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PHYSICS
STANDARD LEVEL
PAPER 2

Monday 10 May 2010 (afternoon)

1 hour 15 minutes

Candidate session number

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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 of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

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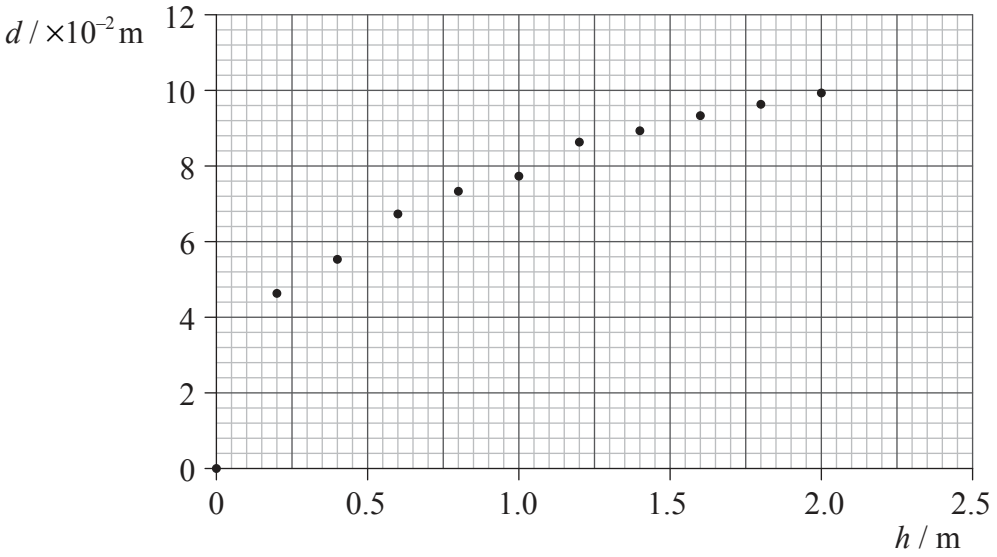
SECTION A

*Answer **all** the questions in the spaces provided.*

A1. Data analysis question.

Gillian carried out an experiment to investigate the craters formed when steel balls are dropped into sand. To try and find the relationship between the diameter of the crater and the energy of impact of steel balls of the same diameter, she dropped a steel ball from different heights h into sand and measured the resulting diameter d of the crater. The data are shown plotted below.



(a) The uncertainty in the measurement of d is ±0.40 cm; the uncertainty in h is too small to be shown. Draw error bars for the data point (0.2, 0.047) and the data point (2.0, 0.10). *[2]*

(b) Draw a best-fit line for the data points. *[2]*

(c) The original hypothesis, made by Gillian, was that the diameter of the crater is directly proportional to the energy of impact of the steel balls. Explain why the data does not support this hypothesis. *[3]*

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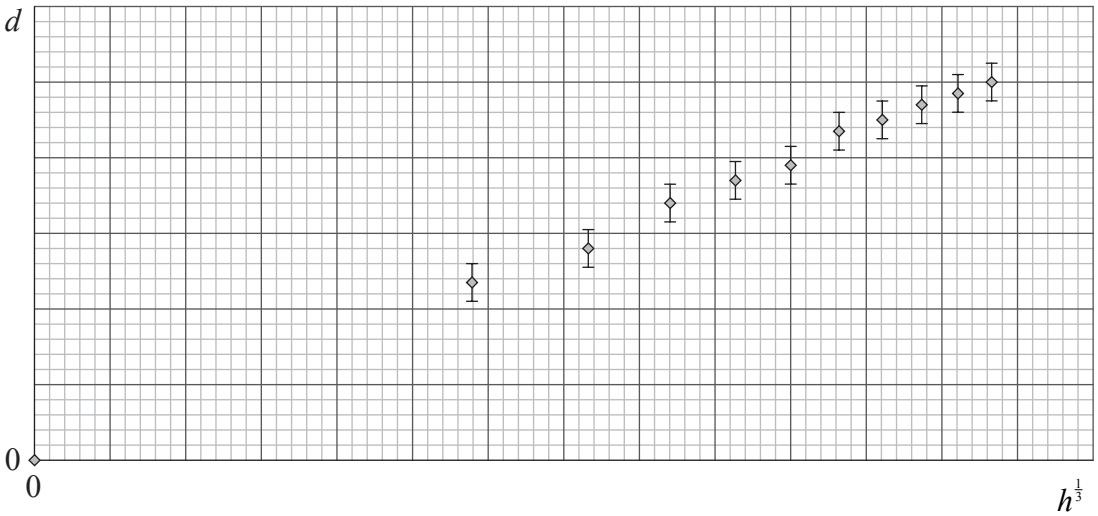
(Question A1 continued)

(d) Since Gillian's data did not support her hypothesis, she researched to find alternative hypotheses. She found that there are two theories used to predict a relationship between d and h. In order to find which theory is best supported by the data, she processed the data in two separate ways. The processed data are shown below.

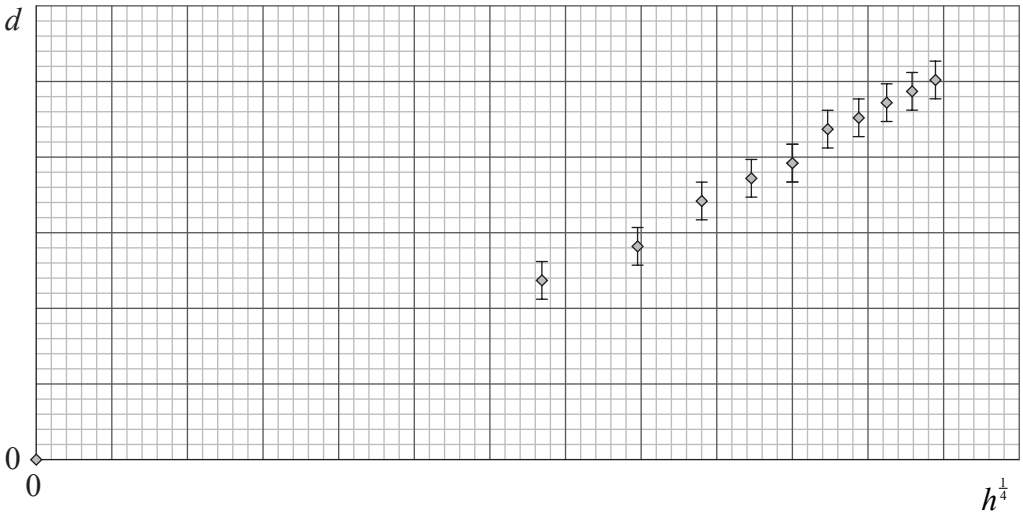
Theory 1

Predicts that $d = const(h)^{\frac{1}{3}}$



Theory 2

Predicts that $d = const(h)^{\frac{1}{4}}$



(i) Draw a line of best-fit on each graph. *[2]*

(ii) State and explain which theory is best supported by the student's data. *[2]*

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A2. This question is about circular motion and global warming.

(a) A car is travelling at constant speed of $18\,m\,s^{-1}$ around a horizontal bend in the road. The mass of the car is $1.5\times10^{3}\,kg$ and the bend forms part of a circle of radius $2.0\times10^{3}\,m$.

(i) State why the car is accelerating. *[1]*

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(ii) Determine the frictional force between the tyres of the car and the surface of the road that produces the acceleration. *[2]*

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(b) It is suggested that the use of fossil fuels to power cars has led to an enhancement of the greenhouse effect.

(i) State the reason for this suggestion. *[1]*

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(ii) Outline **one** mechanism by which the enhanced greenhouse effect may lead to an increase in global warming. *[3]*

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A3. This question is about change of phase of a liquid and latent heat of vaporization.

(a) State the difference between evaporation and boiling with reference to

(i) temperature. *[1]*

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(ii) surface area of a liquid. *[1]*

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(b) A liquid in a calorimeter is heated at its boiling point for a measured period of time. The following data are available.

Power rating of heater	$= 15\,\text{W}$
Time for which liquid is heated at boiling point	$= 4.5 \times 10^{2}\,\text{s}$
Mass of liquid boiled away	$= 1.8 \times 10^{-2}\,\text{kg}$

Use the data to determine the specific latent heat of vaporization of the liquid. *[3]*

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(c) State and explain **one** reason why the calculation in (b) will give a value of the specific latent heat of vaporization of the liquid that is greater than the true value. *[2]*

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SECTION B

*This section consists of three questions: B1, B2 and B3. Answer **one** question.*

B1. This question is in **two** parts. **Part 1** is about fossil fuels and the greenhouse effect. **Part 2** is about radioactive decay and binding energy.

Part 1 Fossil fuels and the greenhouse effect

(a) State **two** reasons why most of the world's energy consumption is provided by fossil fuels. *[2]*

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(b) A power station has an output power of 500 MW and an overall efficiency of 27%. It uses natural gas as a fuel that has an energy density of $56\,\text{MJ}\,\text{kg}^{-1}$.

(i) Define *energy density*. *[1]*

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(ii) Determine the rate of consumption of natural gas in the power station. *[3]*

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(c) Outline why the enhanced greenhouse effect may result in an increase in the temperature of the Earth's surface. *[3]*

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(Question B1, part 1 continued)

(d) (i) The solar intensity at the position of the Earth is $1380\,\text{W}\,\text{m}^{-2}$. The average albedo of Earth is 0.300. State why an average value of albedo is quoted. *[1]*

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(ii) Show that the average reflected intensity from the Earth is about $100\,\text{W}\,\text{m}^{-2}$. *[4]*

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(e) One of the expected results of global warming is an increased sea level. The increase in volume ΔV for a temperature increase ΔT is given by $\Delta V = \gamma V \Delta T$. Show, using the following data, that the resulting rise in sea level is about 0.5 m. *[2]*

$$\begin{aligned} \text{Temperature increase} &= 2.0\,^{\circ}\text{C} \\ \text{Surface area of oceans on Earth} &= 3.6\times10^{8}\,\text{km}^{2} \\ \text{Average ocean depth} &= 3.0\,\text{km} \\ \gamma &= 8.8\times10^{-5}\,\text{K}^{-1} \end{aligned}$$

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(Question B1 continued)

Part 2 Radioactive decay and binding energy

(a) Describe what is meant by radioactive decay. *[2]*

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(b) A nucleus of thallium-206 (Tl-206) undergoes radioactive decay to a nucleus of lead-206 (Pb-206). In the reaction equation below, identify the proton number Z of lead and the particle x. *[2]*

$$^{206}_{82}\text{Tl} \rightarrow {}^{206}_{Z}\text{Pb} + \beta^- + x$$

Z: . . . . . .

x: . . . . . .

(c) The mass of a Tl-206 nucleus is $191\,870\,\text{MeV}\,\text{c}^{-2}$. Determine the binding energy per nucleon of Tl-206. *[4]*

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(d) State why the binding energy of Pb-206 is greater than that of Tl-206. *[1]*

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B2. This question is in **two** parts. **Part 1** is about oscillations and waves. **Part 2** is about electrical resistance and electric circuits.

Part 1 Oscillations and waves

(a) A rectangular piece of wood of length l floats in water with its axis vertical as shown in diagram 1.

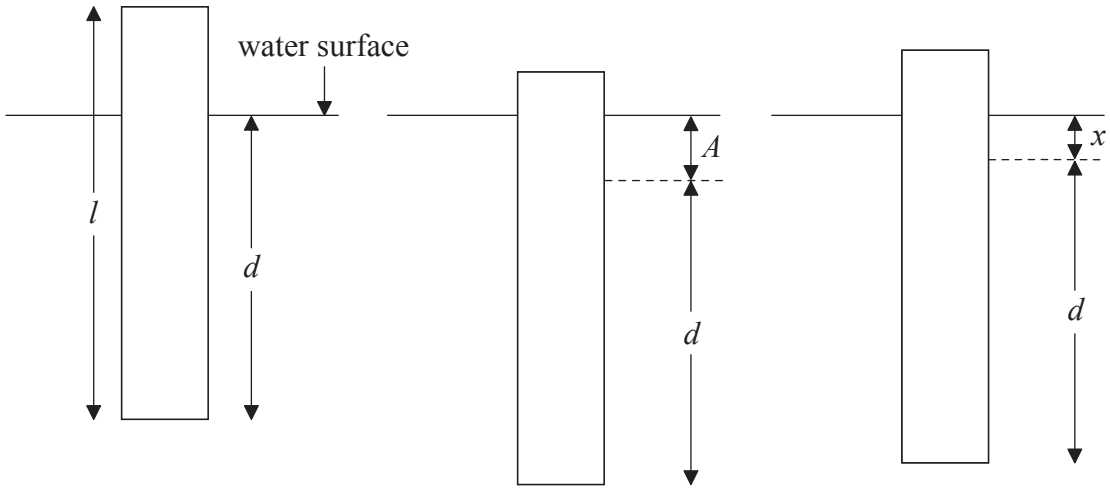

diagram 1 diagram 2 diagram 3

The length of wood below the surface is d. The wood is pushed vertically downwards a distance A such that a length of wood is still above the water surface as shown in diagram 2. The wood is then released and oscillates vertically. At the instant shown in diagram 3, the wood is moving downwards and the length of wood beneath the surface is $d + x$.

(i) On diagram 3, draw an arrow to show the direction of the acceleration of the wood. *[1]*

(ii) The acceleration a of the wood (in m s^{-2}) is related to x (in m) by the following equation.

$$a = -\frac{14}{l}x$$

Explain why this equation shows that the wood is executing simple harmonic motion. *[2]*

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(Question B2, part 1 continued)

(iii) The period of oscillation of the wood is 1.4 s. Show that the length l of the wood is 0.70 m. *[3]*

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(b) The wood in (a), as shown in diagram 2, is released at time $t = 0$. On the axes below, sketch a graph to show how the velocity v of the wood varies with time over one period of oscillation. *[1]*

(c) The distance A that the wood is initially pushed down is 0.12 m.

(i) Calculate the magnitude of the maximum acceleration of the wood. *[2]*

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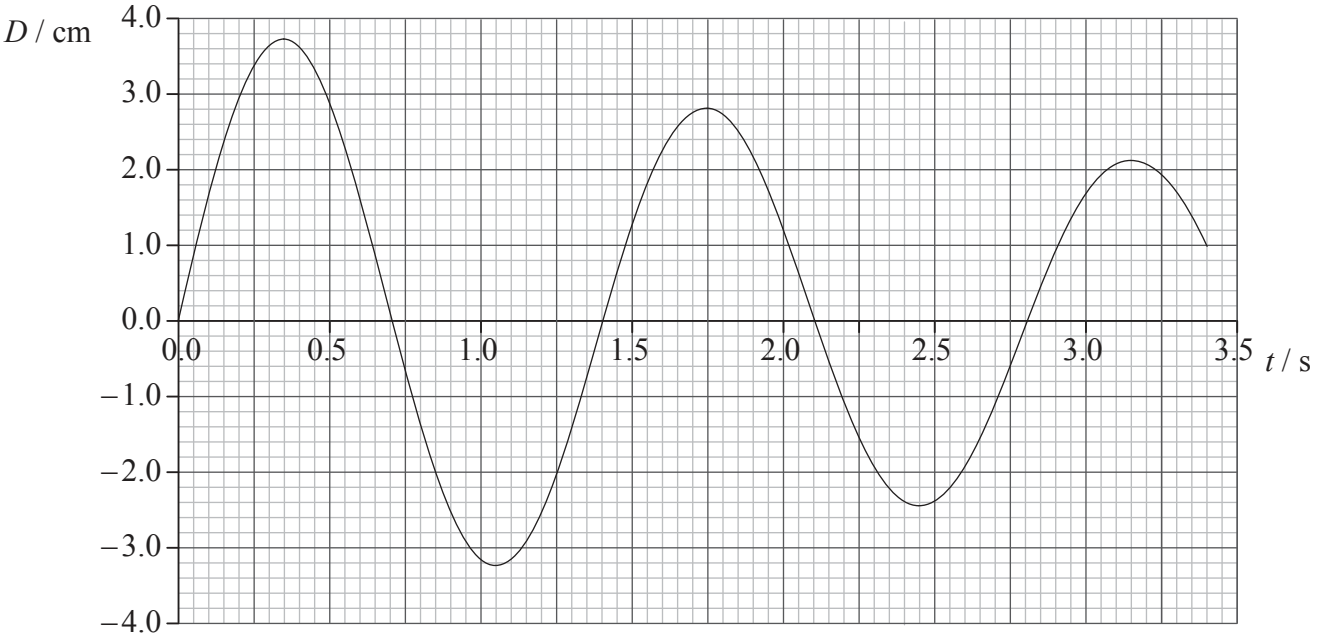
(ii) On your sketch graph in (b) label with the letter P one point where the magnitude of the acceleration is a maximum. *[1]*

(This question continues on the following page)

(Question B2, part 1 continued)

(d) The oscillations of the wood generate waves in the water of wavelength 0.45 m. The graph shows how the displacement D, of the water surface at a particular distance from the wood varies with time t.



Using the graph, calculate the

(i) speed of the waves. *[2]*

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(ii) ratio of the displacement at $t = 1.75$ s to the displacement at $t = 0.35$ s. *[2]*

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(iii) ratio of the energy of the wave at $t = 1.75$ s to the energy at $t = 0.35$ s *[1]*

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(Question B2 continued)

Part 2 Electrical resistance and electric circuits

(a) Define *resistance* and state Ohm's law. *[2]*

Resistance: . . . . . .

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Ohm's law: . . . . . .

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(b) A resistor made from a metal oxide has a resistance of 1.5 Ω. The resistor is in the form of a cylinder of length 2.2×10^{-2} m and radius 1.2×10^{-3} m. Calculate the resistivity of the metal oxide. *[2]*

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(c) The manufacturer of the resistor in (b) guarantees its resistance to be within ±10 % of 1.5 Ω provided the power dissipation in the resistor does not exceed 1.0 W. Calculate the maximum current in the resistor for the power dissipation to be equal to 1.0 W. *[2]*

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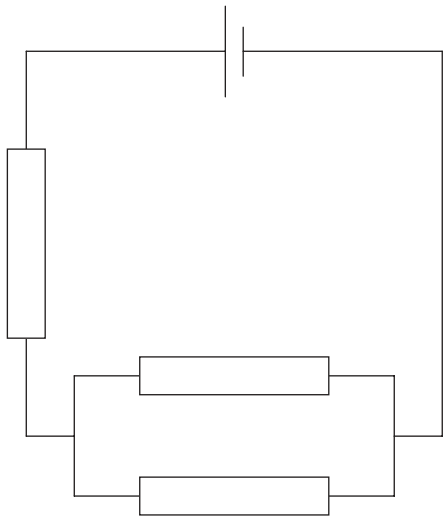
(Question B2, part 2 continued)

(d) The resistance of each of the resistors in the circuit below is measured to be 1.5 Ω with an accuracy of ±10 %.



The cell has an emf of 2.0 V and negligible internal resistance.

(i) Define *emf*. *[1]*

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(ii) Determine the minimum and the maximum power that could be dissipated in this circuit. *[3]*

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B3. This question is in **two** parts. **Part 1** is about momentum, energy and power. **Part 2** is about electric and gravitational fields.

Part 1 Momentum, energy and power

(a) In his *Principia Mathematica* Newton expressed his third law of motion as "to every action there is always opposed an equal reaction". State what Newton meant by this law. *[1]*

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(b) A book is released from rest and falls towards the surface of Earth. Discuss how the conservation of momentum applies to the Earth-book system. *[3]*

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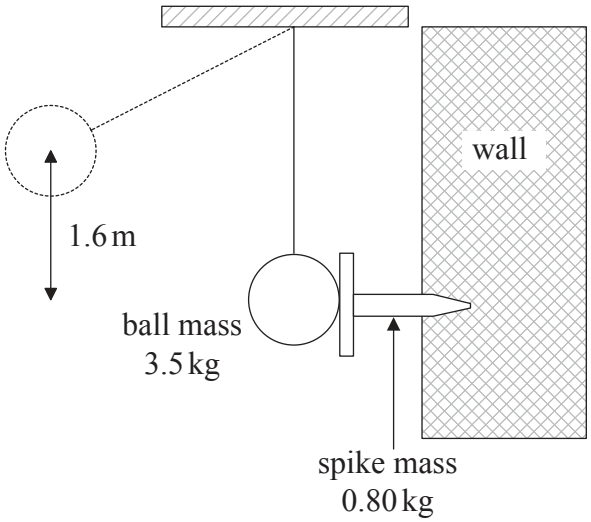
(Question B3, part 1 continued)

(c) A large swinging ball is used to drive a horizontal iron spike into a vertical wall. The centre of the ball falls through a vertical height of 1.6 m before striking the spike in the position shown.



The mass of the ball is 3.5 kg and the mass of the spike is 0.80 kg. Immediately after striking the spike, the ball and spike move together. Show that the

(i) speed of the ball on striking the spike is 5.6 m s^{-1}. *[1]*

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(ii) energy dissipated as a result of the collision is about 10 J. *[4]*

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(Question B3, part 1 continued)

(d) As a result of the ball striking the spike, the spike is driven a distance 7.3×10^{-2} m into the wall. Calculate, assuming it to be constant, the friction force F between the spike and wall. *[3]*

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(e) The machine that is used to raise the ball has a useful power output of 18 W. Calculate how long it takes for the machine to raise the ball through a height of 1.6 m. *[3]*

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(Question B3 continued)

Part 2 Electric and gravitational fields

(a) State, in terms of electrons, the difference between a conductor and an insulator. *[1]*

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(b) Suggest why there must be an electric field inside a current-carrying conductor. *[3]*

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(c) The magnitude of the electric field strength inside a conductor is $55\,\text{N}\,\text{C}^{-1}$. Calculate the force on a free electron in the conductor. *[1]*

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(d) The electric force between two point charges is a fundamental force as is the gravitational force between two point masses. State **one** similarity between these two forces and **one** difference (other than the fact that one applies to charge and the other to mass). *[2]*

Similarity: . . . . . .

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Difference: . . . . . .

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(Question B3, part 2 continued)

(e) The force on a mass of 1.0 kg falling freely near the surface of Jupiter is 25 N. The radius of Jupiter is 7.0×10^7 m.

(i) State the value of the magnitude of the gravitational field strength at the surface of Jupiter. *[1]*

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(ii) Calculate that the mass of Jupiter is about 1.8×10^{27} kg. *[2]*

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