# OCR

Oxford Cambridge and RSA

# A Level Physics A

**H556/01**  Modelling physics

# Practice paper – Set 1
## Time allowed: 2 hours 15 minutes

**You must have:**
* the Data, Formulae and Relationship Booklet

**You may use:**
* a scientific calculator
* a ruler (cm/mm)

| 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.
* Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
* Do **not** write in the barcodes.

## 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 30 minutes on this section.**

**Write your answer to each question in the box provided.**
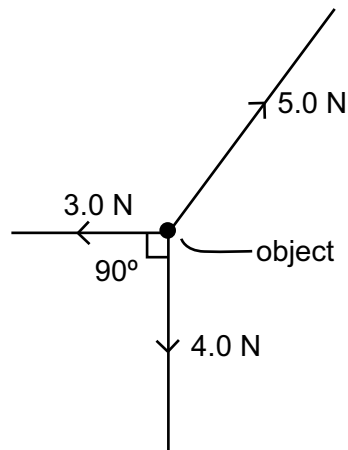
Answer **all** the questions.

1   Which physical quantity has the same base units as energy?

   **A**   moment

   **B**   momentum

   **C**   force

   **D**   pressure

   Your answer ☐

[1]

2   The diagram below shows three forces acting on an object.



The object is **stationary**. All the forces lie in the vertical plane. The weight of the object is 4.0 N.

Which statement is **not** correct?

   **A**   The resultant force on the object is zero.

   **B**   The magnitude of the resultant force of 3.0 N and 4.0 N forces is 5.0 N.

   **C**   The magnitude of the vertical component of the 5.0 N force is 4.0 N.

   **D**   The resultant force in the horizontal direction is 3.0 N.

   Your answer ☐

[1]

**3** A wire of diameter 0.80 mm is stretched by a force of 40 N.

What is the tensile stress in the wire?

**A** 0.016 MPa

**B** 0.05 MPa

**C** 20 MPa

**D** 80 MPa

Your answer ☐

**[1]**

**4** An object is initially at rest. A constant force is applied to the object and it moves in a straight line with constant acceleration. After a time $t$, the object has displacement $s$ and velocity $v$.

Which of the following will **not** produce a straight line graph?

**A** A graph of $v$ against $t$.

**B** A graph of $s$ against $v$.

**C** A graph of $s$ against $t^2$.

**D** A graph of $v^2$ against $s$.

Your answer ☐

**[1]**

**5** A car travels a distance 166 ± 2 m in a time 5.2 ± 0.1 s.

What is the best estimate of the speed of the car?

**A** $32 \pm 1 \text{ m s}^{-1}$

**B** $32.0 \pm 2.1 \text{ m s}^{-1}$

**C** $32.0 \pm 0.2 \text{ m s}^{-1}$

**D** $32 \pm 0.999 \text{ m s}^{-1}$

Your answer ☐

**[1]**

**6**   A spring of force constant 300 N m$^{-1}$ is cut in half. The two halves are then placed in **parallel** with each other. A force of 6.0 N is then applied to this parallel arrangement.

What is the extension of each spring?

force constant = 300 N m$^{-1}$

6.0 N
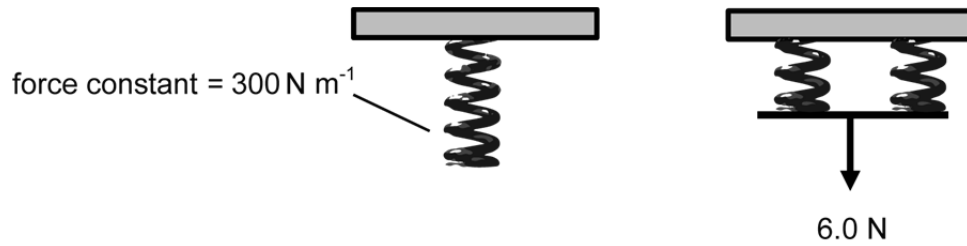
**A**   0.5 cm

**B**   1.0 cm

**C**   2.0 cm

**D**   4.0 cm

Your answer

[1]

**7**   The motion of an oscillator is simple harmonic.

Which statement is correct about the period of the oscillator?

The period …

**A**   is independent of the amplitude.

**B**   depends on the displacement of the oscillator.

**C**   is independent of the frequency of the oscillator.

**D**   depends on the force acting on the oscillator.

Your answer

[1]

8   A hot metal emits a black-body spectrum. The luminosity of the metal at 800 °C is *L*.

What is the luminosity of the metal when at 1000 °C?

A   1.2*L*

B   1.3*L*

C   2.0*L*

D   2.4*L*

Your answer ☐

[1]

9   Which is the most likely evolution of a star which is 10 times more massive than our Sun?

A   main sequence star   →   red supergiant   →   white dwarf   →   black dwarf

B   main sequence star   →   supernova   →   red supergiant   →   neutron star

C   main sequence star   →   red supergiant   →   supernova   →   neutron star

D   main sequence star   →   red giant   →   neutron star   →   black hole

Your answer ☐

[1]

10  The four energy levels of an atom are shown below.
    Four electron transitions are shown by the arrows **A**, **B**, **C** and **D**.
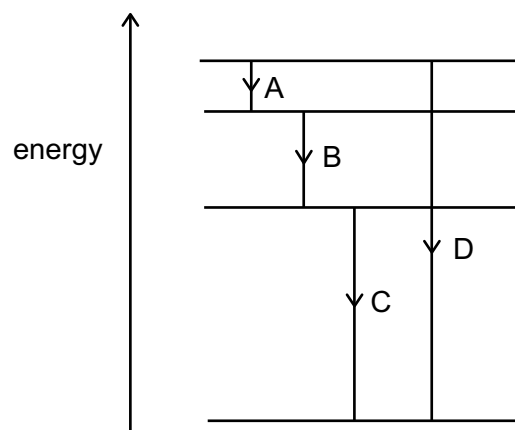


Which electron transition will give the longest wavelength of electromagnetic radiation?

Your answer ☐

[1]

11 A ball is launched horizontally at 5 m s$^{-1}$ from the end of a table. The ball is in flight for 0.4 s before it lands on the floor. The ball is now launched from the end of the same table with a horizontal velocity 10 m s$^{-1}$.

What is the new time of flight of the ball?

A    0.2 s

B    0.4 s

C    0.5 s

D    0.8 s

Your answer ☐

[1]

12 The volume of a fixed mass of an ideal gas is $V$. The gas exerts pressure $p$ and has thermodynamic temperature $T$. The temperature of the gas is now increased to $2T$. The new pressure exerted by the gas is $3p$.

What is the new volume of the gas in terms of $V$?

A    $\frac{1}{6}V$

B    $\frac{2}{3}V$

C    $\frac{3}{2}V$

D    $6V$

Your answer ☐

[1]

13 Which of the following is the greatest astronomical distance?

A    1.0 pc

B    2.0 ly

C    $3.0 \times 10^5$ AU

D    $4.0 \times 10^{13}$ km

Your answer ☐

[1]

**14** A satellite of mass 3000 kg moves from a parking orbit of radius 6800 km to a geostationary orbit of radius 42 000 km. The mass of the Earth is $6.0 \times 10^{24}$ kg.

What is the magnitude of the change in gravitational potential?

**A**　8.4 J kg$^{-1}$

**B**　$2.5 \times 10^4$ J kg$^{-1}$

**C**　$4.9 \times 10^7$ J kg$^{-1}$

**D**　$1.5 \times 10^{11}$ J kg$^{-1}$

Your answer ☐

**[1]**

**15** A 6.0 N force is applied to spring which extends vertically downwards by a distance 5.0 cm. The force is suddenly removed so that the spring flies vertically upwards. The spring has mass 9.0 g.

What is the maximum height reached by the spring?

**A**　0.085 m

**B**　0.17 m

**C**　1.7 m

**D**　3.4 m

Your answer ☐

**[1]**

## SECTION B

Answer **all** the questions

16  Fig.16 shows typical thinking, braking and stopping distances for **cars** driven at different initial speeds. The speed is shown in miles per hour (mph).
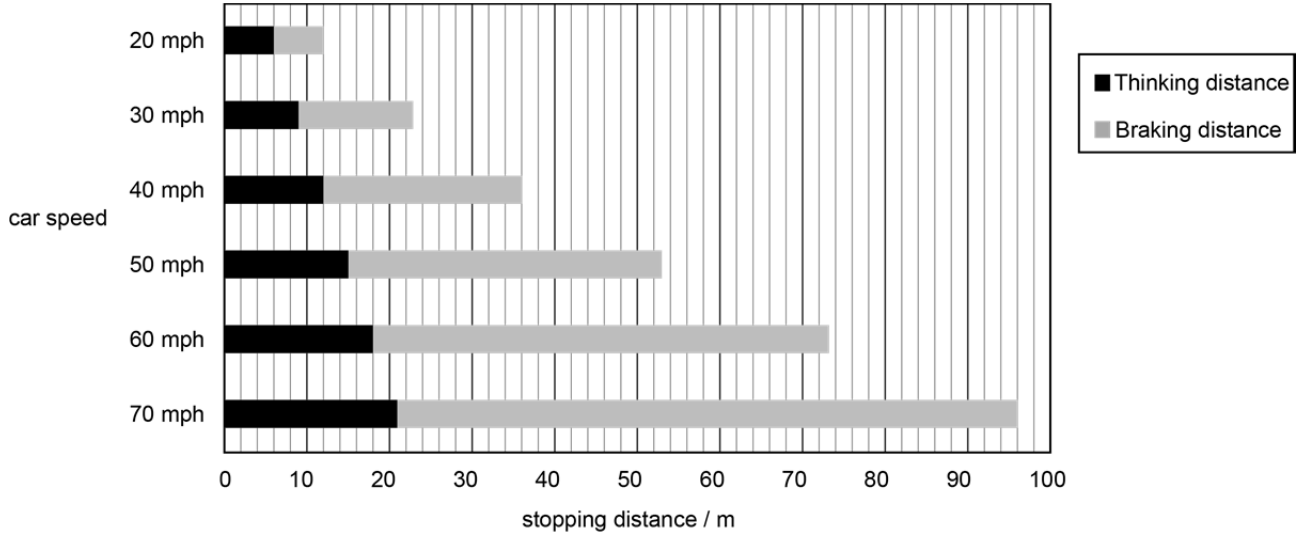


**Fig. 16**

**(a)** State what is meant by *thinking distance* and state how it varies with initial speed of a car.

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**(b)** A **truck** of mass 2300 kg is travelling at a constant speed of 22 m s⁻¹ along a dry, level road. The driver reacts to a hazard ahead and applies the brakes to stop the truck. The reaction time of the driver is 0.97 s. The brakes exert a constant braking force of 8700 N.

**(i)** Calculate the magnitude of the deceleration of the truck when braking.

deceleration = .........................................m s⁻² **[2]**

(ii) Show that the stopping distance of the truck is about 85 m.

[3]

(iii) Show that a speed of 22 m s$^{-1}$ is equivalent to about 50 mph (miles per hour).
1 mile = 1600 m

[1]

(iv) Use Fig. 16 and your answer to (ii) to compare the stopping distance of the car and the truck at 50 mph. Suggest relevant factors that may have affected the stopping distance of the truck.

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**17 (a)** State the *principle of moments*.

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**(b)** A gymnast hangs from the rings apparatus shown in Fig. 17.1. He raises his legs from a vertical to a horizontal position. Fig. 17.2 shows a simple model to demonstrate the forces exerted on his legs in the horizontal position. The total weight $W$ of the legs is 260 N and acts at a point 40 cm from the pivot **P** in the hip. A force $T$ is supplied by his hip flexor muscles which are attached to a point in the bone 3.0 cm from the pivot **P**. When horizontal, force $T$ makes an angle of 50° with his legs.
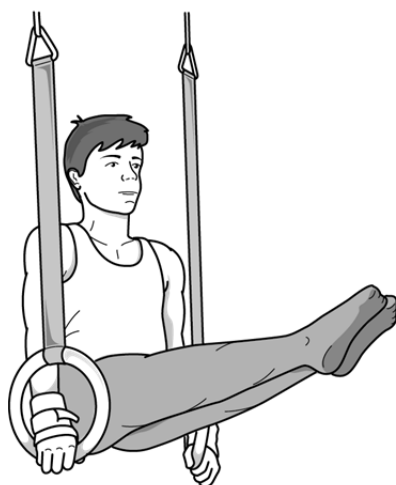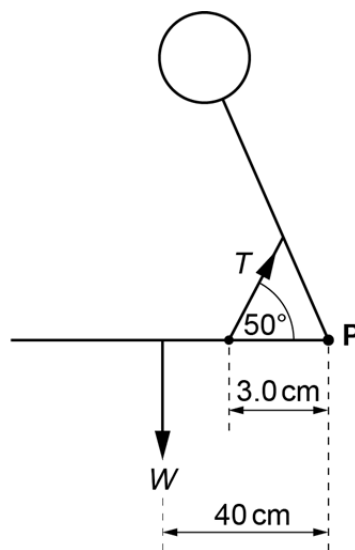
| | |
|---|---|
| **Fig. 17.1** | **Fig. 17.2** |

**(i)** Take moments about **P** to calculate the force $T$ needed to keep his legs horizontal.

$T =$ ............................................................ N **[3]**

**(ii)** Describe and explain the change in the force *T*, if any, as his legs are lowered from the horizontal position to vertical position.

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18 A cylindrical cup of internal diameter 7.0 cm and height 8.5 cm is filled to the top with water.
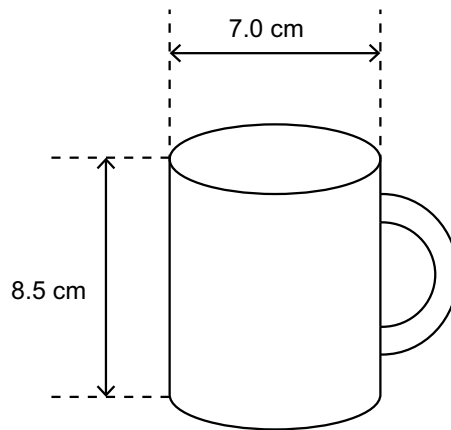


The density of water is 1000 kg m$^{-3}$. The mass of one mole of water is 18 g. The specific heat capacity of water is 4200 J kg$^{-1}$ K$^{-1}$.

(a) Show that the mass of water in the cup is approximately 0.3 kg.

[2]

(b) Calculate the number of water molecules in the cup.

number of molecules = ...................................[2]

**(c)** Show that the minimum time taken for a 0.50 kW camping kettle to bring a cup of water at 20 °C to boiling point is about 200 s.

[3]

**(d)** In a laboratory test, the camping kettle was found to bring a cup of water to the boil in 320 seconds.

Explain why your answer to **(c)** is an underestimate and suggest **two** ways that you can refine the test to ensure that the time to boil is closer to 200 s.

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19 **(a)** Define the *work done* by a force.

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**(b)** Fig. 19 shows a crane lifting a car of mass 850 kg at constant velocity through a height of 12 m in a time of 40 s. The crane has a working efficiency of 60 %.



lifting cable

car mass 850 kg

12 m
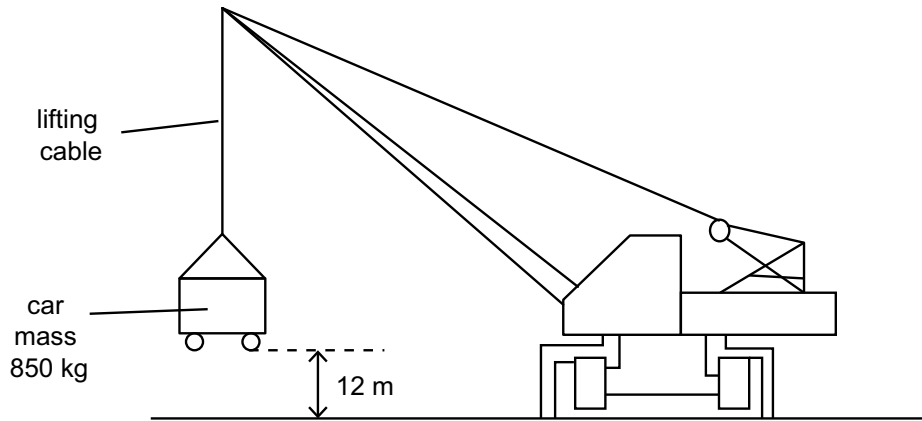
**Fig. 19**

  **(i)** Calculate the tension in the lifting cable.

tension = .................................................. N **[1]**


  **(ii)** Calculate the total input power required by the crane to lift the car.

total input power = ...................................... W **[4]**

(iii) Suggest and explain **two** ways the crane can be modified to improve its efficiency.

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**20** Brownian motion is often demonstrated by observing the microscopic motion of smoke particles suspended in air.

**(a)** State the observation and conclusion associated with this Brownian motion.

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**(b)** Brownian motion provides evidence for a kinetic model of gases.
State **three** key assumptions made in the kinetic theory of gases.

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**(c)** A gas is at a temperature of 20°C. The mass of each molecule is $4.7 \times 10^{-26}$ kg.

**(i)** Show that the root mean square (r.m.s.) speed the gas molecules is about 500 m s$^{-1}$.

**[3]**

(ii) A gas molecule makes a head-on collision with a **stationary** smoke particle. Fig. 20 shows the gas molecule and the smoke particle before and after the collision. The final speed of the smoke particle is 23 m s$^{-1}$.

BEFORE                                              AFTER

500 m s$^{-1}$

gas molecule
mass 4.7 x 10$^{-26}$ kg

smoke particle
mass 1.4 x 10$^{-24}$ kg

88°

45°

23 m s$^{-1}$
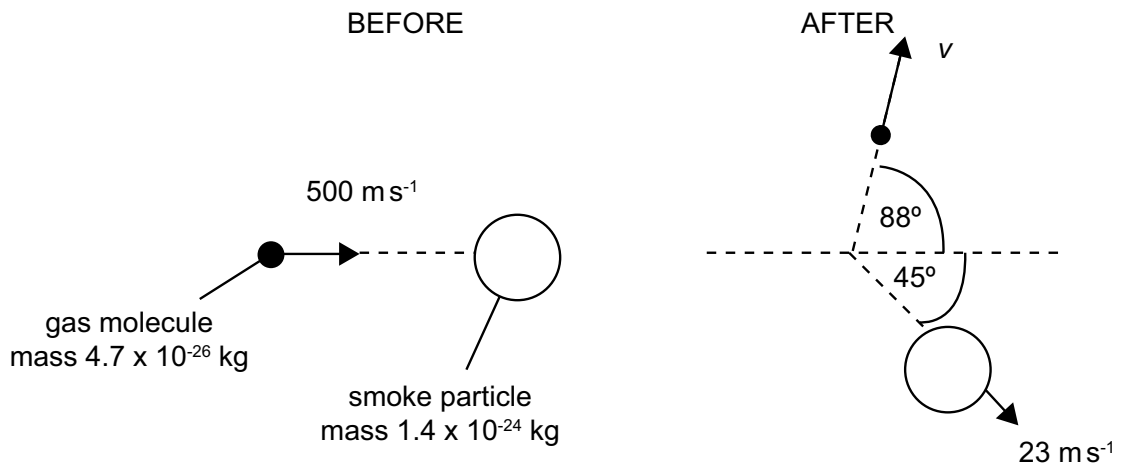
**Fig. 20**

1  State and explain the **total** momentum of the molecule and smoke particle after the collision in a direction perpendicular to initial velocity of the gas molecule.

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2  Calculate the speed $v$ of the gas molecule after the collision.

$v$ = ...................................................... m s$^{-1}$ **[2]**

**21 (a)** For a mass $m$ moving at constant speed $v$ in a circle of radius $r$, the expression for the centripetal force $F$ is

$$F = \frac{mv^2}{r}$$

Explain the term *centripetal force*.

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**(b)** A rope is attached to a bucket. A man swings the bucket in a horizontal circle of radius 1.5 m. The bucket has a constant speed of 4.8 m s$^{-1}$. The mass of the bucket is 5.0 kg.
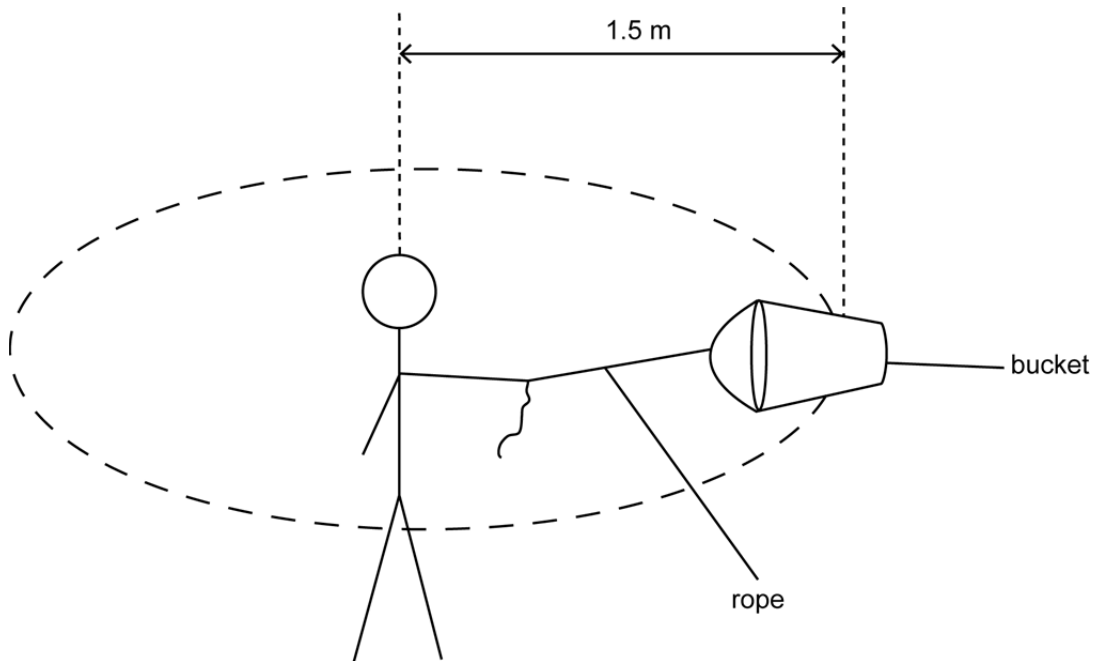


**(i)** Calculate the tension $F$ in the rope.

$F =$ .......................................................... N **[2]**

(ii) Calculate the angular velocity $\omega$ of the rotating bucket.

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

(c)* A student wishes to test the equation $F = \dfrac{mv^2}{r}$ for a constant force $F$ using a whirling bung in the laboratory.

Describe with the aid of a labelled diagram how an experiment can be conducted, and how the data can be analysed to test the validity of this equation for a constant force.

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**22** Observations of the planets led to Kepler's three empirical laws:

    1.    The orbit of a planet is an ellipse with the Sun at one focus.

    2.    A line joining a planet and the Sun sweeps out equal areas during equal time intervals.

    3.    The square of the orbital period $T$ is proportional to the cube of the average orbital radius $r$.

**(a)** With the help of a labelled diagram, illustrate Kepler's second law for the planets in our Solar System.

[2]

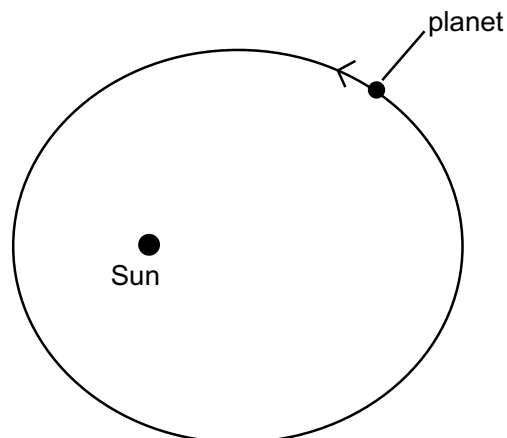**(b)** Fig. 22 shows the elliptical orbit of a planet around the Sun.



**Fig. 22**

Draw the gravitational force acting on the planet at the position shown in Fig. 22.    **[1]**

**(c)** Three exoplanets orbit the star KIC 11442793. Measurements of average orbital radius $r$ and period $T$ for the exoplanets are shown in the table.

| $r$ / AU | $T$ / days |
|----------|-----------|
| 0.0881 | 8.719 |
| 0.520 | 124.9 |
| 0.996 | 331.6 |

It is suggested that the relationship between $T$ and $r$ is given by Kepler's third law:

$$T^2 \propto r^3$$

Propose and carry out a test to check if the relationship is true for the three exoplanets.

Test proposed: ..............................................................................................................

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Working:

Conclusion: ...........................................................................................................**[3]**

**23 (a)** State *Hubble's law*.

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**(b)** Hubble's law can be used to estimate the age of the universe. Fig. 23 shows some of Hubble's early measurements of nearby galaxies plotted on a *v* against *d* graph, where *v* is the recessional speed of a galaxy and *d* is its distance from us.
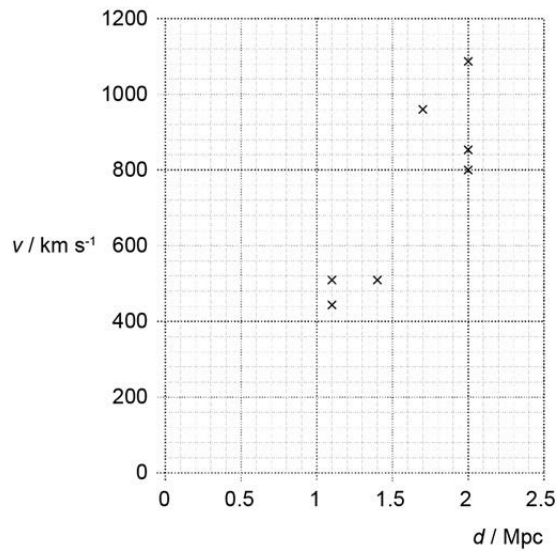


**Fig. 23**

**(i)** State how *v* was determined.

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

**(ii)** Use Fig. 23 to estimate a value for the Hubble constant $H_0$ in km s$^{-1}$ Mpc$^{-1}$.

$H_0$ = .............................................km s$^{-1}$ Mpc$^{-1}$ **[3]**

(iii) Use your answer to part **(ii)** to estimate Hubble's initial value for the age of the universe in years.

age = ..................................................... years **[3]**

(c) Measurements of more distant galaxies taken over the last 85 years have refined the value of $H_0$ to be 68 km s$^1$ Mpc$^{-1}$.

(i) Suggest why measurements for our nearest galaxies can deviate from the current Hubble's law trend line.

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(ii) Suggest why measurements for galaxies at the largest distances deviate from the Hubble's law trend line.

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**24** A group of students are conducting an experiment in the laboratory to determine the acceleration of free $g$ using a simple pendulum as shown below.
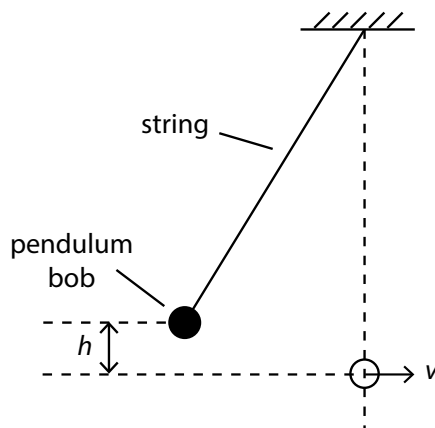


The pendulum bob is released from **rest** from a height $h$. The speed of the pendulum bob as it passes through the vertical position is $v$. The speed $v$ is measured using a light-gate and a computer.

The results from the students are shown in a table.

| $h$ / m | $v$ / m s$^{-1}$ | $v^2$ / m$^2$ s$^{-2}$ |
|---------|------------------|------------------------|
| 0.052 | $1.0 \pm 0.1$ | $1.0 \pm 0.2$ |
| 0.100 | $1.4 \pm 0.1$ | $2.0 \pm 0.3$ |
| 0.151 | $1.7 \pm 0.1$ | $2.9 \pm 0.3$ |
| 0.204 | $1.9 \pm 0.1$ | |
| 0.250 | $2.2 \pm 0.1$ | $4.8 \pm 0.4$ |
| 0.302 | $2.4 \pm 0.1$ | $5.8 \pm 0.5$ |

**(a)** Describe and explain how the students may have made accurate measurement of $h$.

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**(b)** Complete the missing value of $v^2$ in the table. **[1]**
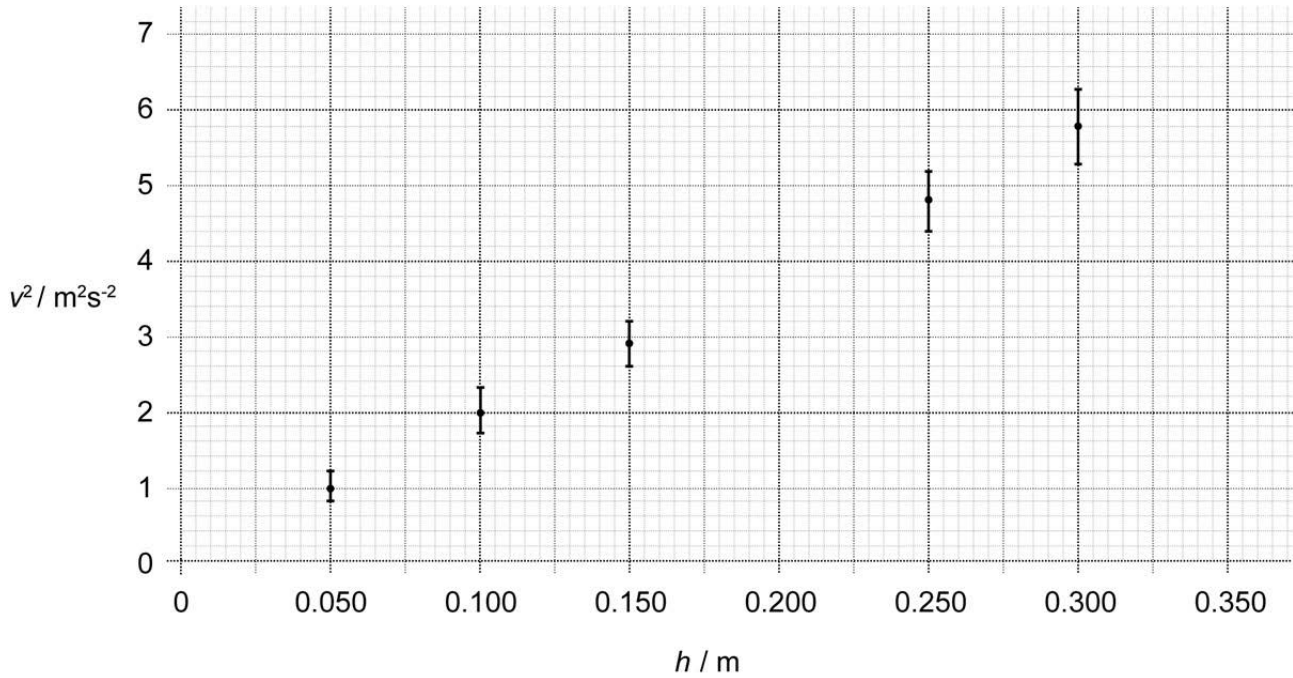
**(c)** Fig. 24 shows the graph of $v^2$ against $h$.



**Fig. 24**

(i) Plot the missing data point and error bar on Fig. 24. [1]

(ii)* Explain how Fig. 24.2 can be used to determine the acceleration of free fall $g$.
Find the value of $g$ and include the uncertainty in your answer.

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**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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