IB Physics Summer Refresh Work

Odell says, "A physics problem a week keeps the phail away."

Summer 2014

215 min

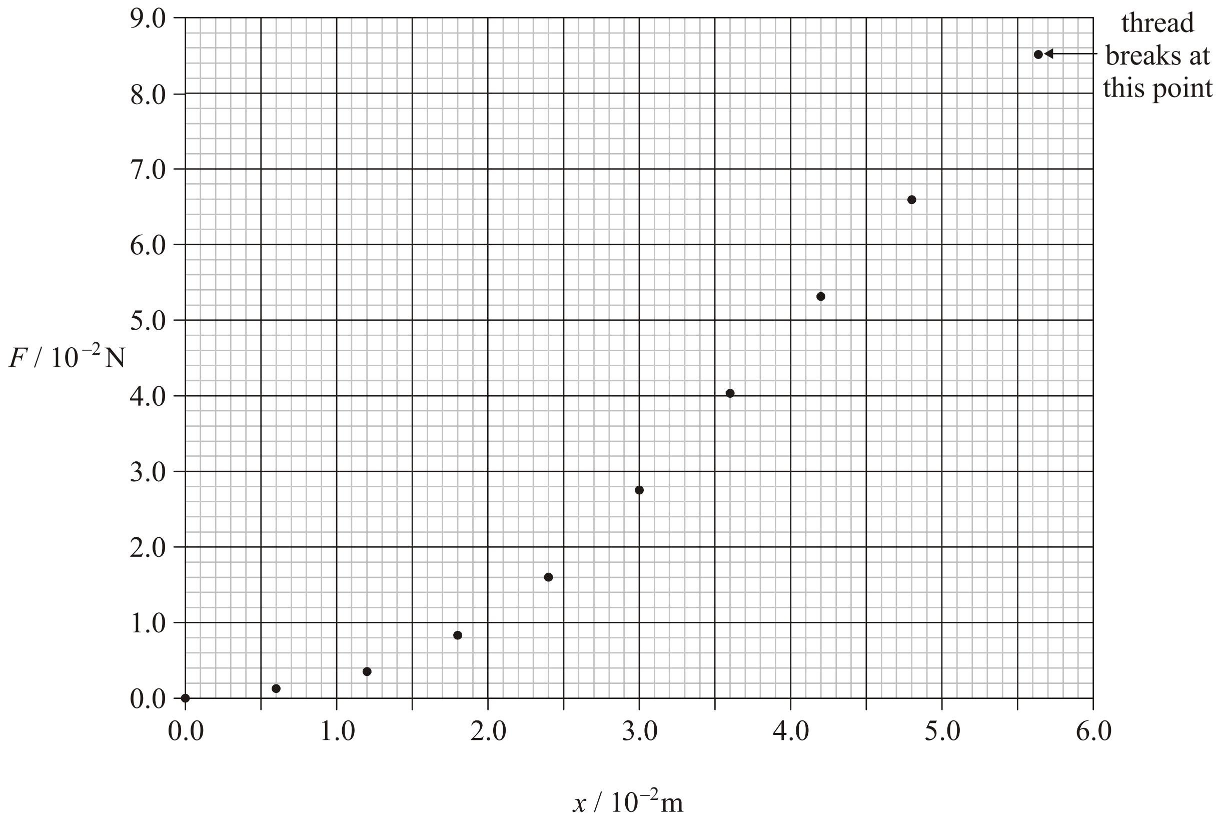
169 marks

Complete this packet and turn in to Mr. Odell the first day of Fall Semester.

Topic 1: Physics and Physical Measurements

1. This question is about a spider's web.

An experiment was carried out to measure the extension x of a thread of a spider's web when a load F is applied to it. The results of the experiment are shown plotted below. Uncertainties in the measurements are not shown.



(a) Draw a best-fit line for the data points.

(1)

(b) When a load is applied to a material, it is said to be under "stress". The magnitude P of the stress is given by

$$P = \frac{F}{A}$$

where, A is the area of cross-section of the sample of the material.

Use the graph and the data below to deduce that the thread used in the experiment has a greater breaking stress than steel.

Breaking stress of steel = 1.0×10^9 N m^{-2}

Radius of spider web thread = 4.5×10^{-6} m

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(3)

(c) In a particular web, one thread has the same original length as the thread used in the experiment. In the making of this web, the original length of the thread is extended by 2.4 $\times 10^{-2}$ m.

(i) Use the graph to deduce that the amount of work required to further extend the thread to the length at which it just breaks, is about 1.6×10^{-3} J. Explain your working.

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(3)

(ii) If the thread is not to break due to the impact of a flying insect, then the thread must be capable of absorbing all the kinetic energy of the insect as it is brought to rest by the impact. Determine the impact speed that an insect of mass 0.15 g must have in order that it just breaks the thread.

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(3)
(Total 10 marks)

Topic 2: Mechanics

2. 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.

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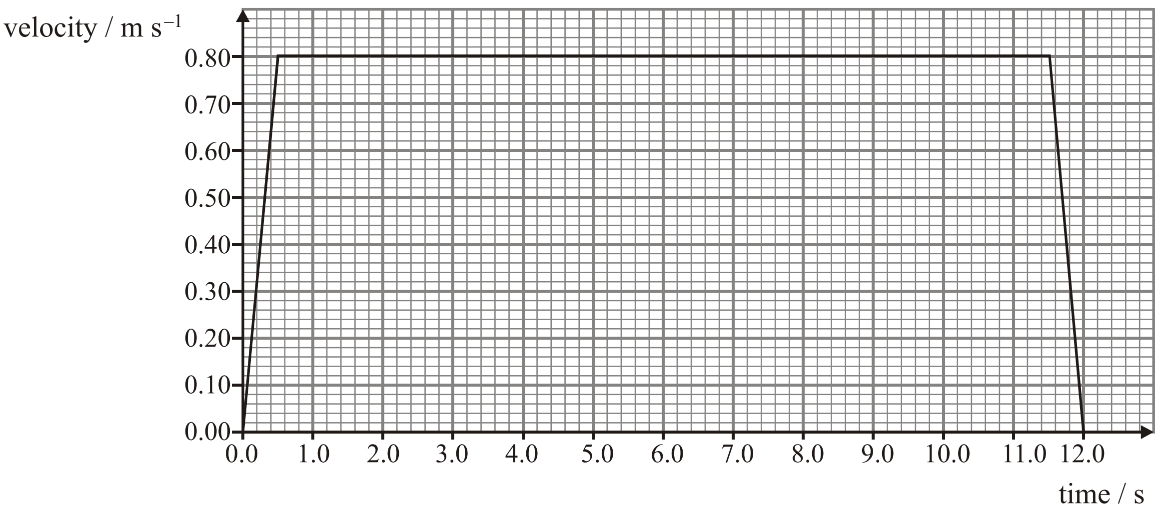
(3)

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.

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(2)

(ii) the total distance travelled by the elevator.

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(2)

(iii) the minimum work required to raise the elevator to the higher floor.

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(2)

(iv) the minimum average power required to raise the elevator to the higher floor.

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(2)

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

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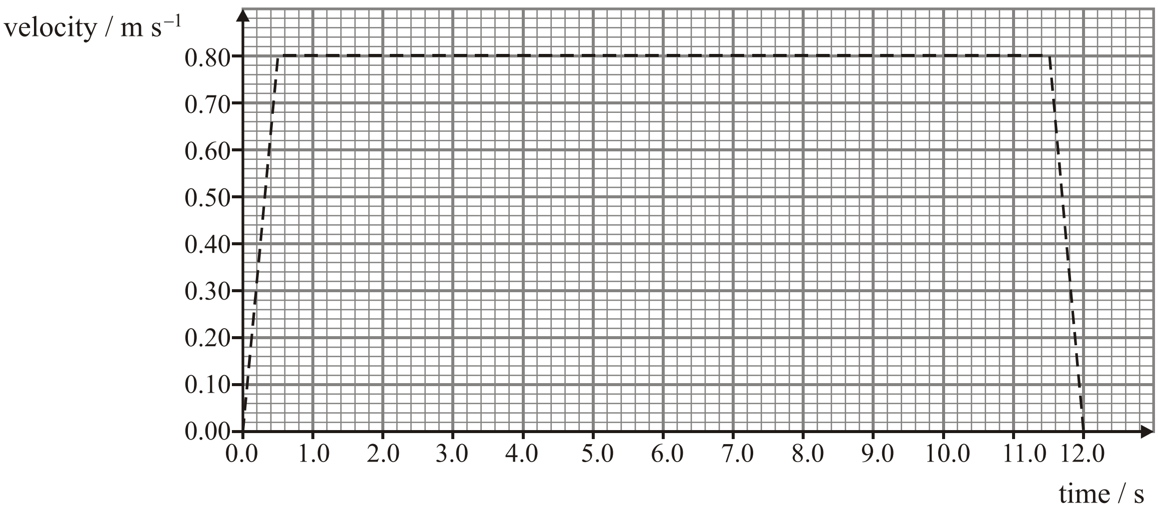
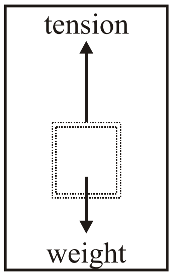
(2)

(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)*



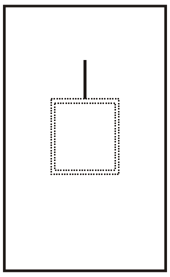
(2)

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.

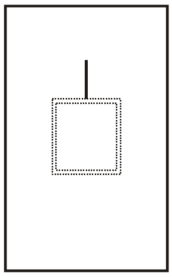


(d) In the space below, draw free-body force diagrams for the elevator during the following time intervals.

(i) 0.5 to 11.50 s



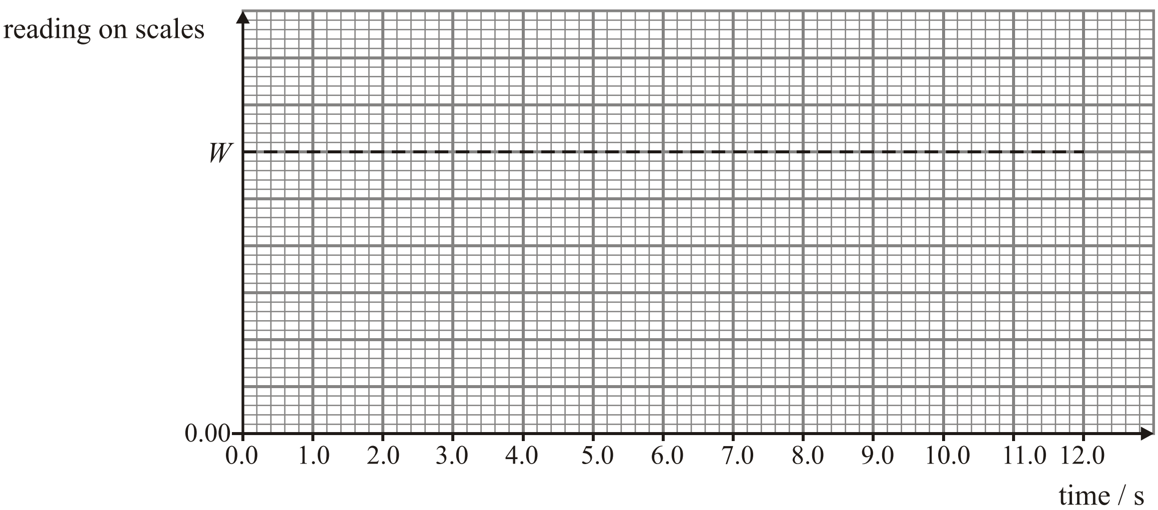
(ii) 11.50 to 12.00 s



(3)

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.

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(4)
(Total 25 marks)

3. 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.

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(4)

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.

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(2)

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

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(3)

(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.

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(6)

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.

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(3)

(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.

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(3)

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

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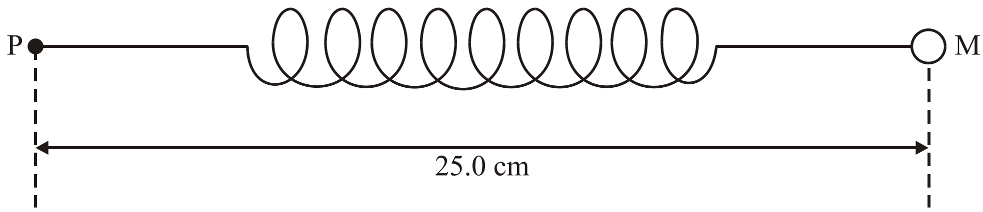
(4)
(Total 25 marks)

4. This question is about circular motion.

A linear spring of negligible mass requires a force of 18.0 N to cause its length to increase by 1.0 cm.

A sphere of mass 75.0 g is attached to one end of the spring. The distance between the centre of the sphere M and the other end P of the unstretched spring is 25.0 cm, as shown below.



The sphere is rotated at constant speed in a horizontal circle with centre P. The distance PM increases to 26.5 cm.

(a) Explain why the spring increases in length when the sphere is moving in a circle.

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(2)

(b) Determine the speed of the sphere.

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(4)
(Total 6 marks)

5. This question is about Newton's laws of motion, the dynamics of a model helicopter and the engine that powers it.

(a) Explain how Newton's third law leads to the concept of conservation of momentum in the collision between two objects in an isolated system.

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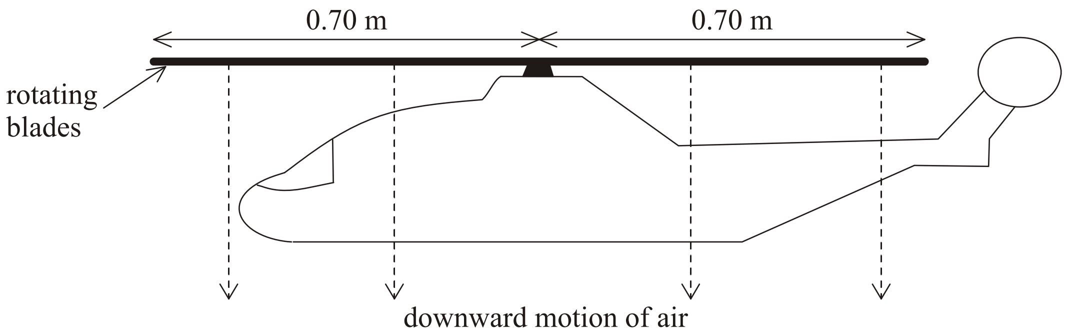
(4)

(b) The diagram illustrates a model helicopter that is hovering in a stationary position.



The rotating blades of the helicopter force a column of air to move downwards. Explain how this may enable the helicopter to remain stationary.

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(3)

c) The length of each blade of the helicopter in (b) is 0.70 m. Deduce that the area that the blades sweep out as they rotate is 1.5 m^2. (Area of a circle = πr^2)

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(1)

(d) For the hovering helicopter in (b), it is assumed that all the air beneath the blades is pushed vertically downwards with the same speed of 4.0 m s^{-1}. No other air is disturbed.

The density of the air is 1.2 kg m^{-3}.

Calculate, for the air moved downwards by the rotating blades,

(i) the mass per second;

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(2)

(ii) the rate of change of momentum.

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(1)

(e) State the magnitude of the force that the air beneath the blades exerts on the blades.

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(1)

(f) Calculate the mass of the helicopter and its load.

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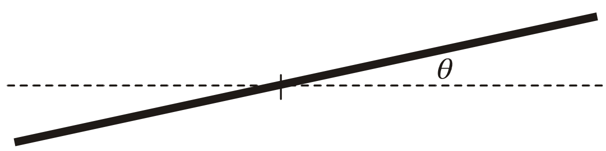
(2)

(g) In order to move forward, the helicopter blades are made to incline at an angle θ to the horizontal as shown schematically below.



While moving forward, the helicopter does not move vertically up or down. In the space provided below draw a free body force diagram that shows the forces acting on the helicopter blades at the moment that the helicopter starts to move forward. On your diagram, label the angle θ.

(4)

(h) Use your diagram in (g) opposite to explain why a forward force F now acts on the helicopter and deduce that the initial acceleration a of the helicopter is given by

$$a = g \tan \theta$$

where g is the acceleration of free fall.

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(5)

(i) Suggest why, even though the forward force F does not change, the acceleration of the helicopter will decrease to zero as it moves forward.

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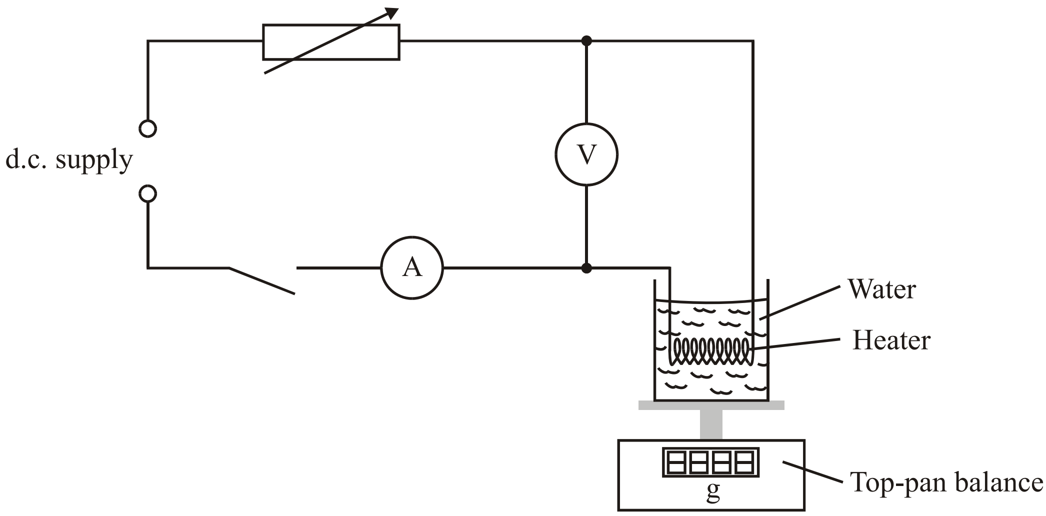
(2)
(Total 25 marks)

Topic 3: Thermal Physics

6. Some students were asked to design and carry out an experiment to determine the specific latent heat of vaporization of water. They set up the apparatus shown below.



The current was switched on and maintained constant using the variable resistor. The readings of the voltmeter and the ammeter were noted. When the water was boiling steadily, the reading of the top-pan balance was taken and, simultaneously, a stopwatch was started. The reading of the top-pan balance was taken again after 200 seconds and then after a further 200 seconds.

The change in reading of the top-pan balance during each 200 second interval was calculated and an average found. The power of the heater was calculated by multiplying together the readings of the voltmeter and the ammeter.

(a) Suggest how the students would know when the water was boiling steadily.

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(1)

(b) Explain why a reading of the mass lost in the first 200 seconds and then a reading of the mass lost in the next 200 second interval were taken, rather than one single reading of the mass lost in 400 seconds.

(2)

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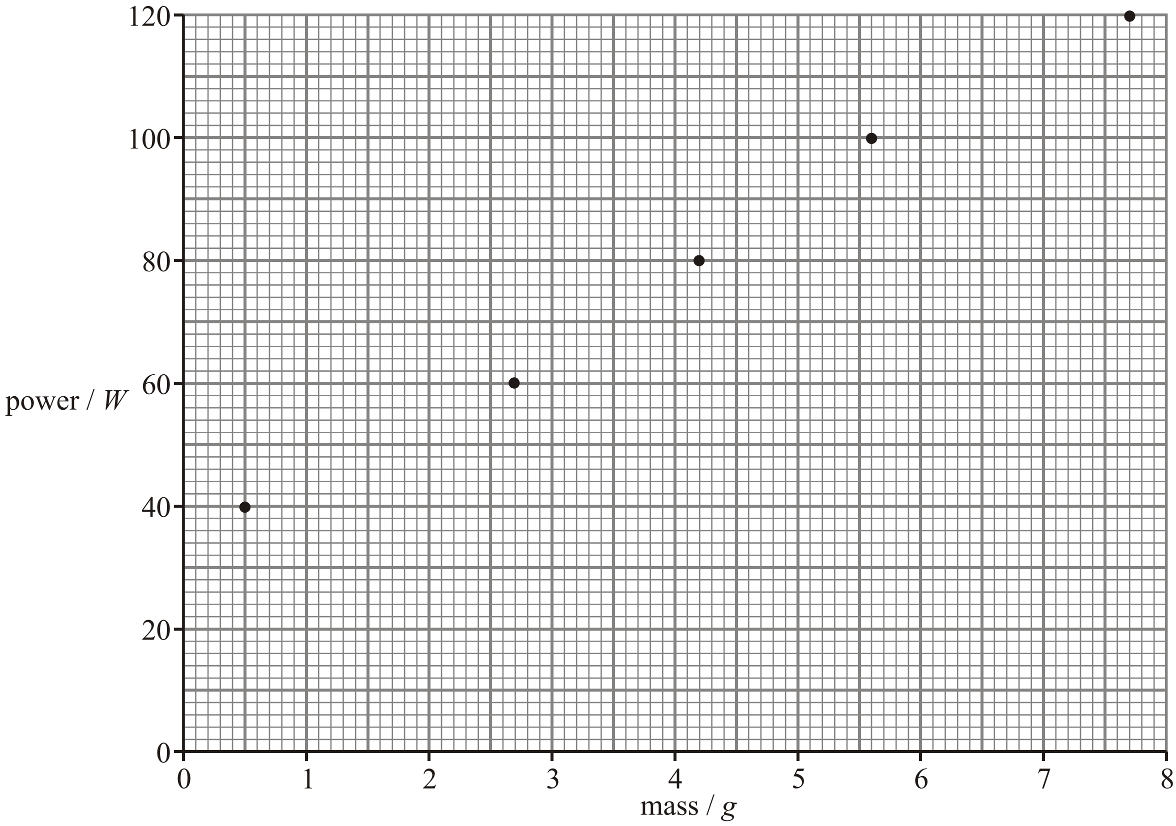
The students repeated the experiment for different powers supplied to the heater. A graph of the power of the heater against the mass of water lost (the change in balance reading) in 200 seconds was plotted. The results are shown below. *(Error bars showing the uncertainties in the measurements are not shown.)*



(c) (i) On the graph above, draw the best-fit straight line for the data points.

(1)

(ii) Determine the gradient of the line you have drawn.

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(3)

In order to find a value for the specific latent heat of vaporization L, the students used the equation

$$P = mL,$$

where P is the power of the heater and m is the mass of water evaporated **per second**.

(d) Use your answer for the gradient of the graph to determine a value for the specific latent heat of vaporization of water.

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(3)

(e) The theory of the experiment would suggest that the graph line should pass through the origin. Explain briefly why the graph does not pass through the origin.

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(2)
(Total 12 marks)

Topic 4: Oscillation and Waves

7. This question is about waves and wave motion.

(a) Describe, by reference to the propagation of energy, what is meant by a transverse wave.

Transverse wave

(2)

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(b) State **one** example, other than a wave on a string, of a transverse wave.

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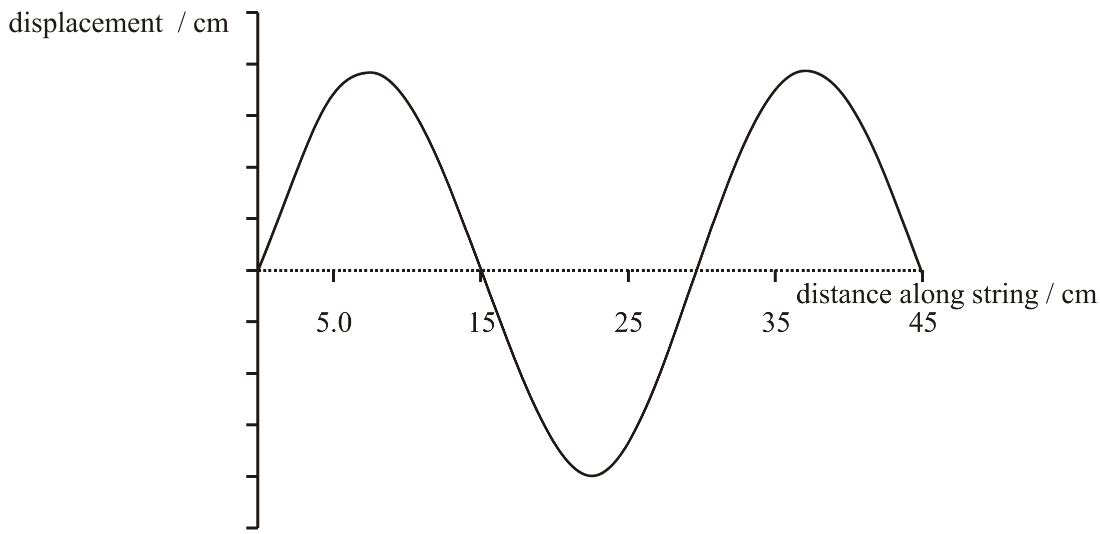
(1)

A transverse wave is travelling along a string that is under tension. The diagram below shows the displacement of part of the string at time $t = 0$. The dotted line shows the position of the string when there is no wave travelling along it.



(c) On the diagram above, draw lines to identify for this wave

(i) the amplitude (label this A);

(1)

(ii) the wavelength (label this λ).

(1)

(d) The period of the wave is 1.2×10^{-3} s. Deduce that the speed of the wave is 250 m s^{-1}.

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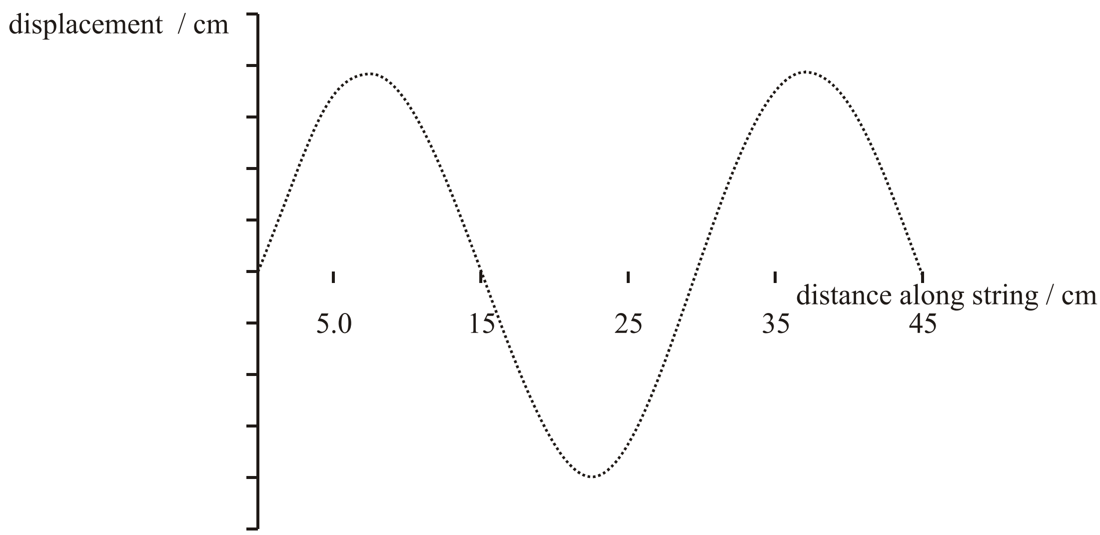
(2)

(e) Using the axes below, draw the displacement of the string when $t = 3.0 \times 10^{-4}$ s. (The displacement of the string at $t = 0$ is shown as a dotted line.)



(3)

(Total 10 marks)

Topic 5: Electric Currents (Everyone's Favorite)

8. This question is about electrical resistance.

(a) Define *electrical resistance*.

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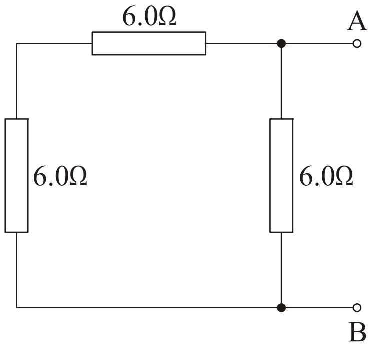
(1)

(b) (i) Three resistors, each of resistance 6.0 Ω, are connected as shown below.



Calculate the total resistance between point A and point B of this arrangement.

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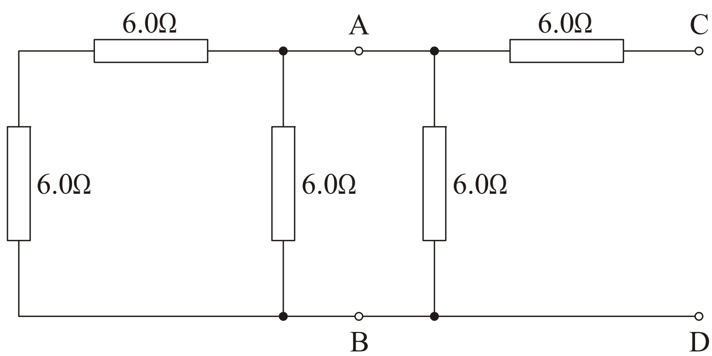
(1)

(ii) The arrangement in (b)(i) is now connected to two more resistors, as shown below. Each resistor is of resistance 6.0 Ω.



Using your answer in (b)(i), deduce that the total resistance between point C and point D is 8.4 Ω.

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(2)

(iii) One of the resistors in the arrangement shown in (b)(ii) becomes faulty. The resistance between point C and point D is found to be 6.0 Ω. On the diagram in (b)(ii) above, identify the faulty resistor by drawing a circle around it. Deduce the nature of the fault.

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(2)
(Total 6 marks)

9. 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.

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(1)

(ii) the resistance of the filament.

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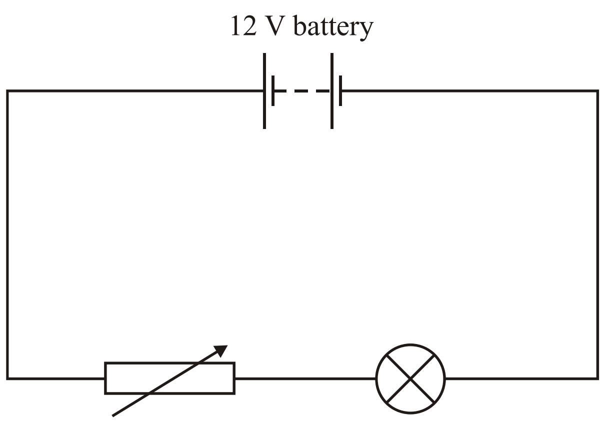
(1)

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)

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

(c) Explain why the potential difference across the lamp

(i) cannot be increased to 12 V.

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(2)

(ii) cannot be reduced to zero.

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(2)

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.

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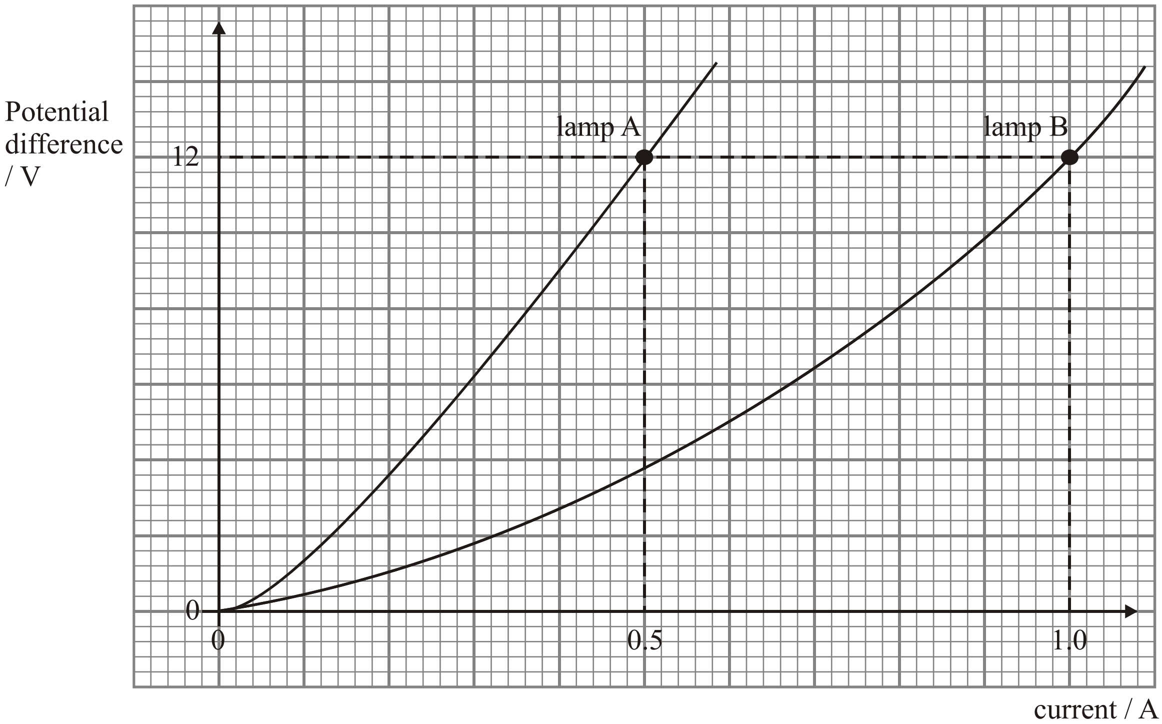
(2)

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.

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(2)

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

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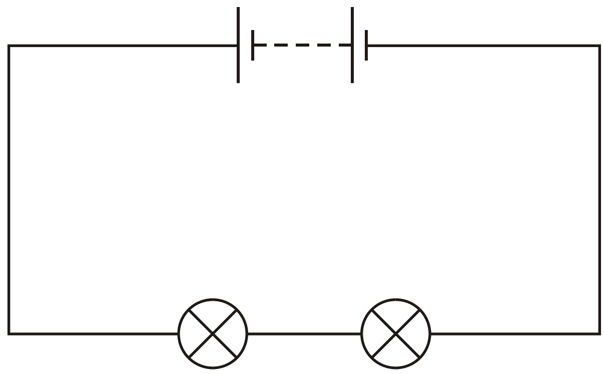
(3)

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.

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(1)

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

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(4)

(iii) Compare the power dissipated by the two lamps.

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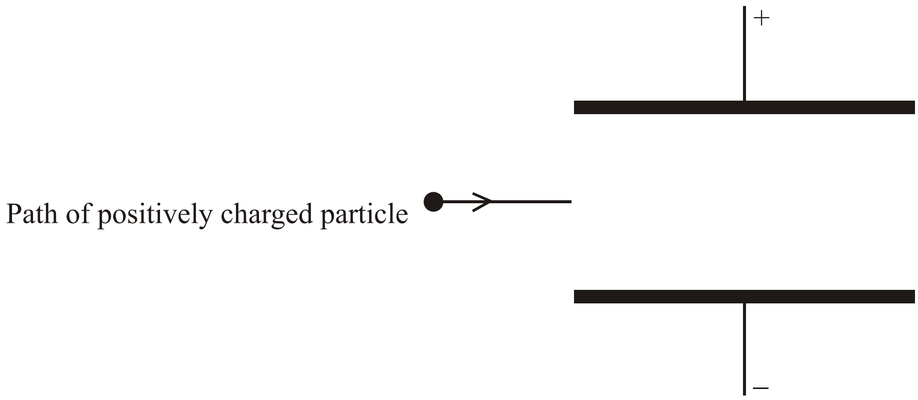
(2)
(Total 25 marks)

Topic 6: Field Forces

10. This question is about forces on charged particles in electric and magnetic fields.

The diagram shows two parallel plates situated in a vacuum. One plate is at a positive potential with respect to the other.



A positively charged particle passes into the region between the plates. Initially, the particle is travelling parallel to the plates.

(a) On the diagram,

(i) draw lines to represent the electric field between the plates.

(3)

(ii) show the path of the charged particle as it passes between, and beyond, the plates.

(2)

(b) An electron is accelerated from rest in a vacuum through a potential difference of 750 V.

(i) Determine the change in electric potential energy of the electron.

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(2)

(ii) Deduce that the final speed of the electron is 1.6×10^{7} m s^{-1}.

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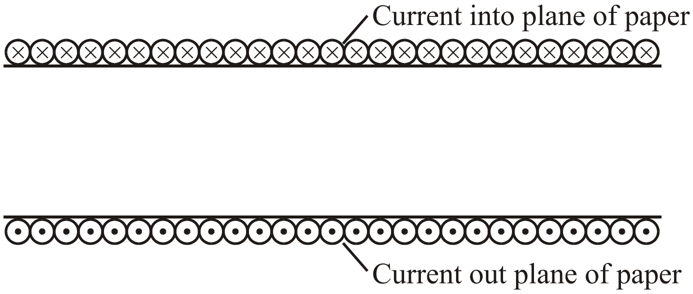
.... **(2)**

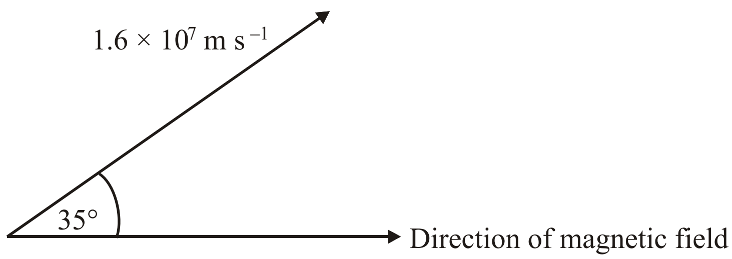
The diagram below shows a cross-section through a current-carrying solenoid. The current is moving into the plane of the paper at the upper edge of the solenoid and out of the plane of the paper at the lower edge. There is a vacuum in the solenoid.



(c) (i) Sketch lines to represent the magnetic field inside and at each end of the solenoid. **(4)**

(ii) A positively charged particle enters the solenoid along its axis. On the diagram, show the path of the particle in the solenoid. **(1)**

An electron is injected into a region of uniform magnetic field of flux density 4.0 mT. The velocity of the electron is 1.6×10^7 m s^{-1} at an angle of 35° to the magnetic field, as shown below.



(d) (i) Determine the component of the velocity of the electron normal to the direction of the magnetic field.

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(ii) Describe, making calculations where appropriate, the motion of the electron due to this component of the velocity.

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(4)

(iii) Determine the component of the velocity of the electron along the direction of the magnetic field.

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(1)

(iv) State and explain the magnitude of the force on the electron due to this component of the velocity.

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(2)

(e) With reference to your answers in (d), describe the shape of the path of the electron in the magnetic field. You may draw a diagram if you wish.

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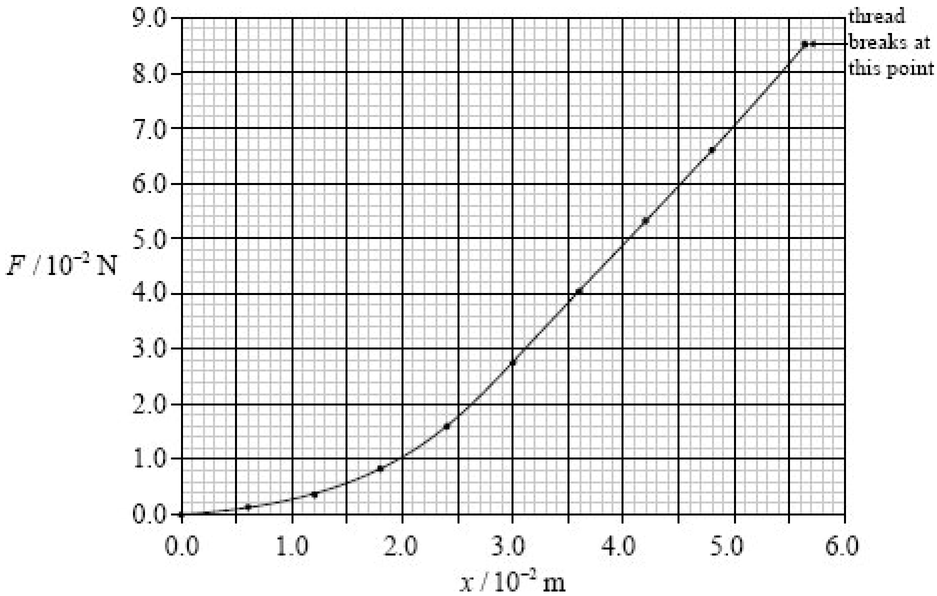
(2)
(Total 25 marks)

IB Physics Summer Refresh Work

Markscheme

1. (a)



correct line of best fit; 1

The line should go through a majority of the points.

(b) from the graph breaking load = 8.5(±0.1) × 10^{-2} N;

breaking stress = $\frac{8.5\times10^{-2}}{3.14\times(4.5)^2\times10^{-12}}=1.3\times10^{9}$ Pa ***or*** Nm^{-2};

some statement of conclusion; 3

(c) (i) work = area under graph;

between (2.4×10^{-2} , 1.6×10^{-2}) and (5.6×10^{-2} , 8.5×10^{-2});

$= (1.6 \times 3.2) \times 10^{-4} + \frac{1}{2}(3.2 \times 6.9) \times 10^{-4}$;

$= 1.6 \times 10^{-3}$ J

If incorrect line of best fit in (a), allow first marking point only.

or

work = average force × distance / displacement / extension;

average force = 5.1×10^{-2} N;

extension = 3.2×10^{-2} m;

to give1.6×10^{-3} J 3

(ii) KE of insect = work needed to break web = 1.6×10^{-3} J;

$v = \sqrt{\frac{2\text{KE}}{m}}$;

$= \sqrt{\frac{3.2 \times 10^{-3}}{1.5 \times 10^{-4}}} = 4.6\,\text{ms}^{-1}$; 3

No ecf from (c)(i) ie the value 1.6×10^{-3} J *must be used.*

[10]

2. (a) statement that gravitational mass and inertial mass have the same numerical value;
understanding of what gravitational mass means;
eg "a quantity that determines the gravitational force on the object"
understanding of what inertial mass means;
eg "a quantity that determines the acceleration of the object" 3 max

(b) (i) the acceleration = gradient of first section of graph;
acceleration = 0.80 / 0.50 = 1.6 m s^{-2}; 2 max

Accept bald correct answer for full marks.

(ii) the total distance travelled by the lift = area under graph;
distance = (11 × 0.80) + (0.50 × 0.80) = 8.8 + 0.4 = 9.2 m; 2 max

Accept bald correct answer for full marks.

(iii) the work done = PE gained (= force × distance);
work done = 2500 × 9.2 = 23000 J = 23 kJ; 2 max

Accept bald correct answer for full marks.

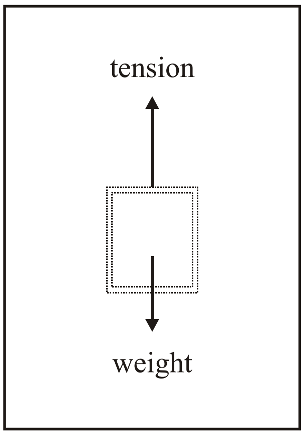
(iv) correct substitution into power = work done / time taken
= 23000 / 12;
= 1916 W
= 1.9 kW; 2 max

(v) correct substitution into efficiency = power out / power in
= 1.9 / 5.0;
= 0.38 = 38%; 2 max

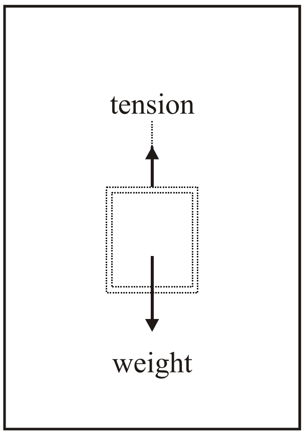
(c) graphs should show curving or "shoulders" at the changes;
since acceleration must be finite / speed cannot change instantaneously / *OWTTE*; 2 max

(d) *Mark part (i) and (ii) together.*
weight arrow the same in both diagrams;
magnitude of tension (size of arrow) **equal to** weight in (i);
magnitude of tension (size of arrow) **less than** weight in (ii);

(i) 0.50 to 11.50 s

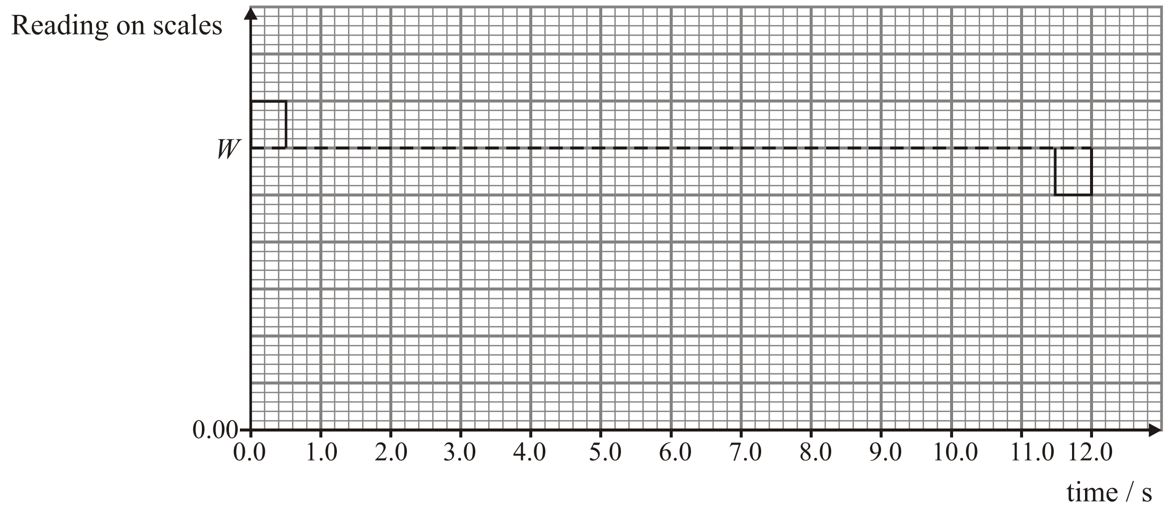


(ii) 11.50 to 12.00 s



3 max

(e) a constant value **greater** than W from 0.00 to 0.50 s;
a constant value **equal** to W from 0.50 to 11.50 s;
a constant value **less** than W from 11.50 to 12.00 s;



3 max

(f) ***[1]** for each appropriate and valid point. Essentially **[2]** for journey up and **[2]** for journey down. Some explanation or justification is required for full marks eg*
the law of conservation of energy does apply to round trip;
energy is all dissipated into heat and sound;
on the way up, most electrical energy converted into g.PE, initially some electrical energy is converted into K.E;
on the way down electrical energy does work "breaking" lift some (not all) g.PE is converted into KE; 4 max

Reject answers that imply that PE converts into KE as lift falls.

[25]

3. (a) ***[1]** for each appropriate and valid point eg*
thermal energy is the KE of the component particles of an object;
thus measured in joules;
the temperature of an object is a measure how hot something is (it can be used to work out the direction of the natural flow of thermal energy between two objects in thermal contact) / measure of the average KE of molecules;
it is measured on a defined scale (Celsius, Kelvin *etc*); 4 max

(b) (i) correct substitution: energy = power × time;
$= 1200 \text{ W} \times (30 \times 60) \text{ s}$;
$= 2.2 \times 10^6 \text{ J}$ 2 max

(ii) use of $E = m c \Delta\theta$;
to get $\Delta\theta = 2.2 \times 10^6 / (4200 \times 70)$ K;
$= 7.5$ K; 3 max

(c) ***[1]** naming each process up to **[3 max]**.*
convection;
conduction;
radiation;

***[1]** for an appropriate (matching) piece of information / outline for each process up to **[3 max]**.*

eg convection is the transfer of thermal energy via bulk movement of a gas due to a change of density;
conduction is transfer of thermal energy via intermolecular collisions;
radiation is the transfer of thermal energy via electromagnetic waves (IR part of the electromagnetic spectrum in this situation) */ OWTTE*; 6 max

(d) (i) ***[1]** for each valid and relevant point eg*
in evaporation the faster moving molecules escape;
this means the average KE of the sample left has fallen;
a fall in average KE is the same as a fall in temperature; 3 max

(ii) energy lost by evaporation $= 50\% \times 2.2 \times 10^6$ J;
$= 1.1 \times 10^6$ J;
correct substitution into $E = m\, l$
to give mass lost $= 1.1 \times 10^6 \text{ J} / 2.26 \times 10^6 \text{ J kg}^{-1}$
$= 0.487$ kg
$= 487$ g; 3 max

(iii) ***[1]** for any valid and relevant factors **[2 max]** eg*
area of skin exposed;
presence or absence of wind;
temperature of air;
humidity of air *etc*;

***[1]** for appropriate and matching explanations **[2 max]** eg*
increased area means greater total evaporation rate;
presence of wind means greater total evaporation rate;
evaporation rate depends on temperature difference;
increased humidity decreases total evaporation rate *etc*; 4 max

[25]

4. (a) for circular motion, force required towards centre of circle / centripetal force;

this provided as a result of extension of the spring; 2

Do not give credit where candidate implies that the spring is pulled outwards by a force.

(b) force produced by spring = 1.5 × 18 = 27 N;

use of $F = \frac{mv^2}{r}$;

$27 = \frac{(0.075 \times v^2)}{0.265}$;

$v = 9.77 \text{ m s}^{-1}$; 4

[6]

5. (a) before and after collision there are no forces acting on the objects;
from Newton 3 when the two bodies are in contact the forces that they exert on each other are equal and opposite / *OWTTE*;
therefore, the net force on the two balls is always zero;
therefore, there is no change in momentum (of the objects) / momentum is conserved;

or

Accept an argument based on change in momentum of each individual object. eg

from Newton 3$F_{12} = -F_{21}$; *(accept statement in words)*

$F_{12} = \frac{\Delta p_1}{\Delta t}$ and $F_{21} = \frac{\Delta p_2}{\Delta t}$;

$\frac{\Delta p_1}{\Delta t} = -\frac{\Delta p_2}{\Delta t}$;

therefore, $\Delta p_1 + \Delta p_2 = 0$; 4

(b) the blades exert a force on the air and by Newton's third law the air exerts an equal and opposite force on the blades / air has change in momentum downwards giving rise to a force and from Newton 3 there will a force upwards;
if this force equals the weight of the helicopter;
the net vertical force on the helicopter will be zero / *OWTTE*; 3

(c) area = $\pi 0.7^2$;

$= 1.5 \text{ m}^2$ 1

(d) (i) volume of air per second = $1.5 \times 4.0 (\text{m}^3\text{s}^{-1})$;
mass = volume × density = $(1.2 \times 1.5 \times 4.0) = 7.2 \text{kgs}^{-1}$; 2

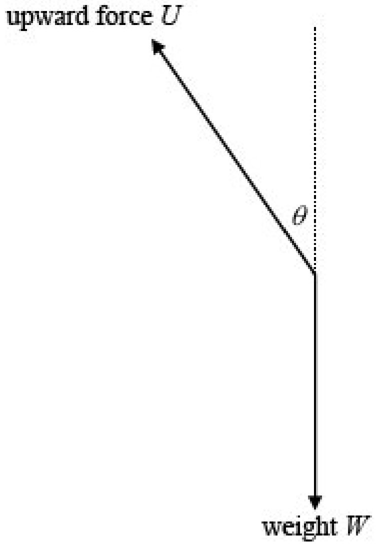
No unit error for 7.2 kg.

(ii) momentum per second = $(7.2 \times 4.0) = 29N$; 1

(e) 29 N; 1

(f) recognize that the force on the blades = Mg;
to give 3.0 kg; 2

(g)



correct relative directions of forces;
upward force length greater than weight by eye;
appropriate labelling of forces;
angle θ as shown above; 4
Award ***[2 max]*** *if extra force(s) drawn.*

(h) the forward force is the horizontal component of U;
resolve vertically $U\cos\theta = W$;
horizontal component $F = U\sin\theta$;
divide to get $\frac{F}{W} = \tan\theta$;
$F = (W\tan\theta) = Mg\tan\theta = Ma$;
to give $a = g\tan\theta$ 5

Award ***[5 max]*** *for a correctly labelled force diagram incorporating mass with a justifying statement. Award* ***[1 max]*** *for triangle mixing accelerations and force.*

(i) air resistance increases as speed of helicopter increases;
until this resistance equals the forward force; 2
[25]

6. (a) bubbles rise at constant rate / constant temperature using a thermometer; 1

(b) can check that rate of boiling is constant;
because the two masses should be equal; 2

(c) (i) reasonable line drawn; 1

(ii) triangle for gradient with hypotenuse at least half length of line;
some working shown (*eg* coordinates used made clear);
answer 12 (W g^{-1}) ± 1; 3

(d) gradient = $\frac{L}{200}$;
L = 2400 *allow ecf from (c)(ii)*;
correct unit J g^{-1}; 3

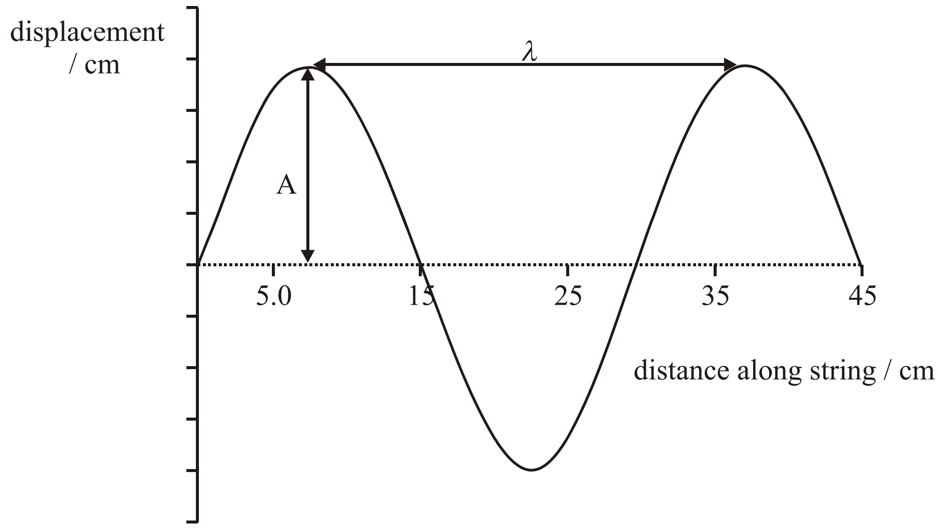
(e) heat energy losses / systematic error;
to the atmosphere / any other detail; 2

[12]

7. (a) a wave in which the direction of energy propagation;
is at right angles to the direction of vibration of the particles of the medium through which the wave is travelling / *OWTTE*; 2
or
suitable labelled diagram eg

(b) any em wave / elastic waves in solids / accept water; 1

(c)



correct annotation

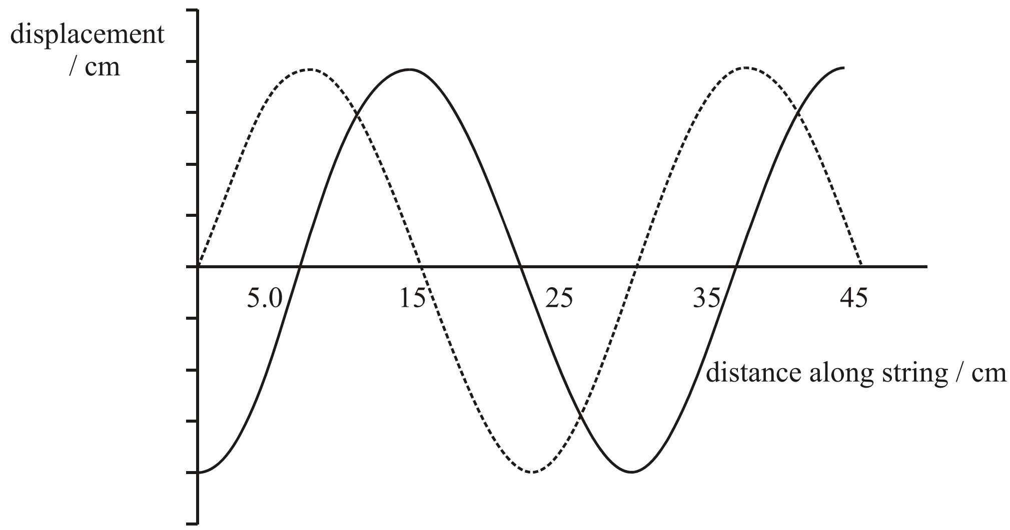
(i) A (4.0 cm); 1

(ii) λ (30.0 cm); 1

(d) $f = \frac{1}{T} = \frac{1}{1.2 \times 10^{-3}} = 830$ Hz;

$c = f\lambda = 830 \times 0.30 = 250$ m s^{-1}; 2

(e)



troughs / peaks moved to the right;
by λ / 4 (7.5 cm); *(judge by eye)*
wave continuous between $x = 0$ and $x = 45$ cm; 3

[10]

8. (a) $\frac{\text{p.d. across resistor}}{\text{current in resistor}}$; *(ratio must be clear)* 1

(b) (i) combined resistance = 4.0Ω; 1

(ii) use of parallel resistors formula to give 2.4Ω;

combined resistance = 2.4 + 6.0;

= 8.4Ω 2

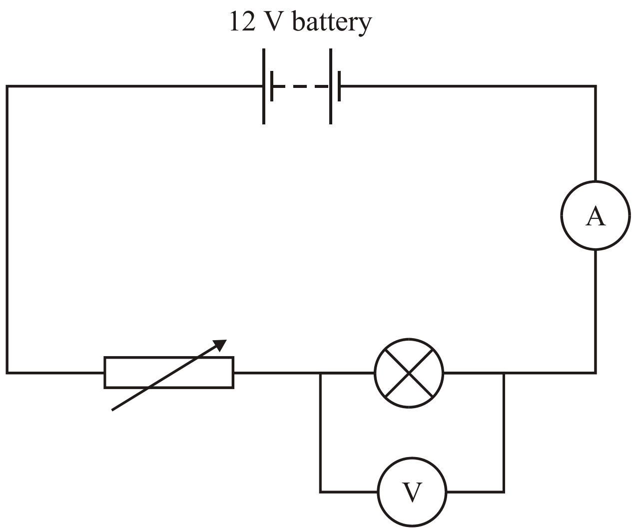
(iii) (vertical) resistor either side of terminals AB circled;
resistor has shorted / became zero resistance; 2

[6]

9. (a) (i) correct substitution into power = p.d. × current
to give power = 12 × 0.5 = 6 W; 1 max

(ii) correct substitution into $V = I \times R$
to give $R = \frac{12}{0.5} = 24\Omega$; 1 max

(b) correct positioning of ammeter;
correct positioning of voltmeter;
eg

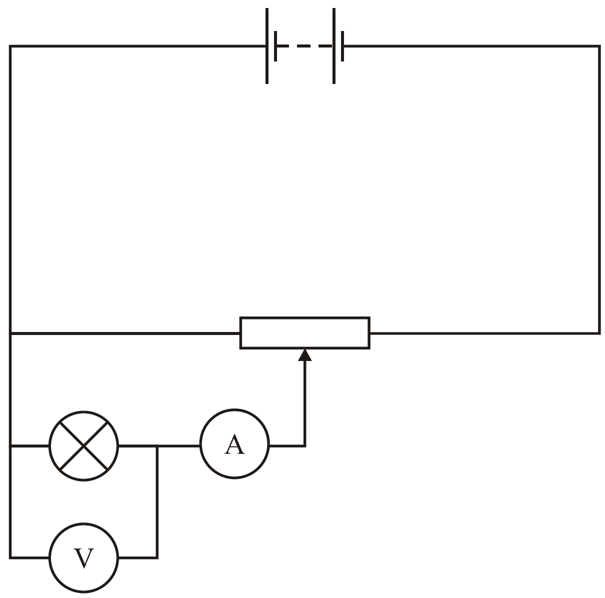


2 max

(c) (i) the battery (**or** the ammeter **or** the wires) must have some resistance;
some p.d. is "used up" so less "available" / *OWTTE*; 2 max

(ii) low voltage requires low current and thus large resistance;
max resistance of variable resistor not infinite / *OWTTE*; 2 max

(d) (i) any circuit involving potentiometer or equivalent;
that correctly controls the p.d. across the bulb;
with meters still correctly connected;



3 max

(ii) ***[1]** for each relevant point eg*
the 12 V is "shared" by the two halves of the resistor;
if the LH half is zero resistance, the p.d. will be zero / *OWTTE*; 2 max

(e) (i) appropriate statement of Ohm's law;
eg p.d. proportional to current of constant temperature.
temperature is not constant as current varies / *OWTTE*; 2 max

(ii) lamp B must have greater power dissipation;
since it has a greater current for the same p.d. / *OWTTE*;
so power dissipation (= $V \times$ I) is greater; 3 max

(f) (i) current lamp A equals the current in lamp B / *OWTTE*; 1 max

(ii) any answer that is less than 0.5 A but above 0.3 A;
realization (seen or implied) that each lamp does not have the same p.d.;
explanation (or evidence from the graph) of trying to find the
current when the individual p.d.s sum to 12 V;

to give 0.4 A (± 0.1); 4 max

(iii) lamp A will have greater power dissipation;
since current the same, but it takes greater share of p.d.; 2 max

[25]

10. (a) (i) lines parallel and normal to plates; *(ignore any edge effect)*
equally spaced;
direction from (+) to (–); 3

(ii) curved path between plates and no curvature outside;
in downward direction; 2

(b) (i) change = $q\Delta V$;
$= 1.6 \times 10^{-19} \times 750$
$= 1.2 \times 10^{-16}$ J; 2

Or 750 eV.

(ii) $\frac{1}{2}mv^2 = 1.2 \times 10^{-16}$;
$\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 = 1.2 \times 10^{-16}$ / $v^2 = 2.64 \times 10^{14}$
to give $v = 1.67 \times 10^7$ m s^{-1}; 2

(c) (i) inside solenoid, lines parallel to axis;
line spacing about double at ends / lines equally spaced in solenoid;
reasonable shape (symmetry and curving);
correct direction (to left); 4

(ii) path with no deviation along axis; 1

(d) (i) velocity component normal to field $= 1.6 \times 10^7 \times \sin 35$;
$= 9.2 \times 10^6$ m s^{-1}; 2

(ii) circular motion;
in plane normal to paper;
$\frac{mv^2}{r} = Bqv$ / $r = \frac{(9.1 \times 10^{-31} \times 9.2 \times 10^6)}{(4.0 \times 10^{-3} \times 1.6 \times 10^{-19})}$;
radius of circle $= 1.3 \times 10^{-2}$ m; 4

(iii) velocity component along field $= 1.6 \times 10^7 \times \cos 35$
$= 1.3 \times 10^7$ m s^{-1}; 1

(iv) force is zero;

because $F = Bqv \sin\theta$ and $\theta = 0$ *or in "words"*; 2

(e) helical shape *(allow spiral shape)*;
any further detail *eg* constant pitch *etc*; 2

Award **[2]** *for a good diagram.*

[25]

IB Physics Summer Refresh Work

Examiner Report

1. [HL and SL] - *Data analysis question*

Many candidates drew a straight line of "best fit". (See above).

(b) **[HL only]**

Many candidates were successful here. A common error however, was to suggest a plot of lg(*F/k*) against *n*lgx.

(c) **[(b) SL]**

This was often done well but some candidates failed to state a conclusion based on a calculation of the breaking stress of the thread.

(d) **[HL only]**

Many candidates failed to double the percentage error.

(e) **[SL (c)]**

It was unfortunate that proof reading did not detect the unit error given in the question (2.4×10^{-2} cm rather than 2.4×10^{-2} m). Many candidates, in fact, read the unit as metres and those that did not and correctly used the area under the graph, obtained an answer very close to the answer given in (i). Those candidates who used average force correctly did, of course, have no problem. Unfortunately a significant number of candidates did not know either method of solution. A common error was to multiply the breaking force by the breaking extension. Part (ii) was often done well.

2. SL only

This was a very popular question on the paper and in general was satisfactorily done. In part (a) very few candidates were able to explain the difference between gravitational mass and inertial mass – many just explained the difference between mass and weight. Candidates did quite well in part (b). A few candidates used $P = Fv$ and then found the force from $F = ma$, without realising that for most of the motion the acceleration was zero. In part (c) quite a few candidates realised that a realistic graph meant (in this case) a smooth curve without comers at 0.5 s and 11.5 s but missed that point that the curve also had to be without comers at 0 s and 12 s as well.

In part (d) most candidates realised the relative sizes of the arrows representing the forces but were not always careful to show equal length arrows for the forces representing the (same) weight in the two diagrams.

Part (f) of this question proved difficult for the great majority of candidates. Many, incorrectly, thought that the problem was similar to a ball bouncing up and down under gravity with potential and kinetic energies transforming into each other. Most were content to answer the question with statements such as "the potential energy is increasing on the way up because the height of the elevator is increasing" and so on. One of the action verbs in the question was "explain" and therefore the answers to this question had to be a bit more detailed and sophisticated than the majority of the ones given. Only a disappointingly small number of candidates realised that electrical energy was involved here and even fewer realised that at the end of the up and down trip all the electrical energy delivered by the motor would have been converted into thermal energy and sound.

3. SL only

This was a popular choice and there were some candidates who scored very highly indeed. Having said this, the beginning was done very poorly with most candidates muddling the concepts. A good answer was very rare and many defined thermal energy as simply "heat". The mechanisms of heat transfer could often be named but candidates often missed out appropriate detail to gain full marks. In (d)(i) it was satisfying to see many complete answers with excellent explanations as to why cooling occurs in evaporation. Surface area was one obvious answer in (d)(iii) which was often missed. The role of temperature was seldom explained well and many confused the air temperature with the skin temperature.

4. SL only

(a) Most candidates did mention a centripetal force. However, the great majority of answers went on to state, or imply, that the sphere is in equilibrium, rather than explaining that the tension in the extended spring *provides* the necessary centripetal force.

(b) In most scripts, a correct expression for centripetal force was given. The most common error was in determining the tension in the spring.

5. **[HL and SL] Model helicopter**

(a) Many candidates were familiar with, and able to state, a version of Newton's third law although not very many were able to proceed beyond this in order to show how it leads to the principle of momentum conservation.

(b) Many candidates realised that the air supports the helicopter but not all made any connection with Newton's third law and equilibrium.

(c) Nearly all candidates gained the mark here.

(d) and (ii) Calculating the mass of air and rate of change of momentum defeated most candidates.

(e) The link between this and the answer to (d) (ii) was often made and many candidates gained an error-carried-forward mark here.

(f) Again, error-carried-forward marks were often gained here.

(g) Free-body diagrams were often poor, with a variety of fictitious forces shown such as the forward thrust force.

(h) Explanations as to why a forward force acts on the helicopter were often inventive but not often correct. A large amount of incorrect and inappropriate work was seen with many candidates mixing force and acceleration diagrams. Correct resolution, or a correct triangle with correct explanation, was rarely seen.

(i) [**SL only**] Most candidates realised that the helicopter would experience resistance to motion but few were able to explain that this force increased as the speed of the helicopter increased.

(i)-(j) **[HL only]**

(i) This was usually answered correctly.

(j) (i) This was usually answered correctly.

(ii) Strictly speaking, it should have been stated in the question that CD and AB are adiabatic changes. However, the vast majority of candidates understood that something must be happening during BC and DA. Others clearly had no understanding of the situation. In this respect, the examining team did not feel that any candidates had been disadvantaged by the omission.

6. SL and HL

It was common to find that candidates thought that the balance reading would be constant when the water is boiling steadily. However, many did refer to either constant temperature or a steady rate of production of bubbles. Very few candidates appreciated the reason for taking two intervals instead of one. Many referred vaguely to it being "more accurate" without saying why. It was pleasing to note that, when determining the gradient, very few used two points on the line that were close together. Very few candidates were able to determine the specific latent heat. Most answers did not include any factor to allow for the time of collection of the water. There were some good responses but many referred to 'errors in the meters' or 'energy losses in the variable resistor'.

7. SL only

(a) The meaning of 'transverse' did not seem to be understood by the vast majority of the candidates. Typically the phrases 'direction of the wave' and 'direction of energy propagation' were thought of as distinct directions. Although it was a specific requirement given in the questions, few candidates referred to the propagation of energy at any time at all in their answer.

(c) & (d) The terms amplitude, wavelength, period and the wave equation were generally well understood though a significant number thought the amplitude was the distance from crest to trough.

(e) Although many were unable to provide all the correct information in their diagram, a pleasing majority correctly shifted the wave profile by $\lambda/4$.

8. [HL and SL] - Electric circuits

It is very clear that many students have a very weak understanding of electric circuits and are poorly prepared for questions on this topic. This is in fact one of the parts of the course where the questions are usually straightforward. Further it is one where inexpensive, accurate and relatively easy experiments can be conducted to support the textbook material. At many schools more emphasis needs to be placed on this topic by combining the theoretical and practical sides of things."

[HL only]

The first parts to this question were well done by most. The problems appeared in (c) where very few candidates realized that they had to draw a horizontal line on the graph and, by trial and error, see which current gives a *sum* of voltages across T and R equal to 4.0 V.

[SL only]

(a) Students had great trouble with the definition of resistance. Many defined it in terms of "the difficulty of electrons to move" and in other similar ways. Even among those who realized that a ratio of potential difference to current was involved (the formula in the booklet) very few paid attention to the fact that they had to refer to the potential difference across the device and the *current through* it. Many students were able to do the rest of the question well.

9. SL only

This was not a very popular question. Parts (a) and (b) of this question were very well done. In part (c) most candidates realised that the internal resistance of the battery or that of the wires or of the ammeter had something to do with the answer but few could a produce a clear argument. Many resorted to "if the voltage is reduced to zero the lamp won't work".

Part (d) involved the potential divider (potentiometer). It should be noted that the potential divider is on the syllabus and teachers are encouraged to use it both in practical laboratory work as well as in solving problems involving circuits.

In part (f) many candidates answered that the current in lamps A and B would be the same but then went on to contradict themselves in part (iii) by calculating the power in each lamp using a different current in each. Part (ii) of this question was not at all well done. Very few candidates realised that they had to use the graph to find two voltages adding up to 12 V.

HL only

Candidates tended to do poorly on this question. Few were able to understand the limits to the experimental technique described and the vast majority had clearly never come across the potentiometer as a three terminal device. This is surprising as it is good procedure to use such a circuit in practical situations. It should be noted that the potential divider is on the syllabus and teachers are encouraged to use it both in practical laboratory work as well as in solving problems involving circuits. Having said this, many were able to calculate which bulb had the greater power dissipation at 12 V. As might have been expected few were able to correctly use the information provided in the graph to identify the total current drawn when the two bulbs were placed in series. Some candidates calculated the resistance at 12 V and then assumed that it remained constant. I as, however, pleasing to see that a number could use the graph properly.

10. SL only

It is always disappointing to find candidates losing marks through careless drawing. It is expected that main features will be shown, for example, the parallel field lines equally spaced and normal to the plates. A parabolic path for the charged particle was not required but it is reasonable to expect to see a smooth curve between the plates and a straight path when outside the field.

As is usual in these calculations, there were some candidates who did not know how to begin the task. Candidates should always remember that, where they are asked to deduce a result, the marks are awarded for the working, not the result.

When drawing the magnetic field lines, diagrams were frequently too poor to be awarded credit. Field lines should not touch or cross!

There was a marked division between candidates. Some had little idea as to how to approach the calculations but it was obvious that some were well-practised in taking components and consequently performed well.

This final part of the question proved to be a good discriminator. Either a spiral or a helix (correct) was accepted by the examiners.

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It was common to find that candidates thought that the balance reading would be constant when the water is boiling steadily. However, many did refer to either constant temperature or a steady rate of production of bubbles. Very few candidates appreciated the reason for taking two intervals instead of one. Many referred vaguely to it being "more accurate" without saying why. It was pleasing to note that, when determining the gradient, very few used two points on the line that were close together. Very few candidates were able to determine the specific latent heat. Most answers did not include any factor to allow for the time of collection of the water. There were some good responses but many referred to 'errors in the meters' or 'energy losses in the variable resistor'.

7. SL only

(a) The meaning of 'transverse' did not seem to be understood by the vast majority of the candidates. Typically the phrases 'direction of the wave' and 'direction of energy propagation' were thought of as distinct directions. Although it was a specific requirement given in the questions, few candidates referred to the propagation of energy at any time at all in their answer.

(c) & (d) The terms amplitude, wavelength, period and the wave equation were generally well understood though a significant number thought the amplitude was the distance from crest to trough.

(e) Although many were unable to provide all the correct information in their diagram, a pleasing majority correctly shifted the wave profile by $\lambda/4$.

8. [HL and SL] - Electric circuits

It is very clear that many students have a very weak understanding of electric circuits and are poorly prepared for questions on this topic. This is in fact one of the parts of the course where the questions are usually straightforward. Further it is one where inexpensive, accurate and relatively easy experiments can be conducted to support the textbook material. At many schools more emphasis needs to be placed on this topic by combining the theoretical and practical sides of things."

[HL only]

The first parts to this question were well done by most. The problems appeared in (c) where very few candidates realized that they had to draw a horizontal line on the graph and, by trial and error, see which current gives a *sum* of voltages across T and R equal to 4.0 V.

[SL only]

(a) Students had great trouble with the definition of resistance. Many defined it in terms of "the difficulty of electrons to move" and in other similar ways. Even among those who realized that a ratio of potential difference to current was involved (the formula in the booklet) very few paid attention to the fact that they had to refer to the potential difference across the device and the *current through* it. Many students were able to do the rest of the question well.

9. SL only

This was not a very popular question. Parts (a) and (b) of this question were very well done. In part (c) most candidates realised that the internal resistance of the battery or that of the wires or of the ammeter had something to do with the answer but few could a produce a clear argument. Many resorted to "if the voltage is reduced to zero the lamp won't work".

Part (d) involved the potential divider (potentiometer). It should be noted that the potential divider is on the syllabus and teachers are encouraged to use it both in practical laboratory work as well as in solving problems involving circuits.

In part (f) many candidates answered that the current in lamps A and B would be the same but then went on to contradict themselves in part (iii) by calculating the power in each lamp using a different current in each. Part (ii) of this question was not at all well done. Very few candidates realised that they had to use the graph to find two voltages adding up to 12 V.

HL only

Candidates tended to do poorly on this question. Few were able to understand the limits to the experimental technique described and the vast majority had clearly never come across the potentiometer as a three terminal device. This is surprising as it is good procedure to use such a circuit in practical situations. It should be noted that the potential divider is on the syllabus and teachers are encouraged to use it both in practical laboratory work as well as in solving problems involving circuits. Having said this, many were able to calculate which bulb had the greater power dissipation at 12 V. As might have been expected few were able to correctly use the information provided in the graph to identify the total current drawn when the two bulbs were placed in series. Some candidates calculated the resistance at 12 V and then assumed that it remained constant. I as, however, pleasing to see that a number could use the graph properly.

10. SL only

It is always disappointing to find candidates losing marks through careless drawing. It is expected that main features will be shown, for example, the parallel field lines equally spaced and normal to the plates. A parabolic path for the charged particle was not required but it is reasonable to expect to see a smooth curve between the plates and a straight path when outside the field.

As is usual in these calculations, there were some candidates who did not know how to begin the task. Candidates should always remember that, where they are asked to deduce a result, the marks are awarded for the working, not the result.

When drawing the magnetic field lines, diagrams were frequently too poor to be awarded credit. Field lines should not touch or cross!

There was a marked division between candidates. Some had little idea as to how to approach the calculations but it was obvious that some were well-practised in taking components and consequently performed well.

This final part of the question proved to be a good discriminator. Either a spiral or a helix (correct) was accepted by the examiners.