ERUVIO MENTORING · EXTERNAL-STYLE EXAMINATION

Physics

Units 3 and 4 · Gravity and electromagnetism; revolutions in modern physics

Paper 2

SHORT RESPONSE · 50 MARKS

STUDENT DETAILS

GIVEN NAME(S) _____ FAMILY NAME _____

SCHOOL _____ DATE _____ BOOK OF _____

DO NOT WRITE ON THIS PAGE

Structure of this examination

PAPER	SECTION	QUESTION TYPE	TIME	MARKS
Paper 1	Section 1	Multiple choice, 20 questions	10 min perusal 90 min working	20
	Section 2	Short response, 5 questions		30
Paper 2	Section 1	Short response, 9 questions	10 min perusal 90 min working	50
Total		**34 questions**	**200 minutes**	**100**

Instructions

- **Perusal time: 10 minutes. Working time: 90 minutes.**
- You may use a QCAA-approved scientific or graphics calculator. The QCAA Physics formula and data book is provided.
- Write using black or blue pen. Planning paper will not be marked.
- All questions are drawn from Unit 3 (gravity and electromagnetism) and Unit 4 (revolutions in modern physics).
- **Paper 2 contains 9 short response questions.** Answer all questions in the spaces provided. Show all working.

Show all working. Marks are awarded for method as well as for the final answer, so a response with no working cannot receive full marks.

Section I

Short response · 9 questions · 50 marks

1 This question is about gravity. [3 marks]

(a) State Newton's law of universal gravitation. [1]

(b) Explain why an astronaut in a stable circular orbit around the Earth appears to be weightless, even though the gravitational field strength at that altitude is large. [2]

2 A ball is thrown from the roof of a building 45 m high with a speed of 15 m s^{-1} at 30° above the horizontal. Air resistance is negligible. [6 marks]

(a) Calculate the time taken for the ball to reach its maximum height. [2]

WORKING

t = _____ s

(b) Determine the maximum height of the ball above the ground. [2]

WORKING

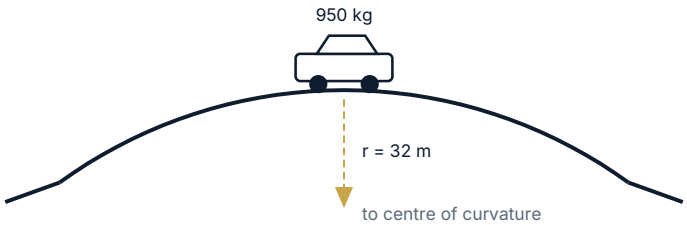
h = _____ m

(c) Calculate the total time of flight of the ball until it reaches the ground. [2]

WORKING

t = _____ s

3 A car of mass 950 kg travels over the crest of a humpback bridge. The crest has a radius of curvature of 32 m. Take g = 9.8 m s^{-2}. [5 marks]



(a) Explain why the normal force acting on the car at the crest is smaller than the weight of the car. [2]

(b) Determine the maximum speed at which the car can pass over the crest without losing contact with the road. [3]

WORKING

v = _____ m s^{-1}

4 The table shows the mean orbital radius and the orbital period of four moons of Jupiter. [6 marks]

Moon	Io	Europa	Ganymede	Callisto
Orbital radius (m)	4.22×10^8	6.71×10^8	1.07×10^9	1.88×10^9
Period (s)	1.53×10^5	3.07×10^5	6.18×10^5	1.44×10^6

(a) Calculate r^3/T^2 for Io and for Callisto, and state what your results show. [3]

WORKING

Io = _____ Callisto = _____

(b) Use the data to determine the mass of Jupiter. [3]

WORKING

M = _____ kg

5 A proton enters a uniform magnetic field of magnitude 0.25 T at a speed of 3.0×10^{6} m s^{-1}, moving at right angles to the field. The mass of a proton is 1.673×10^{-27} kg. [5 marks]

(a) Calculate the magnitude of the magnetic force acting on the proton. [2]

WORKING

F = _____ N

(b) Determine the radius of the circular path followed by the proton. [2]

WORKING

r = _____ m

(c) Explain why the speed of the proton does not change while it is in the field. [1]

6 A power station generates 5.0 MW of electrical power at 11 kV. The transmission lines between the station and a town have a total resistance of 4.0 Ω. [7 marks]

(a) Calculate the current in the transmission lines and the power dissipated in them if the power is transmitted at 11 kV. [3]

WORKING

I = _____ A P = _____ W

(b) A step-up transformer with a turns ratio of 1:30 is installed at the power station. Calculate the new transmission voltage, the new current in the lines and the new power dissipated in them. [3]

WORKING

V = _____ V I = _____ A P = _____ W

(c) Explain why a transformer cannot be used to change the voltage of a direct current supply. [1]

7 An electron is accelerated to a speed of 0.95c. The rest mass of an electron is 9.11×10^{-31} kg. [6 marks]

(a) Calculate the Lorentz factor for the electron. [1]

WORKING

γ = _____

(b) Calculate the relativistic momentum of the electron. [2]

WORKING

p = _____ kg m s^{-1}

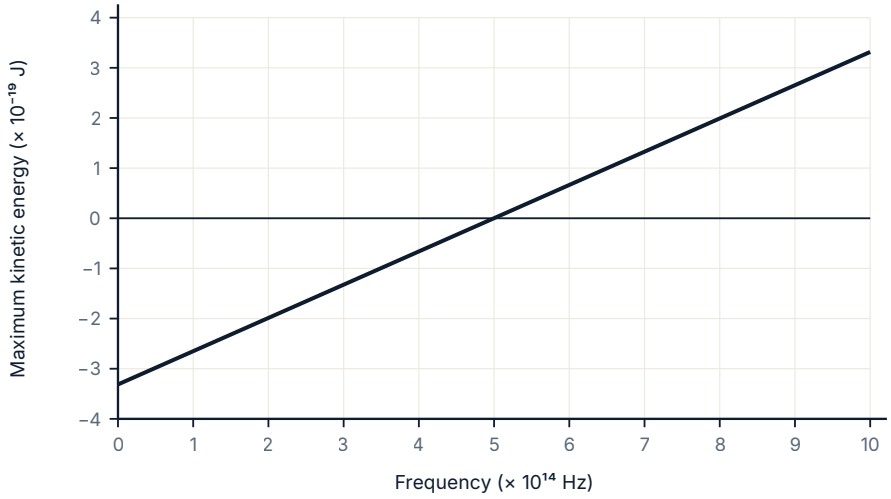
(c) Determine the total energy of the electron, in MeV. [2]

WORKING

E = _____ MeV

(d) Explain why an object that has mass cannot be accelerated to the speed of light. [1]

8 The graph shows the maximum kinetic energy of the photoelectrons emitted from a metal surface plotted against the frequency of the incident light. [6 marks]



(a) Determine the threshold frequency of the metal. [1]

WORKING

f_0 = _____ Hz

(b) Determine the work function of the metal, in electronvolts. [2]

WORKING

W = _____ eV

(c) Use the gradient of the graph to determine a value for Planck's constant. [2]

WORKING

h = _____ J s

(d) State the effect on the maximum kinetic energy of the photoelectrons of doubling the intensity of the incident light at a fixed frequency. [1]

9 Free neutrons are unstable and decay according to the equation below. [6 marks]

$$n \rightarrow p + e^{-} + \bar{\nu}_e$$

(a) State the quark composition of a neutron and of a proton. [2]

Neutron

Proton

(b) Identify the fundamental interaction responsible for this decay and name the exchange particle involved. [2]

(c) Show that both charge and lepton number are conserved in this decay. [2]

WORKING

END OF PAPER