Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Monday 9 November 2015 (morning)

Candidate session number

1 hour 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the 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 **[50 marks]**.

20 pages

8815–6505

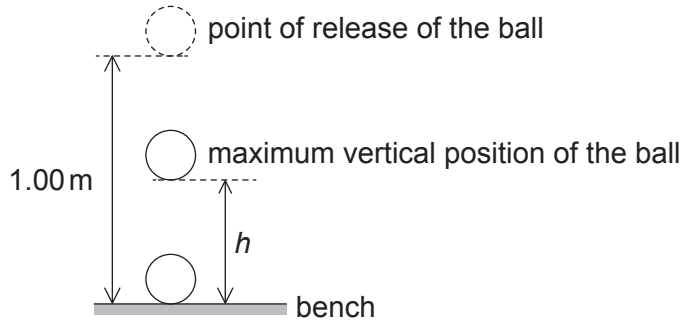
Section A

Answer **all** questions. Write your answers in the boxes provided.

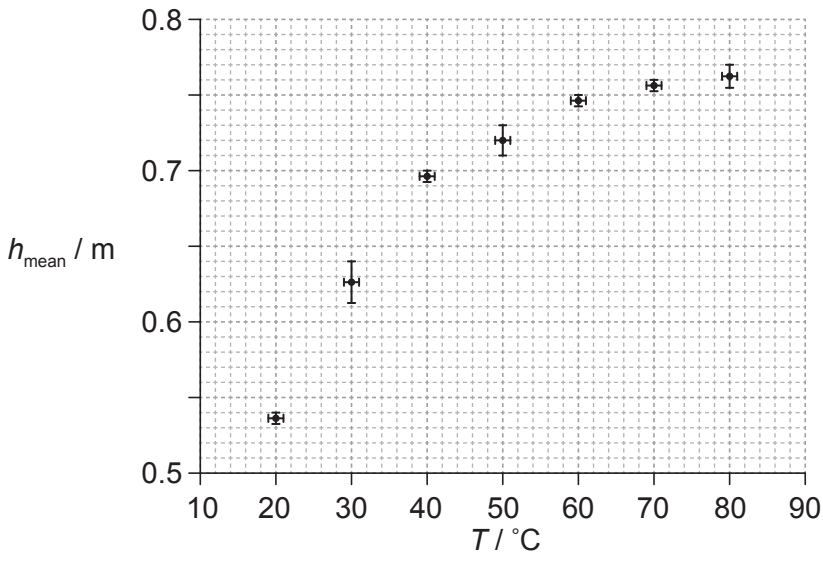
1. Data analysis question.

An experiment is undertaken to investigate the relationship between the temperature of a ball and the height of its first bounce.

A ball is placed in a beaker of water until the ball and the water are at the same temperature. The ball is released from a height of 1.00 m above a bench. The maximum vertical height h from the bottom of the ball above the bench is measured for the first bounce. This procedure is repeated twice and an average h_{mean} is calculated from the three measurements.



The procedure is repeated for a range of temperatures. The graph shows the variation of h_{mean} with temperature T.



(a) Draw the line of best-fit for the data. [1]

(This question continues on the following page)

(Question 1 continued)

(b) State why the line of best-fit suggests that h_{mean} is not proportional to T. [1]

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(c) (i) State the uncertainty in each value of T. [1]

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(ii) The temperature is measured using a liquid in glass thermometer. State what physical characteristic of the thermometer suggests that the change in the liquid's length is proportional to the change in temperature. [1]

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(d) Another hypothesis is that $h_{mean} = KT^3$ where K is a constant. Using the graph on page 2, calculate the absolute uncertainty in K corresponding to $T = 50\,^{\circ}C$. [4]

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Answers written on this page
will not be marked.

2. This question is about gravitation and uniform circular motion.

Phobos, a moon of Mars, has an orbital period of 7.7 hours and an orbital radius of 9.4×10^3 km.

(a) Outline why Phobos moves with uniform circular motion. [3]

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(b) Show that the orbital speed of Phobos is about $2\,\text{km}\,\text{s}^{-1}$. [2]

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(c) Deduce the mass of Mars. [3]

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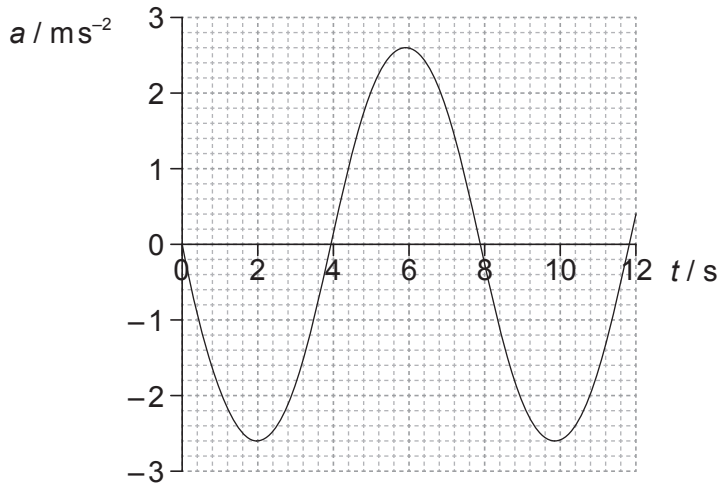
3. This question is about simple harmonic motion (SHM).

The graph shows the variation with time t of the acceleration a of an object X undergoing simple harmonic motion (SHM).



(a) Define *simple harmonic motion (SHM)*. [2]

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(b) X has a mass of 0.28 kg. Calculate the maximum force acting on X. [1]

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(This question continues on the following page)

(Question 3 continued)

(c) Determine the maximum displacement of X. Give your answer to an appropriate number of significant figures. [4]

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(d) A second object Y oscillates with the same frequency as X but with a phase difference of $\frac{\pi}{4}$. Sketch, using the graph opposite, how the acceleration of object Y varies with t. [2]

Section B

This section consists of three questions: 4, 5 and 6. Answer **one** question. Write your answers in the boxes provided.

4. This question is in **two** parts. **Part 1** is about the nuclear model of the atom and radioactive decay. **Part 2** is about waves.

Part 1 Nuclear model of the atom and radioactive decay

(a) Outline how the evidence supplied by the Geiger–Marsden experiment supports the nuclear model of the atom. [4]

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(b) Outline why classical physics does not permit a model of an electron orbiting the nucleus. [3]

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(Question 4, part 1 continued)

(c) The nuclide radium-226 $\left({}^{226}_{88}\text{Ra}\right)$ decays into an isotope of radon (Rn) by the emission of an alpha particle and a gamma-ray photon.

(i) State what is meant by the terms nuclide and isotope. [2]

Nuclide:

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Isotope:

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(ii) Construct the nuclear equation for the decay of radium-226. [3]

$${}^{226}_{88}\text{Ra} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{Rn} + {}^{\cdots\cdots}_{\cdots\cdots}\text{He} + {}^{\cdots\cdots}_{\cdots\cdots}\gamma$$

(iii) Radium-226 has a half-life of 1600 years. Determine the time, in years, it takes for the activity of radium-226 to fall to $\frac{1}{64}$ of its original activity. [2]

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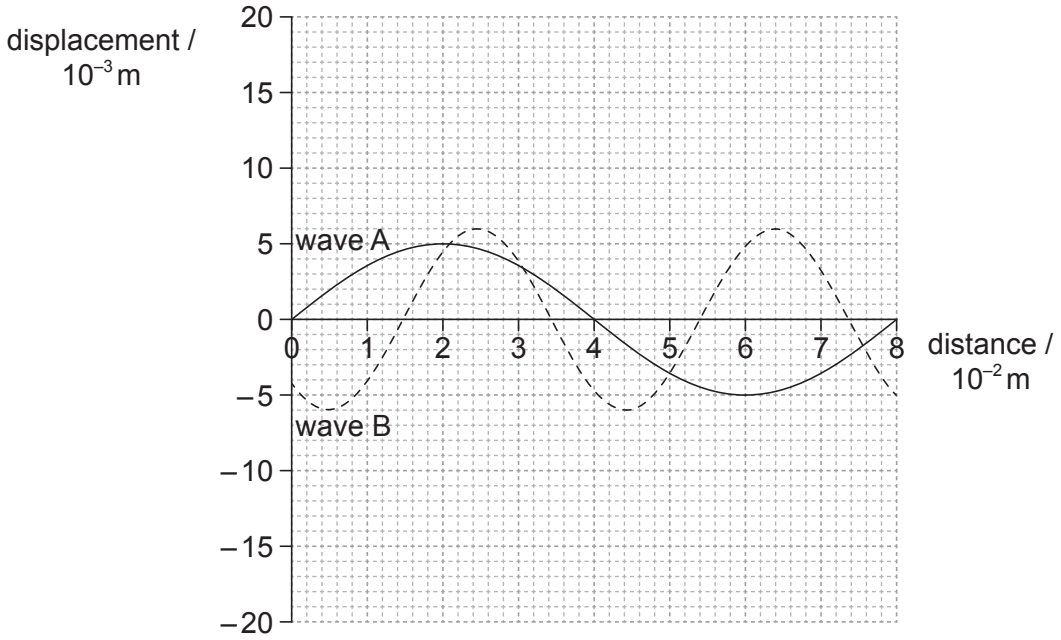
(This question continues on the following page)

(Question 4 continued)

Part 2 Waves

Two waves, A and B, are travelling in opposite directions in a tank of water. The graph shows the variation of displacement of the water surface with distance along the wave at a particular instant.



(d) State the amplitude of wave A. [1]

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(This question continues on the following page)

(Question 4, part 2 continued)

(e) (i) Wave A has a frequency of 9.0 Hz. Calculate the velocity of wave A. [2]

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(ii) Deduce the frequency of wave B. [3]

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(f) (i) State what is meant by the principle of superposition of waves. [2]

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(ii) On the graph opposite, sketch the wave that results from the superposition of wave A and wave B at that instant. [3]

5. This question is in **two** parts. **Part 1** is about energy resources. **Part 2** is about thermal physics.

Part 1 Energy resources

Electricity can be generated using nuclear fission, by burning fossil fuels or using pump storage hydroelectric schemes.

(a) Outline which of the three generation methods above is renewable. [2]

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(b) In a nuclear reactor, outline the purpose of the

(i) heat exchanger. [1]

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(ii) moderator. [2]

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(Question 5, part 1 continued)

(c) Fission of one uranium-235 nucleus releases 203 MeV.

(i) Determine the maximum amount of energy, in joule, released by 1.0 g of uranium-235 as a result of fission. [3]

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(ii) Coal has an energy density of $2.8 \times 10^7\,\text{J kg}^{-1}$.

Calculate the ratio $\frac{\text{energy density of uranium-235}}{\text{energy density of coal}}$. [1]

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(iii) Using your answer to (c)(ii), outline why fossil fuel stations are often built near to the source of the fossil fuel but nuclear power stations are rarely close to the source of the nuclear fuel. [2]

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(Question 5, part 1 continued)

(d) (i) Describe the main principles of the operation of a pump storage hydroelectric scheme. [3]

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(ii) A hydroelectric scheme has an efficiency of 92 %. Water stored in the dam falls through an average height of 57 m. Determine the rate of flow of water, in $kg\,s^{-1}$, required to generate an electrical output power of 4.5 MW. [3]

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Part 2 Thermal physics

(e) Distinguish between specific heat capacity and specific latent heat. [2]

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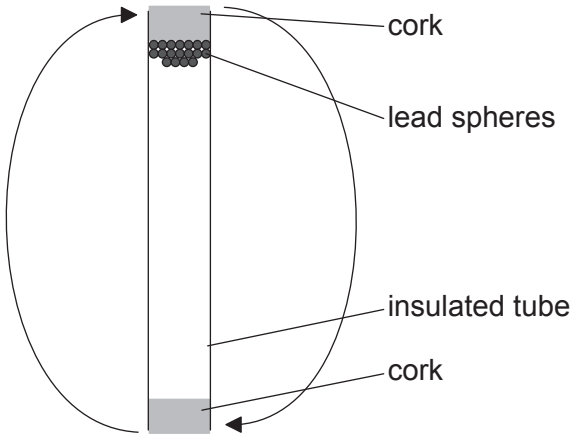
(Question 5, part 2 continued)

(f) A mass of 0.22 kg of lead spheres is placed in a well-insulated tube. The tube is turned upside down several times so that the spheres fall through an average height of 0.45 m each time the tube is turned. The temperature of the spheres is found to increase by 8 °C.



(i) Discuss the changes to the energy of the lead spheres. [2]

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(ii) The specific heat capacity of lead is $1.3 \times 10^2\,J\,kg^{-1}\,K^{-1}$. Deduce the number of times that the tube is turned upside down. [4]

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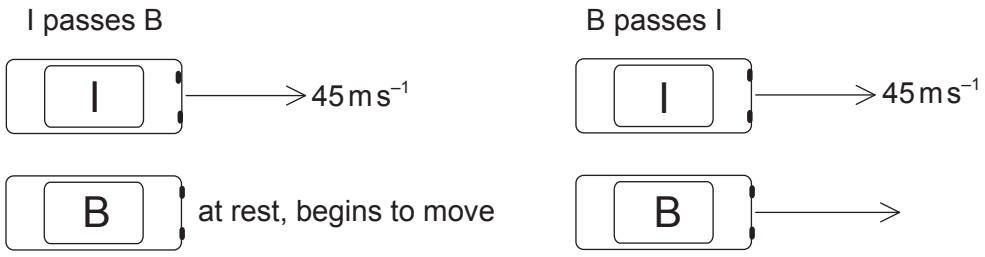
6. This question is in **two** parts. **Part 1** is about kinematics and Newton's laws of motion. **Part 2** is about electrical circuits.

Part 1 Kinematics and Newton's laws of motion

Cars I and B are on a straight race track. I is moving at a constant speed of $45\,m\,s^{-1}$ and B is initially at rest. As I passes B, B starts to move with an acceleration of $3.2\,m\,s^{-2}$.



At a later time B passes I. You may assume that both cars are point particles.

(a) (i) Show that the time taken for B to pass I is approximately 28 s. [4]

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(ii) Calculate the distance travelled by B in this time. [2]

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(Question 6, part 1 continued)

(b) B slows down while I remains at a constant speed. The driver in each car wears a seat belt. Using Newton's laws of motion, explain the difference in the tension in the seat belts of the two cars. [3]

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(c) A third car O with mass 930 kg joins the race. O collides with I from behind, moving along the same straight line as I. Before the collision the speed of I is 45 $m\,s^{-1}$ and its mass is 850 kg. After the collision, I and O stick together and move in a straight line with an initial combined speed of 52 $m\,s^{-1}$.

(i) Calculate the speed of O immediately before the collision. [2]

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(ii) The duration of the collision is 0.45 s. Determine the average force acting on O. [2]

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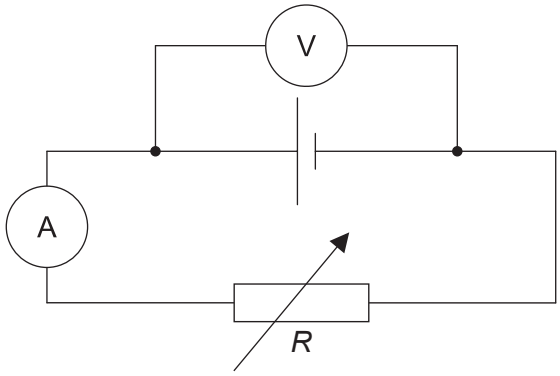
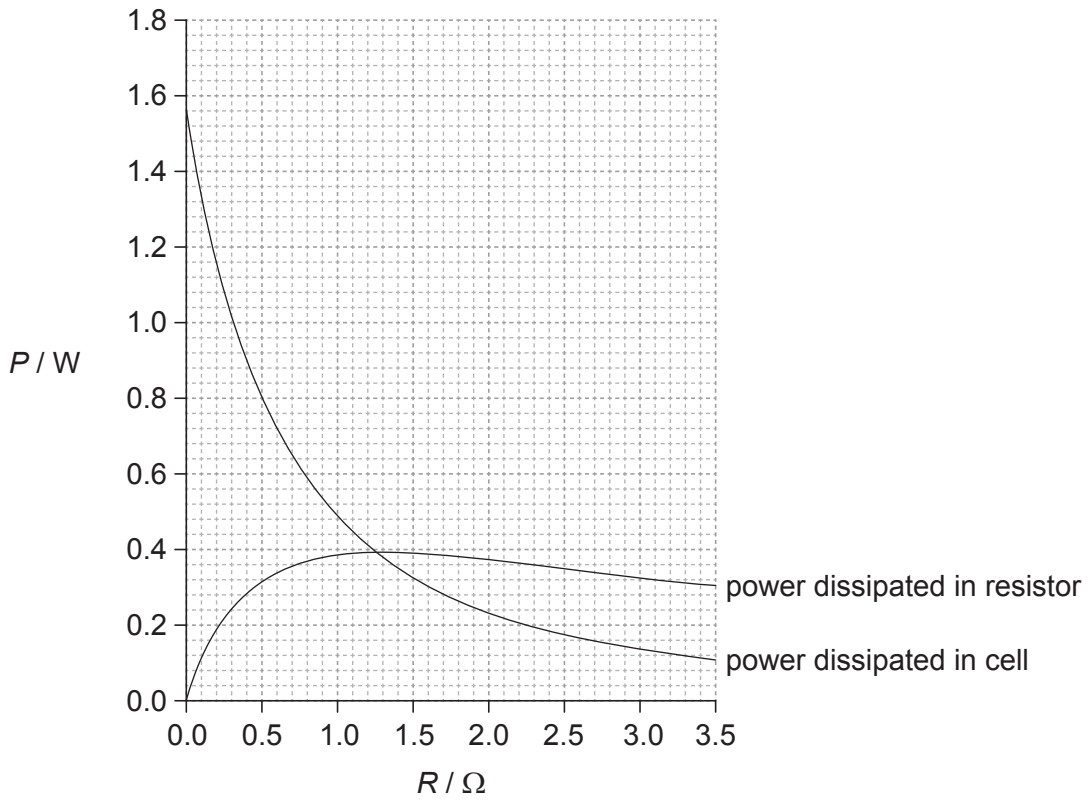
(Question 6 continued)

Part 2 Electrical circuits

The circuit shown is used to investigate how the power developed by a cell varies when the load resistance *R* changes.



The variable resistor is adjusted and a series of current and voltage readings are taken. The graph shows the variation with *R* of the power dissipated in the cell and the power dissipated in the variable resistor.



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(Question 6, part 2 continued)

(d) An ammeter and a voltmeter are used to investigate the characteristics of a variable resistor of resistance R. State how the resistance of the ammeter and of the voltmeter compare to R so that the readings of the instruments are reliable. [2]

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(e) Show that the current in the circuit is approximately 0.70 A when $R = 0.80\,\Omega$. [3]

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(f) The cell has an internal resistance.

(i) Outline what is meant by the internal resistance of a cell. [2]

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(ii) Determine the internal resistance of the cell. [3]

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(Question 6, part 2 continued)

(g) Calculate the electromotive force (emf) of the cell. [2]

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