

Physics
PAPER 1
Higher Tier

Total Marks

Wednesday 22 May 2024 – 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

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 you make are related or follow on from each other where appropriate.

There may be spare copies of some diagrams.

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 (a) Nuclear fusion is a process that releases energy.**

Which of these statements applies to a nuclear fusion reaction?

(1 mark)

- ☐ **A it emits daughter nuclei**
- ☐ **B it is a controlled chain reaction**
- ☐ **C it produces radioactive waste**
- ☐ **D it requires high temperature and pressure**

(continued on the next page)

1 continued.

(b) In the Sun, four protons start the process of nuclear fusion.

These protons combine and finally produce a helium nucleus.

The helium nucleus has a smaller mass than the four protons.

This difference in mass is converted to energy.

**Four protons have a total mass
of 6.69×10^{-27} kg**

**A helium nucleus has a mass
of 6.64×10^{-27} kg**

**Calculate the percentage of the original mass that
has been converted to energy.
(3 marks)**

Answer space continues on the next page.

1(b) continued.

**percentage of mass
converted to energy _____ %**

(continued on the next page)

1 continued.

(c) Look at Figure 1 for Question 1(c) in the Diagram Booklet. It shows the spectrum of an element detected in the light from a distant galaxy, from a nearby galaxy and from a source on Earth.

- (i) Estimate the difference between the wavelength of line **P** in the spectrum from the distant galaxy and the wavelength of line **P** in the spectrum on Earth.
(1 mark)**

difference in wavelength = _____nm

(continued on the next page)

1(c) continued.

- (ii) Scientists have discovered that light from almost all distant galaxies has spectral lines shifted towards the red end of the spectrum.**

Explain how red shift in light, received from galaxies at different distances from the Earth, supports the idea that the Universe is expanding.

(3 marks)

(Total for Question 1 = 8 marks)

Turn over

- 2 Look at Figure 2 for Question 2 in the Diagram Booklet. It shows a person on a skateboard at the top of a ramp.**

At P, the person is not moving.

- (a) The person rides the skateboard down the ramp from P to Q.**

The gravitational potential energy of the person decreases by 980 J

The mass of the person is 35 kg

**Calculate h , the height of the ramp.
(2 marks)**

Use $g = 10 \text{ N/kg}$

Use the equation

change in gravitational potential energy = $m \times g \times h$

Answer space continues on the next page.

2(a) continued.

change in gravitational potential energy = $m \times g \times h$

$h =$ _____ **m**

(continued on the next page)

2 continued.

(b) The kinetic energy, KE , of the person at Q is 950 J

The mass of the person is 35 kg

**Calculate the velocity of the person at Q.
(3 marks)**

Use the equation

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

velocity = _____ m/s

(continued on the next page)

Turn over

2 continued.

(c) Look at Figure 3 for Question 2(c) in the Diagram Booklet. It is a diagram that represents energy changes from **P to **Q**.**

(i) State what is represented by **X.**
(1 mark)

(ii) Calculate the value of **X.**
(1 mark)

value of **X** = _____ J

(continued on the next page)

2(c) continued.

- (iii) Look again at Figure 3 for Question 2(c) in the Diagram Booklet. Calculate the efficiency of the system represented in Figure 3.
(2 marks)**

efficiency = _____

(Total for Question 2 = 9 marks)

- 3 (a) Two people, **L** and **M**, have a **100 m** race.

L starts running before **M**.

Look at Figure 4 for Question 3(a) in the Diagram Booklet. It shows a distance/time graph of the race.

- (i) State the **DISTANCE** that **L** has run when **M** overtakes.
(1 mark)

distance = _____ m

- (ii) Calculate the velocity of **L** when running the **100 m** race.
(2 marks)

velocity = _____ m/s

(continued on the next page)

Turn over

3 continued.

(b) A motorcycle is travelling at a velocity of 6.2 m/s

The motorcycle accelerates at 2.5 m/s^2 until its velocity is 10 m/s

**(i) Calculate the time taken for this acceleration.
(2 marks)**

Use the equation

$$\text{time taken} = \frac{\text{change in velocity}}{\text{acceleration}}$$

time taken = _____ s

(continued on the next page)

3(b) continued.

- (ii) The motorcycle now decelerates (slows down) from **10 m/s** to a stop.

The deceleration is at a constant rate of **4.4 m/s²**

Calculate the distance the motorcycle travels as it slows down to a stop.
(2 marks)

Use the equation

$$v^2 - u^2 = 2 \times a \times x$$

distance = _____ m

(continued on the next page)

3 continued.

(c) A car collides with a barrier on a road.

The time of the collision is very short.

Explain ONE factor, other than the time of the collision, that would affect the force on the car in the collision.

Your explanation should refer to an equation in the Equation Booklet.

(2 marks)

(Total for Question 3 = 9 marks)

Turn over

4 (a) Radiation is used to treat tumours (cancer).

The source of the radiation can be inside or outside the human body.

Which of these has a radiation source that can be positioned inside the body to treat tumours?

(1 mark)

☐ **A gamma rays**

☐ **B x-rays**

☐ **C radio waves**

☐ **D microwaves**

(continued on the next page)

4 continued.

(b) Look at Figure 5 for Question 4(b) in the Diagram Booklet. It shows a **PET scanner used to detect cancerous tumours.**

A radioactive isotope is injected into a patient.

The isotope is absorbed by the tumour.

The isotope emits positrons from the location of the tumour.

The ring of radiation detectors rotates around the person.

**(i) Explain how the scan can give the location of the tumour.
(3 marks)**

Answer space continues on the next page.

Turn over

4(b)(i) continued.

(continued on the next page)

4(b) continued.

- (ii) Explain why the radioactive isotope injected into the patient must be produced near to the place where it is to be used.
(2 marks)**

(continued on the next page)

4 continued.

(c) Radiotherapy can involve irradiation of patients.

Radioactive tracers can involve contamination of patients.

**State TWO differences between irradiation and radioactive contamination.
(2 marks)**

1 _____

2 _____

(continued on the next page)

4 continued.

(d) Look at Figure 6 for Question 4(d) in the Diagram Booklet. It shows the decay curves of two different isotopes, Q and P.

**(i) Use the graph in Figure 6 to determine the half-life of isotope P.
(2 marks)**

half-life of isotope P = _____ hours

**(ii) Suggest a reason why the sample of isotope Q could be more dangerous to humans than the sample of isotope P.
(1 mark)**

(Total for Question 4 = 11 marks)

- 5 Ultraviolet (**UV**) waves from the Sun travel towards the Earth.

Ultraviolet waves can be grouped by wavelength.

The three groups of wavelengths are **UVA**, **UVB** and **UVC**.

Look at Figure 7 for Question 5 in the Diagram Booklet. It shows, for each group,

- the wavelength range
- the effect of the Earth's atmosphere on each type of **UV** wave.

- (a) (i) Explain why **UVC** is potentially the most dangerous ultraviolet radiation but does not cause harm to people.
(2 marks)

5(a) continued.

**(ii) The speed of electromagnetic radiation
is $3.00 \times 10^8 \text{ m/s}$**

**Calculate the frequency of the shortest
wavelength of **UVB** radiation.
(3 marks)**

frequency = _____ Hz

(continued on the next page)

5 continued.

- (b) **UV** radiation of wavelength **365 nm** is used to detect forged banknotes.

In a genuine banknote there are marks that **CANNOT** be seen using visible light. These marks **CAN** be seen using **UV** radiation.

Explain why the marks can be seen when the **UV** radiation shines on the banknote.

Your answer should refer to the energy of electrons in atoms.

You may draw a diagram to help with your answer.
(4 marks)

Answer space continues on the next page.

5(b) continued.

(Total for Question 5 = 9 marks)

**6 (a) (i) The law of reflection of light applies to reflections from
(1 mark)**

- ☐ **A all surfaces**
- ☐ **B only shiny surfaces**
- ☐ **C only rough surfaces**
- ☐ **D only smooth surfaces**

(continued on the next page)

6(a) continued.

- (ii) A student uses a mirror to demonstrate that the angle of incidence is equal to the angle of reflection.**

Look at Figure 8 for Question 6(a)(ii) in the Diagram Booklet. It shows the apparatus the student uses.

Describe the procedure the student should use with the ray and mirror in the position shown in Figure 8.

You should include any extra equipment needed.

**You may add to Figure 8 to help your answer.
(3 marks)**

Answer space continues on the next page.

6(a)(ii) continued.

(continued on the next page)

6 continued.

- (b) Look at Figure 9 for Question 6(b) in the Diagram Booklet. It shows a ray of light from a ray box passing through a semi-circular glass block.**

A student uses the apparatus in Figure 9 to determine the critical angle for glass.

- (i) State why the ray of light does not change direction as it enters the glass block at X.
(1 mark)**

(continued on the next page)

6(b) continued.

- (ii) Describe how the critical angle for glass can be determined using the apparatus shown in Figure 9.
(3 marks)**

(continued on the next page)

6 continued.

- (c) Look at Figure 10 for Question 6(c) in the Diagram Booklet. It shows a ray diagram of the VIRTUAL IMAGE produced by a diverging lens.**

**State what is meant by the term VIRTUAL IMAGE.
(1 mark)**

(Total for Question 6 = 9 marks)

7 (a) Look at Figure 11 for Question 7(a) in the Diagram Booklet. A car starts from rest and then travels for 70 s as shown on the graph in Figure 11.

**(i) Complete the sentence using data from Figure 11.
(1 mark)**

The car is travelling at constant velocity

from _____ s

to _____ s.

(continued on the next page)

7(a) continued.

- (ii) Look again at Figure 11 for Question 7(a) in the Diagram Booklet. Use data from the graph in Figure 11 to show that the car travels a total distance of about 710 m in 70 s.
(3 marks)**

(continued on the next page)

7(a) continued.

- (iii) Calculate the average speed of the car for the total distance travelled.
(1 mark)**

average speed = _____ m/s

(continued on the next page)

7 continued.

- (b) The INERTIAL mass of an object is a measure of how difficult it is to change the velocity of the object.**

A force of 450 N acts on a car to give the car an acceleration of 0.35 m/s^2

**Calculate the INERTIAL mass of the car.
(2 marks)**

inertial mass of car _____ kg

(continued on the next page)

7 continued.

- (c) Look at Figure 12 for Question 7(c) in the Diagram Booklet. It shows a different velocity/time graph.**

This straight line graph can be represented by the equation

$$\mathbf{y = mx + c}$$

- (i) Give the quantities that **X** and **y** represent in the equation.
(1 mark)**

X represents _____

y represents _____

(continued on the next page)

7(c) continued.

- (ii) Look again at Figure 12 for Question 7(c) in the Diagram Booklet. Calculate the value of m from the graph in Figure 12.
(2 marks)**

$$m = \underline{\hspace{4cm}} \text{ m/s}^2$$

(continued on the next page)

7(c) continued.

- (iii) Look again at Figure 12 for Question 7(c) in the Diagram Booklet. State the value of **C** from the graph in Figure 12.
(1 mark)**

value of **C = _____**

(Total for Question 7 = 11 marks)

8 (a) An electron has a charge of -1

The charge on an alpha particle is
(1 mark)

☐ A -2

☐ B 0

☐ C $+1$

☐ D $+2$

(b) Alpha, beta and gamma are all
IONISING radiations.

Give the meaning of the term IONISING.
(1 mark)

(continued on the next page)

8 continued.

- (c) A teacher determines the background radiation count rate in a laboratory.**

Explain how to determine a value for the background radiation count rate.

(3 marks)

(continued on the next page)

Turn over

8 continued.

- (d) The teacher now investigates the absorption of beta radiation by different thicknesses of aluminium.**

The apparatus available is

- **a source of beta radiation**
- **a Geiger–Müller (G-M) tube and counter**
- **10 pieces of aluminium, each 0.5 mm thick**
- **a metre rule.**

- (i) Sketch a labelled diagram showing the positions of the apparatus when the measurements are being taken.**

(2 marks)

8(d) continued.

- (ii) Give the independent variable in this investigation.
(1 mark)**

- (iii) Name a quantity that must be kept constant during the investigation.
(1 mark)**

- (iv) Strontium-90 is the source of beta minus radiation in this investigation.**

**Look at the equation for Question 8(d)(iv) in the Diagram Booklet. Complete the nuclear equation for this emission of beta minus radiation.
(2 marks)**

(Total for Question 8 = 11 marks)

9 (a) Look at Figure 13 for Question 9(a) in the Diagram Booklet. It shows a ball being rotated in a horizontal circle.

**(i) Which arrow in Figure 13 shows the direction of the centripetal force on the ball?
(1 mark)**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

**(ii) The ball is moving at constant speed. Give ONE reason why the velocity of the ball is continuously changing.
(1 mark)**

(continued on the next page)

9 continued.

(b) Look at Figure 14 for Question 9(b) in the Diagram Booklet. It shows a gymnast landing on a mat and coming to rest.

The gymnast has a mass of 53 kg

The gymnast lands on the mat with a velocity of 4.0 m/s

The average force exerted by the mat on the gymnast is 3500 N

Calculate the time taken for the gymnast to come to rest.

Give your answer to an appropriate number of significant figures.

(3 marks)

Use the equation

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

Answer space continues on the next page.

9(b) continued.

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

time = _____ s

(continued on the next page)

9 continued.

***(c) Look at Figure 15 for Question 9(c) in the Diagram Booklet. It shows two trolleys, **P** and **Q**, moving at the same speed, **V**, directly towards each other.**

The trolleys have the same mass.

When the trolleys collide, they stick together and stop.

Explain how momentum and energy are both conserved in this collision.

(6 marks)

Answer space continues on the next 2 pages.

Turn over

9(c) continued.

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Turn over

9(c) continued.

(Total for Question 9 = 11 marks)

- 10 (a) Which row of the table shows two transverse waves?
(1 mark)

☐**A****infrasound****infrared**☐**B****infrared****ultraviolet**☐**C****ultrasound****infrasound**☐**D****ultraviolet****ultrasound**

(continued on the next page)

10 continued.

(b) Look at Figure 16 for Question 10(b) in the Diagram Booklet. It is an energy diagram for a sound wave incident on a sound-insulating board.

(i) The incident energy is 0.25 J

The absorbed energy is 67% of the incident energy.

The reflected energy is 15% of the incident energy.

**Calculate the amount of the transmitted energy.
(2 marks)**

transmitted energy = _____ J

10(b) continued.

- (ii) Give ONE way to reduce the percentage of energy transmitted through the sound-insulating board.
(1 mark)**

(continued on the next page)

10 continued.

- (c) The ratio of the absorbed energy E_a to incident energy E_i is the coefficient of absorption of sound α .

$$\alpha = \frac{E_a}{E_i}$$

Look at Figure 17 for Question 10(c) in the Diagram Booklet. The table gives the coefficient of absorption for various materials.

Explain why rooms with carpets and curtains are less noisy than rooms without them.

Use the information given in Figure 17 in your answer.
(2 marks)

Answer space continues on the next page.

Turn over

10(c) continued.

(continued on the next page)

10 continued.

- *(d) Explain how sound waves can be used to determine the depth of the ocean directly underneath a boat.**

**You may draw a diagram to help with your answer.
(6 marks)**

Answer space continues on the next 2 pages.

Turn over

10(d) continued.

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Turn over

10(d) continued.

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(Total for Question 10 = 12 marks)

TOTAL FOR PAPER = 100 MARKS
END OF PAPER