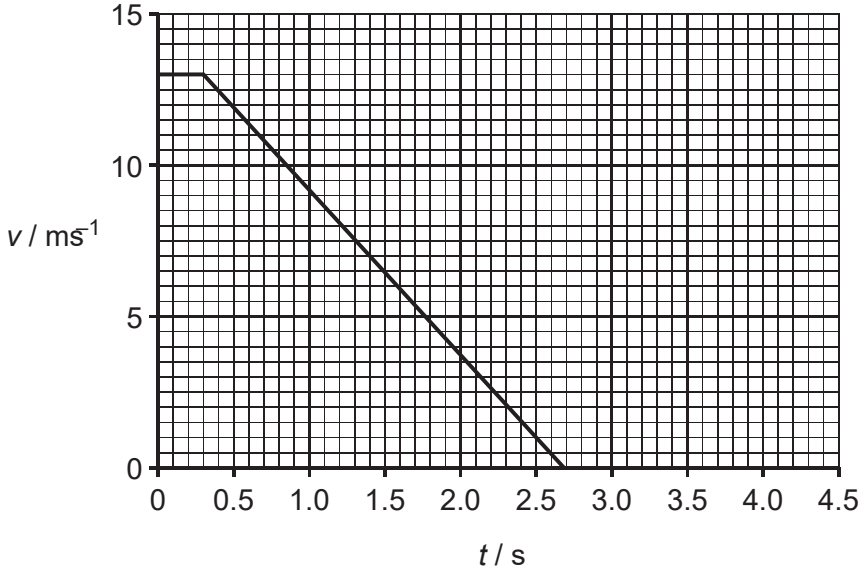
.....**[2]**

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(b) **Figure 16.2** shows similar data for a self-driving car under the same conditions as in **(a)**.

At time $t = 0$ the sensors of the self-driving car detect an obstruction and the car's control systems bring it to rest in the shortest possible distance.

Figure 16.2



(i) Calculate the stopping distance for the self-driving car.

Stopping distance = ... m **[3]**

(ii) The car in **(a)** and the self-driving car in **(b)** have the same mass.

Explain the difference in stopping distances for the two cars.

No calculations are required.

.....

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

(c) There is an unsecured book on the back seat of the car described in **(a)**.

Explain the movement of the book during the emergency stop.

Use your knowledge of Newton's first law of motion.

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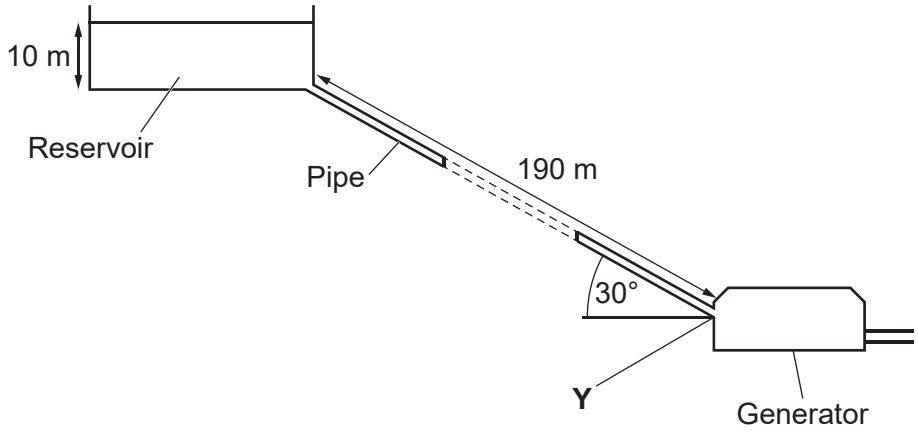
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.....**[2]**

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17 **Figure 17.1** shows a hydroelectric power station.

Figure 17.1



Water flows from a reservoir to a generator through a pipe. The reservoir contains 10 000 m^3 of water and is filled to a depth of 10 m.

The pipe:
- has a circular cross-section
- is 190 m long
- is at an angle of 30° to the horizontal.

The lower end of the pipe is sealed at point **Y** by a circular plate.

(a) The water pressure depends on the total vertical distance from the water surface in the reservoir to the circular plate.

Show that the water pressure exerted on the circular plate is about 1 MPa when the reservoir is full.

Density of water = 1000 kg m^{-3}.

[2]

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Question 17(b) starts on page 14

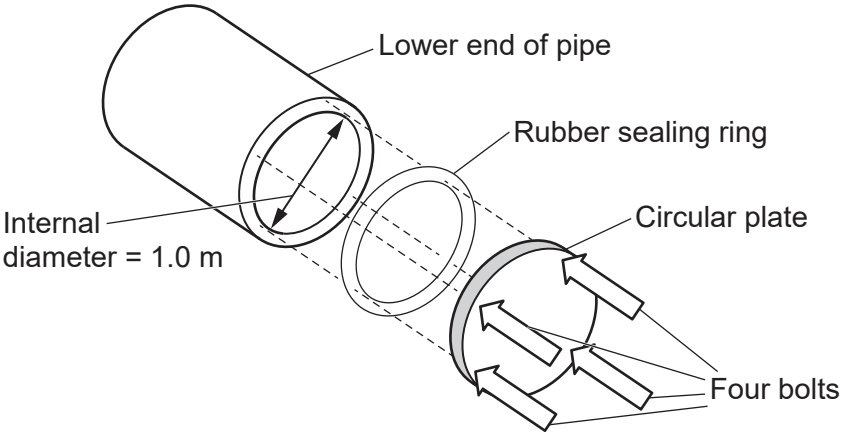
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(b) Four bolts are used to secure the circular plate at point **Y** as shown in **Figure 17.2**.

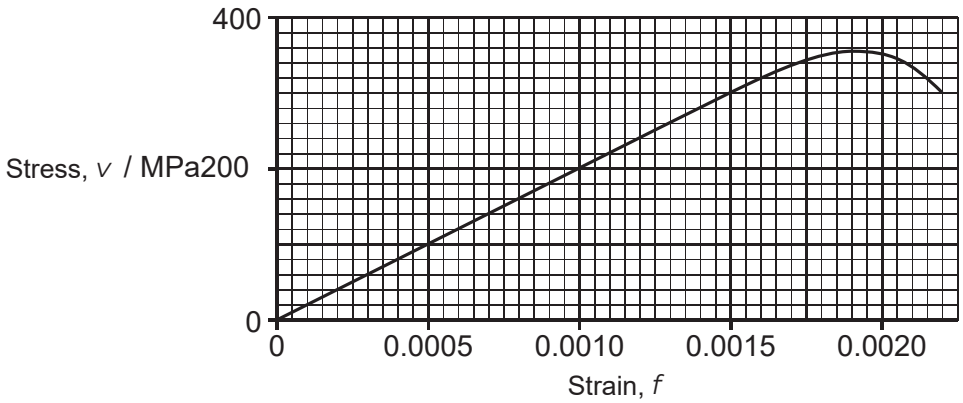
Each bolt has a:
- cross-sectional area of 0.001 m^2
- length of 0.10 m.

The internal diameter of the pipe is 1.0 m.

Figure 17.2



The stress-strain graph for the material used to make the bolts is shown.



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(i) Show that the bolts behave elastically when used to hold the circular plate in position.

Use the water pressure found in **(a)** and the graph.

[4]

(ii) Calculate the extension of **one** bolt.

Extension = ... m **[2]**

(iii) Suggest **one** reason why a rubber sealing ring is fitted between the circular plate and the end of the pipe.

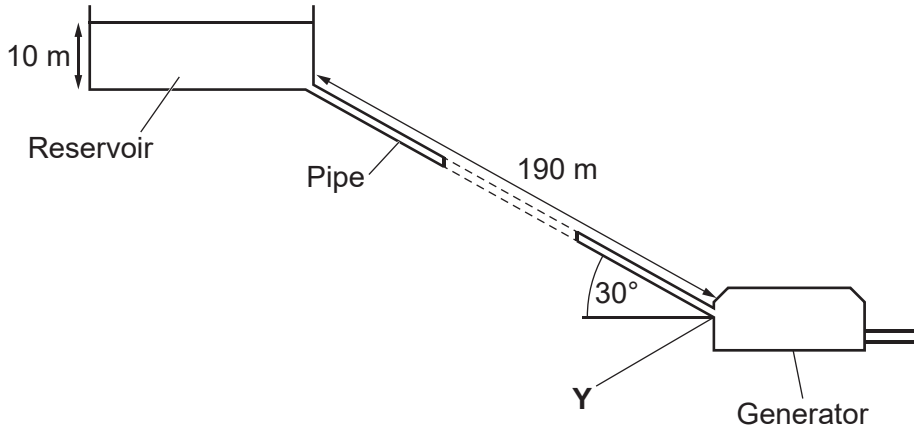
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.....**[1]**

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(c) **Figure 17.1** from the start of the question is shown again:

Figure 17.1



The generator produces an electrical power output of 8.0 MW. Assume the electrical power output remains constant while the water flows.

Water flows through the generator at a constant rate of 10 000 kg s^{-1}.

Calculate the electrical energy generated if the whole volume of water in the reservoir is used.

Give your answer in **MJ**.

The reservoir contains 10 000 m^3 of water.

Density of water = 1000 kg m^{-3}

Electrical energy generated = ... MJ **[3]**

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(d) One suggested change to the design of the power station is the addition of finely ground stone particles to the water to increase its density.

Explain **one** advantage and **one** disadvantage of this suggested change.

Advantage .....

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Disadvantage .....

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[4]

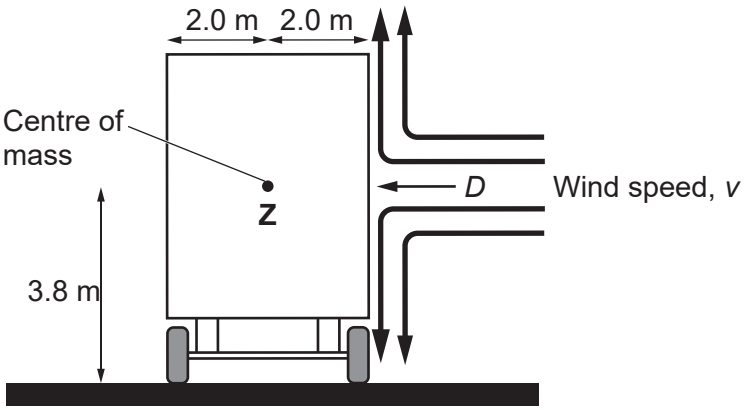
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18 **Figure 18.1** shows a rear view of a stationary lorry of weight 20 kN on a level road.

Wind blows horizontally towards the side of the lorry at wind speed v. v is measured in m s^{-1}.
After striking the lorry, the airflow splits equally and flows parallel to the side of the lorry.

The area of the side of the lorry A is 35 m^2.
The mass of air striking the lorry in one second is 1.2 Av.

Figure 18.1



(a) Show that the wind force D is given by: $D = 42\ v^2$.

Use Newton's second law of motion.

[2]

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(b) The wind force *D* can be modelled as acting at the centre of the side of the lorry, 3.8 m above the ground.

The centre of mass of the lorry is at point **Z**.

Point **Z** is 3.8 m above the ground and 2.0 m from each side of the lorry.

Calculate the wind speed *v* at which the right hand wheels of the lorry start to lose contact with the road.

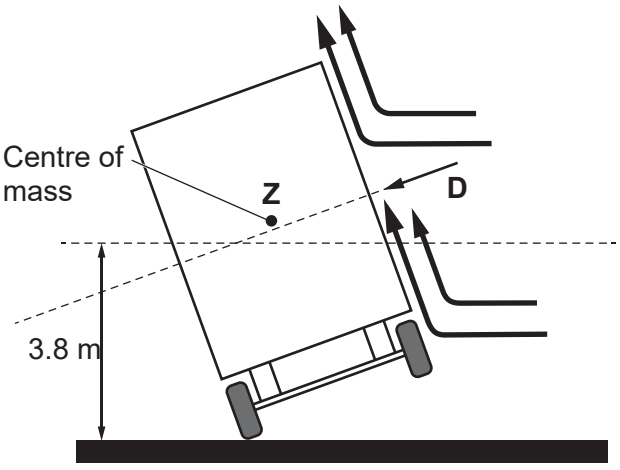
Take moments about a suitable pivot.

Wind speed = ... ms^{-1} **[3]**

(c) **Figure 18.2** shows that one side of the lorry has lifted after a further increase in wind speed. All of the airflow is now deflected upwards towards the upper edge of the lorry.

The wind force continues to act at the same point. The wind force acts perpendicular to the side of the lorry.

Figure 18.2



Explain any change in the turning effect of the wind force when the lorry is in this position.

.....

.....

.....

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

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19

(a) Describe the **two** conditions required for simple harmonic motion.

1 .....

..... 2

.....

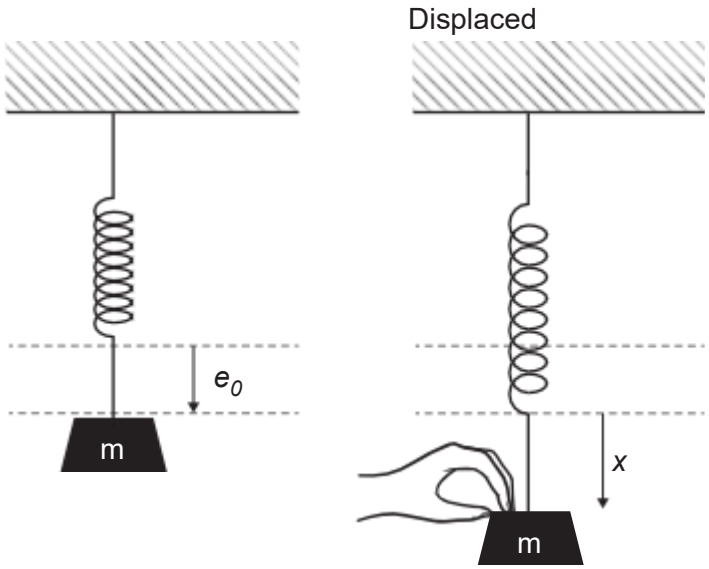
.....

[2]

(b) **Figure 19.1** shows a mass *m* on a spring of force constant *k*.

The spring is shown:
- in equilibrium with extension e_0
- with the mass displaced a distance *x*.

Figure 19.1



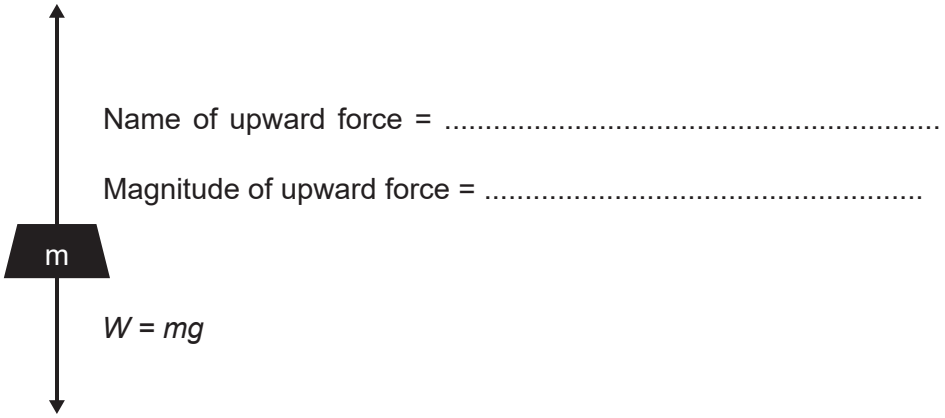
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The mass is then released from the displaced position.

(i) State the name **and** magnitude of the upward force acting on the mass in **Figure 19.2**.

Give the magnitude in terms of k, e_0 and x.

Figure 19.2



[2]

(ii) Show that the magnitude of the acceleration a of the mass immediately after release is given by:

$a = \frac{kx}{m}$.

[2]

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(c)* A student compares two experimental methods for determining the force constant of a spring.
A sample of their measurements is shown:

Method 1 (Hooke's law)	**Method 2 (Oscillations)**
$k = g \times \frac{\text{mass}}{\text{extension}}$	$k = 4\pi^2 \times \frac{\text{mass}}{\text{period}^2}$
Original length = 21 mm Extended length = 71 mm	Time taken for multiple oscillations = 7.80 s

The apparatus used included a spring, masses, stopwatch, metre rule, retort stand and a clamp.

A sample of the 100 g masses were found to be between 99.0 and 101.0 g using a known accurate balance.

Discuss the two methods by:
- determining the percentage uncertainties associated with each method
- explaining how the uncertainties can be reduced without using any additional equipment
- explaining the characteristics of the spring that limit the improvements in each method.

You do **not** need to calculate the value of the force constant. **[6]**

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Extra answer space if required.

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20

(a)

(i) Describe what is meant by the internal energy of an ideal gas.

.....

.....**[1]**

(ii) Show that the internal energy E of a fixed mass of ideal gas is given by

$$E = \frac{3}{2}pV$$

where p is the pressure of the gas and V is its volume.

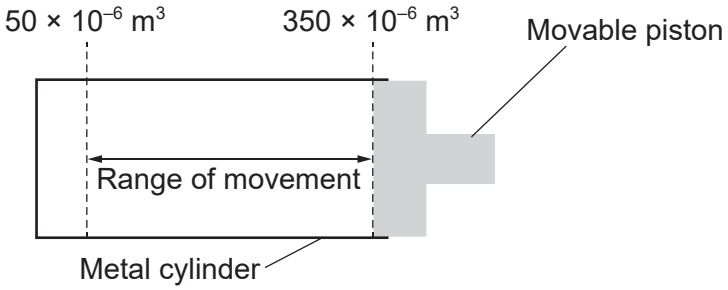
[3]

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26

(b) The diagram shows a metal cylinder with a movable piston. The volume of the air inside the cylinder is 350×10^{-6} m^3 when the piston is fully raised, and 50×10^{-6} m^3 when the piston is fully lowered.

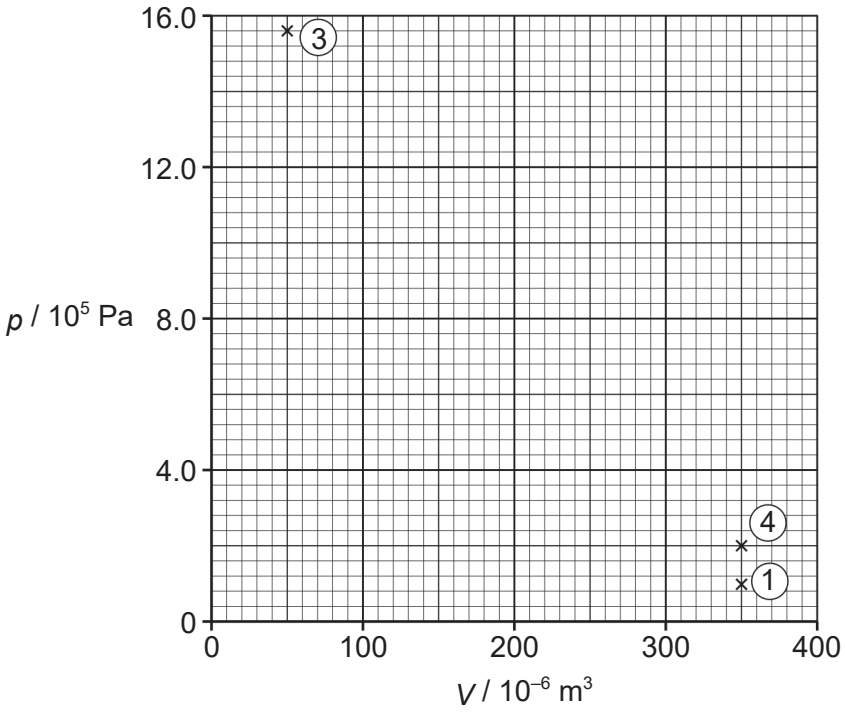
The fixed mass of air in the cylinder can be treated as an ideal gas.



The air passes through three processes which are described in the table.

Process	Description
1 ⟶ 2	350×10^{-6} m^3 of air at 100 kPa is compressed at constant temperature to a volume of 50×10^{-6} m^3.
2 ⟶ 3	Fuel is burnt outside the cylinder and 43 J of chemical energy is transferred to the internal energy of the air in the cylinder.
3 ⟶ 4	The air is allowed to expand to fill the cylinder and internal energy is transferred to useful work.

The graph shows the changes to the pressure and volume of the air. The volume of the cylinder remains constant.



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(i) Calculate the pressure of the air at point **2**.

Pressure = ... Pa **[2]**

(ii) Plot point **2** on the graph. **[1]**

(iii) Show that the change in internal energy between points 3 and 4 is about 10 J.

[2]

(iv) Calculate the efficiency of the overall process.

Efficiency = ... **[1]**

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21

(a) The Sun contains 99% of the mass of the solar system. The Sun has a mass of 2.0×10^{30} kg.

The number of stars in the Milky Way galaxy is believed to be about 1×10^{11}.

The majority of stars orbit within 50 000 light years of the galactic centre.

(i) Suggest why the mass of the Sun may be taken as a reasonable estimate for the average mass of a main sequence star.

.....

.....**[1]**

(ii) Estimate the total mass of stars in the Milky Way assuming each star has the mass of the Sun.

Total mass of stars = ...kg **[1]**

(b) A small number of stars called hypervelocity stars orbit at very large distances beyond the recognised edge of the Milky Way galaxy.

One such star is moving at 3.0×10^2 km / s relative to the centre of the galaxy at a distance of 66 kpc.

(i) Show that the angular velocity of this star is about 1.5×10^{-16} rad s^{-1}.

[2]

(ii) Show that the orbital period of this star is about 4.0×10^{16} s.

Use your answer from **(b)(i)**.

[1]

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(iii) Calculate the total mass of the Milky Way.

Give your answer to an appropriate number of significant figures.

Use Kepler's third law.

Total mass of the Milky Way = ...kg **[4]**

(iv) Suggest **one** reason for the difference between your answers for **(a)(ii)** and **(b)(iii)**.

.....

.....**[1]**

(v) The second method of analysis using Kepler's third law relies on Newton's law of gravitation:

$F = -\frac{GMm}{r^2}$.

Suggest why analysing hypervelocity stars may give a more accurate estimate of the total galactic mass than analysing stars close to the galactic centre.

.....

.....**[1]**

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22 A spherical nebula of radius 90 light years contains 3.5×10^{31} kg of matter.

The nebula collapses under gravitational forces to form a protostar of radius 6.2×10^{11} m.

(a) Show that the change in gravitational potential from the outer edge of the nebula to the outer edge of the protostar is about 4×10^{9} J kg^{-1}.

[2]

(b) The relationship between T, the temperature of an ideal gas, and KE, the average kinetic energy of a particle is given by

$$T = \frac{2}{3}\frac{KE}{k}$$

where k is the Boltzmann constant.

(i) Show that the temperature of the gas reaches about 300 000 K as the gas particles fall from the outer edge of the nebula to the outer edge of the protostar.

The mass of each gas particle is 1.6×10^{-27} kg.

[2]

(ii) Suggest why an initial nebula with greater mass is likely to form a hotter protostar.

.....

.....**[1]**

(iii) The temperature of the core of stable main sequence stars is estimated to be at least 10 times greater than the answer to **(b)(i)**.

Suggest **one** reason for the difference.

.....

.....**[1]**

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(c)* The life cycle of most stars includes a relatively brief period as either a red giant or a red super giant star.

Compare these two types of star, including:
- the transitions from a main sequence star
- the conditions in and around the core
- the likely next stage in the life cycle.

[6]

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Extra answer space if required.

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23 **Figure 23.1** shows a spectrum of hydrogen gas measured in a laboratory.

Figure 23.2 shows a spectrum observed from a distant galaxy.

Figure 23.1

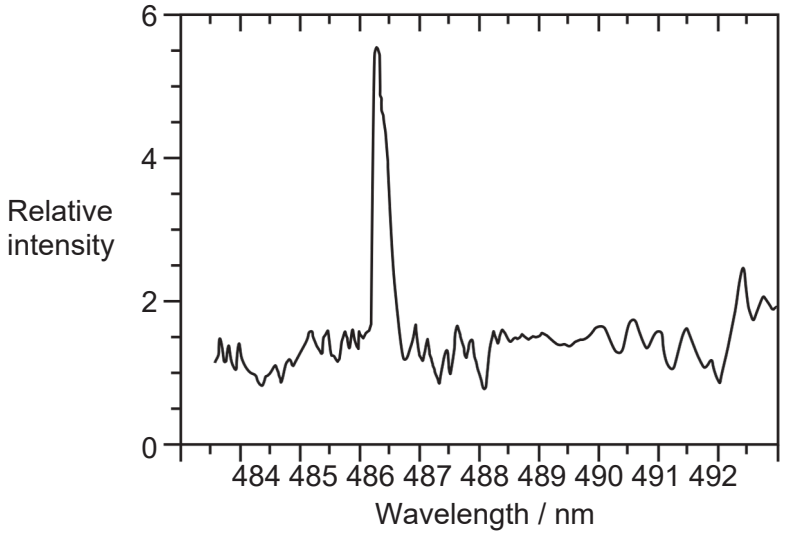
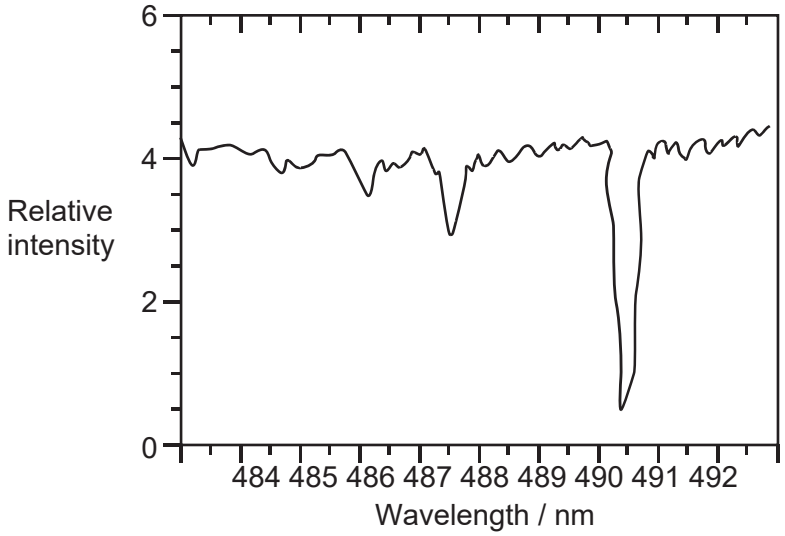


Figure 23.2



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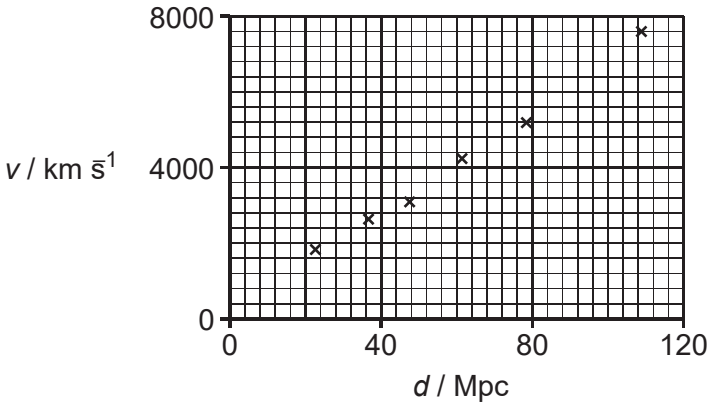
(a) Show that the recession velocity v of this galaxy is about 3000 kms^{-1}.

Use the largest peak from **Figure 23.1** and the largest trough from **Figure 23.2**.

[2]

(b) **Figure 23.3** shows recession velocity v plotted against distance from Earth d for some galaxies.

Figure 23.3



Use **Figure 23.3** to estimate the distance of the galaxy in **(a)** from Earth.

Distance = ... Mpc **[1]**

(c) Describe how to use the gradient of the graph in **Figure 23.3** to estimate the age of the Universe.

You do not need to make any calculations.

.....

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.....

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

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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