



**Test Papers
Hub.**

QCAA Physics Units 3 & 4 Practice Paper 1

External Assessment: Paper 2 — Extended Response & Problem Solving

Perusal 10 minutes · Working time 90 minutes · Extended response and problem solving · 50 marks in all

How to use this booklet

- Perusal time – 10 minutes. Working time – 90 minutes. Write using black or blue pen.
- A QCAA-approved scientific or graphics calculator may be used. A formula and data sheet is provided at the back of the paper.
- Attempt ALL questions (1 – 9). Show all relevant working, formulae, substitutions and units.
- Worked solutions follow the paper: every question has step-by-step working and a key takeaway.

EXTENDED RESPONSE

50 marks · Attempt ALL questions (1 – 9) · Allow 90 minutes

Answer all questions in the spaces provided. Show all relevant working and reasoning; unsupported final answers may not receive full marks.

Question 1 (5 marks)

A 1700 kg lander is on the surface of Mars (mass 6.42×10^{23} kg, radius 3.39×10^6 m).

(a) What is the escape speed from the surface? [3 marks]

(b) How much energy must be supplied to the lander to escape from the surface? [2 marks]

Question 2 (5 marks)

A satellite orbits Earth in a circular orbit at an altitude of 7.2×10^5 m above Earth's surface. ($G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$, $M_E = 5.97 \times 10^{24}$ kg, $R_E = 6.371 \times 10^6$ m.)

(a) What is the orbital speed of the satellite? [3 marks]

(b) What is the period of the orbit? [2 marks]

Question 3 (5 marks)

A straight wire of length 0.57 m carries a current of 5.9 A in a uniform magnetic field of 0.75 T. The wire makes an angle of 50° with the field lines.

(a) What is the magnitude of the magnetic force on the wire? [3 marks]

(b) The same wire (current and field unchanged) is held at 90° to the field. By what factor does the force change? [2 marks]

Question 4 (6 marks)

An electron is accelerated from rest through 3600 V and then enters a uniform magnetic field of 0.29 T at right angles to its velocity. ($e = 1.602 \times 10^{-19}$ C, electron mass 9.109×10^{-31} kg, proton mass 1.673×10^{-27} kg.)

(a) What is the radius of the circular path in the field? [4 marks]

(b) What is the period of the circular motion? [2 marks]

Question 5 (4 marks)

A laser of power 1.0×10^{-3} W emits monochromatic light of wavelength 7.80×10^{-7} m. ($h = 6.626 \times 10^{-34}$ J s, $c = 3.00 \times 10^8$ m s $^{-1}$.)

WORKED SOLUTIONS

Answers & worked solutions

EXTENDED RESPONSE

Question 1 (5 marks) [Gravitation and orbits]

A 1700 kg lander is on the surface of Mars (mass 6.42×10^{23} kg, radius 3.39×10^6 m).

(a) What is the escape speed from the surface?

(a) Answer: 5030 m s^{-1}

- To escape, kinetic energy must equal the magnitude of gravitational potential energy: $\frac{1}{2}mv^2 = GMm/R$.
- $v = \sqrt{(2GM/R)} = \sqrt{(2 \times 6.67 \times 10^{-11} \times 6.42 \times 10^{23} \div 3.39 \times 10^6)} = 5030 \text{ m s}^{-1}$

(b) How much energy must be supplied to the lander to escape from the surface?

(b) Answer: $2.15 \times 10^{10} \text{ J}$

- Escape energy = $|E_p|$ at the surface = GMm/R .
- $E = 6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1700 \div 3.39 \times 10^6 = 2.15 \times 10^{10} \text{ J}$

LOS: Gravitation and orbits

KEY TAKEAWAY

Gravitational potential energy is $-GMm/r$. To escape, the lander needs kinetic energy equal to GMm/R , giving $v_{\text{esc}} = \sqrt{(2GM/R)}$.

Question 2 (5 marks) [Gravitation and orbits]

A satellite orbits Earth in a circular orbit at an altitude of 7.2×10^5 m above Earth's surface. ($G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$, $M_E = 5.97 \times 10^{24} \text{ kg}$, $R_E = 6.371 \times 10^6 \text{ m}$.)

(a) What is the orbital speed of the satellite?

(a) Answer: 7490 m s^{-1}

- Orbital radius $r = R_E + \text{altitude} = 6.371 \times 10^6 + 7.2 \times 10^5 = 7.09 \times 10^6 \text{ m}$.
- Gravity provides the centripetal force: $GMm/r^2 = mv^2/r$, so $v = \sqrt{(GM/r)}$.
- $v = \sqrt{(6.67 \times 10^{-11} \times 5.97 \times 10^{24} \div 7.09 \times 10^6)} = 7490 \text{ m s}^{-1}$

(b) What is the period of the orbit?

(b) Answer: 5950 s

- Period = circumference $\div$ speed = $2\pi r \div v$.
- $T = 2\pi \times 7.09 \times 10^6 \div 7490 = 5950 \text{ s}$

LOS: Gravitation and orbits

KEY TAKEAWAY

Orbits: gravity supplies the centripetal force, so $v = \sqrt{(GM/r)}$ — and r is measured from the CENTRE of the planet, not from its surface.