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PHYSICS
STANDARD LEVEL
PAPER 2

Candidate session number

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Thursday 10 May 2012 (afternoon)

1 hour 15 minutes

Examination code

2	2	1	2	–	6	5	1	7

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]*.

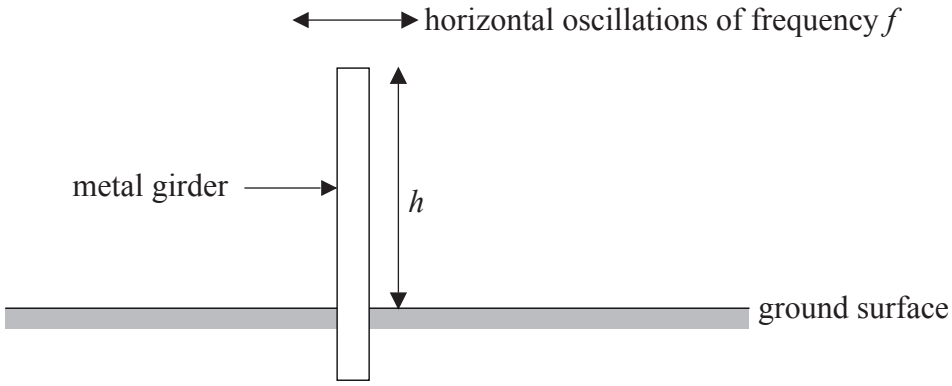
0128

SECTION A

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

A1. Data analysis question.

Metal girders are often used in buildings that have been constructed to withstand earthquakes. To aid the design of these buildings, experiments are undertaken to measure how the natural frequency f of horizontal oscillations of metal girders varies with their dimensions. In an experiment, f was measured for vertically supported girders of the same cross-sectional area but with different heights h.



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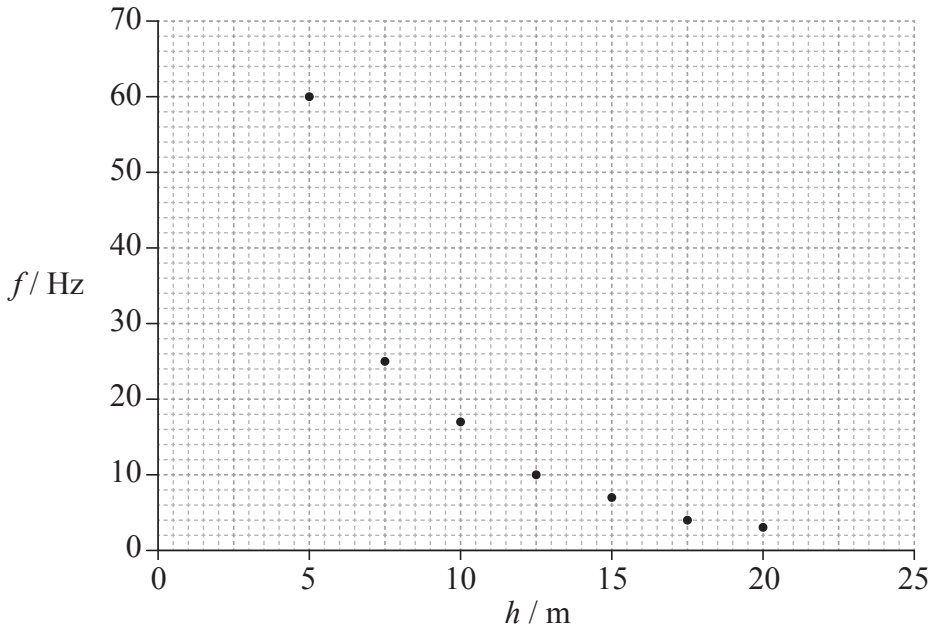
(Question A1 continued)

The graph shows the plotted data for this experiment. Uncertainties in the data are not shown.



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

(b) It is hypothesized that the frequency f is inversely proportional to the height h.

By choosing **two** well separated points on the best-fit line that you have drawn in (a), show that this hypothesis is incorrect. *[4]*

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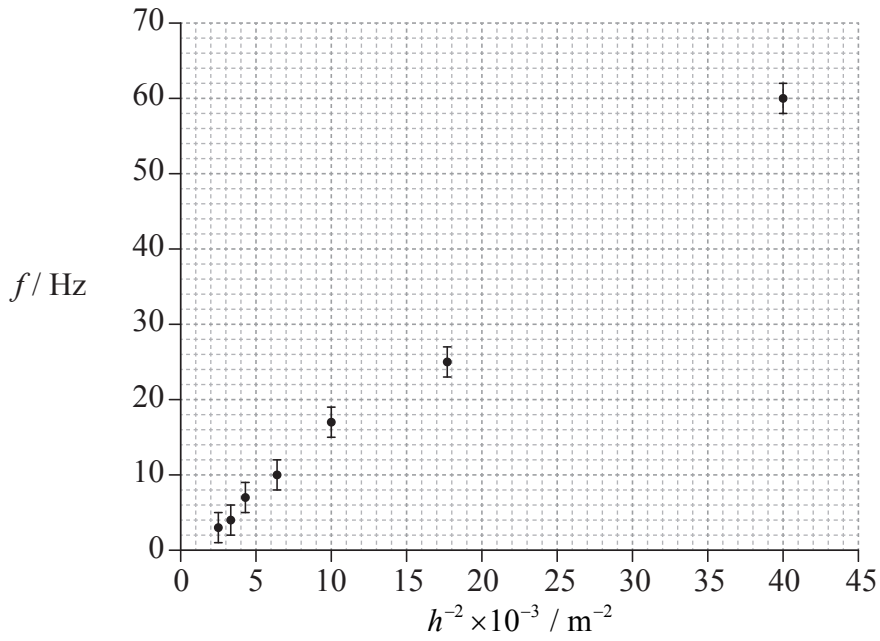
(Question A1 continued)

(c) Another suggestion is that the relationship between f and h is of the form shown below, where k is a constant.

$$f = \frac{k}{h^2}$$

The graph shows a plot of f against h^{-2}.



The uncertainties in h^{-2} are too small to be shown.

(i) Draw a best-fit line for the data that supports the relationship $f = \frac{k}{h^2}$. *[2]*

(ii) Determine, using the graph, the constant k. *[3]*

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(Question A1 continued)

(d) State **one** reason why the results of the experiment could not be used to predict the natural frequency of oscillation for girders of height 50 m. *[1]*

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A2. This question is about kinematics.

(a) State the difference between average speed and instantaneous speed. *[2]*

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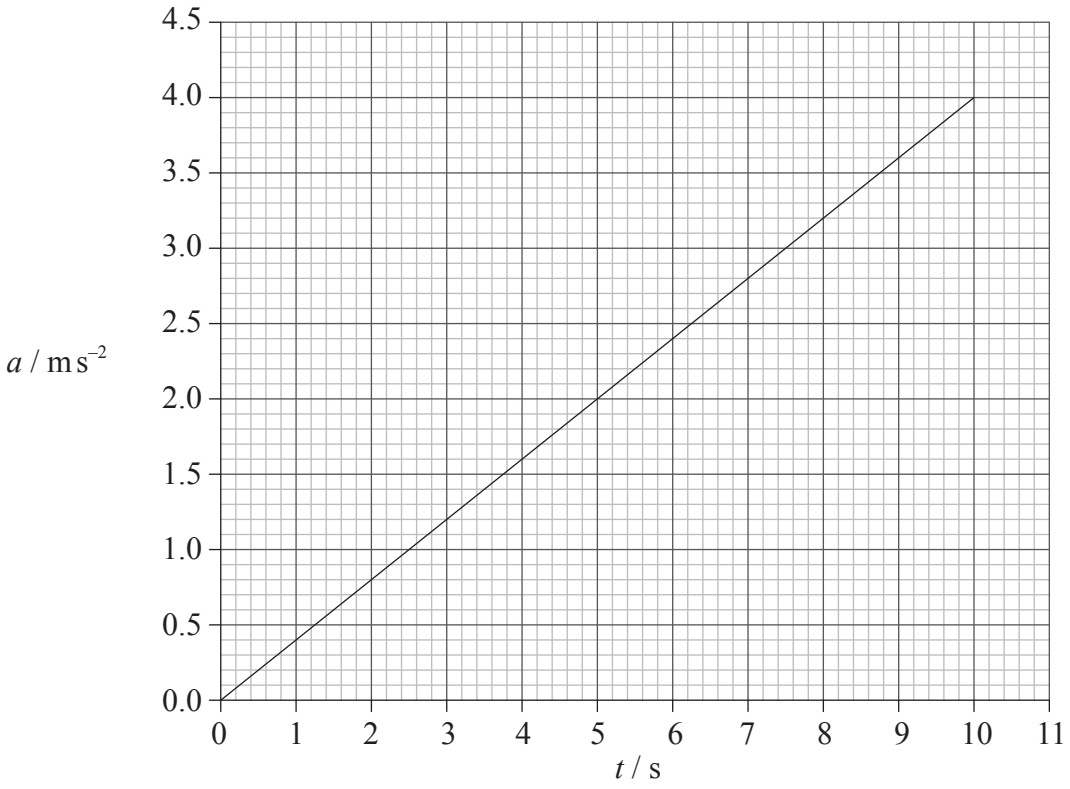
(b) The graph shows how the acceleration a of a particle varies with time t.



At time $t = 0$ the instantaneous speed of the particle is zero.

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(Question A2 continued)

(i) Calculate the instantaneous speed of the particle at $t = 7.5\,\text{s}$. *[2]*

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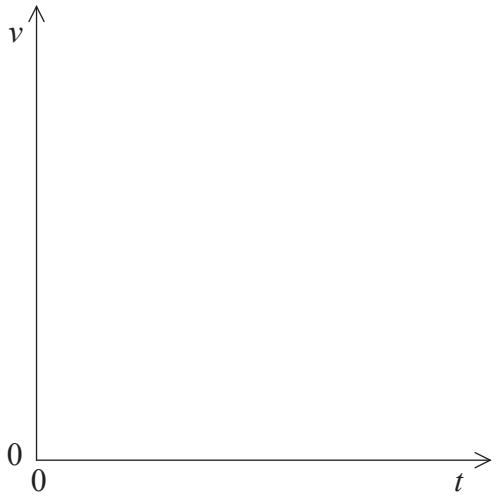
(ii) Using the axes below, sketch a graph to show how the instantaneous speed v of the particle varies with t. *[1]*



A3. This question is about nuclear reactions.

(a) The nuclide U-235 is an isotope of uranium. A nucleus of U-235 undergoes radioactive decay to a nucleus of thorium-231 (Th-231). The proton number of uranium is 92.

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

Nuclide: . . . . . .
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Isotope: . . . . . .
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(ii) One of the particles produced in the decay of a nucleus of U-235 is a gamma photon. State the name of another particle that is also produced. *[1]*

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(b) The daughter nuclei of U-235 undergo radioactive decay until eventually a stable isotope of lead is reached.

Explain why the nuclei of U-235 are unstable whereas the nuclei of the lead are stable. *[3]*

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(Question A3 continued)

(c) Nuclei of U-235 bombarded with low energy neutrons can undergo nuclear fission. The nuclear reaction equation for a particular fission is shown below.

$$ {}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{144}_{56}\mathrm{Ba} + {}^{89}_{36}\mathrm{Kr} + 3\,{}^{1}_{0}\mathrm{n} $$

Show, using the following data, that the kinetic energy of the fission products is about 200 MeV. *[3]*

Mass of nucleus of U-235 = 235.04393 u
Mass of nucleus of Ba-144 = 143.922952 u
Mass of nucleus of Kr-89 = 88.91763 u
Mass of neutron = 1.00867 u

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SECTION B

*This section consists of three questions: B1, B2 and B3. Answer **one** question. Write your answers in the boxes provided.*

B1. This question is in **two** parts. **Part 1** is about ideal gases and specific heat capacity. **Part 2** is about simple harmonic motion and waves.

Part 1 Ideal gases and specific heat capacity

(a) State **two** assumptions of the kinetic model of an ideal gas. *[2]*

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(b) Argon behaves as an ideal gas for a large range of temperatures and pressures. One mole of argon is confined in a cylinder by a freely moving piston.

(i) Define what is meant by the term *one mole of argon*. *[1]*

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(This question continues on the following page)

(Question B1, part 1 continued)

(ii) The temperature of the argon is 300 K. The piston is fixed and the argon is heated at constant volume such that its internal energy increases by 620 J. The temperature of the argon is now 350 K.

Determine the specific heat capacity of argon in $Jkg^{-1}K^{-1}$ under the condition of constant volume. (The molecular weight of argon is 40) *[3]*

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(c) At the temperature of 350 K, the piston in (b) is now freed and the argon expands until its temperature reaches 300 K.

Explain, in terms of the molecular model of an ideal gas, why the temperature of argon decreases on expansion. *[3]*

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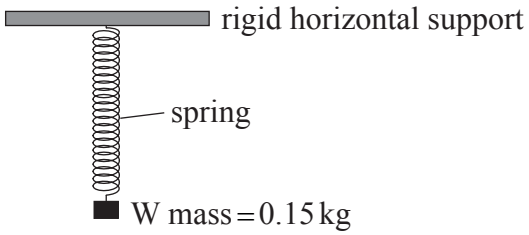
(Question B1 continued)

Part 2 Simple harmonic motion and waves

(a) One end of a light spring is attached to a rigid horizontal support.



An object W of mass 0.15 kg is suspended from the other end of the spring. The extension x of the spring is proportional to the force F causing the extension. The force per unit extension of the spring k is $18\,\text{N}\,\text{m}^{-1}$.

A student pulls W down such that the extension of the spring increases by 0.040 m. The student releases W and as a result W performs simple harmonic motion (SHM).

(i) State what is meant by the expression "W performs SHM". *[2]*

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(ii) Determine the maximum acceleration of W. *[2]*

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(Question B1, part 2 continued)

(iii) Determine the period of oscillation of the spring. *[3]*

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(iv) Determine the maximum kinetic energy of W. *[1]*

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(b) W in (a) is immersed in a beaker of oil. As a result of this immersion the oscillations of W are critically damped. Describe what is meant by critically damped. *[2]*

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(Question B1, part 2 continued)

(c) A spring, such as that in (a), is stretched horizontally and a longitudinal travelling wave is set up in the spring, travelling to the right.

(i) Describe, in terms of the propagation of energy, what is meant by a longitudinal travelling wave. *[2]*

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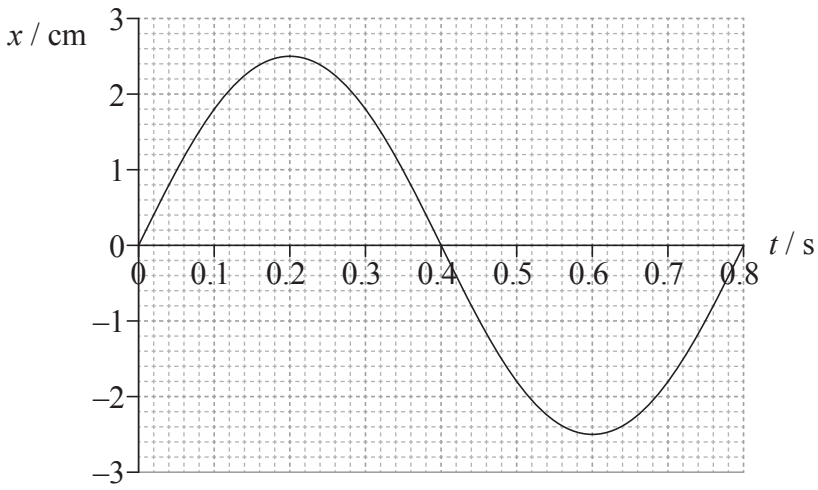
(Question B1, part 2 continued)

(ii) The graph shows how the displacement x of one coil C of the spring varies with time t.



The speed of the wave is $3.0\,\text{cm}\,\text{s}^{-1}$. Determine the wavelength of the wave. *[2]*

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(iii) Draw, on the graph in (c)(ii), the displacement of a coil of the spring that is 1.8 cm away from C in the direction of travel of the wave, explaining your answer. *[2]*

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B2. This question is in **two** parts. **Part 1** is about kinematics and mechanics. **Part 2** is about electric potential difference and electric circuits.

Part 1 Kinematics and mechanics

(a) Define *linear momentum*. *[1]*

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(b) State, in terms of momentum, Newton's second law of motion. *[1]*

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(c) Show, using your answer to (b), how the impulse of a force F is related to the change in momentum Δp that it produces. *[1]*

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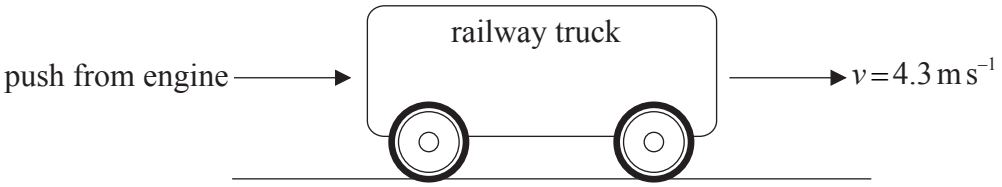
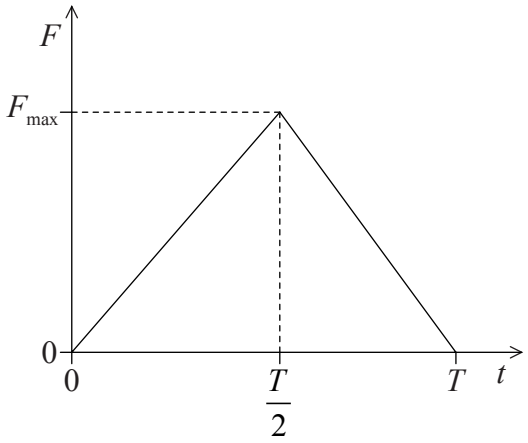
(Question B2, part 1 continued)

(d) A railway truck on a level, straight track is initially at rest. The truck is given a quick, horizontal push by an engine so that it now rolls along the track.



The engine is in contact with the truck for a time $T = 0.54\,\text{s}$ and the initial speed of the truck after the push is $4.3\,\text{m s}^{-1}$. The mass of the truck is $2.2 \times 10^3\,\text{kg}$.

Due to the push, a force of magnitude F is exerted by the engine on the truck. The sketch shows how F varies with contact time t.



(i) Determine the magnitude of the maximum force F_{max} exerted by the engine on the truck. *[4]*

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(Question B2, part 1 continued)

(ii) After contact with the engine ($t = 0.54\,\text{s}$) the truck moves a distance 15 m along the track. After travelling this distance the speed of the truck is $2.8\,\text{m s}^{-1}$. Assuming a uniform acceleration, calculate the time it takes the truck to travel 15 m. *[2]*

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(iii) Calculate the average rate at which the kinetic energy of the truck is dissipated as it moves along the track. *[2]*

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(iv) When the speed of the truck is $2.8\,\text{m s}^{-1}$ it collides with a stationary truck of mass $3.0 \times 10^3\,\text{kg}$. The two trucks move off together with a speed V. Show that the speed $V = 1.2\,\text{m s}^{-1}$. *[2]*

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(Question B2, part 1 continued)

(v) Outline the energy transformations that take place during the collision of the two trucks. *[2]*

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(Question B2 continued)

Part 2 Electric potential difference and electric circuits

(a) Ionized hydrogen atoms are accelerated from rest in the vacuum between two vertical parallel conducting plates. The potential difference between the plates is V. As a result of the acceleration each ion gains an energy of 1.9×10^{-18} J.

Calculate the value of V. *[2]*

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(b) The plates in (a) are replaced by a cell that has an emf of 12.0 V and internal resistance 5.00 Ω. A resistor of resistance R is connected in series with the cell. The energy transferred by the cell to an electron as it moves through the resistor is 1.44×10^{-18} J.

(i) Define *resistance* of a resistor. *[1]*

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(ii) Describe what is meant by internal resistance. *[2]*

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(Question B2, part 2 continued)

(iii) Show that the value of R is 15.0 Ω. *[4]*

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(iv) Calculate the total power supplied by the cell. *[1]*

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Answers written on this page
will not be marked.

B3. This question is in **two** parts. **Part 1** is about solar power and climate models. **Part 2** is about gravitational fields and electric fields.

Part 1 Solar power and climate models

(a) Distinguish, in terms of the energy changes involved, between a solar heating panel and a photovoltaic cell. *[2]*

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(b) State an appropriate domestic use for a

(i) solar heating panel. *[1]*

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(ii) photovoltaic cell. *[1]*

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(Question B3, part 1 continued)

(c) The radiant power of the Sun is 3.90×10^{26} W. The average radius of the Earth's orbit about the Sun is 1.50×10^{11} m. The albedo of the atmosphere is 0.300 and it may be assumed that no energy is absorbed by the atmosphere.

Show that the intensity incident on a solar heating panel at the Earth's surface when the Sun is directly overhead is 966 W m^{-2}. *[3]*

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(d) Show, using your answer to (c), that the average intensity incident on the Earth's surface is 242 W m^{-2}. *[3]*

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(Question B3, part 1 continued)

(e) Assuming that the Earth's surface behaves as a black-body and that no energy is absorbed by the atmosphere, use your answer to (d) to show that the average temperature of the Earth's surface is predicted to be 256 K. *[2]*

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(f) Outline, with reference to the greenhouse effect, why the average surface temperature of the Earth is higher than 256 K. *[4]*

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(Question B3 continued)

Part 2 Gravitational fields and electric fields

(a) The magnitude of gravitational field strength g is defined from the equation shown below.

$$g = \frac{F_g}{m}$$

The magnitude of electric field strength E is defined from the equation shown below.

$$E = \frac{F_E}{q}$$

For each of these defining equations, state the meaning of the symbols

(i) F_g. *[1]*

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(ii) F_E. *[1]*

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(iii) m. *[1]*

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(Question B3, part 2 continued)

(iv) *q*. *[1]*

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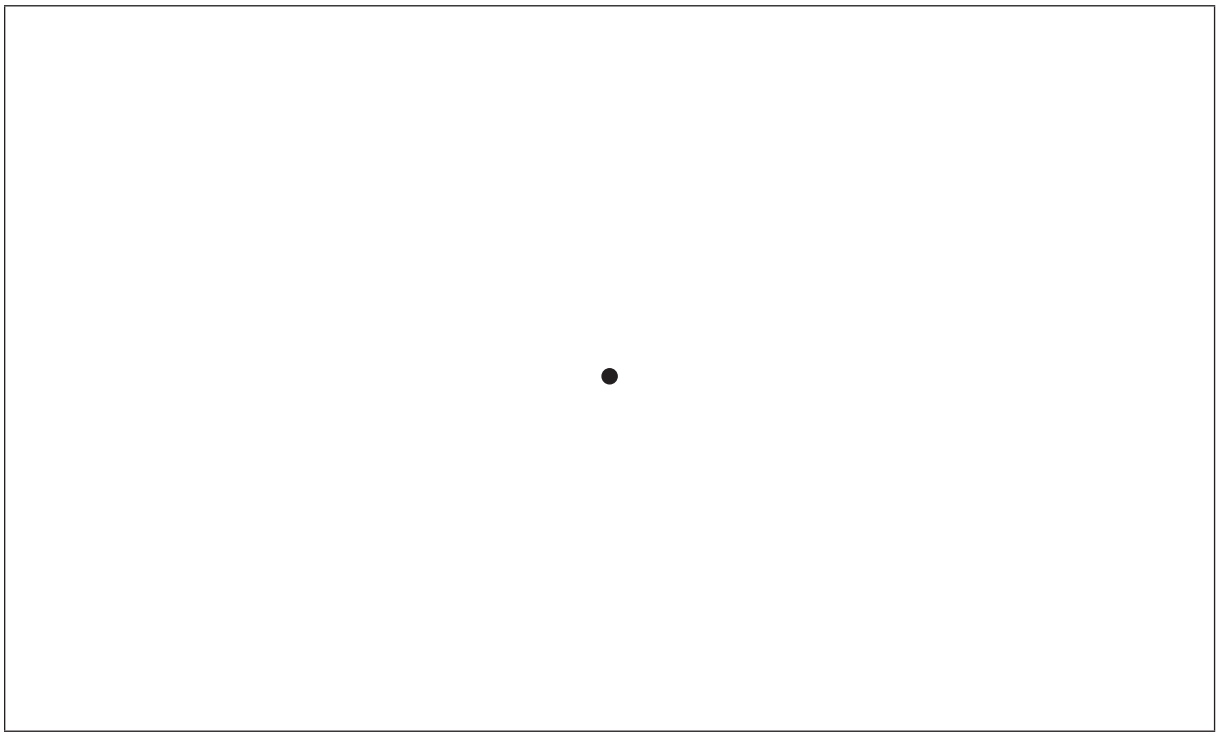
(b) In a simple model of the hydrogen atom, the electron is regarded as being in a circular orbit about the proton. The magnitude of the electric field strength at the electron due to the proton is E_p. The magnitude of the gravitational field strength at the electron due to the proton is g_p.

(i) Draw the electric field pattern of the proton alone. *[2]*



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(Question B3, part 2 continued)

(ii) Determine the order of magnitude of the ratio shown below. *[3]*

$$\frac{E_p}{g_p}$$

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