PHYSICS
STANDARD LEVEL
PAPER 2

Candidate number

Tuesday 11 November 2003 (afternoon)

1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

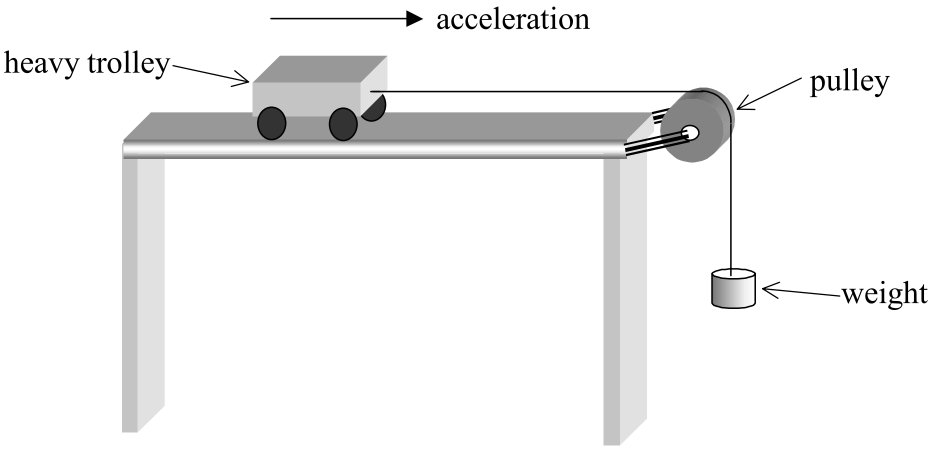
- Write your candidate number in the box above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided. You may continue your answers on answer sheets. Write your candidate number on each answer sheet, and attach them to this examination paper using the tag provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

SECTION A

*Candidates must answer **all** questions in the spaces provided.*

A1. This question is about an experiment designed to investigate Newton's second law.

In order to investigate Newton's second law, David arranged for a heavy trolley to be accelerated by small weights, as shown below. The acceleration of the trolley was recorded electronically. David recorded the acceleration for different weights up to a maximum of 3.0 N. He plotted a graph of his results.



(a) Describe the graph that would be expected if two quantities are proportional to one another. *[2]*

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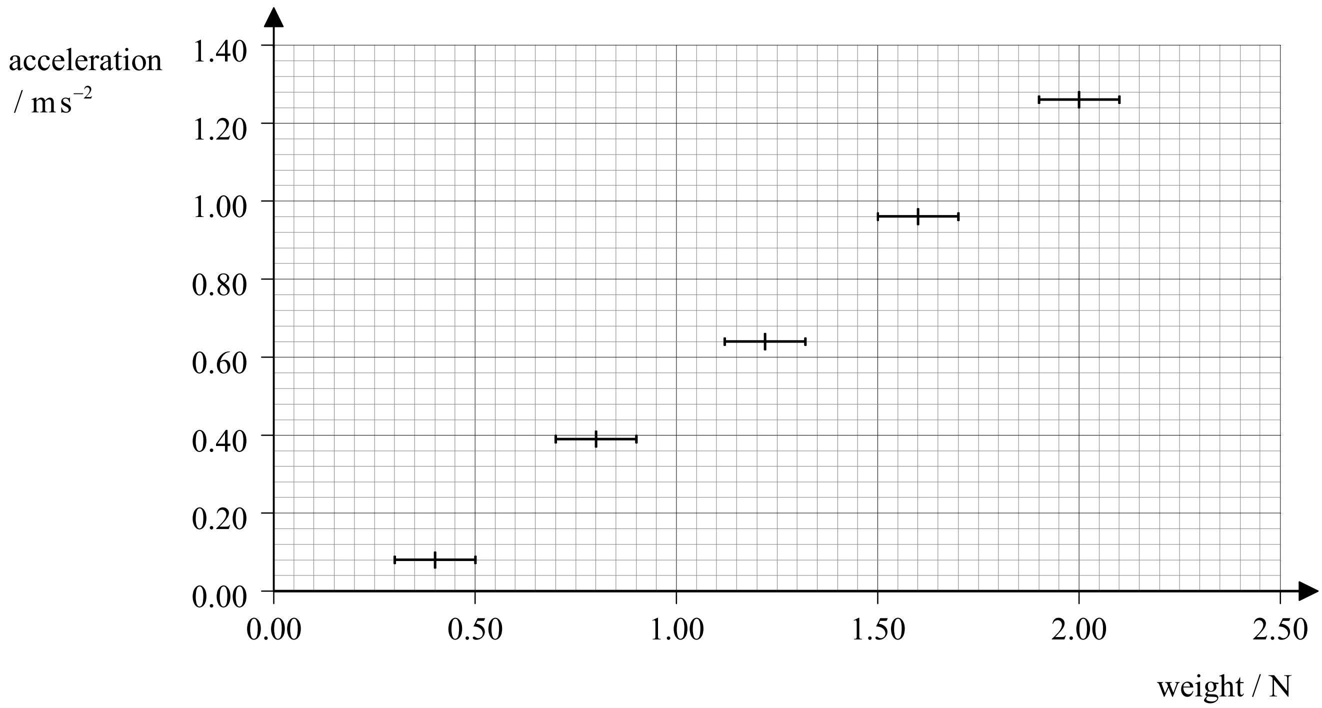
(Question A1 continued)

(b) David's data are shown below, with uncertainty limits included for the value of the weights. Draw the best-fit line for these data. *[2]*



(c) Use the graph to

(i) explain what is meant by a *systematic* error. *[2]*

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(ii) estimate the value of the frictional force that is acting on the trolley. *[1]*

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(iii) estimate the mass of the trolley. *[2]*

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A2. This question is about atomic and nuclear structure.

In a nuclear model of the atom, most of the atom is regarded as empty space. A tiny nucleus is surrounded by a number of electrons.

(a) Outline **one** piece of experimental evidence that supports this **nuclear** model of the atom. *[3]*

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(b) Explain why the protons in a nucleus do not fly apart from each other. *[2]*

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(c) In total, there are approximately 10^{29} electrons in the atoms making up a person.

(i) Estimate the electrostatic force of repulsion between two people standing 100 m apart as a result of these electrons. *[4]*

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(ii) Explain why two people standing 100 m apart would not feel the force that you have calculated in part (i). *[2]*

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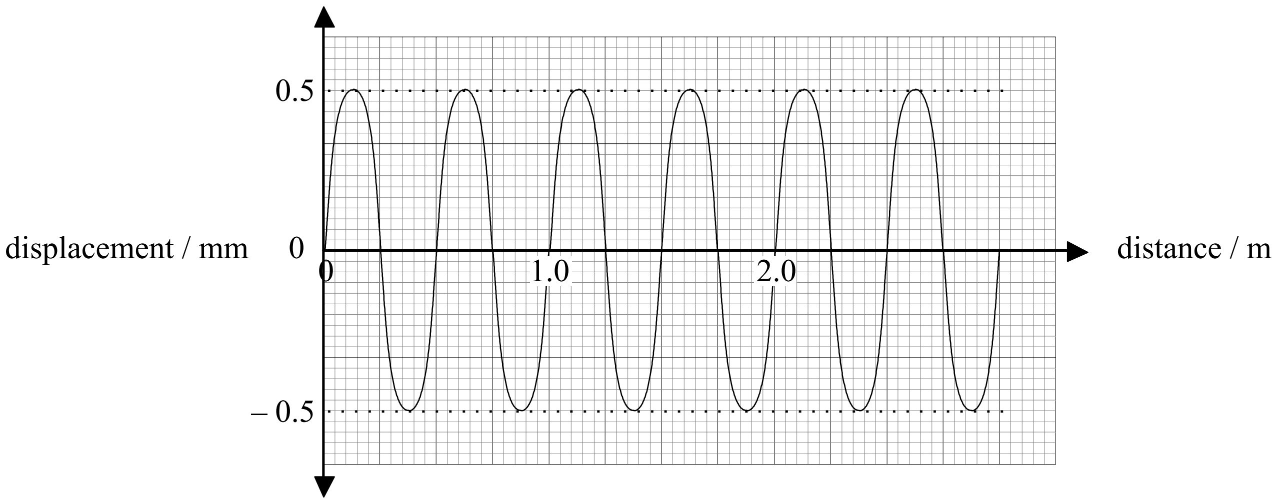
A3. This question is about sound waves.

A sound wave of frequency 660 Hz passes through air. The variation of particle displacement with distance along the wave at one instant of time is shown below.



(a) State whether this wave is an example of a longitudinal **or** a transverse wave. *[1]*

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(b) Using data from the above graph, deduce for this sound wave,

(i) the wavelength. *[1]*

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(ii) the amplitude. *[1]*

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(iii) the speed. *[2]*

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SECTION B

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

B1. This question compares the electrical properties of two 12 V filament lamps.

A lamp is designed to operate at normal brightness with a potential difference of 12 V across its filament. The current in the filament is 0.50 A.

(a) For the lamp at normal brightness, calculate

(i) the power dissipated in the filament. *[1]*

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(ii) the resistance of the filament. *[1]*

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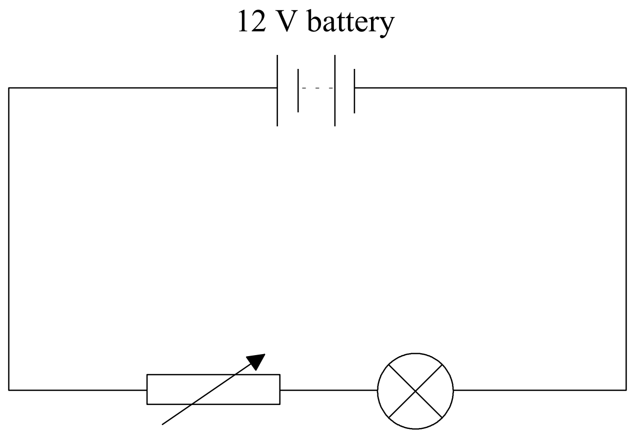
In order to measure the voltage-current *(V-I)* characteristics of a lamp, a student sets up the following electrical circuit.



(b) On the circuit above, add circuit symbols showing the correct positions of an ideal ammeter **and** an ideal voltmeter that would allow the *V-I* characteristics of this lamp to be measured. *[2]*

(This question continues on the following page)

(Question B1 continued)

The voltmeter and the ammeter are connected correctly in the circuit opposite.

(c) Explain why the potential difference across the lamp

(i) cannot be increased to 12 V. *[2]*

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(ii) cannot be reduced to zero. *[2]*

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An alternative circuit for measuring the *V-I* characteristic uses a *potential divider*.

(d) (i) Draw a circuit that uses a potential divider to enable the *V-I* characteristics of the filament to be found. *[3]*

(ii) Explain why this circuit enables the potential difference across the lamp to be reduced to zero volts. *[2]*

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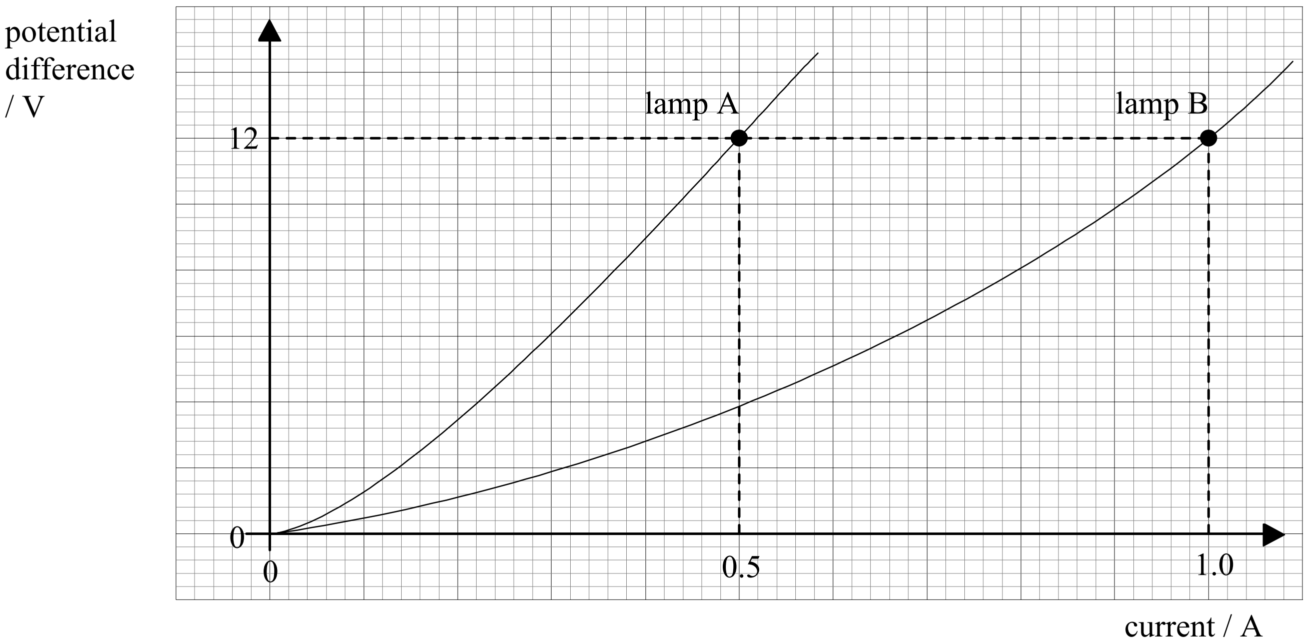
(Question B1 continued)

The graph below shows the *V-I* characteristic for two 12 V filament lamps A and B.



(e) (i) Explain why these lamps do not obey Ohm's law. *[2]*

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(ii) State and explain which lamp has the greater power dissipation for a potential difference of 12 V. *[3]*

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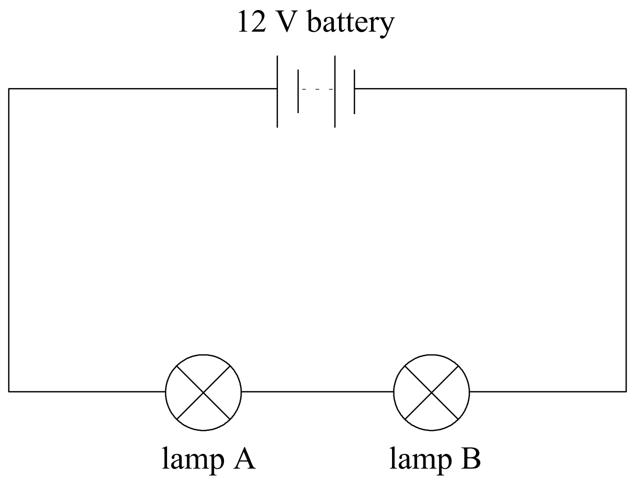
(Question B1 continued)

The two lamps are now connected in series with a 12 V battery as shown below.



(f) (i) State how the current in lamp A compares with that in lamp B. *[1]*

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(ii) Use the *V-I* characteristics of the lamps to deduce the total current from the battery. *[4]*

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(iii) Compare the power dissipated by the two lamps. *[2]*

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B2. This question is about the kinematics of an elevator (lift).

(a) Explain the difference between the gravitational mass and the inertial mass of an object. *[3]*

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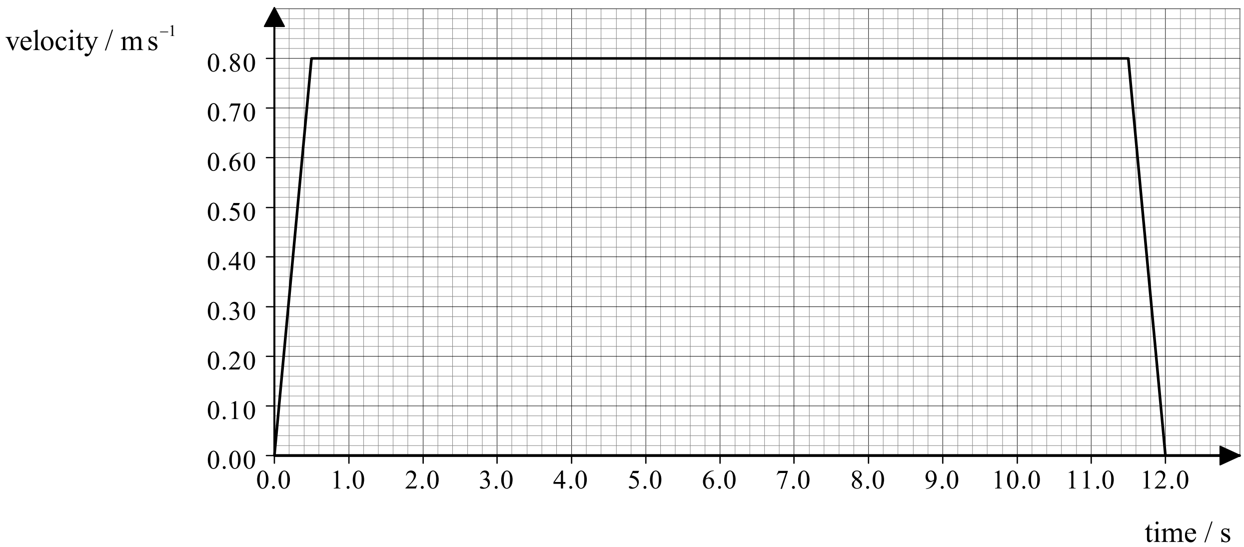
An elevator (lift) starts from rest on the ground floor and comes to rest at a higher floor. Its motion is controlled by an electric motor. A simplified graph of the variation of the elevator's velocity with time is shown below.



(b) The mass of the elevator is 250 kg. Use this information to calculate

(i) the acceleration of the elevator during the first 0.50 s. *[2]*

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(ii) the total distance travelled by the elevator. *[2]*

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(This question continues on the following page)

(Question B2 continued)

(iii) the minimum work required to raise the elevator to the higher floor. *[2]*

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(iv) the minimum average power required to raise the elevator to the higher floor. *[2]*

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(v) the efficiency of the electric motor that lifts the elevator, given that the input power to the motor is 5.0 kW. *[2]*

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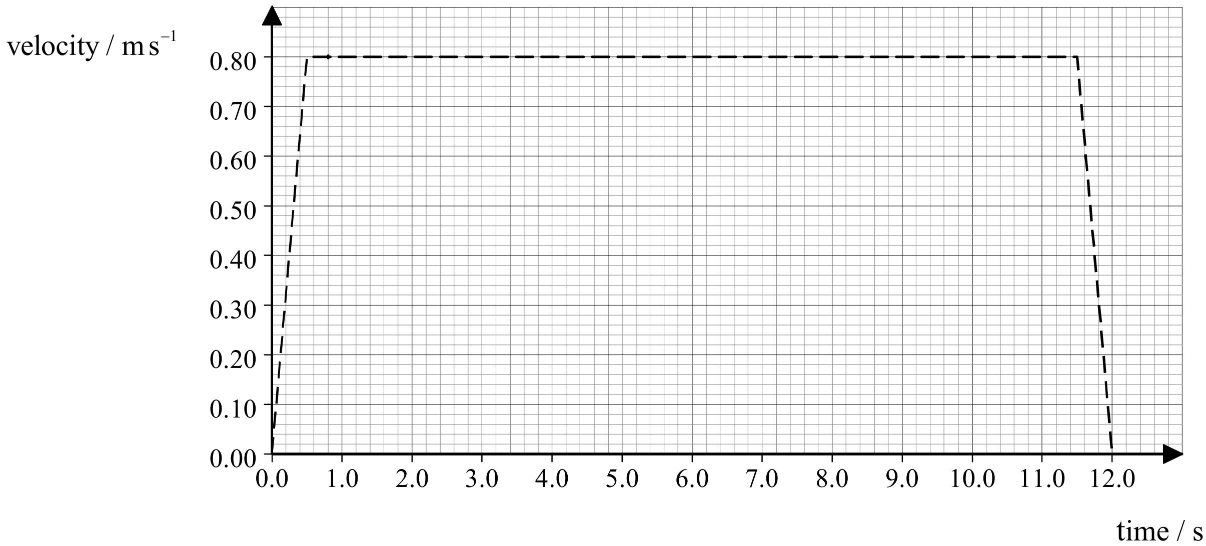
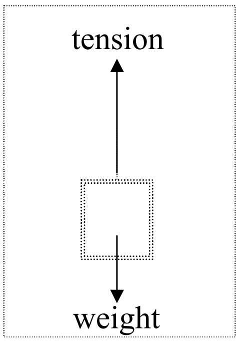
(Question B2 continued)

(c) On the graph axes below, sketch a realistic variation of velocity for the elevator. Explain your reasoning. *(The simplified version is shown as a dotted line)* *[2]*

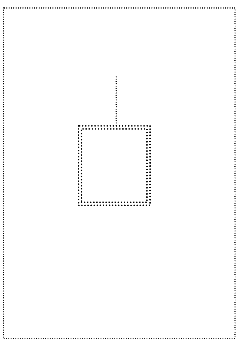


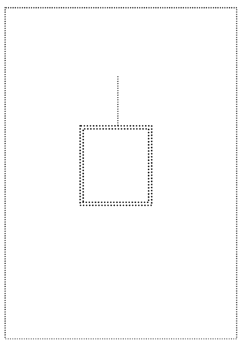
The elevator is supported by a cable. The diagram below is a free-body force diagram for when the elevator is moving upwards during the first 0.50 s.



(d) In the space below, draw free-body force diagrams for the elevator during the following time intervals.

(i) 0.50 to 11.50 s   (ii) 11.50 to 12.00 s *[3]*





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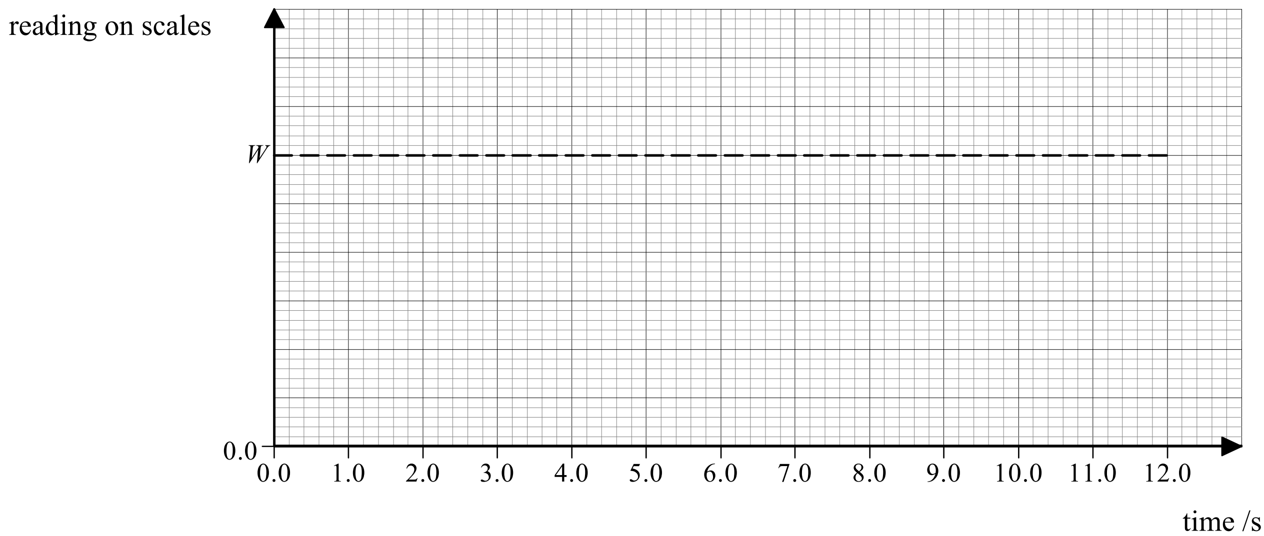
(Question B2 continued)

A person is standing on weighing scales in the elevator. Before the elevator rises, the reading on the scales is W.

(e) On the axes below, sketch a graph to show how the reading on the scales varies during the whole 12.00 s upward journey of the elevator. *(Note that this is a sketch graph – you do not need to add any values.)* *[3]*



(f) The elevator now returns to the ground floor where it comes to rest. Describe and explain the energy changes that take place during the whole up and down journey. *[4]*

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B3. This question is about modelling the thermal processes involved when a person is running.

When running, a person generates *thermal energy* but maintains approximately constant *temperature*.

(a) Explain what *thermal energy* and *temperature* mean. Distinguish between the two concepts. *[4]*

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The following simple model may be used to estimate the rise in temperature of a runner assuming no thermal energy is lost.

A closed container holds 70 kg of water, representing the mass of the runner. The water is heated at a rate of 1200 W for 30 minutes. This represents the energy generation in the runner.

(b) (i) Show that the thermal energy generated by the heater is 2.2×10^{6} J. *[2]*

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(ii) Calculate the temperature rise of the water, assuming no energy losses from the water. The specific heat capacity of water is $4200\,\mathrm{J\,kg^{-1}\,K^{-1}}$. *[3]*

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(Question B3 continued)

(c) The temperature rise calculated in (b) would be dangerous for the runner. Outline **three** mechanisms, other than evaporation, by which the container in the model would transfer energy to its surroundings. *[6]*

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A further process by which energy is lost from the runner is the evaporation of sweat.

(d) (i) Describe, in terms of molecular behaviour, why evaporation causes cooling. *[3]*

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(ii) Percentage of generated energy lost by sweating: 50 %
Specific latent heat of vaporization of sweat: 2.26×10^6 J kg^{-1}

Using the information above, and your answer to (b) (i), estimate the mass of sweat evaporated from the runner. *[3]*

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(Question B3 continued)

(iii) State and explain **two** factors that affect the rate of evaporation of sweat from the skin of the runner. *[4]*

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