Physics

Higher Level

Paper 2 — Mock Examination

Mock Exam 2

Calculator required

Time allowed: **2 hours 30 minutes**

Maximum mark: **90 marks**

Candidate information

Candidate name: .....

Session number: .....

Date: .....

Topic emphasis: mechanics and projectile motion, thermal physics, electric circuits, waves and optics, electric fields, transformers and magnetism, nuclear and atomic physics, rotational motion, oscillations and relativity

Instructions to candidates

- Write your session number in the box on the cover.
- Do not open this examination paper until you are told to do so.
- Answer **all** questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[90 marks]**.

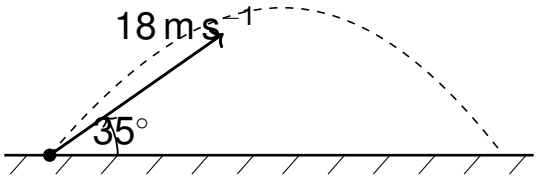
Where necessary, take the magnitude of the gravitational field strength at the Earth's surface to be $g = 9.81\,\text{N}\,\text{kg}^{-1}$ and the speed of sound in air to be $340\,\text{m}\,\text{s}^{-1}$. Values of all other constants are given in the data booklet.

Working must be shown for all questions requiring calculation. Where a question asks you to ***show that*** *a quantity has a given value, full substitution must be seen and the answer should be given to at least one more significant figure than the value quoted.*

Mark allocation

Question 1	[11 marks]	Question 5	[11 marks]
Question 2	[10 marks]	Question 6	[12 marks]
Question 3	[10 marks]	Question 7	[12 marks]
Question 4	[12 marks]	Question 8	[12 marks]

1. A ball of mass 0.15 kg is kicked from level ground with a speed of $18\,\text{m}\,\text{s}^{-1}$ at an angle of 35° above the horizontal. Air resistance is negligible.



(a) **(i)** Show that the initial vertical component of the velocity of the ball is about $10\,\text{m}\,\text{s}^{-1}$. **[1]**

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(ii) Calculate the maximum height reached by the ball. **[2]**

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(iii) Calculate the horizontal range of the ball. **[2]**

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(b) State and explain the effect of air resistance on the horizontal range of the ball. **[2]**

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(c) The ball returns to the ground with a speed of $18\,\text{m}\,\text{s}^{-1}$ and is brought to rest by a player's hands in a time of $0.12\,\text{s}$.

(i) Calculate the magnitude of the average force exerted by the hands on the ball. **[2]**

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(ii) State the magnitude and direction of the force exerted by the ball on the hands. **[1]**

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(d) Calculate the kinetic energy of the ball just before it is caught. **[1]**

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2. An electric kettle rated at 2.0 kW contains 0.80 kg of water at a temperature of 18 °C. The specific heat capacity of water is 4200 J kg^{-1} K^{-1} and the specific latent heat of vaporization of water is 2.3 × 10^{6} J kg^{-1}.

(a) Assuming that all the electrical energy is transferred to the water, calculate the time taken for the water to reach its boiling point of 100 °C. **[2]**

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(b) In practice the water takes 165 s to reach its boiling point. Determine the efficiency of the kettle. **[2]**

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(c) The kettle is left switched on for a further 60 s after the water begins to boil. Estimate, using your answer to (b), the mass of water vaporized in this time. **[3]**

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(d) Explain, in terms of the behaviour of the molecules, why the temperature of the water does not change while it is boiling. **[2]**

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(e) State one reason why the assumption in (a) is unrealistic. **[1]**

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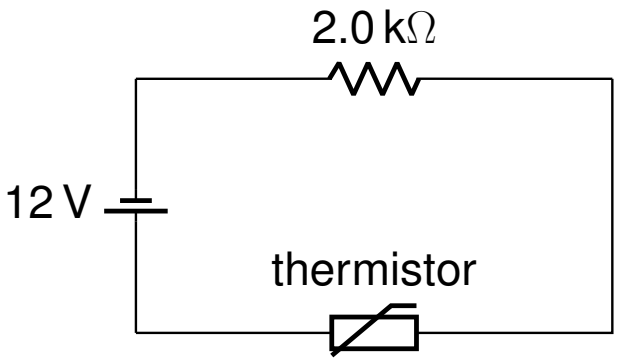
3. A battery of emf 12 V and negligible internal resistance is connected in series with a fixed resistor of resistance 2.0 kΩ and a negative temperature coefficient (NTC) thermistor. At a temperature of 20 °C the resistance of the thermistor is 4.0 kΩ.



(a) Calculate the potential difference across the fixed resistor at 20 °C. **[2]**

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(b) The temperature of the thermistor increases until its resistance falls to 1.0 kΩ. Determine the change in the potential difference across the fixed resistor. **[2]**

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(c) Calculate the total power dissipated in the circuit at this higher temperature. **[2]**

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(d) Explain, in terms of charge carriers, why the resistance of an NTC thermistor decreases as its temperature increases. **[2]**

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(e) The battery is now replaced by one of emf 12 V and internal resistance 500 Ω. State and explain the effect of this change on the potential difference across the fixed resistor. **[2]**

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4. This question is about waves.

(a) A string of length 1.2 m is fixed at both ends. The string vibrates in its third harmonic at a frequency of 240 Hz.

(i) Calculate the wavelength of the standing wave on the string. **[1]**

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(ii) Calculate the speed of the waves on the string. **[1]**

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(iii) Determine the frequency of the first harmonic of the string. **[1]**

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(b) Light of wavelength 633 nm is incident normally on two narrow parallel slits separated by 0.25 mm. The interference pattern is observed on a screen placed 1.8 m from the slits.

(i) Calculate the separation of adjacent bright fringes on the screen. **[2]**

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(ii) State and explain the effect on the fringe separation of doubling the distance between the slits. **[2]**

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(c) Unpolarized light of intensity I_0 is incident on a polarizer. A second polarizer is placed behind the first with its transmission axis at 60° to that of the first.

(i) Determine, in terms of I_0, the intensity of the light transmitted by the second polarizer. **[2]**

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(ii) State the angle between the transmission axes of the two polarizers for which the transmitted intensity is a maximum. **[1]**

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(iii) Explain why sound waves travelling in air cannot be polarized. **[2]**

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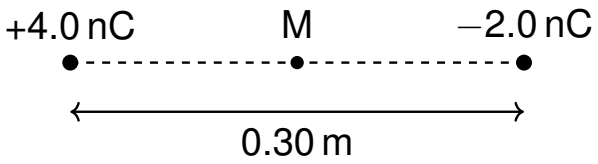
5. Two point charges, +4.0 nC and −2.0 nC, are fixed a distance of 0.30 m apart in a vacuum. Point M is the midpoint of the line joining the charges.



(a) Determine the magnitude and direction of the resultant electric field strength at M. **[3]**

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(b) Calculate the electric potential at M. **[2]**

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(c) A small charge of +1.5 nC is placed at M and then moved to a point a very large distance from both charges. Determine the magnitude of the work done on the charge by the electric field. **[2]**

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(d) Explain why there is a point on the line through the two charges, beyond the −2.0 nC charge, at which the resultant electric field strength is zero. **[2]**

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(e) State one similarity and one difference between electric fields and gravitational fields. **[2]**

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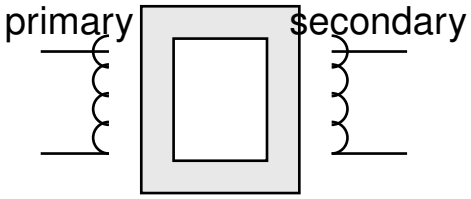
6. This question is about transformers and about magnetic forces.

(a) An ideal transformer has 1200 turns on its primary coil, which is connected to an alternating supply of 240 V. The secondary coil supplies 12 V to a lamp of resistance 6.0 Ω.



(i) Calculate the number of turns on the secondary coil. **[1]**

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(ii) Calculate the current in the lamp. **[1]**

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(iii) Determine the current in the primary coil. **[2]**

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(iv) Explain why the core of a real transformer is made from laminated sheets of iron. **[2]**

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(b) A coil rotates at a constant rate in a uniform magnetic field, generating an alternating emf.

(i) State two changes that would increase the peak emf generated by the coil. **[2]**

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(ii) Explain why the induced emf is zero at the instant when the plane of the coil is perpendicular to the magnetic field. **[2]**

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(c) A straight horizontal wire of length 0.20 m and mass 0.010 kg carries a current of 4.0 A at right angles to a horizontal magnetic field of magnitude 0.15 T. Determine whether the magnetic force on the wire is large enough to support the weight of the wire. **[2]**

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7. This question is about nuclear structure and about atomic spectra.

(a) A nucleus of lithium-7 $\left({}^{7}_{3}\text{Li}\right)$ has a mass of 7.01600 u. The mass of a proton is 1.00728 u and the mass of a neutron is 1.00867 u.

(i) Calculate, in u, the mass defect of the lithium-7 nucleus. **[2]**

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(ii) Determine, in MeV, the binding energy per nucleon of lithium-7. **[2]**

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(b) The energy levels of a hydrogen atom are given by $E_n = -\frac{13.6}{n^2}$ eV.

(i) Calculate the wavelength of the photon emitted when a hydrogen atom makes a transition from the $n = 4$ level to the $n = 2$ level. **[2]**

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(ii) Explain how the emission spectrum of hydrogen provides evidence for discrete atomic energy levels. **[2]**

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(c) A radioactive source has a half-life of 6.0 hours. The initial activity of the source is 8.0×10^5 Bq.

(i) Calculate, in s^{-1}, the decay constant of the source. **[1]**

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(ii) Determine the activity of the source after 15 hours. **[2]**

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(iii) State what is meant by the statement that radioactive decay is a random process. **[1]**

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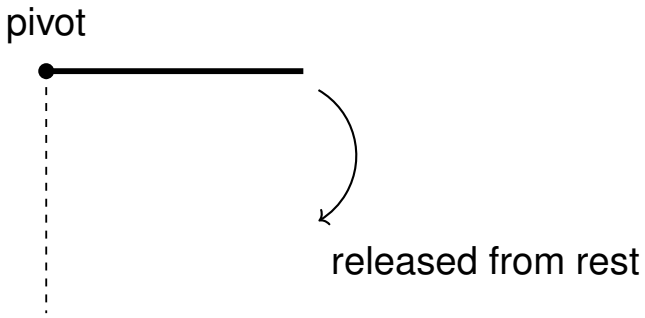
8. This question is about rotational motion, oscillations and special relativity.

(a) A uniform rod of length 1.5 m and mass 3.0 kg is pivoted at one end so that it can rotate in a vertical plane. The moment of inertia of the rod about this pivot is $\frac{1}{3}ML^2$. The rod is held horizontally and released from rest.



(i) Calculate the moment of inertia of the rod about the pivot. **[1]**

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(ii) Determine the angular speed of the rod as it passes through the vertical position. **[3]**

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(iii) Calculate the linear speed of the free end of the rod at this instant. **[1]**

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(b) A simple pendulum oscillates with a period of 2.0 s.

(i) Determine the length of the pendulum. **[2]**

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(ii) State the effect on the period of the pendulum of doubling the mass of the bob. **[1]**

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(c) A spacecraft of proper length 90 m travels past the Earth at a constant speed of 0.80*c*.

(i) Calculate the length of the spacecraft as measured by an observer on Earth. **[2]**

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(ii) Determine, as measured by the observer on Earth, the time taken for the spacecraft to pass a fixed point on the Earth. **[2]**

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End of examination.

Total: **90 marks**