

Physics
PAPER 1
Higher Tier

Total Marks

Thursday 25 May 2023 – Morning

Time: 1 hour 45 minutes

In the boxes below, write your name, centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

YOU MUST HAVE

Calculator, ruler, Equation Booklet (enclosed)

YOU WILL BE GIVEN

Diagram Booklet

Formulae Booklet

INSTRUCTIONS

Answer ALL questions.

Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet– there may be more space than you need.

INFORMATION

The total mark for this paper is 100.

The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.

In questions marked with an ASTERISK (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

A list of equations is provided as a separate booklet.

There may be spare copies of some diagrams.

Turn over

ADVICE

Read each question carefully before you start to answer it.

Try to answer every question.

Check your answers if you have time at the end.

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

- 1 Look at Figure 1 for Question 1(a) in the Diagram Booklet. It shows a bat and its prey.**

The bat emits a high frequency sound pulse to locate its prey.

The speed of sound in air is 330 m/s.

- (a) The wavelength of the sound is 11 mm.**

**Calculate the frequency of the sound.
(2 marks)**

Use the equation

$$v = f \times \lambda$$

Answer space continues on the next page.

1 continued.

frequency = _____ Hz

(continued on the next page)

1 continued.

(b) The pulse returns to the bat after a time of 18 ms.

**Calculate the distance from the bat to its prey.
(4 marks)**

distance = _____ m

(Total for Question 1 = 6 marks)

Turn over

2 (a) Which of these is a scalar quantity?
(1 mark)

☐ **A acceleration**

☐ **B distance**

☐ **C force**

☐ **D weight**

(continued on the next page)

2 continued.

(b) A student has some cupcake cases.

Look at the diagrams for Question 2(b) in the Diagram Booklet. One cupcake case is shown in Figure 2.

The student drops a stack of cupcake cases with the base facing downwards, as shown in Figure 3.

The speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(i) The student also has a stop clock and a metre rule.

Describe an investigation to show how the speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(4 marks)

Answer space continues on the next page.

Turn over

2(b)(i) continued.

(continued on the next page)

2(b) continued.

- (ii) A stack of cupcake cases has a mass of 0.005 kg.**

Calculate the weight, in newtons, of the stack of cupcake cases.

**Gravitational field strength = 10 N/kg
(2 marks)**

Use the equation

$$W = mg$$

weight = _____ N

(continued on the next page)

Turn over

2(b) continued.

Look at Figure 4 for Question 2(b)(iii) in the Diagram Booklet. It shows a cupcake case that is falling at a constant velocity.

(iii) Draw an arrow on Figure 4 to show the force due to air resistance on the cupcake case.

(1 mark)

(iv) State the value of the acceleration of the cupcake case when it is falling at a constant velocity.

(1 mark)

(Total for Question 2 = 9 marks)

- 3 (a) Look at Figure 5 for Question 3(a) in the Diagram Booklet. It shows a football kicked against a wall.

The football has a mass of 0.42 kg.

- (i) The football gains 11 J of gravitational potential energy as it moves from the ground to the wall.

Calculate the height at which the ball hits the wall.

(3 marks)

Gravitational field strength = 10 N/kg

Use the equation

$$\Delta \text{GPE} = m \times g \times \Delta h$$

height = _____ m

3(a) continued.

- (ii) Calculate the kinetic energy of the football when it is moving at a velocity of 12m/s.
(2 marks)**

Use the equation

$$\text{KE} = \frac{1}{2} \times m \times v^2$$

kinetic energy = _____ J

(continued on the next page)

3(a) continued.

- (iii) Describe the energy transfers that happen when the ball hits the wall.
(2 marks)**

(continued on the next page)

3 continued.

(b) A stone is held at rest above the ground.

The stone is released and falls until its velocity is 17 m/s.

**Calculate the distance the stone has fallen when its velocity has reached 17 m/s.
(2 marks)**

distance = _____ m

(Total for Question 3 = 9 marks)

- 4 (a) Look at Figure 6 for Question 4(a) in the Diagram Booklet. It shows two objects, **E** and **D**.

E emits a sound.

D detects the sound.

E is moving in the direction shown by the arrow, but **D** is not moving.

E emits a sound of wavelength 1.86 m.

D measures the wavelength of this sound as 1.98 m.

(continued on the next page)

1 continued.

- (i) Calculate the difference between the wavelength that **E** emits and the wavelength that **D** detects.
(1 mark)

difference in wavelength =

_____ m

(continued on the next page)

4(a) continued.

(ii) The velocity of sound is 330 m/s.

Calculate the velocity of E.
(2 marks)

Use the equation

velocity of E =

$$\frac{\text{velocity of sound} \times \text{difference in wavelength}}{\text{wavelength E emits}}$$

velocity of E = _____ m/s

(continued on the next page)

4 continued.

- (b) The wavelength of light emitted from distant galaxies is different when the light is detected on Earth.**

Explain how this difference in wavelength shows that the Universe is expanding.

(2 marks)

(continued on the next page)

4 continued.

- (c) CMB radiation provides evidence that the Universe had a definite beginning.**

**Look at Figure 7 for Question 4(c) in the Diagram Booklet. Use the table in Figure 7 to give a typical value for the wavelength of CMB radiation.
(2 marks)**

wavelength = _____

(continued on the next page)

4 continued.

(d) During the evolution of a star, the nebula collapses and becomes a main sequence star.

**(i) State what causes the nebula to collapse.
(1 mark)**

(continued on the next page)

4(d) continued.

- (ii) Explain why the nebula stops collapsing as it becomes a main sequence star.
(3 marks)**

(Total for Question 4 = 11 marks)

- 5 Look at Figure 8 for Question 5 in the Diagram Booklet. It shows a velocity/time graph for a lift moving upwards in a tall building.**

(a) For what length of time is the lift at rest during the first 16 s?
(1 mark)

☐ **A 1.4 s**

☐ **B 3.0 s**

☐ **C 3.6 s**

☐ **D 4.0 s**

(continued on the next page)

5 continued.

- (b) Use the graph in Figure 8 to determine the maximum velocity of the lift during the first 16 s. (1 mark)**

maximum velocity = _____ m/s

- (c) Use the graph in Figure 8 to determine the acceleration of the lift during the first 1.4 s. (3 marks)**

acceleration = _____ m/s²

5 continued.

- (d) Use the graph in Figure 8 to determine the distance that the lift travelled during the first 6.0 s. (3 marks)**

distance = _____ m

- (e) At 18 s, the lift starts to move downwards.**

Sketch a line on Figure 8 in the Diagram Booklet to show the lift moving downwards after 18 s.

(1 mark)

(Total for Question 5 = 9 marks)

- 6 (a) Look at Figure 9 for Question 6(a) in the Diagram Booklet. It shows two technicians, L and M, measuring the speed of sound in air.**

L fires a starting pistol.

M starts a stopwatch when first seeing the smoke from the starting pistol.

M stops the stopwatch when hearing the bang made by the starting pistol.

The distance between L and M is 120 m.

M's reaction time is 0.23 s.

The speed of sound in air is 330 m/s.

(continued on the next page)

6(a) continued.

- (i) Calculate M's reaction time as a percentage of the time sound takes to travel from L to M.
(3 marks)**

_____ %

(continued on the next page)

6(a) continued.

**(ii) Which of these would improve the technicians' measurement of the speed of sound?
(1 mark)**

- ☐ **A Use a firework 'banger' instead of the starting pistol.**
- ☐ **B Use a stop clock that measures time in minutes.**
- ☐ **C Increase the distance between L and M.**
- ☐ **D Decrease the distance between L and M.**

(continued on the next page)

6 continued.

- (b) Look at Figure 10 for Question 6(b) in the Diagram Booklet. It shows the difference in refraction of sound waves and light waves when these waves travel from air into water.**

Explain why the refraction of the sound wave is different from the refraction of the light wave in Figure 10.

(3 marks)

(continued on the next page)

Turn over

6 continued.

(c) Light is one example of an electromagnetic wave.

Light can transfer energy from a lamp to the leaf of a plant, causing chemical reactions in the leaf.

Describe examples of TWO other electromagnetic waves transferring energy.

(4 marks)

Answer space continues on the next page.

1 _____

6(c) continued.

2 _____

(Total for Question 6 = 11 marks)

- 7 (a) Look at Figure 11 for Question 7(a) in the Diagram Booklet. It shows the symbol for a nucleus of americium-241.

Americium-241 is a radioactive isotope of americium.

Americium-241 decays by emitting alpha (α) particles.

- (i) Which of these is the symbol for another radioactive isotope of americium?
(1 mark)



(continued on the next page)

7(a) continued.

- (ii) Which of these is the approximate maximum distance that alpha particles can travel in air at normal atmospheric pressure?
(1 mark)**

☐ **A 5 mm**

☐ **B 5 cm**

☐ **C 5 m**

☐ **D 5 km**

- (iii) Look at Figure 12 for Question 7(a)(iii) in the Diagram Booklet. Complete the equation in Figure 12 for americium-241 decaying into neptunium (Np).
(3 marks)**

(continued on the next page)

7 continued.

(b) Look at Figure 13 for Question 7(b) in the Diagram Booklet.

The activity of a radioactive source is measured as 128 Bq.

This is shown as a point on the graph in Figure 13.

The half-life of this radioactive source is 17 s.

**Use this information to plot three more points on the graph grid in Figure 13 to show how the activity of the source changes with time.
(3 marks)**

(continued on the next page)

7 continued.

- (c) Describe what happens in the nucleus of an atom when a positron is emitted.
(2 marks)**

(Total for Question 7 = 10 marks)

- 8 (a) Look at Figure 14 for Question 8(a)(i) in the Diagram Booklet.

A student does an experiment to determine the critical angle for glass.

The student shines a ray of light into a semicircular glass block and measures the angles i and r , as shown in Figure 14.

- (i) The ray of light does not change direction when it enters the glass block at point X.

Which of these EXPLAINS why the ray of light does not change direction when it enters the glass block at point X.

(1 mark)

- ☐ A The ray enters along a normal to the edge of the block.
- ☐ B The ray enters at right angles to a normal to the edge of the block.
- ☐ C The ray speeds up as it enters the glass.
- ☐ D The ray slows down as it enters the glass.

(continued on the next page)

8(a) continued.

- (ii) The student repeats the procedure for different values of angle i .**

Look at Figure 15 for Question 8(a)(ii) in the Diagram Booklet. It shows a graph of the student's results.

Describe how the student should use the graph in Figure 15 to determine the critical angle for glass.

(3 marks)

Answer space continues on the next page.

8(a)(ii) continued.

(continued on the next page)

8 continued.

- (b) Look at Figure 16 for Question 8(b)(i) in the Diagram Booklet. It shows two iron spheres, P and Q, near to a radiant heater. P is painted black and Q is painted white.**

Each sphere is the same distance away from the heater.

The spheres have the same radius.

The heater is switched on and the spheres heat up.

The temperature of each sphere is monitored.

- (i) Explain why the temperature of sphere P increases at a faster rate than the temperature of sphere Q.
(2 marks)**

Answer space continues on the next page.

8(b)(i) continued.

(continued on the next page)

8(b) continued.

(ii) The heater remains switched on.

Look at Figure 17 for Question 8(b)(ii) in the Diagram Booklet. It shows how the temperature of sphere P changes with time.

Explain why the temperature of P reaches a constant value, even though the heater remains switched on.

(4 marks)

Answer lines continue on the next page.

8(b)(ii) continued.

(Total for Question 8 = 10 marks)

- 9 (a) An atom of mass 6.6×10^{-26} kg is moving with a velocity of 480 m/s.

Calculate the momentum of the atom.
(3 marks)

momentum = _____ kg m/s

(continued on the next page)

9 continued.

- (b) Look at Figure 18 for Question 9(b) in the Diagram Booklet. It shows a ball before and after it collides with a wall.**

The arrows show the direction of movement of the ball.

Before the collision, the momentum of the ball is 0.80 kg m/s .

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms during the collision.

**Calculate the force exerted on the ball by the wall.
(3 marks)**

Use an equation selected from the list of equations in the Equation Booklet.

Answer space continues on the next page.

9(b) continued.

force = _____ N

(continued on the next page)

9 continued.

***(c) Look at Figure 19 for Question 9(c) in the Diagram Booklet.**

Newton's second law can be stated as

force = mass \times acceleration

A student is provided with a trolley and a runway on a bench, as shown in Figure 19, and access to other equipment.

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

**You may add to the diagram in Figure 19 to help your answer.
(6 marks)**

Answer space continues on the next page.

9(c) continued.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

(Total for Question 9 = 12 marks)

- 10 (a)** Look at Figure 20 for Question 10(a) in the Diagram Booklet. It shows a Mars rover, a vehicle used for exploring the surface of the planet Mars.

The power supply in a Mars rover is called an RTG.

The RTG contains a radioactive isotope that releases thermal energy as it decays.

The RTG uses the thermal energy released in the decay to provide electrical power for the rover.

- (i)** An RTG has an efficiency rating of only 7%.

Calculate the useful energy transferred by the RTG when 1300 J of thermal energy is released in the decay.

(2 marks)

Use the equation

$$\text{efficiency} = \frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})} \times 100\%$$

Answer space continues on the next page.

10(a) continued.

useful energy transferred = _____ J

(continued on the next page)

10(a) continued.

- (ii) Suggest, with a reason, ONE property the isotope must have to be suitable for use in the RTG.
(2 marks)**

(continued on the next page)

10 continued.

- (b) Look at Figure 21 for Question 10(b) in the Diagram Booklet. It shows the fission of a uranium nucleus.**

The total mass of all the particles after the reaction is less than the total mass of the particles before the reaction.

The energy released in the reaction comes from the change in mass.

This is shown in the equation

$$\text{energy released} = (\text{change in mass}) \times (\text{speed of light})^2$$

The energy released in one fission reaction = $1.49 \times 10^{-10} \text{ J}$.

The speed of light = $3.00 \times 10^8 \text{ m/s}$.

**Calculate the change in mass.
(3 marks)**

Answer space continues on the next page.

10(b) continued.

change in mass = _____ kg

(continued on the next page)

10 continued.

- *(c) The energy released in a single uranium fission is very small.**

In a nuclear power station, the fission of uranium in the reactor releases large amounts of energy.

The energy released is enough to generate electricity for thousands of homes.

The demand for electricity varies.

Explain

- how large amounts of energy can be released in the reactor**
 - how the rate of energy release is controlled as the demand for electricity varies.**
- (6 marks)**

Answer space continues on the next 2 pages.

10(c) continued.

[illegible]

Turn over

10(c) continued.

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS
END OF PAPER