Mathmatical Statements

Name: ____________________

Class: ____________________

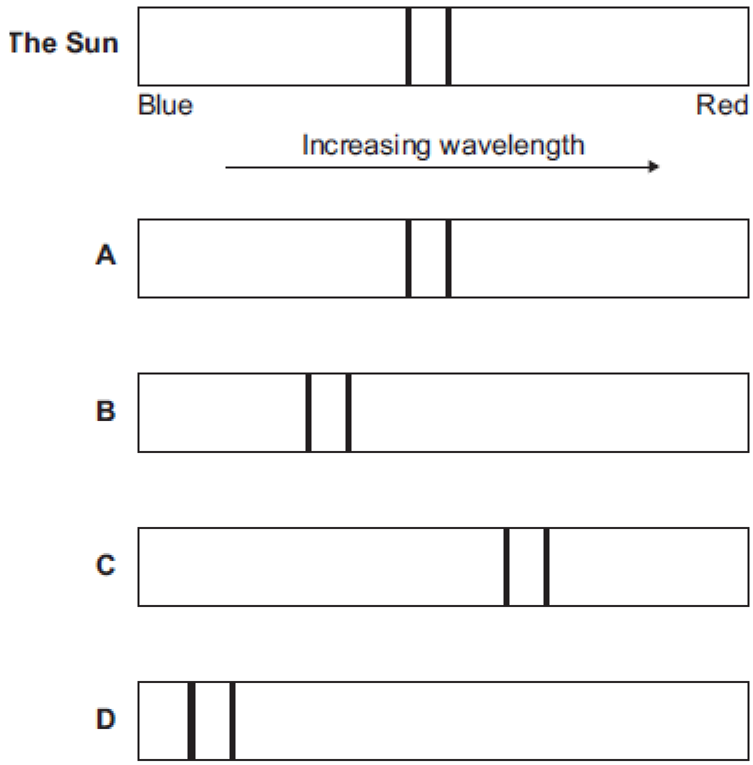
Date: ____________________

Time:	**514 minutes**
Marks:	**514 marks**
Comments:	

1 Scientists can use the visible light spectrum from distant stars to determine whether the stars are moving.

The visible light spectrum from stars includes dark lines at specific wavelengths.

(a) The diagram shows the visible light spectrum from the Sun and from four other stars, **A**, **B**, **C** and **D**.



(i) Which star, **A**, **B**, **C** or **D**, is moving away from the Earth? [ ]

(1)

(ii) How does the speed of star **B** compare with the speed of star **D**?

Tick (✓) **one** box.

	Tick (✓)
The speed of star **B** is greater than the speed of star **D**.	
The speed of star **B** is less than the speed of star **D**.	
The speed of star **B** is the same as the speed of star **D**.	

(1)

(b) A radio wave is emitted by a star.
The radio wave has a wavelength of 1500 m and a frequency of 200 000 Hz.

Calculate the speed of this radio wave.

Choose the correct unit from the list below.

m **m / s** **m / s^2**

....

....

....

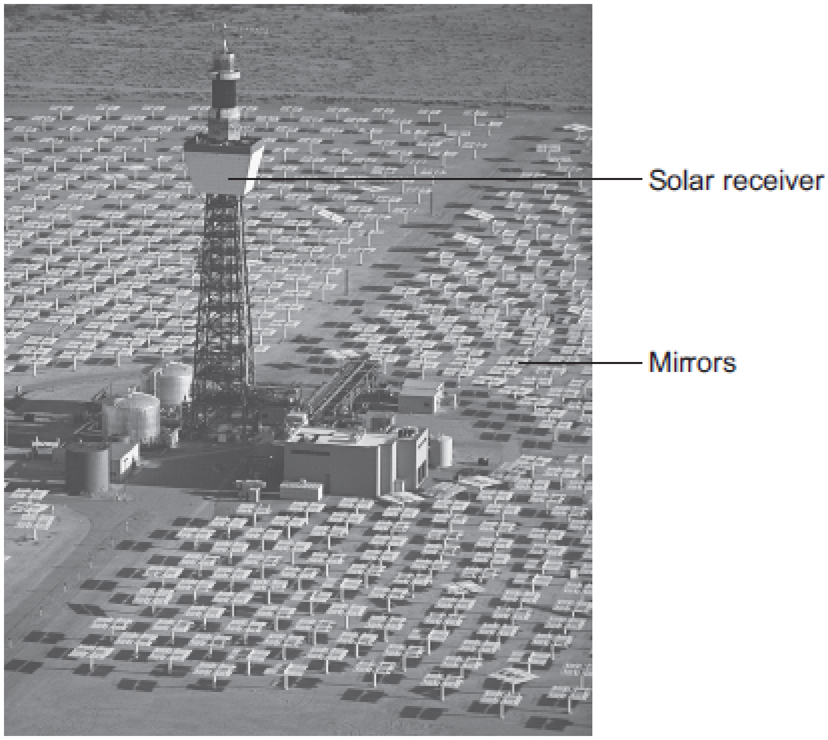
Speed = ... unit ....

(3)
(Total 5 marks)

2 The image below shows a solar thermal power station that has been built in a hot desert.

The power station uses energy from the Sun to heat water to generate electricity.

Energy from the Sun is reflected towards a solar receiver using many mirrors.



© Kim Steele/Photodisc/Thinkstock

(a) (i) Which part of the electromagnetic spectrum provides most of the energy to heat the water in a solar thermal power station?

....

(1)

(ii) Describe how heated water is used to generate electricity by this solar thermal power station.
The process is the same as in a fossil fuel power station.

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(3)

(b) A new type of solar power station, called a solar storage power station, is able to store energy from the Sun by heating molten chemical salts.
The stored energy can be used to generate electricity at night.

(i) It is important that the molten chemical salts have a high specific heat capacity.
Suggest **one** reason why.

....

....

(1)

(ii) The solar storage power station can store a maximum of 2 200 000 kWh of energy.
The solar storage power station can supply a town with a maximum electrical power of 140 000 kW.

Calculate for how many hours the energy stored by the solar storage power station can supply the town with electrical power.

Give your answer to 2 significant figures.

....

....

....

Time = ... hours

(3)

(iii) **Table 1** gives information about the place where the solar storage power station has been built.

Table 1

Season	**Mean number of daylight hours**	**Mean power received from the Sun per square metre in kW**
Spring	11.5	0.90
Summer	13.5	1.10
Autumn	12.0	0.95
Winter	10.5	0.71

The solar storage power station does not operate at the maximum possible electrical output every day of the year.

Suggest why.

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....

....

(2)

(c) Power stations do not work at maximum possible electrical output all the time.The ‘capacity factor’ of a power station is calculated using the equation:

$$\text{Capacity factor} = \frac{\text{actual electrical output per year}}{\text{maximum possible electrical output per year}}$$

Table 2 shows capacity factors for different types of power station.

Table 2

Type of power station	Renewable energy source	Capacity factor
Coal	No	0.41
Natural gas	No	0.48
Nuclear	No	0.66
Solar thermal	Yes	0.33
Tidal	Yes	0.26
Wind turbine	Yes	0.30

(i) Compare the capacity factors of the renewable power stations with those of the non-renewable power stations in **Table 2**.
Explain the reason for the difference between the capacity factors.

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(3)

(ii) The capacity factor of a solar storage power station is higher than for all other renewable power stations.
Suggest **one** reason why.

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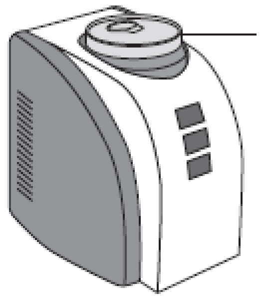
(1)
(Total 14 marks)

3 A 'can-chiller' is used to make a can of drink colder.

The image below shows a can-chiller.



(a) The initial temperature of the liquid in the can was 25.0 °C.
The can-chiller decreased the temperature of the liquid to 20.0 °C.
The amount of energy transferred from the liquid was 6930 J.
The mass of liquid in the can was 0.330 kg.

Calculate the specific heat capacity of the liquid.

Give the unit.

....

....

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....

Specific heat capacity = ... unit ....

(4)

(b) Energy is transferred through the metal walls of the can of drink by conduction.
Explain how.

....

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(4)

(c) The energy from the can of drink is transferred to the air around the can-chiller. A convection current is set up around the can-chiller. Explain how.

....

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(3)

(d) The can-chiller has metal cooling fins that are designed to transfer energy quickly to the surroundings.

Give **two** features that would help the metal cooling fins to transfer energy quickly to the surroundings.

1..

2..

(2)
(Total 13 marks)

4 (a) When a force is applied to a spring, the spring extends by 0.12 m.
The spring has a spring constant of 25 N / m.

Calculate the force applied to the spring.

....

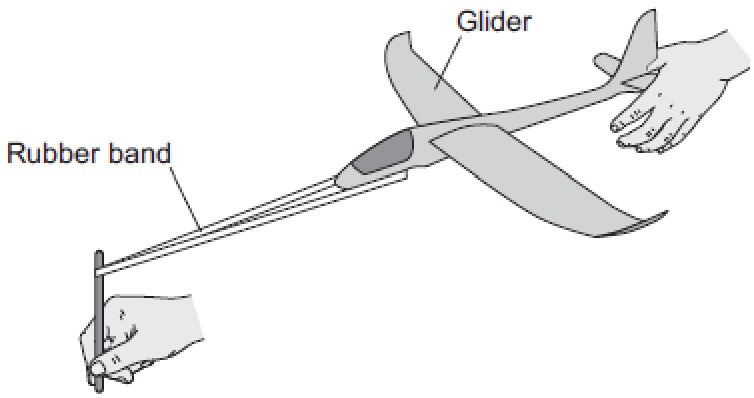
....

Force = ... N

(2)

(b) **Figure 1** shows a toy glider. To launch the glider into the air, the rubber band and glider are pulled back and then the glider is released.

Figure 1



(i) Use the correct answers from the box to complete the sentence.

chemical	**elastic potential**	**kinetic**	**thermal**

When the glider is released, the .... energy

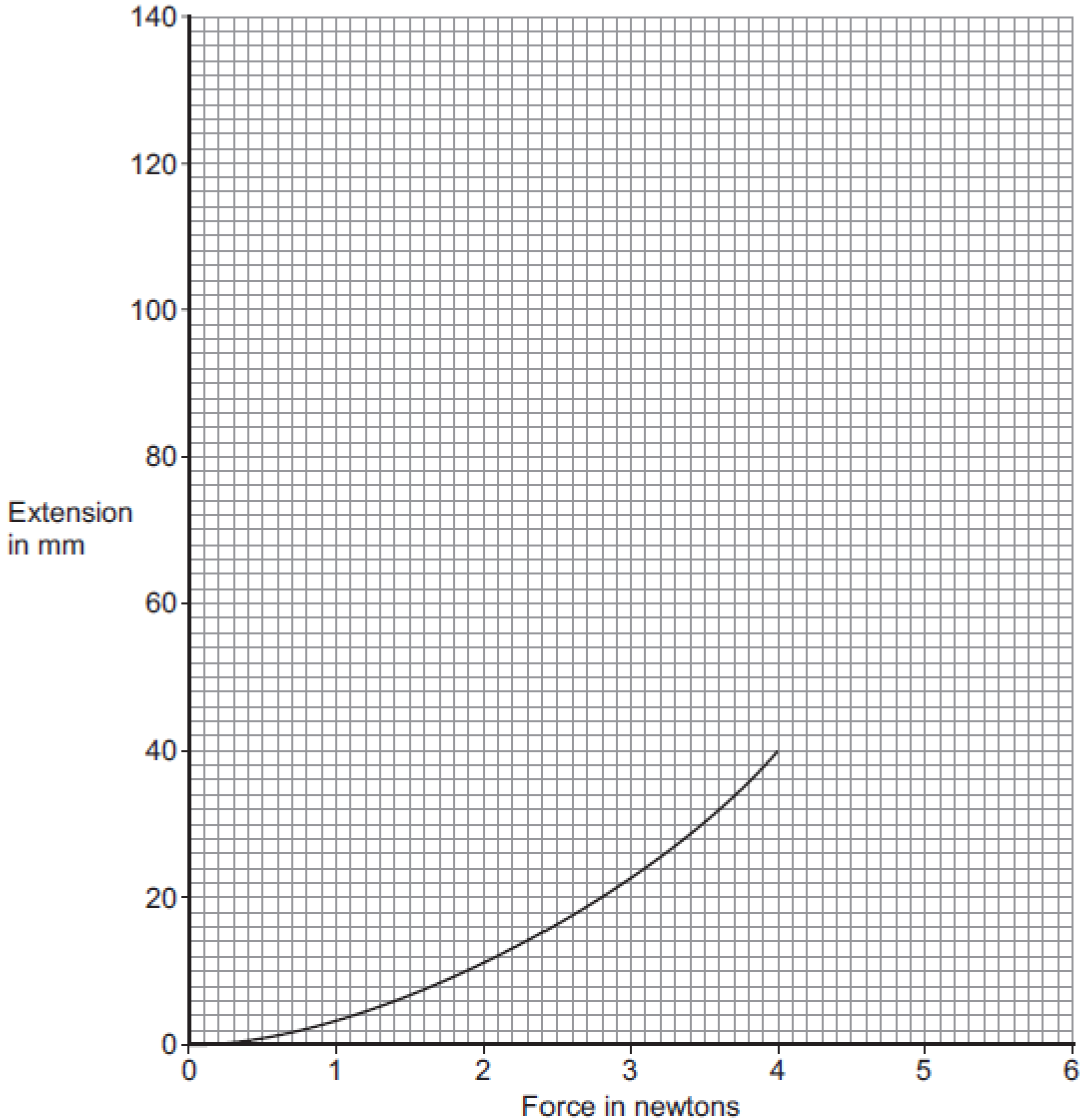
stored in the rubber band decreases and the glider gains

.... energy.

(2)

(ii) **Figure 2** shows how the extension of the rubber band varies with the force applied to the rubber band.

Figure 2



What can you conclude, from **Figure 2**, would happen to the extension of the rubber band if the force applied to the rubber band was increased to 6 N?

The rubber band does **not** break.

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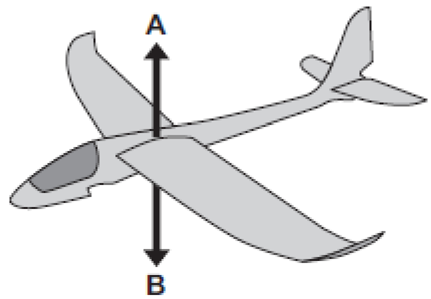
(2)

(c) **Figure 3** shows the vertical forces, **A** and **B**, acting on the glider when it is flying.

Figure 3



(i) What name is given to the force labelled **B**?

Draw a ring around the correct answer.

drag **friction** **weight**

(1)

(ii) Which **one** of the following describes the downward speed of the glider when force **B** is greater than force **A**?

Tick (✓) **one** box.

Downward speed increases	☐
Downward speed is constant	☐
Downward speed decreases	☐

(1)
(Total 8 marks)

5 (a) A car driver sees the traffic in front is not moving and brakes to stop his car.

The stopping distance of a car is the thinking distance plus the braking distance.

(i) What is meant by the 'braking distance'?

....

....

(1)

(ii) The braking distance of a car depends on the speed of the car and the braking force.

State **one** other factor that affects braking distance.

....

....

(1)

(iii) How does the braking force needed to stop a car in a particular distance depend on the speed of the car?

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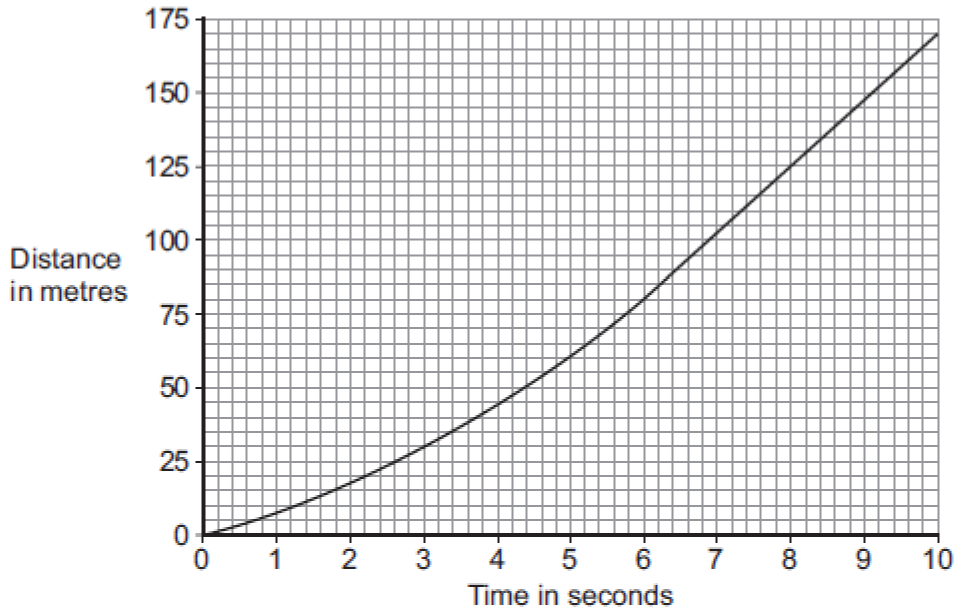
(1)

(b) **Figure 1** shows the distance−time graph for the car in the 10 seconds before the driver applied the brakes.

Figure 1



Use **Figure 1** to calculate the maximum speed the car was travelling at.
Show clearly how you work out your answer.

....

....

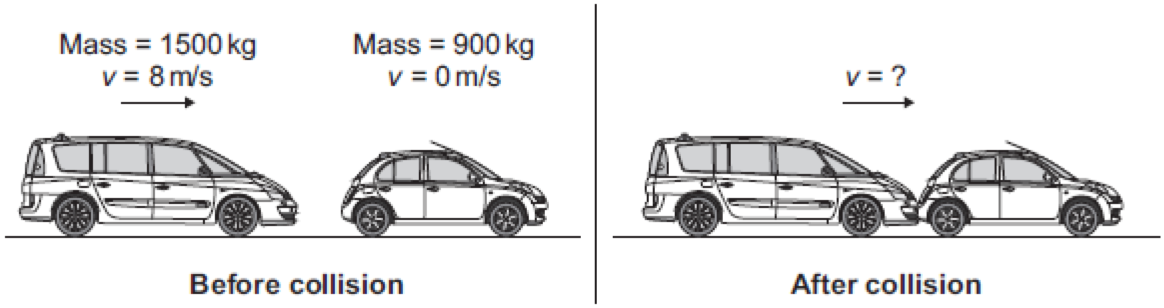
Maximum speed = ... m / s

(2)

(c) The car did not stop in time. It collided with the stationary car in front, joining the two cars together.

Figure 2 shows both cars, just before and just after the collision.

Figure 2



(i) The momentum of the two cars was conserved.

What is meant by the statement 'momentum is conserved'?

....

....

(1)

(ii) Calculate the velocity of the two joined cars immediately after the collision.

....

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....

Velocity = ... m / s

(3)

(d) Since 1965, all cars manufactured for use in the UK must have seat belts.

It is safer for a car driver to be wearing a seat belt, compared with not wearing a seat belt, if the car is involved in a collision.

Explain why.

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(4)
(Total 13 marks)

6 Light changes direction as it passes from one medium to another.

(a) Use the correct answer from the box to complete the sentence.

diffraction	**reflection**	**refraction**

The change of direction when light passes from one medium to another is

called ....

(1)

(b) Draw a ring around the correct answer to complete the sentence.

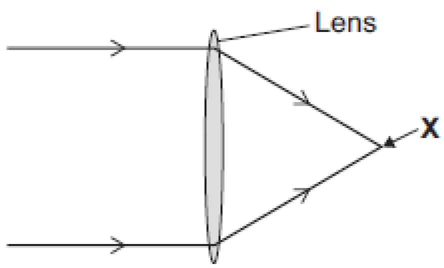
When light passes from air into a glass block, it changes

direction	away from the normal. towards the normal. to always travel along the normal.

(1)

(c) **Diagram 1** shows light rays entering and passing through a lens.

Diagram 1



(i) Which type of lens is shown in **Diagram 1**?

Draw a ring around the correct answer.

concave **convex** **diverging**

(1)

(ii) In **Diagram 1**, what is the point **X** called?

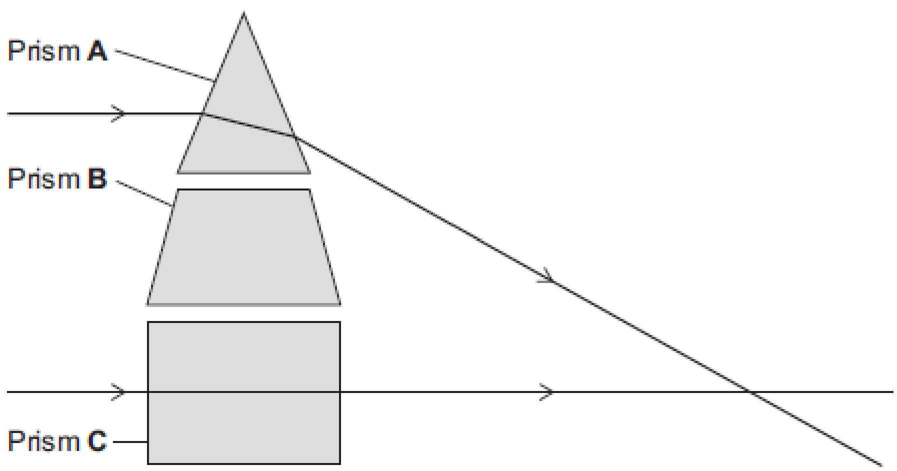
....

(1)

(d) A lens acts like a number of prisms.

Diagram 2 shows two parallel rays of light entering and passing through prism **A** and prism **C**.

Diagram 2



Draw a third parallel ray entering and passing through prism **B**.

(4)

(e) What **two** factors determine the focal length of a lens?

1 ....

2 ....

(2)
(Total 10 marks)

7 A student finds some information about energy-saving light bulbs.

(a) A 30W light bulb uses 600J of electrical energy in a certain period of time. In that time, it produces 450 J of light energy. The rest of the energy is wasted.

(i) Calculate the energy wasted by the light bulb in this period of time.

....

Wasted energy = ... J

(1)

(ii) What happens to the energy wasted by the light bulb?

....

....

(1)

(iii) Calculate the efficiency of this light bulb.

....

....

Efficiency = ...

(2)

(iv) Calculate the period of time, in seconds, during which the 600 J is provided to the 30 W light bulb.

....

....

Time = ... s

(2)

(b) A company that makes light bulbs provides information about some of their products.

The table shows some of this information.

	Power in watts	Lifetime in hours	Cost of bulb in £
Filament bulb	60	1250	2.00
LED bulb	12	50 000	16.00

(i) Suggest why it is important to confirm this information independently.

....

(1)

(ii) A homeowner is thinking about replacing his filament bulbs with LED bulbs.

A 12 W LED bulb gives the same light output as a 60 W filament bulb.

Suggest reasons why the homeowner is likely to choose LED bulbs.

Use the information given in the table.

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(2)

(iii) State **one** factor, other than efficiency, that is important when considering the choice of a bulb for lighting in the home.

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(1)
(Total 10 marks)

8 Solid, liquid and gas are three different states of matter.

(a) Describe the difference between the solid and gas states, in terms of the arrangement and movement of their particles.

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(4)

(b) What is meant by 'specific latent heat of vaporisation'?

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(2)

(c) While a kettle boils, 0.018 kg of water changes to steam.

Calculate the amount of energy required for this change.

Specific latent heat of vaporisation of water = 2.3×10^6 J / kg.

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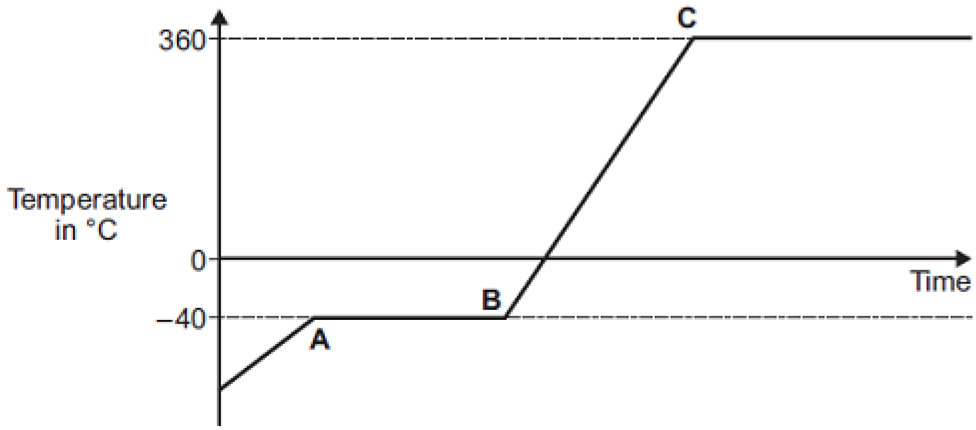
....

Energy required = ... J

(2)

(d) The graph shows how temperature varies with time for a substance as it is heated.

The graph is **not** drawn to scale.



Explain what is happening to the substance in sections **AB** and **BC** of the graph.

Section **AB** ....

....

....

....

....

Section **BC** ....

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(4)
(Total 12 marks)

9 On 14 October 2012, a skydiver set a world record for the highest free fall from an aircraft.

After falling from the aircraft, he reached a maximum steady velocity of 373 m / s after 632 seconds.

(a) Draw a ring around the correct answer to complete the sentence.

This maximum steady velocity is called the	frictional initial terminal	velocity.

(1)

(b) The skydiver wore a chest pack containing monitoring and tracking equipment.
The weight of the chest pack was 54 N.

The gravitational field strength is 10 N / kg.

Calculate the mass of the chest pack.

....

....

Mass of chest pack = ... kg

(2)

(c) During his fall, the skydiver's acceleration was not uniform.

Immediately after leaving the aircraft, the skydiver's acceleration was 10 m / s ^{2}.

(i) Without any calculation, estimate his acceleration a few seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate ....

Explanation ....

....

....

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....

....

(3)

(ii) Without any calculation, estimate his acceleration 632 seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate ....

Explanation ....

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(3)
(Total 9 marks)

10 An investigation was carried out to show how thinking distance, braking distance and stopping distance are affected by the speed of a car.

The results are shown in the table.

Speed in metres per second	**Thinking distance in metres**	**Braking distance in metres**	**Stopping distance in metres**
10	6	6	12
15	9	14	43
20	12	24	36
25	15	38	53
30	18	55	73

(a) Draw a ring around the correct answer to complete each sentence.

As speed increases, thinking distance
- decreases.
- increases.
- stays the same.

As speed increases, braking distance
- decreases.
- increases.
- stays the same.

(2)

(b) One of the values of stopping distance is incorrect.

Draw a ring around the incorrect value in the table.

Calculate the correct value of this stopping distance.

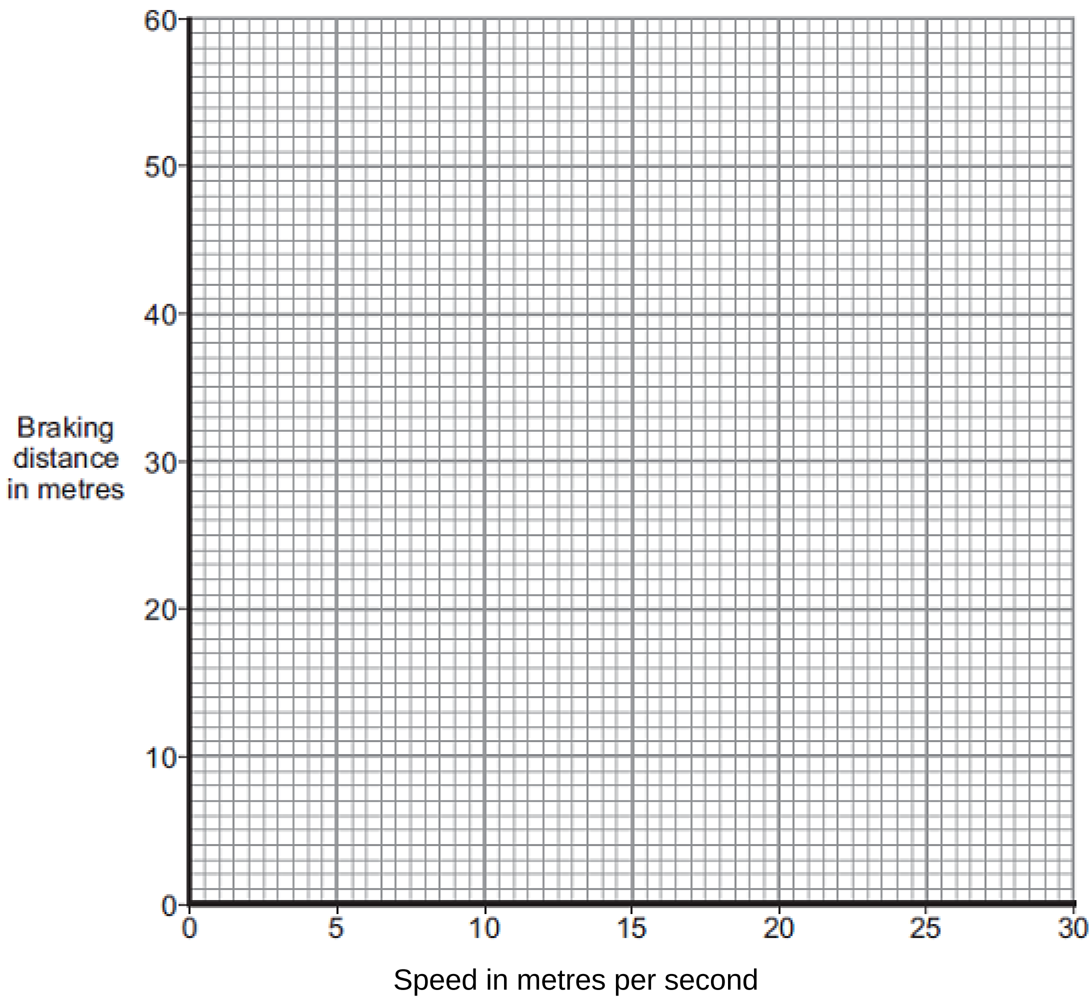
....

Stopping distance = ... m

(2)

(c) (i) Using the results from the table, plot a graph of braking distance against speed.

Draw a line of best fit through your points.



(3)

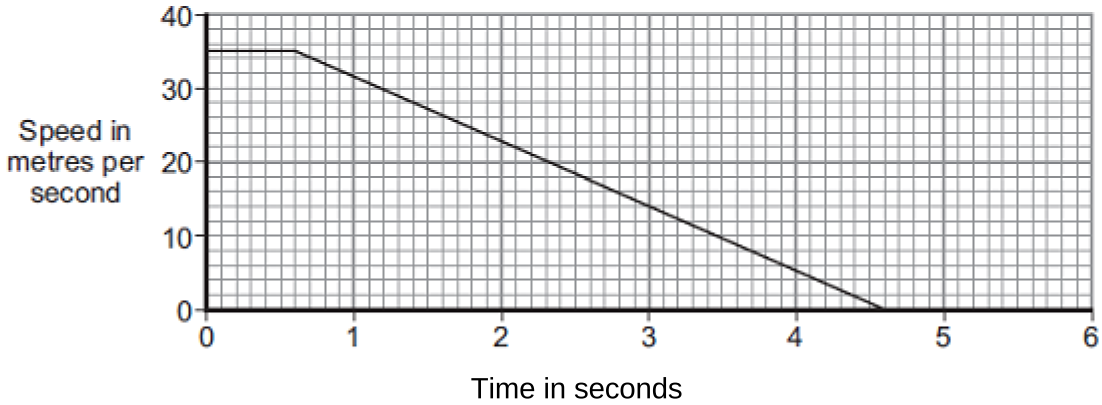
(ii) Use your graph to determine the braking distance, in metres, at a speed of 22 m / s.

Braking distance = ... m

(1)

(d) The speed–time graph for a car is shown below.

While travelling at a speed of 35 m / s, the driver sees an obstacle in the road at time $t = 0$. The driver reacts and brakes to a stop.



(i) Determine the braking distance.

....

....

....

....

Braking distance = ... m

(3)

(ii) If the driver was driving at 35 m / s on an icy road, the speed–time graph would be different.

Add another line to the speed–time graph above to show the effect of travelling at 35 m / s on an icy road and reacting to an obstacle in the road at time $t = 0$.

(3)

(e) A car of mass 1200 kg is travelling with a velocity of 35 m / s.

(i) Calculate the momentum of the car.

Give the unit.

....

....

....

Momentum = ...

(3)

(ii) The car stops in 4 seconds.

Calculate the average braking force acting on the car during the 4 seconds.

....

....

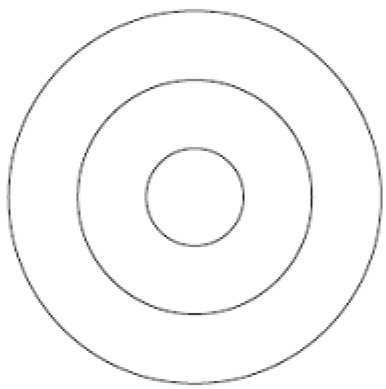
Force = ... N

(2)
(Total 19 marks)

11 A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1



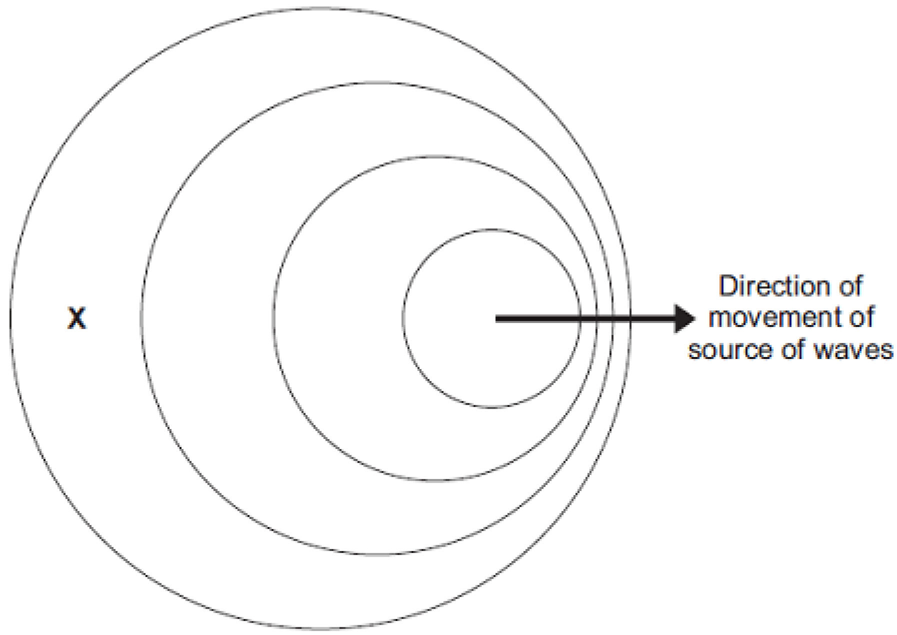
(a) Show on **Diagram 1** the wavelength of the waves.

(1)

(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)



(i) Use the correct answer from the box to complete each sentence.

decreased	**increased**	**stayed the same**

In **Diagram 2**, the observed wavelength of the waves at **X**

has ....

In **Diagram 2**, the frequency of the waves at **X**

has ....

(2)

(ii) Take measurements from **Diagram 2** to determine the wavelength of the waves received at **X**.

Give the unit.

....

....

Wavelength = ...

(3)

(c) The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

....

(1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

....

....

(1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

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(4)

(iv) State **one** other piece of evidence that supports the Big Bang theory of the formation of the Universe.

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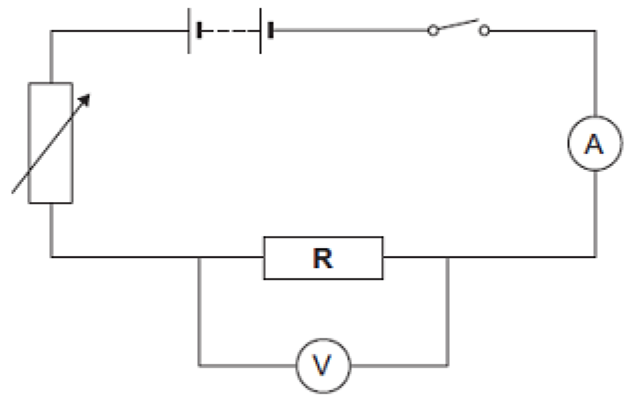
(1)
(Total 13 marks)

12 (a) A resistor is a component that is used in an electric circuit.



(i) Describe how a student would use the circuit to take the readings necessary to determine the resistance of resistor **R**.

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(6)

(ii) Explain why the student should open the switch after each reading.

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(2)

(iii) In an experiment using this circuit, an ammeter reading was 0.75 A.
The calculated value of the resistance of resistor **R** was 16 Ω.

What is the voltmeter reading?

....

....

Voltmeter reading = ... V

(2)

(iv) The student told his teacher that the resistance of resistor **R** was 16 Ω.

The teacher explained that the resistors used could only have one of the following values of resistance.

10 Ω **12 Ω** **15 Ω** **18 Ω** **22 Ω**

Suggest which of these resistors the student had used in his experiment.

Give a reason for your answer.

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(2)

(b) The diagram shows a fuse.

Describe the action of the fuse in a circuit.

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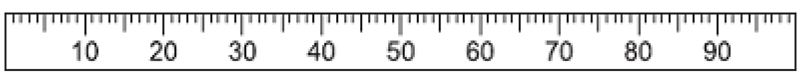
(3)
(Total 15 marks)

13 A student carries out an investigation using a metre rule as a pendulum.

(a) **Diagram 1** shows a metre rule.

Diagram 1



(i) Draw, on **Diagram 1**, an **X** to show the position of the centre of mass of the rule.

(1)

(ii) State what is meant by the 'centre of mass of an object'.

....

....

(1)

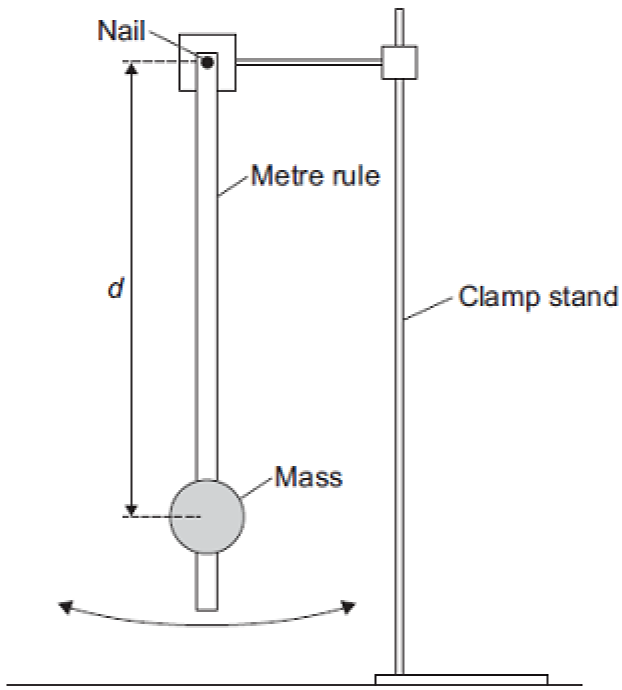
(b) The student taped a 100 g mass to a metre rule.

She set up the apparatus as shown in **Diagram 2**.

She suspended the metre rule from a nail through a hole close to one end, so she could use the metre rule as a pendulum.

The distance d is the distance between the nail and the 100 g mass.

Diagram 2



(i) Draw, on **Diagram 2**, a **Y** to show a possible position of the centre of mass of the pendulum.

(1)

(ii) The student carried out an investigation to find out how the time period of the pendulum varies with *d*.

Some of her results are shown in the table.

	Time for 10 swings in seconds				
***d* in cm**	**First test**	**Second test**	**Third test**	**Mean value**	**Mean time for 1 swing in seconds**
10.0	15.3	15.4	15.5	15.4	1.54
30.0	14.7	14.6	14.7	14.7	1.47
50.0	15.3	15.6	15.4	15.4	1.54
70.0	16.5	16.6	16.5		

Complete the table.

You may use the space below to show your working.

....

....

(3)

(iii) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Describe how the student would carry out the investigation to get the results in the table in part (ii).

You should include:

- any other apparatus required
- how she should use the apparatus
- how she could make it a fair test
- a risk assessment
- how she could make her results as accurate as possible.

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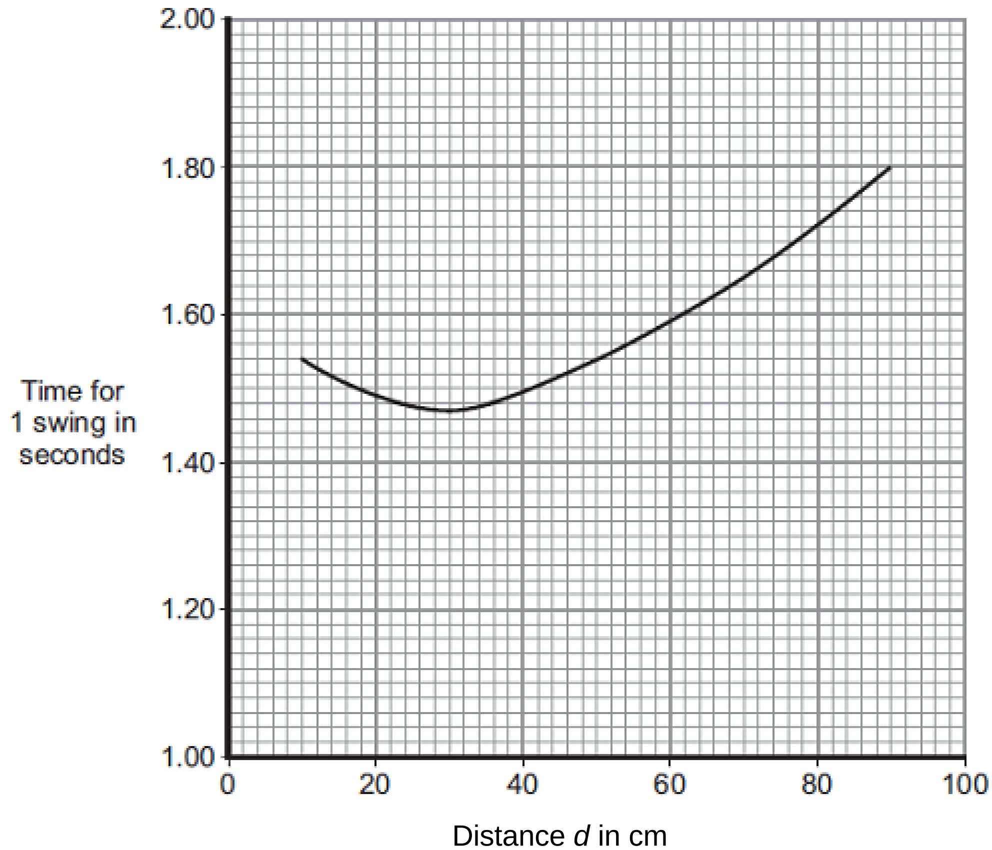
(6)

(c) A graph of the student's results is shown below.



(i) Describe the pattern shown by the graph.

....

....

....

....

(2)

(ii) The student thinks that the measurements of time for d = 10 cm might be anomalous, so she takes a fourth measurement.

Her four measurements are shown below.

15.3 s **15.4 s** **15.5 s** **15.3 s**

State whether you consider any of these measurements to be anomalous.

Justify your answer.

....

....

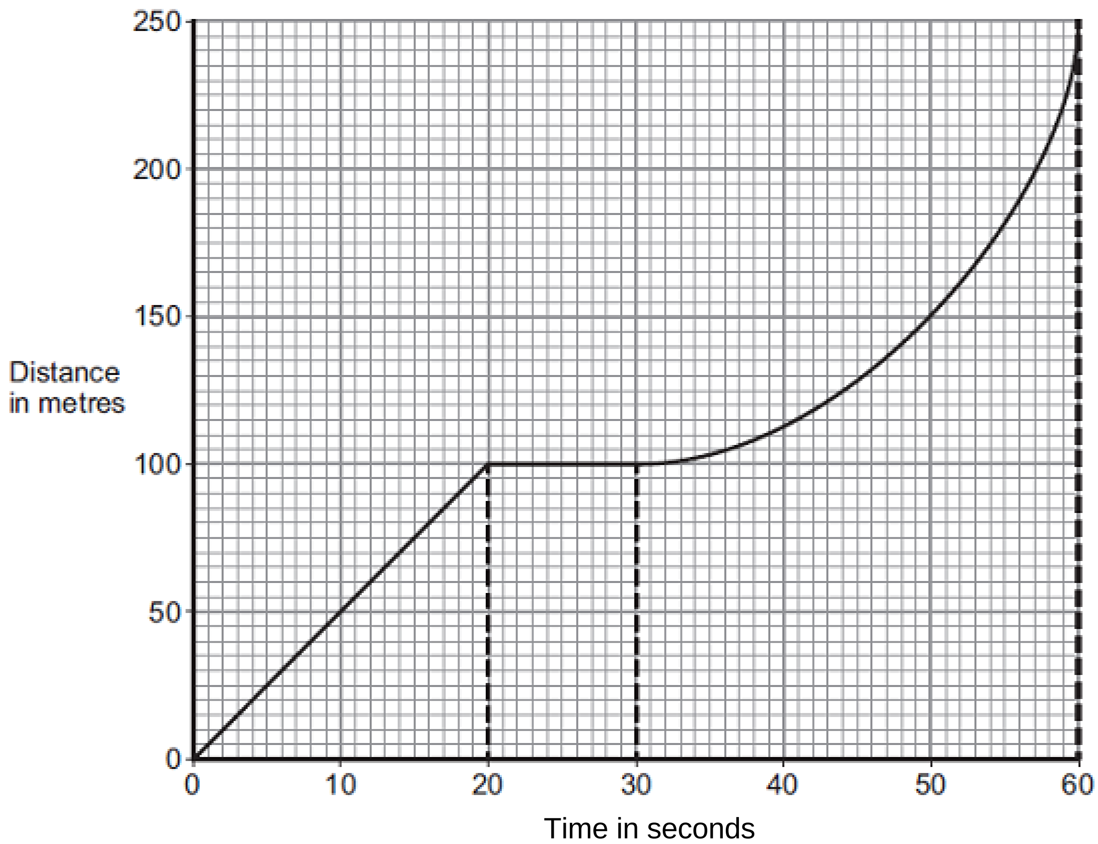
....

....

(2)
(Total 16 marks)

14 A bus is taking some children to school.

(a) The bus has to stop a few times. The figure below shows the distance–time graph for part of the journey.



(i) How far has the bus travelled in the first 20 seconds?

Distance travelled = ... m

(1)

(ii) Describe the motion of the bus between 20 seconds and 30 seconds.

....

....

(1)

(iii) Describe the motion of the bus between 30 seconds and 60 seconds.

Tick (✓) **one** box.

	Tick (✓)
Accelerating	
Reversing	
Travelling at constant speed	

(1)

(iv) What is the speed of the bus at 45 seconds?

Show clearly on the figure above how you obtained your answer.

....

....

....

Speed = ... m / s

(3)

(b) Later in the journey, the bus is moving and has 500 000 J of kinetic energy.

The brakes are applied and the bus stops.

(i) How much work is needed to stop the bus?

....

Work = ... J

(1)

(ii) The bus stopped in a distance of 25 m.

Calculate the force that was needed to stop the bus.

....

....

Force = ... N

(2)

(iii) What happens to the kinetic energy of the bus as it is braking?

....

....

....

....

(2)
(Total 11 marks)

15 (a) Radio waves, microwaves and visible light are all electromagnetic waves that are used for communication.

(i) Name another electromagnetic wave that is used for communication.

....

(1)

(ii) Name an electromagnetic wave which is **not** used for communication.

State a use for this electromagnetic wave.

Electromagnetic wave ....

Use ....

....

(2)

(b) The table below shows the wavelengths for some electromagnetic waves, **A**, **B**, **C** and **D**.

Wave	**Wavelength**
A	1000 m
B	100 m
C	10 m
D	3 cm

A teacher is going to demonstrate diffraction of waves through a gap. She will carry out the demonstration in a classroom.

The teacher is able to generate waves **A**, **B**, **C** and **D**.

Which wave, **A**, **B**, **C** or **D**, would she use? ☐

Explain your answer.

....

....

....

....

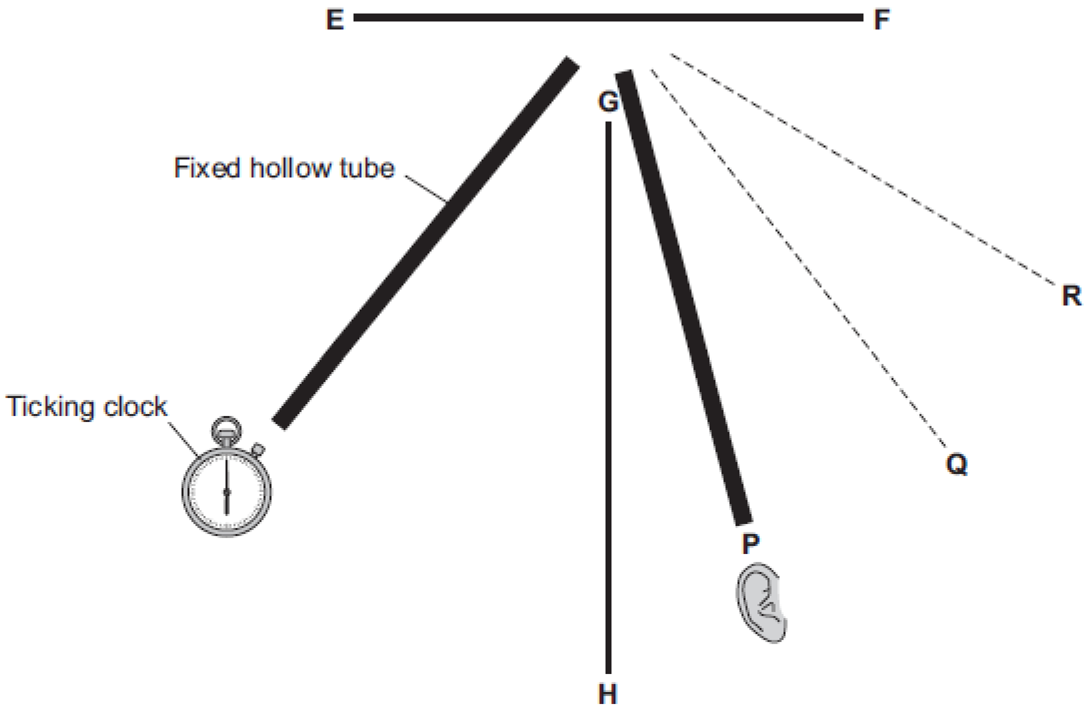
....

....

(3)

(c) In another demonstration, a teacher used a loud ticking clock as a source of sound, two hollow tubes and two smooth surfaces, **EF** and **GH**.

The figure below shows one of the hollow tubes fixed in position with a ticking clock at one end.



A student placed his ear at one end of the other hollow tube in position **P**. He moved this hollow tube, in turn, to positions **Q** and **R**.

(i) At which position, **P**, **Q** or **R**, did he hear the loudest sound? ☐

(1)

(ii) Explain your answer to part **(i)**.

....

....

....

....

....

....

(3)

(iii) Suggest why smooth surface **GH** in the figure above was needed.

....

....

(1)

(iv) The frequency of a sound wave is 15 Hz.

The speed of sound is 330 m / s.

Calculate the wavelength of the sound wave.

....

....

Wavelength = ... m

(2)

(v) Give a reason why it would **not** be possible to do the demonstration in the figure above using sound waves with a frequency of 15 Hz.

....

....

(1)
(Total 14 marks)

16 The current in a circuit depends on the potential difference (p.d.) provided by the cells and the total resistance of the circuit.

(a) Using the correct circuit symbols, draw a diagram to show how you would connect 1.5 V cells together to give a p.d. of 6 V.

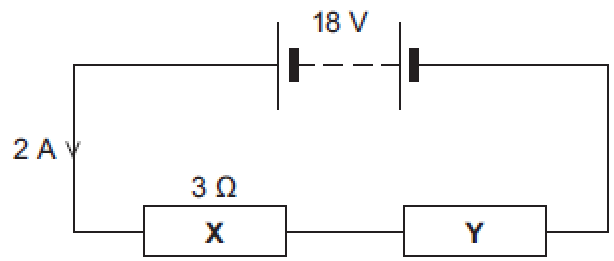
(2)

(b) **Figure 1** shows a circuit containing an 18 V battery.

Two resistors, **X** and **Y**, are connected in series.

- **X** has a resistance of 3 Ω.
- There is a current of 2 A in **X**.

Figure 1



(i) Calculate the p.d. across **X**.

....

....

P.d. across **X** = ... V

(2)

(ii) Calculate the p.d. across **Y**.

....

....

....

P.d. across **Y** = ... V

(2)

(iii) Calculate the total resistance of **X** and **Y**.

....

....

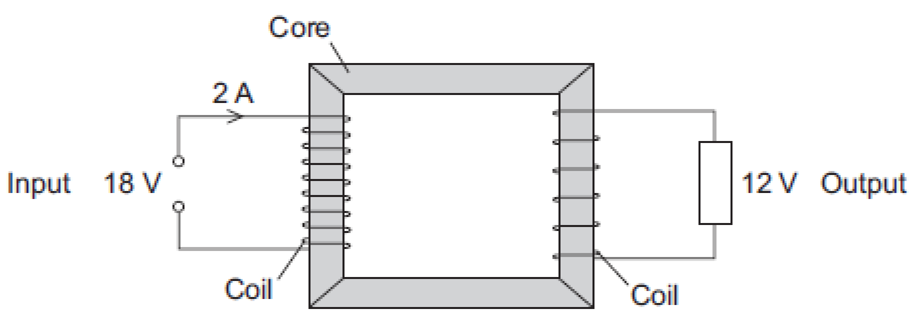
....

Total resistance of **X** and **Y** = ... Ω

(2)

(c) **Figure 2** shows a transformer.

Figure 2



(i) An 18 V battery could **not** be used as the input of a transformer.

Explain why.

....

....

....

....

(2)

(ii) The transformer is 100% efficient.

Calculate the output current for the transformer shown in **Figure 2**.

....

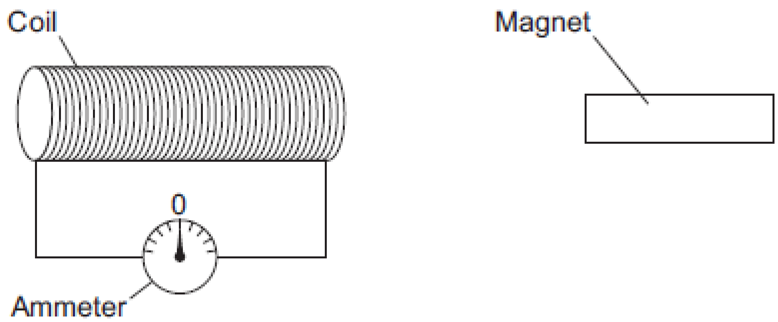
....

....

Output current = ... A

(2)
(Total 12 marks)

17 The figure below shows a coil and a magnet. An ammeter is connected to the coil.



The ammeter has a centre zero scale, so that values of current going in either direction through the coil can be measured.

(a) A teacher moves the magnet slowly towards the coil.

Explain why there is a reading on the ammeter.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

(6)

(b) The table below shows some other actions taken by the teacher.

Complete the table to show the effect of each action on the ammeter reading.

Action taken by teacher	**What happens to the ammeter reading?**
Holds the magnet stationary and moves the coil slowly towards the magnet	
Holds the magnet stationary within the coil	
Moves the magnet quickly towards the coil	
Reverses the magnet and moves it slowly towards the coil	

(4)

(c) The magnet moves so that there is a steady reading of 0.05 A on the ammeter for 6 seconds.

Calculate the charge that flows through the coil during the 6 seconds.

Give the unit.

....

....

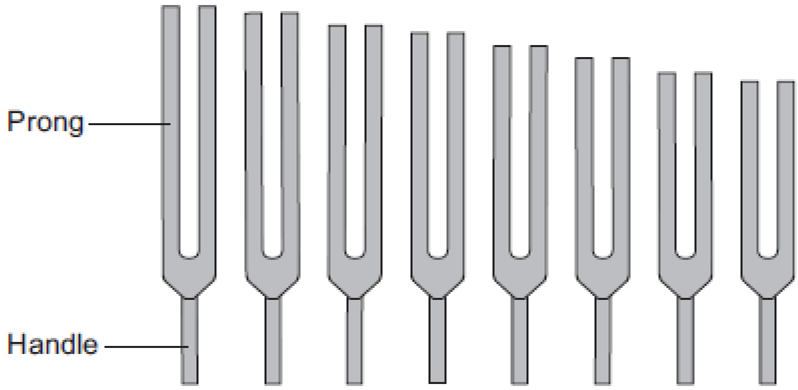
....

Charge = ...

(3)
(Total 13 marks)

18 **Figure 1** shows a set of tuning forks.

Figure 1



A tuning fork has a handle and two prongs. It is made from metal.

When the prongs are struck on a hard object, the tuning fork makes a sound wave with a single frequency. The frequency depends on the length of the prongs.

(a) Use the correct answer from the box to complete each sentence.

direction	**loudness**	**pitch**	**speed**

The frequency of a sound wave determines its ....

The amplitude of a sound wave determines its ....

(2)

(b) Each tuning fork has its frequency engraved on it. A student measured the length of the prongs for each tuning fork.

Some of her data is shown in the table.

Frequency in hertz	Length of prongs in cm
320	9.5
384	8.7
480	7.8
512	7.5

(i) Describe the pattern shown in the table.

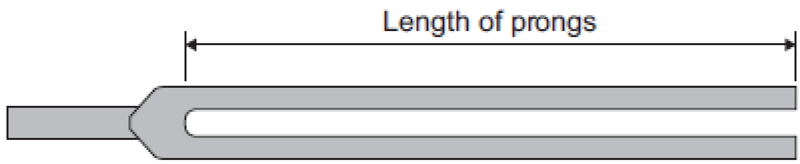
....

....

(1)

(ii) **Figure 2** shows a full-size drawing of a tuning fork.

Figure 2



Measure and record the length of the prongs.

Length of prongs = ... cm

(1)

Use the data in the table above to estimate the frequency of the tuning fork in **Figure 2**.

Explain your answer.

....

....

....

....

....

Estimated frequency = ... Hz

(3)

(c) Ultrasound waves are used in hospitals.

(i) Use the correct answer from the box to complete the sentence.

electronic	**hydraulic**	**radioactive**

Ultrasound waves can be produced by .... systems.

(1)

(ii) The frequency of an ultrasound wave used in a hospital is 2×10^6 Hz.

It is **not** possible to produce ultrasound waves of this frequency using a tuning fork.

Explain why.

....

....

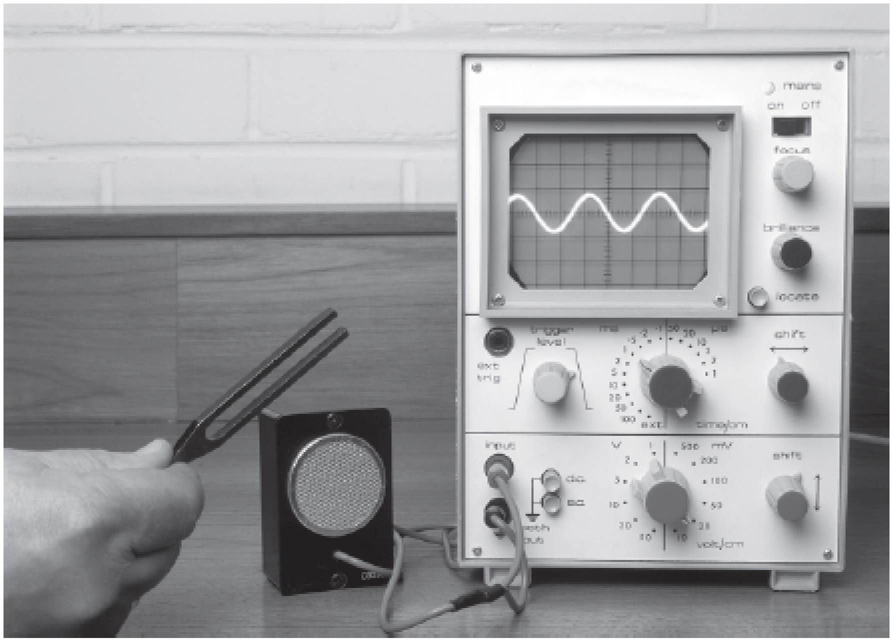
....

....

(2)

(d) **Figure 3** shows a tuning fork and a microphone. The microphone is connected to an oscilloscope.

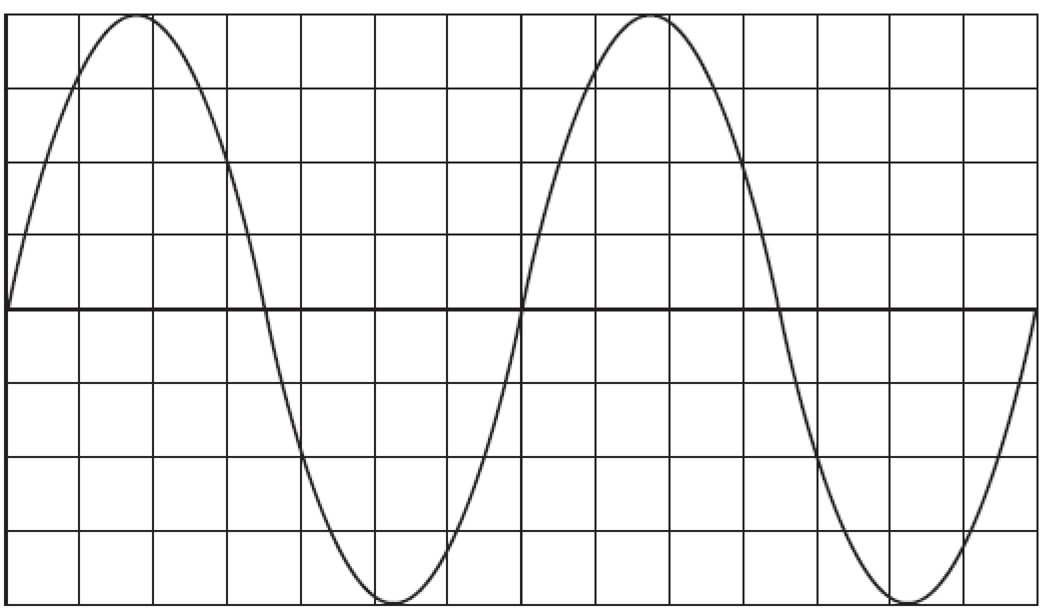
Figure 3



When the tuning fork is struck and then placed in front of the microphone, a trace appears on the oscilloscope screen.

Figure 4 shows part of the trace on the screen.

Figure 4



Each horizontal division in **Figure 4** represents a time of 0.0005 s.

What is the frequency of the tuning fork?

....

....

....

Frequency = ... Hz

(3)
(Total 13 marks)

19 (a) A company is developing a system which can heat up and melt ice on roads in the winter. This system is called 'energy storage'.

During the summer, the black surface of the road will heat up in the sunshine.

This energy will be stored in a large amount of soil deep under the road surface. Pipes will run through the soil. In winter, cold water entering the pipes will be warmed and brought to the surface to melt ice.

The system could work well because the road surface is black.

Suggest why.

....

....

(1)

(b) (i) What is meant by specific latent heat of fusion?

....

....

....

....

(2)

(ii) Calculate the amount of energy required to melt 15 kg of ice at 0 °C.

Specific latent heat of fusion of ice = 3.4×10^5 J/kg.

....

....

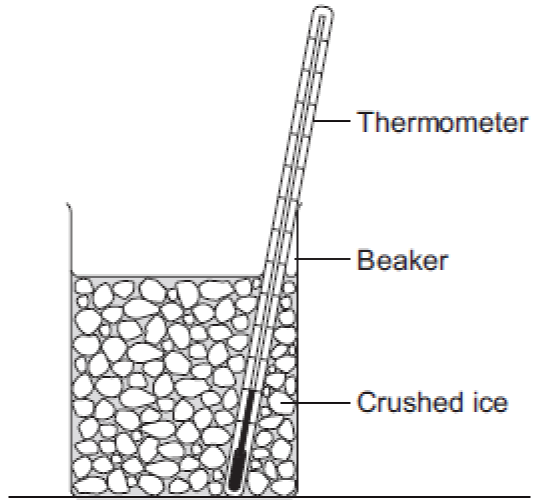
Energy = ... J

(2)

(c) Another way to keep roads clear of ice is to spread salt on them.
When salt is added to ice, the melting point of the ice changes.

A student investigated how the melting point of ice varies with the mass of salt added.

The figure below shows the equipment that she used.



The student added salt to crushed ice and measured the temperature at which the ice melted.

(i) State **one** variable that the student should have controlled.

....

....

(1)

(ii) During the investigation the student stirred the crushed ice.

Suggest **two** reasons why.

Tick (✓) **two** boxes.

	Tick (✓)
To raise the melting point of the ice	
To lower the melting point of the ice	
To distribute the salt throughout the ice	
To keep all the ice at the same temperature	
To reduce energy transfer from the surroundings to the ice	

(2)

(iii) The table below shows the data that the student obtained.

Mass of salt added in grams	0	10	20
Melting point of ice in °C	0	-6	-16

Describe the pattern shown in the table.

....

....

(1)

(d) Undersoil electrical heating systems are used in greenhouses. This system could also be used under a road.

A cable just below the ground carries an electric current. One greenhouse system has a power output of 0.50 kW.

Calculate the energy transferred in 2 minutes.

....

....

....

Energy transferred = ... J

(3)

(e) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

A local council wants to keep a particular section of a road clear of ice in the winter.

Describe the advantages and disadvantages of keeping the road clear of ice using:

- energy storage
- salt
- undersoil electrical heating.

....

....

....

....

....

....

....

....

....

....

....

....

Extra space ....

....

....

....

....

....

....

(6)
(Total 18 marks)

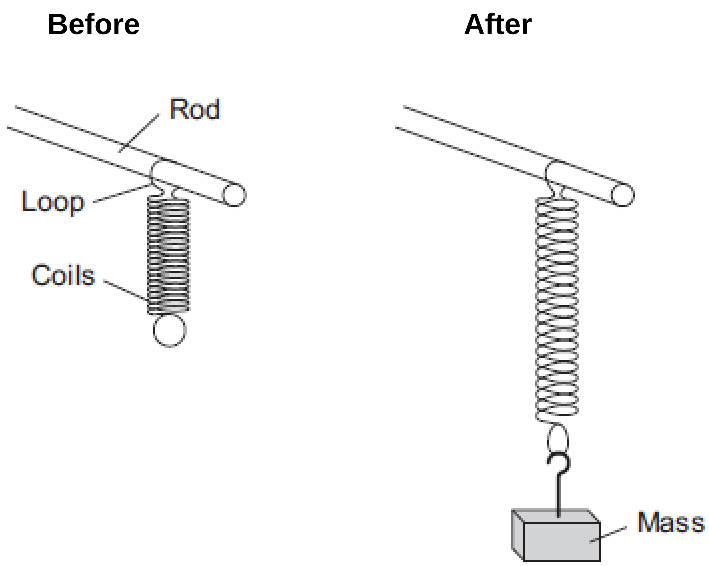
20 A student investigated the behaviour of springs. She had a box of identical springs.

(a) When a force acts on a spring, the shape of the spring changes.

The student suspended a spring from a rod by one of its loops. A force was applied to the spring by suspending a mass from it.

Figure 1 shows a spring before and after a mass had been suspended from it.

Figure 1



(i) State **two** ways in which the shape of the spring has changed.

1 ....

2 ....

(2)

(ii) No other masses were provided.

Explain how the student could test if the spring was behaving elastically.

....

....

....

....

(2)

(b) In a second investigation, a student took a set of measurements of force and extension.

Her results are shown in **Table 1** .

Table 1

Force in newtons	0.0	1.0	2.0	3.0	4.0	5.0	6.0
Extension in cm	0.0	4.0		12.0	16.0	22.0	31.0

(i) Add the missing value to **Table 1**.

Explain why you chose this value.

....

....

....

....

(3)

(ii) During this investigation the spring exceeded its limit of proportionality.

Suggest a value of force at which this happened.

Give a reason for your answer.

Force = ... N

Reason ....

....

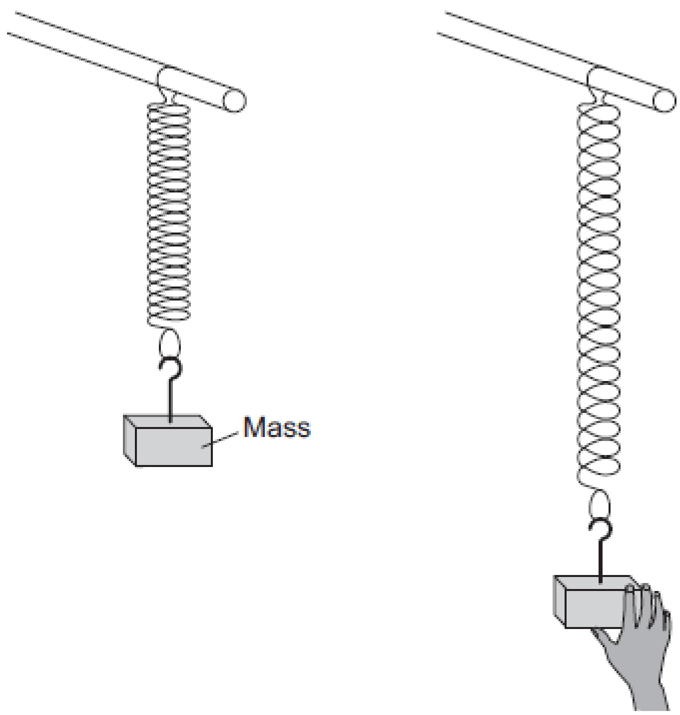
....

(2)

(c) In a third investigation the student:

- suspended a 100 g mass from a spring
- pulled the mass down as shown in **Figure 2**
- released the mass so that it oscillated up and down
- measured the time for 10 complete oscillations of the mass
- repeated for masses of 200 g, 300 g and 400 g.

Figure 2



Her results are shown in **Table 2**.

Table 2

	Time for 10 complete oscillations in seconds			
Mass in g	**Test 1**	**Test 2**	**Test 3**	**Mean**
100	4.34	5.20	4.32	4.6
200	5.93	5.99	5.86	5.9
300	7.01	7.12	7.08	7.1
400	8.23	8.22	8.25	8.2

(i) Before the mass is released, the spring stores energy.

What type of energy does the spring store?

Tick (✓) **one** box.

	Tick (✓)
Elastic potential energy	
Gravitational potential energy	
Kinetic energy	

(1)

(ii) The value of time for the 100 g mass in **Test 2** is anomalous.

Suggest **two** likely causes of this anomalous result.

Tick (✓) **two** boxes.

	Tick (✓)
Misread stopwatch	
Pulled the mass down too far	
Timed half oscillations, not complete oscillations	
Timed too few complete oscillations	
Timed too many complete oscillations	

(2)

(iii) Calculate the correct mean value of time for the 100 g mass in **Table 2**.

....

....

Mean value = ... s

(1)

(iv) Although the raw data in **Table 2** is given to 3 significant figures, the mean values are correctly given to 2 significant figures.

Suggest why.

....

....

....

....

(2)

(v) The student wanted to plot her results on a graph. She thought that four sets of results were not enough.

What extra equipment would she need to get more results?

....

....

....

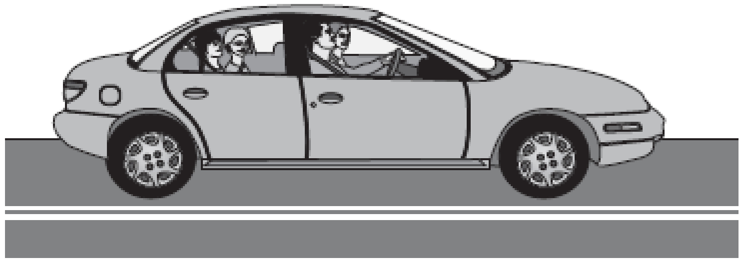
....

(2)

(Total 17 marks)

21 The figure below shows a car with an electric motor.

The car is moving along a flat road.



(a) (i) Use the correct answers from the box to complete each sentence.

light	**electrical**	**kinetic**	**potential**	**sound**

The car's motor transfers .... energy

into useful .... energy as the car moves.

Some energy is wasted as .... energy.

(3)

(ii) What happens to the wasted energy?

....

....

(1)

(b) The electric motor has an input energy of 50 000 joules each second.

The motor transfers 35 000 joules of useful energy each second.

Calculate the efficiency of the electric motor.

....

....

....

Efficiency = ...

(2)
(Total 6 marks)

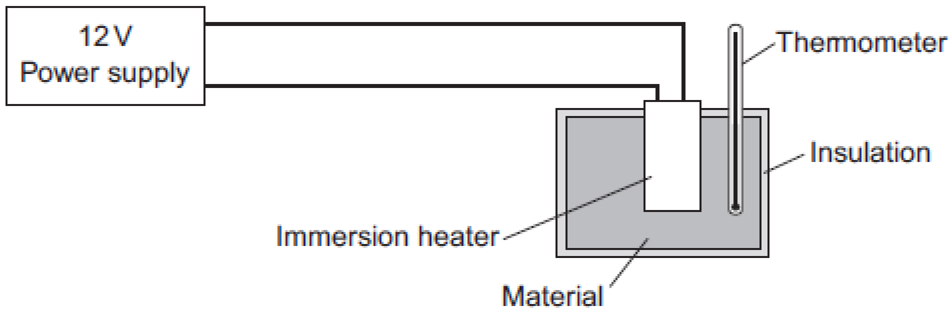
22 A student used the apparatus in **Figure 1** to compare the energy needed to heat blocks of different materials.

Each block had the same mass.

Each block had holes for the thermometer and the immersion heater.

Each block had a starting temperature of 20 °C.

Figure 1



The student measured the time taken to increase the temperature of each material by 5 °C.

(a) (i) State **two** variables the student controlled.

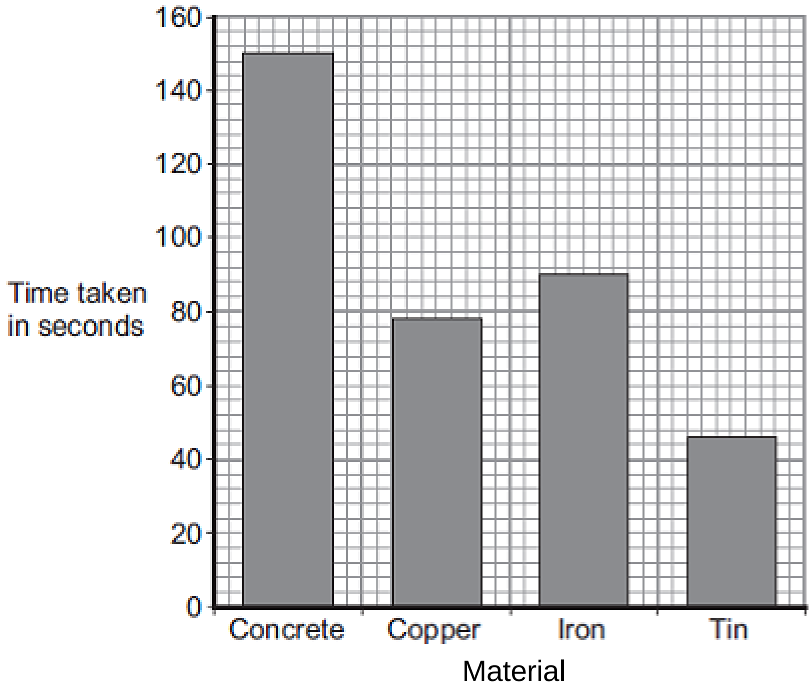
1 ....

2 ....

(2)

Figure 2 shows the student's results.

Figure 2



(ii) Why was a bar chart drawn rather than a line graph?

....

....

(1)

(iii) Which material was supplied with the most energy?

....

Give the reason for your answer.

....

....

(2)

(iv) The iron block had a mass of 2 kg.

Calculate the energy transferred by the heater to increase the temperature of the iron block by 5 °C.

The specific heat capacity of iron is 450 J / kg °C.

....

....

....

Energy transferred = ... J

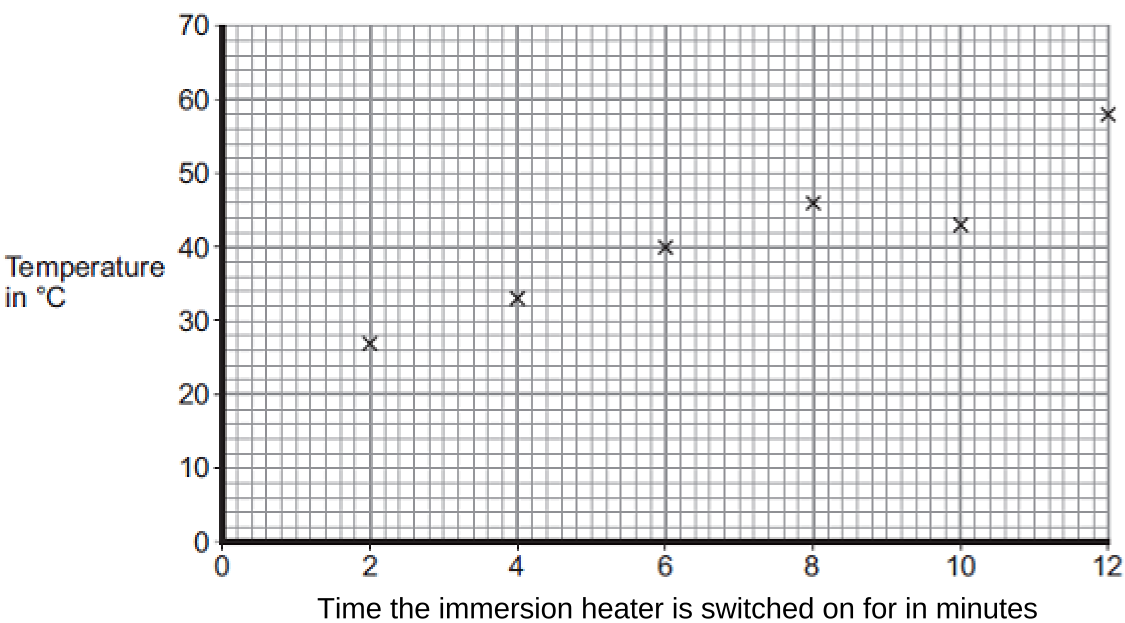
(2)

(b) The student used the same apparatus to heat a 1 kg block of aluminium.

He recorded the temperature of the block as it was heated from room temperature.

The results are shown in **Figure 3**.

Figure 3



(i) One of the student's results is anomalous.

Draw a ring around the anomalous result.

(1)

(ii) Draw the line of best fit for the points plotted in **Figure 3**.

(1)

(iii) What was the temperature of the room?

Temperature = ... °C

(1)

(iv) What was the interval of the time values used by the student?

Interval = ... minutes

(1)
(Total 11 marks)

23 Electricity can be generated using various energy sources.

(a) Give **one** advantage and **one** disadvantage of using nuclear power stations rather than gas-fired power stations to generate electricity.

Advantage ....

....

Disadvantage ....

....

(2)

(b) (i) A single wind turbine has a maximum power output of 2 000 000 W.

The wind turbine operated continuously at maximum power for 6 hours.

Calculate the energy output in kilowatt-hours of the wind turbine.

....

....

....

Energy output = ... kWh

(2)

(ii) Why, on average, do wind turbines operate at maximum power output for only 30% of the time?

....

....

(1)

(c) An on-shore wind farm is made up of many individual wind turbines.

They are connected to the National Grid using underground power cables.

Give **one** advantage of using underground power cables rather than overhead power cables.

....

....

(1)
(Total 6 marks)

24 A note was played on an electric keyboard.

The frequency of the note was 440 Hz.

(a) (i) What does a frequency of 440 Hz mean?

....

....

(1)

(ii) The sound waves produced by the keyboard travel at a speed of 340 m / s.

Calculate the wavelength of the note.

Give your answer to **three** significant figures.

....

....

....

Wavelength = ... metres

(3)

(b) **Figure 1** shows a microphone connected to a cathode ray oscilloscope (CRO) being used to detect the note produced by the keyboard.

Figure 1

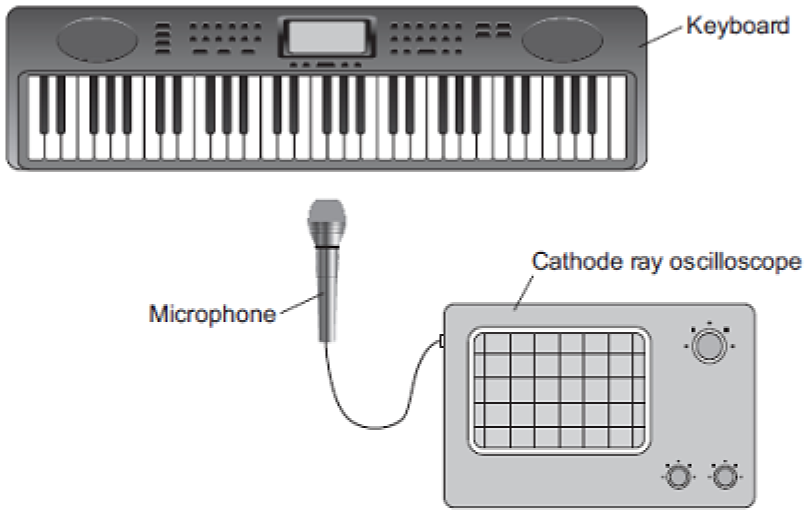
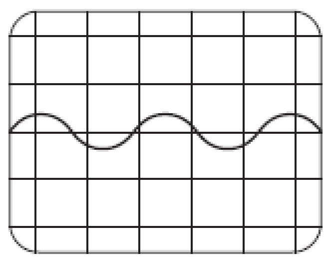


Figure 2 shows the trace produced by the sound wave on the CRO.

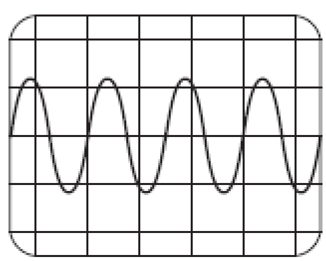
Figure 2



A second note, of different wavelength, was played on the keyboard.

Figure 3 shows the trace produced by the sound wave of the second note on the CRO.

Figure 3



The settings on the CRO were unchanged.

What **two** conclusions should be made about the **second** sound wave produced by the keyboard compared with the **first** sound wave?

Give a reason for each conclusion.

Conclusion 1 ....

....

Reason ....

....

Conclusion 2 ....

....

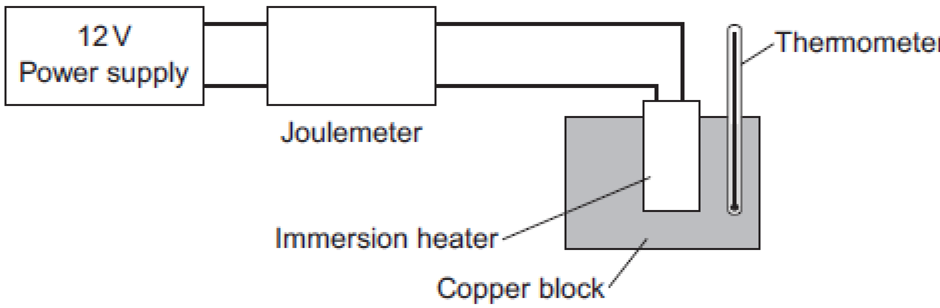
Reason ....

....

(4)
(Total 8 marks)

25 A student used the apparatus in **Figure 1** to obtain the data needed to calculate the specific heat capacity of copper.

Figure 1



The initial temperature of the copper block was measured.

The power supply was switched on.

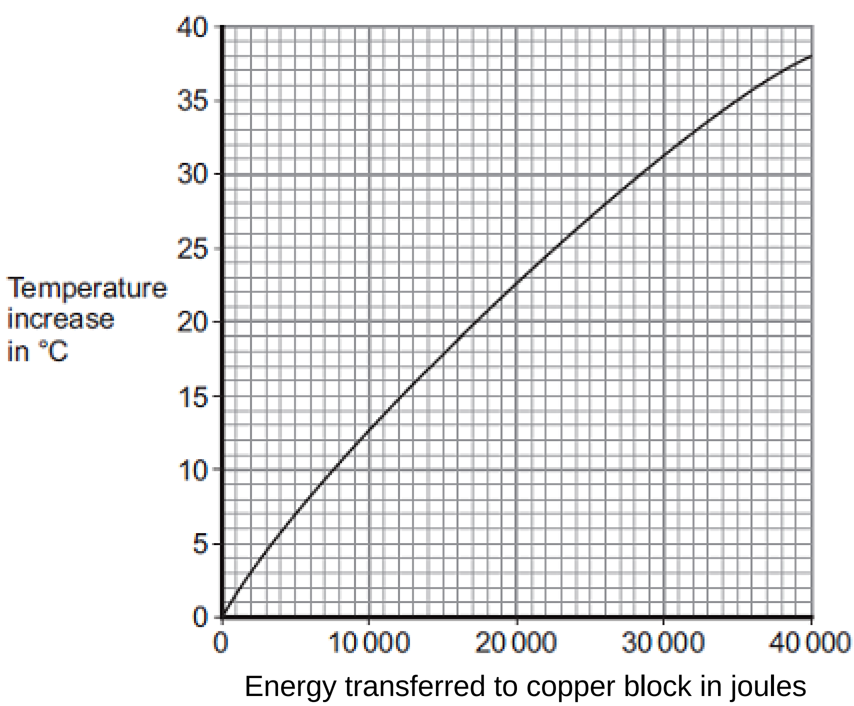
The energy transferred by the heater to the block was measured using the joulemeter.

The temperature of the block was recorded every minute.

The temperature increase was calculated.

Figure 2 shows the student's results.

Figure 2



(a) Energy is transferred through the copper block.

What is the name of the process by which the energy is transferred?

Tick (✓) **one** box.

Conduction ☐

Convection ☐

Radiation ☐

(1)

(b) Use **Figure 2** to determine how much energy was needed to increase the temperature of the copper block by 35 °C.

.... joules

(1)

(c) The copper block has a mass of 2 kg.

Use your answer to part (b) to calculate the value given by this experiment for the specific heat capacity of copper. Give the unit.

....

....

....

....

Specific heat capacity = ...

(3)

(d) This experiment does **not** give the correct value for the specific heat of copper.

Suggest **one** reason why.

....

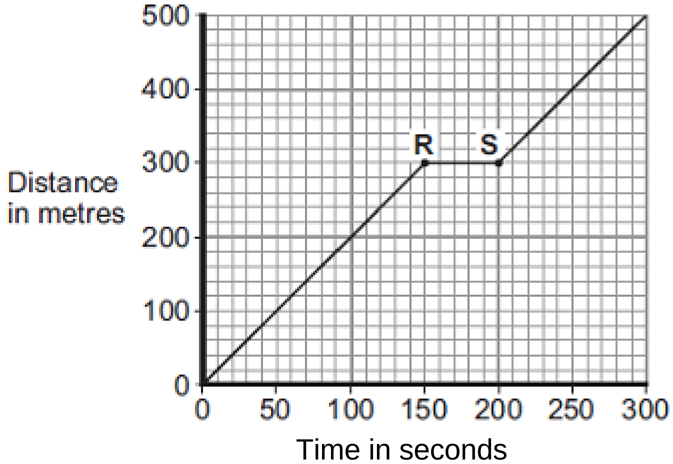
....

(1)

(Total 6 marks)

26 (a) **Figure 1** shows the distance–time graph for a person walking to a bus stop.

Figure 1



(i) Which **one** of the following statements describes the motion of the person between points **R** and **S** on the graph?

Tick (✓) **one** box.

Not moving ☐

Moving at constant speed ☐

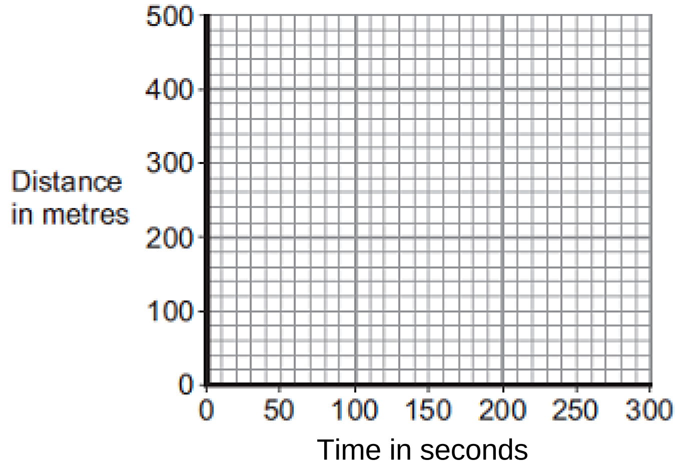
Moving with increasing speed ☐

(1)

(ii) Another person, walking at constant speed, travels the same distance to the bus stop in 200 seconds.

Complete **Figure 2** to show a distance–time graph for this person.

Figure 2



(1)

(b) A bus accelerates away from the bus stop at 2.5 m/s^2.

The total mass of the bus and passengers is 14 000 kg.

Calculate the resultant force needed to accelerate the bus and passengers.

....

....

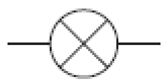
....

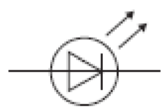
Resultant force = ... N

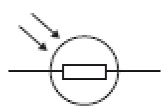
(2)
(Total 4 marks)

27 (a) Draw **one** line from each circuit symbol to its correct name.

Circuit symbol







Name

Diode

Light-dependent resistor (LDR)

Lamp

Light-emitting diode (LED)

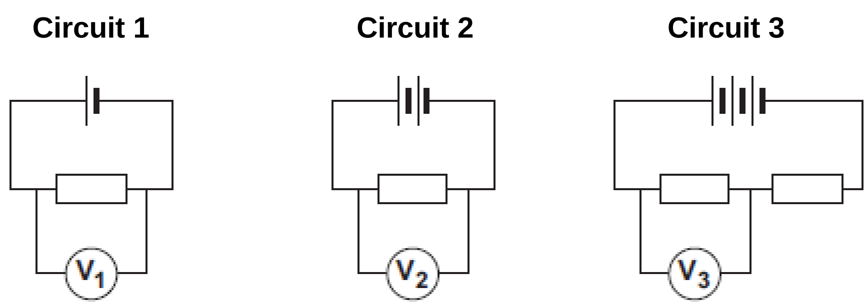
(3)

(b) **Figure 1** shows three circuits.

The resistors in the circuits are identical.

Each of the cells has a potential difference of 1.5 volts.

Figure 1



(i) Use the correct answer from the box to complete the sentence.

half	**twice**	**the same as**

The resistance of **circuit 1** is .... the resistance of **circuit 3**.

(1)

(ii) Calculate the reading on voltmeter $\mathbf{V_2}$.

....

Voltmeter reading $\mathbf{V_2}$ = ... V

(1)

(iii) Which voltmeter, $\mathbf{V_1}$, $\mathbf{V_2}$ or $\mathbf{V_3}$, will give the lowest reading?

Draw a ring around the correct answer.

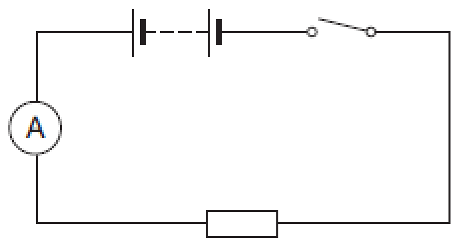
$\mathbf{V_1}$ $\mathbf{V_2}$ $\mathbf{V_3}$

(1)

(c) A student wanted to find out how the number of resistors affects the current in a series circuit.

Figure 2 shows the circuit used by the student.

Figure 2



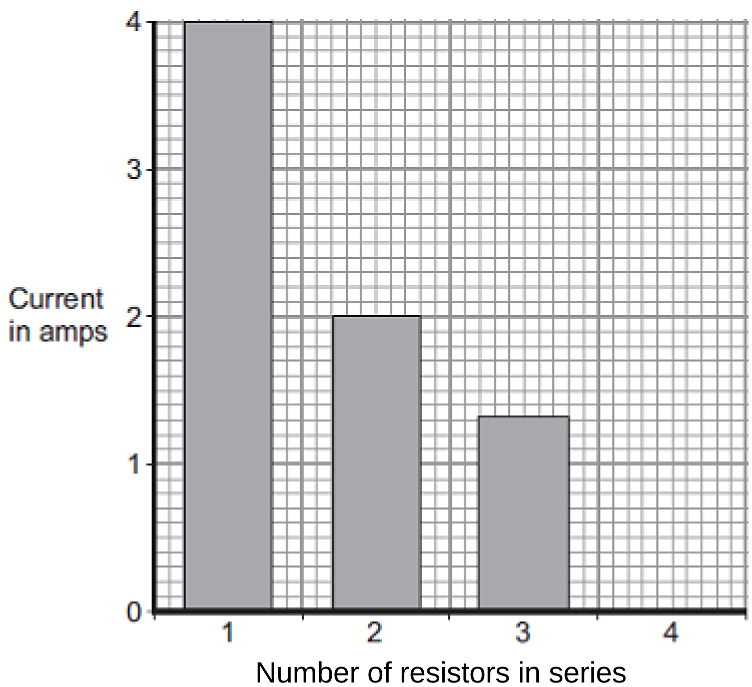
The student started with one resistor and then added more identical resistors to the circuit.

Each time a resistor was added, the student closed the switch and took the ammeter reading.

The student used a total of 4 resistors.

Figure 3 shows three of the results obtained by the student.

Figure 3



(i) To get valid results, the student kept one variable the same throughout the experiment.

Which variable did the student keep the same?

....

(1)

(ii) The bar chart in **Figure 3** is not complete. The result using 4 resistors is not shown.

Complete the bar chart to show the current in the circuit when 4 resistors were used.

(2)

(iii) What conclusion should the student make from the bar chart?

....

....

(1)
(Total 10 marks)

28 A paintball gun is used to fire a small ball of paint, called a paintball, at a target.

The figure below shows someone just about to fire a paintball gun.

The paintball is inside the gun.

(a) What is the momentum of the paintball before the gun is fired?

....

Give a reason for your answer.

....

....

(2)

(b) The gun fires the paintball forwards at a velocity of 90 m / s.

The paintball has a mass of 0.0030 kg.

Calculate the momentum of the paintball just after the gun is fired.

....

....

....

Momentum = ... kg m / s

(2)

(c) The momentum of the gun and paintball is conserved.

Use the correct answer from the box to complete the sentence.

equal to	**greater than**	**less than**

The total momentum of the gun and paintball just after the gun is fired

will be .... the total momentum of the gun and paintball

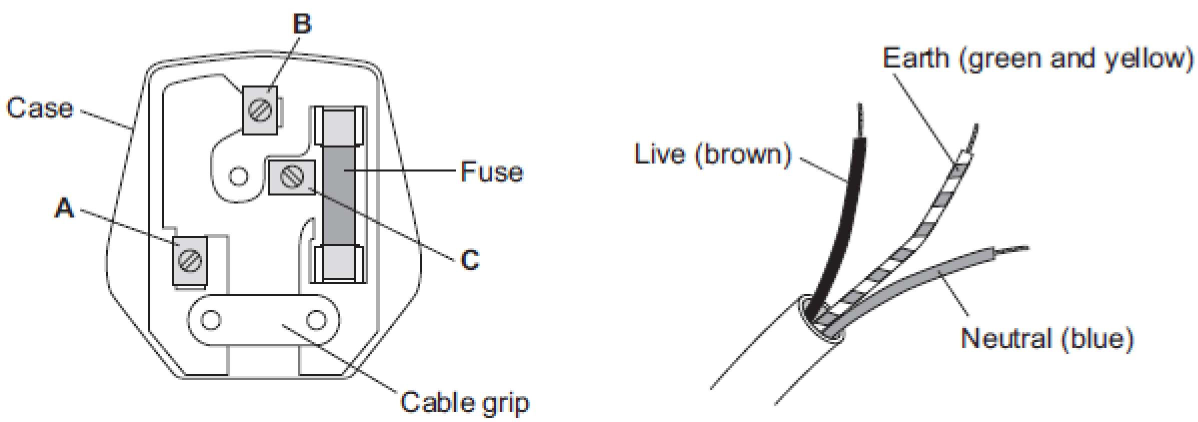
before the gun is fired.

(1)
(Total 5 marks)

29 (a) **Figure 1** shows the inside of a three-pin plug and a length of three-core cable.

The cable is to be connected to the plug.

Figure 1



(i) Complete **Table 1** to show which plug terminal, **A**, **B** or **C**, connects to each of the wires inside the cable.

Table 1

Wire	Plug terminal
Live	
Neutral	
Earth	

(2)

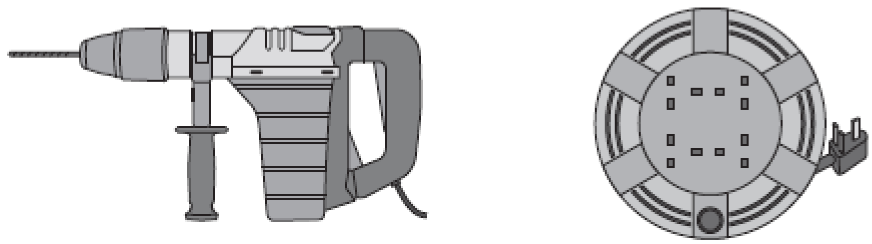
(ii) Name a material that could be used to make the case of the plug.

....

(1)

(b) **Figure 2** shows an electric drill and an extension lead. The drill is used with the extension lead.

Figure 2



Electric drill　　　　Extension lead

(i) The drill is used for 50 seconds.

In this time, 30 000 joules of energy are transferred from the mains electricity supply to the drill.

Calculate the power of the drill.

....

....

....

Power = ... W

(2)

(ii) A second drill is used with the extension lead. The power of this drill is 1200 W.

The instructions for using the extension lead include the following information.

> **When in use the lead may get hot:**
>
> **DO NOT go over the maximum power**
> - lead wound inside the case: 820 watts
> - lead fully unwound outside the case: 3100 watts

It would **not** be safe to use this drill with the extension lead if the lead was left wound inside the plastic case.

Explain why.

....

....

....

....

....

....

(3)

(c) **Table 2** gives information about three different electric drills.

Table 2

Drill	**Power input in watts**	**Power output in watts**
X	640	500
Y	710	500
Z	800	500

A person is going to buy **one** of the drills, **X**, **Y** or **Z**. The drills cost the same to buy.

Use only the information in the table to decide which **one** of the drills, **X**, **Y** or **Z**, the person should buy.

Write your answer in the box. ☐

Give a reason for your answer.

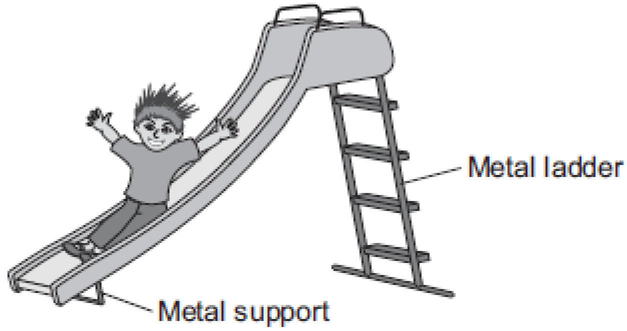
....

....

....

(1)
(Total 9 marks)

30 The figure below shows a slide in a children's playground.



(a) A child of mass 18 kilograms goes down the slide.

The vertical distance from the top to the bottom of the slide is 2.5 metres.

Calculate the decrease in gravitational potential energy of the child sliding from the top to the bottom of the slide.

Gravitational field strength = 10 N / kg

....

....

....

Decrease in gravitational potential energy = ... J

(2)

(b) The slide is made of plastic.

(i) The child becomes electrically charged when he goes down the slide.

Explain why.

....

....

....

....

(2)

(ii) Going down the slide causes the child's hair to stand on end.

What conclusion about the electrical charge on the child's hair can be made from this observation?

....

....

Give a reason for your answer.

....

....

(2)

(iii) Why would the child **not** become electrically charged if the slide was made from metal?

....

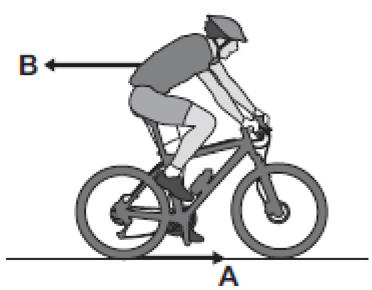
....

(1)

(Total 7 marks)

31 (a) **Figure 1** shows the horizontal forces acting on a moving bicycle and cyclist.

Figure 1



(i) What causes force **A**?

Draw a ring around the correct answer.

friction **gravity** **weight**

(1)

(ii) What causes force **B**?

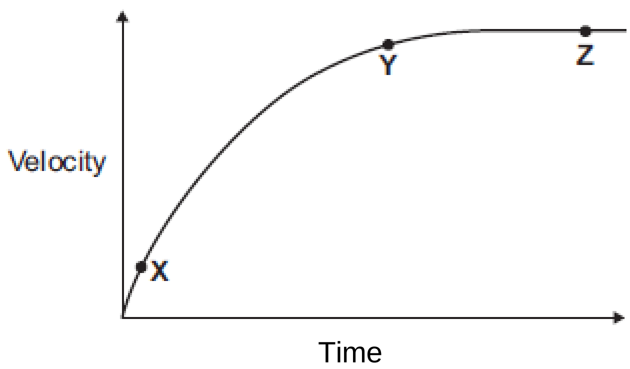
....

(1)

(iii) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Figure 2 shows how the velocity of the cyclist changes during the first part of a journey along a straight and level road. During this part of the journey the force applied by the cyclist to the bicycle pedals is constant.

Figure 2



Describe how **and** explain, in terms of the forces **A** and **B**, why the velocity of the cyclist changes:

- between the points **X** and **Y**
- and between the points **Y** and **Z**, marked on the graph in **Figure 2**.

....

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....

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....

Extra space ....

....

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....

....

....

....

(6)

(b) (i) The cyclist used the brakes to slow down and stop the bicycle.

A constant braking force of 140 N stopped the bicycle in a distance of 24 m.

Calculate the work done by the braking force to stop the bicycle. Give the unit.

....

....

....

Work done = ...

(3)

(ii) Complete the following sentences.

When the brakes are used, the bicycle slows down. The kinetic energy of the

bicycle ....

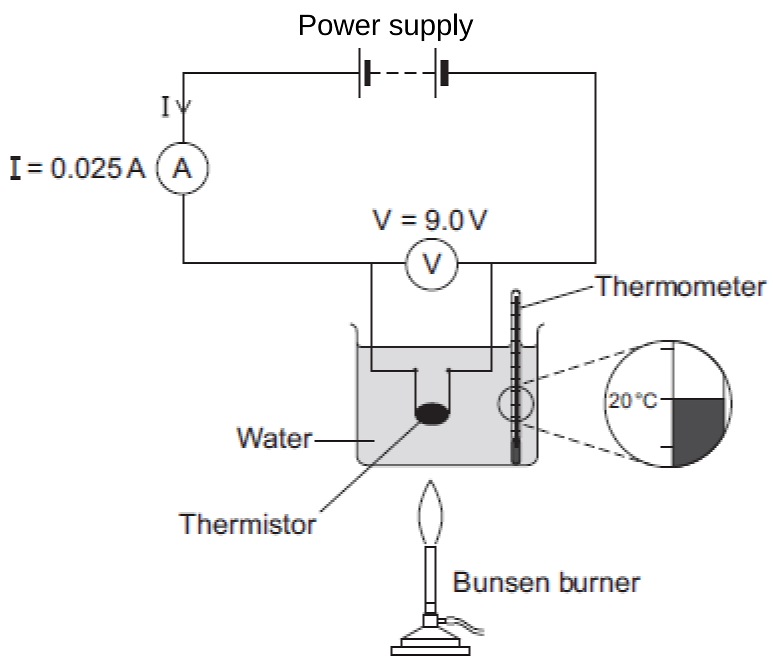
At the same time, the .... of the brakes increases.

(2)

(Total 13 marks)

32 (a) **Figure 1** shows the apparatus used to obtain the data needed to calculate the resistance of a thermistor at different temperatures.

Figure 1



(i) In the box below, draw the circuit symbol for a thermistor.

(1)

(ii) Use the data given in **Figure 1** to calculate the resistance of the thermistor at 20 °C.

....

....

....

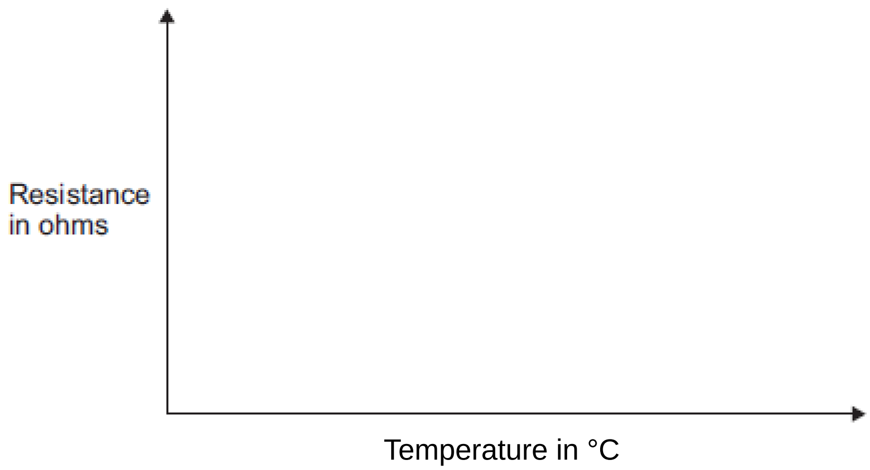
Resistance = ... ohms

(2)

(iii) **Figure 2** shows the axes for a sketch graph.

Complete **Figure 2** to show how the resistance of the thermistor will change as the temperature of the thermistor increases from 20 °C to 100 °C.

Figure 2



(1)

(iv) Which **one** of the following is most likely to include a thermistor?

Tick (✓) **one** box.

An automatic circuit to switch a plant watering system on and off. ☐

An automatic circuit to switch an outside light on when it gets dark. ☐

An automatic circuit to switch a heating system on and off. ☐

(1)

(b) The ammeter used in the circuit has a very low resistance.

Why is it important that ammeters have a very low resistance?

....

....

(1)

(c) The table below gives the temperature of boiling water using three different temperature scales.

Temperature	**Scale**
100	Celsius (°C)
212	Fahrenheit (°F)
80	Réaumur (°Re)

Scientists in different countries use the same temperature scale to measure temperature.

Suggest **one** advantage of doing this.

....

....

....

(1)

(d) A student plans to investigate how the resistance of a light-dependent resistor (LDR) changes with light intensity.

The student starts with the apparatus shown in **Figure 2** but makes three changes to the apparatus.

One of the changes the student makes is to replace the thermistor with an LDR.

Describe what other changes the student should make to the apparatus.

....

....

....

....

(2)
(Total 9 marks)

33 The figure below shows a skateboarder jumping forwards off his skateboard.

The skateboard is stationary at the moment the skateboarder jumps.

(a) The skateboard moves backwards as the skateboarder jumps forwards.

Explain, using the idea of momentum, why the skateboard moves backwards.

....

....

....

....

....

....

....

....

(3)

(b) The mass of the skateboard is 1.8 kg and the mass of the skateboarder is 42 kg.

Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m / s.

....

....

....

....

....

....

Velocity of skateboard = ... m / s

(3)

(Total 6 marks)

34 (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

....

(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

....

....

(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

....

(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \longrightarrow {}^{99}_{43}\text{Tc} + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

....

Give a reason for your answer.

....

....

(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term 'half-life'?

....

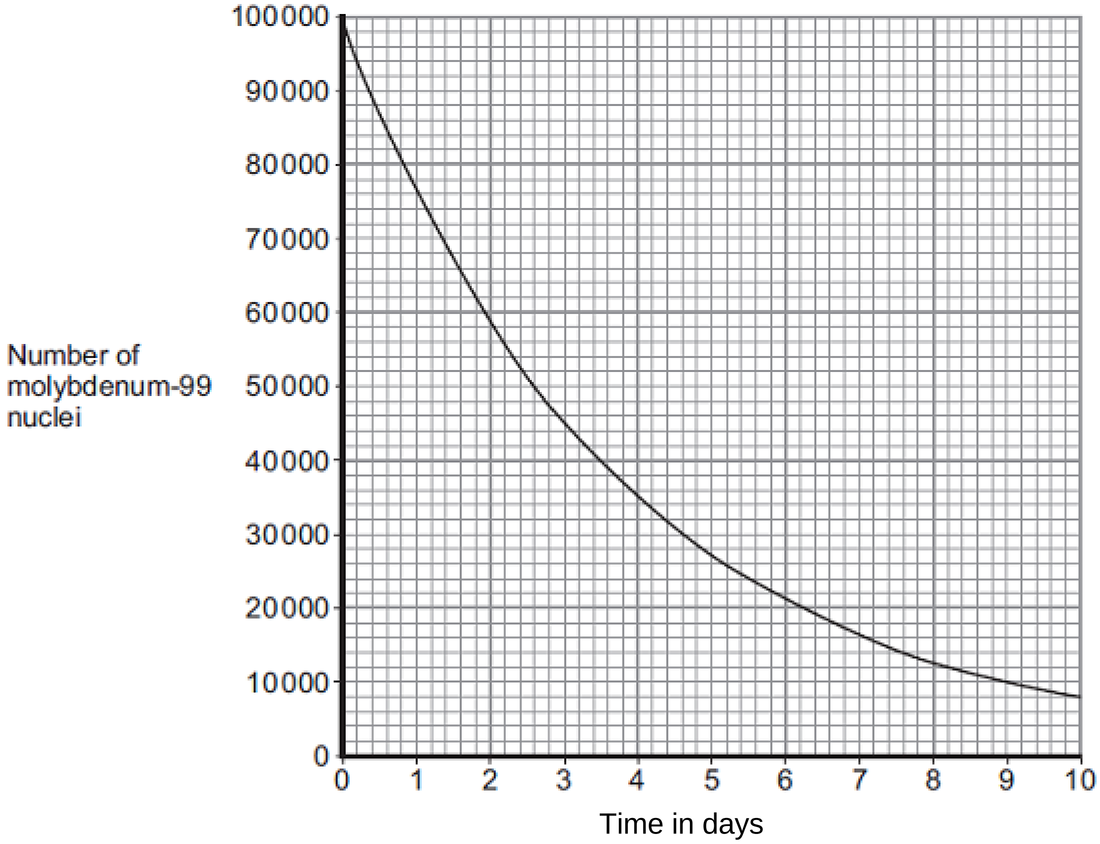
....

....

(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

....

....

....

Number of days = ...

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

....

....

....

....

(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

....

....

(1)
(Total 11 marks)

35 The figure below shows an X-ray image of a human skull.

Stockdevil/iStock/Thinkstock

(a) Use the correct answers from the box to complete the sentence.

absorbs	**ionises**	**reflects**	**transmits**

When X-rays enter the human body, soft tissue .... X-rays

and bone .... X-rays.

(2)

(b) Complete the following sentence.

The X-rays affect photographic film in the same way that .... does.

(1)

(c) The table below shows the total dose of X-rays received by the human body when different parts are X-rayed.

Part of body X-rayed	**Dose of X-rays received by human body in arbitrary units**
Head	3
Chest	4
Pelvis	60

Calculate the number of head X-rays that are equal in dose to one pelvis X-ray.

....

....

....

Number of head X-rays = ...

(2)

(d) Which **one** of the following is another use of X-rays?

Tick (✓) **one** box.

Cleaning stained teeth ☐

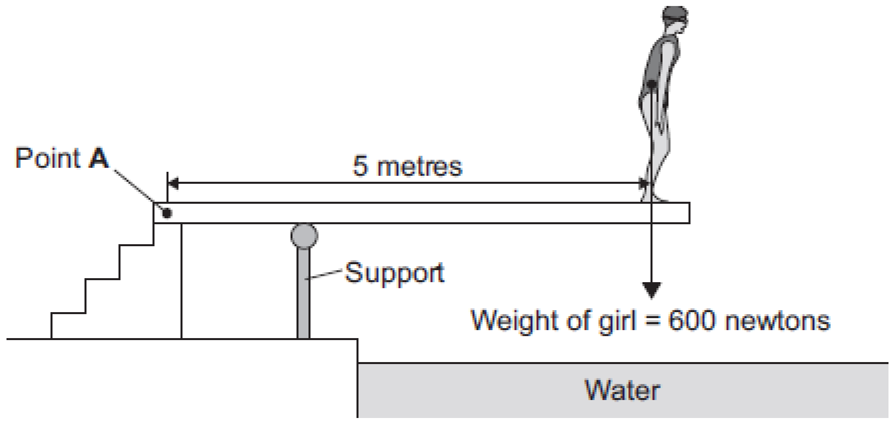
Killing cancer cells ☐

Scanning of unborn babies ☐

(1)
(Total 6 marks)

36 **Figure 1** shows a girl standing on a diving board.

Figure 1



(a) Calculate the moment of the girl's weight about Point **A**.

....

....

....

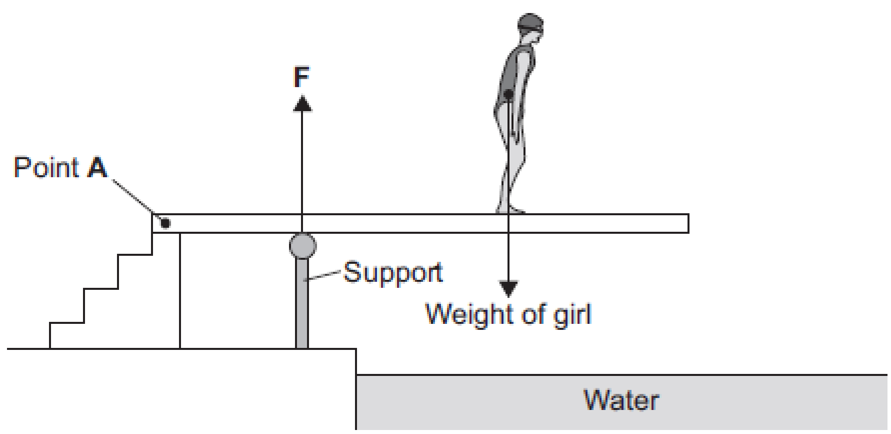
Moment = ... newton metres

(2)

(b) **Figure 2** shows the girl standing at a different place on the diving board.

The support provides an upward force **F** to keep the diving board balanced.

Figure 2



Complete the following sentence.

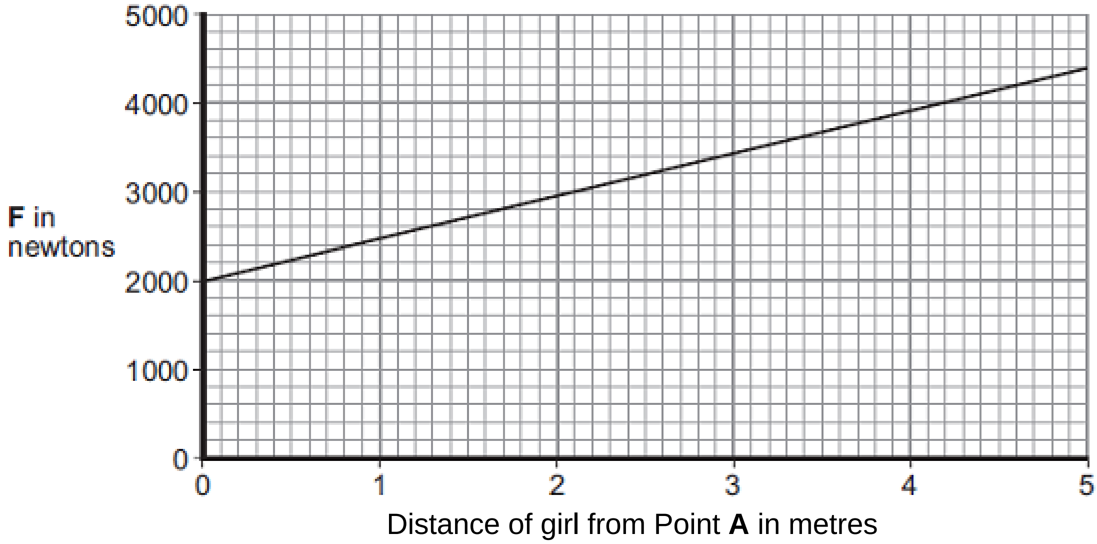
The diving board is not turning. The total clockwise moment is balanced

by the total ....

(1)

(c) **Figure 3** shows how the upward force **F** varies with the distance of the girl from Point **A**.

Figure 3



(i) Use **Figure 3** to determine the upward force **F** when the girl is standing at a distance of 3 metres from point **A**.

Upward force **F** = ... newtons

(1)

(ii) What conclusion should be made from **Figure 3**?

....

....

....

(1)
(Total 5 marks)

37 (a) Some humans are short-sighted.

Complete the following sentence.

Short sight can be caused by the eyeball being too ....

(1)

(b) Spectacles can be worn to correct short sight.

The table below gives information about three different lenses that can be used in spectacles.

	Lens feature		
	Material	**Mass in grams**	**Type**
Lens A	Plastic	5.0	Concave (diverging)
Lens B	Glass	6.0	Convex (converging)
Lens C	Glass	5.5	Convex (converging)

Which lens from **Table 2** would be used to correct short sight?

Draw a ring around the correct answer.

Lens A **Lens B** **Lens C**

Give the reason for your answer.

....

....

(2)

(c) Every lens has a focal length.

Which factor affects the focal length of a lens?

Tick (✓) **one** box.

The colour of the lens ☐

The refractive index of the lens material ☐

The size of the object being viewed ☐

(1)

(d) A lens has a focal length of 0.25 metres.

Calculate the power of the lens.

....

....

....

Power of lens = ... dioptres

(2)

(e) Laser eye surgery can correct some types of eye defect.

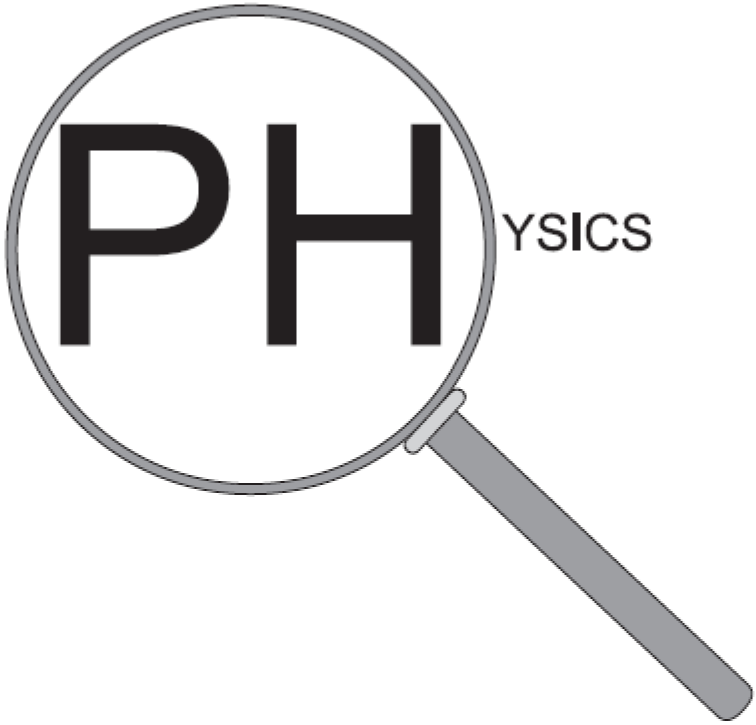
Which of the following is another medical use for a laser?

Tick (✓) **one** box.

Cauterising open blood vessels	☐
Detecting broken bones	☐
Imaging the lungs	☐

(1)

(f) The figure shows a convex lens being used as a magnifying glass.



Not to scale

An object of height 14 mm is viewed through a magnifying glass.

The image height is 70 mm.

Calculate the magnification produced by the lens in the magnifying glass.

....

....

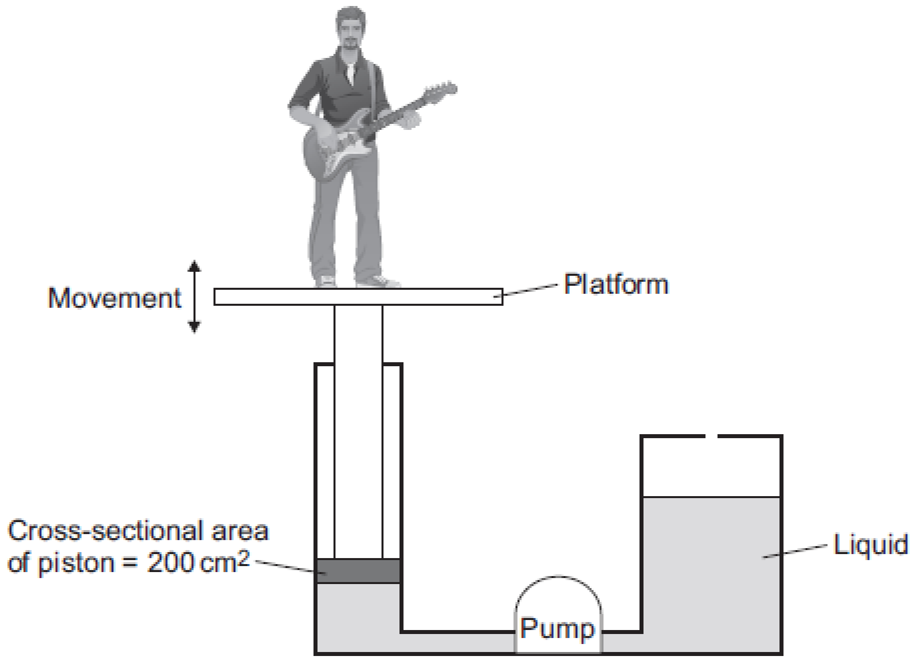
....

Magnification = ...

(2)
(Total 9 marks)

38 Musicians sometimes perform on a moving platform.

The figure below shows the parts of the lifting machine used to move the platform up and down.



(a) What name is given to a system that uses liquids to transmit forces?

Draw a ring around the correct answer.

electromagnetic **hydraulic** **ionising**

(1)

(b) To move the platform upwards, the liquid must cause a force of 1800 N to act on the piston.

The cross-sectional area of the piston is 200 cm^2.

Calculate the pressure in the liquid, in N / cm^2, when the platform moves.

....

....

....

Pressure = ... N / cm^2

(2)

(c) A new development is to use oil from plants as the liquid in the machine.

Growing plants and extracting the oil requires **less energy** than producing the liquid usually used in the machine.

Draw a ring around the correct answer to complete the sentence.

Using the oil from the plants gives	an environmental an ethical a social	advantage over the liquid

usually used.

(1)
(Total 4 marks)

39 (a) What is ultrasound?

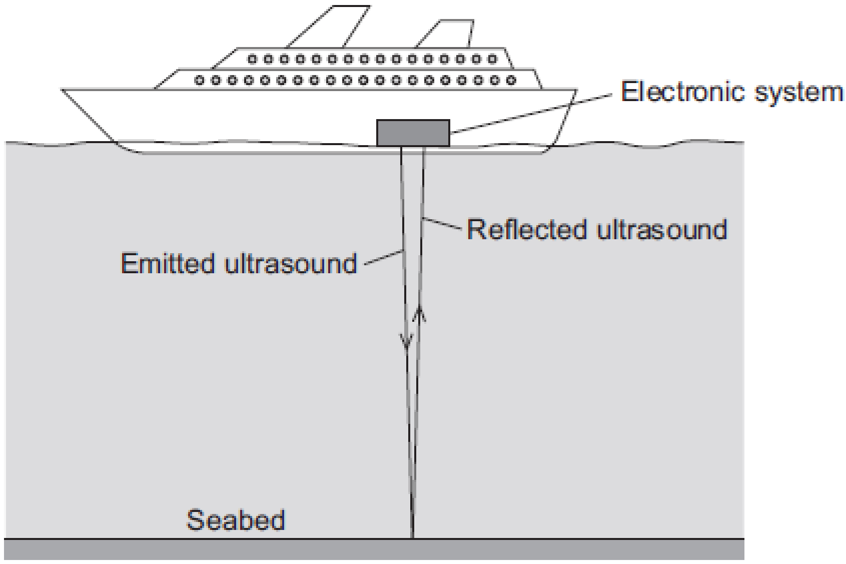
....

....

(1)

(b) **Figure 1** shows how ultrasound is used to measure the depth of water below a ship.

Figure 1



A pulse of ultrasound is sent out from an electronic system on-board the ship.

It takes 0.80 seconds for the emitted ultrasound to be received back at the ship.

Calculate the depth of the water.

Speed of ultrasound in water = 1600 m / s

....

....

....

....

Depth of water = ... metres

(3)

(c) Ultrasound can be used in medicine for scanning.

State **one** medical use of ultrasound scanning.

....

(1)

(d) Images of the inside of the human body can be made using a Computerised Tomography (CT) scanner. The CT scanner in **Figure 2** uses X-rays to produce these images.

Figure 2

monkeybusinessimages/iStock/Thinkstock

State **one** advantage and **one** disadvantage of using a CT scanner, compared with ultrasound scanning, for forming images of the inside of the human body.

Advantage of CT scanning ....

....

....

Disadvantage of CT scanning ....

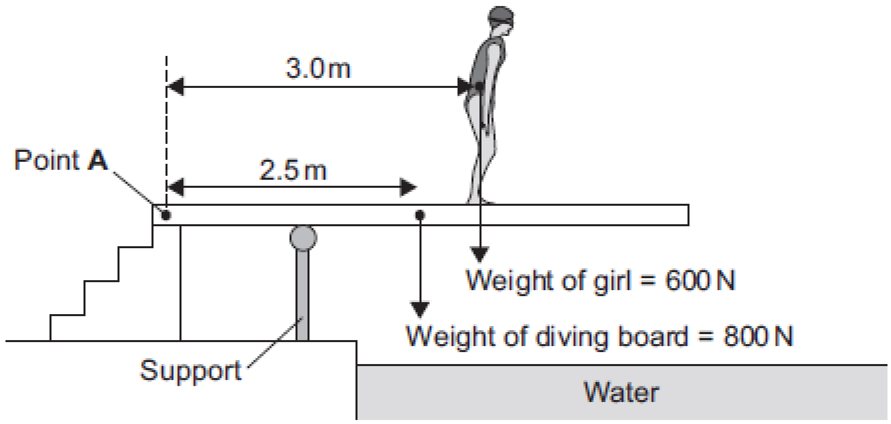
....

....

(2)
(Total 7 marks)

40 (a) **Figure 1** shows a girl standing on a diving board.

Figure 1



Calculate the total clockwise moment of the weight of the diving board and the weight of the girl about Point **A**. Give the unit.

....

....

....

....

....

....

....

Total clockwise moment about Point **A** = ...

(4)

(b) **Figure 2** shows the girl standing at a different place on the diving board.

The support provides an upward force **F** to keep the diving board balanced.

Figure 2

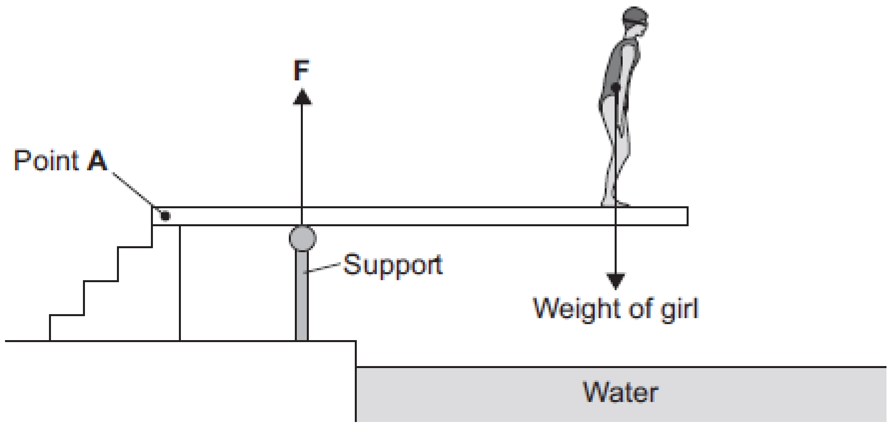
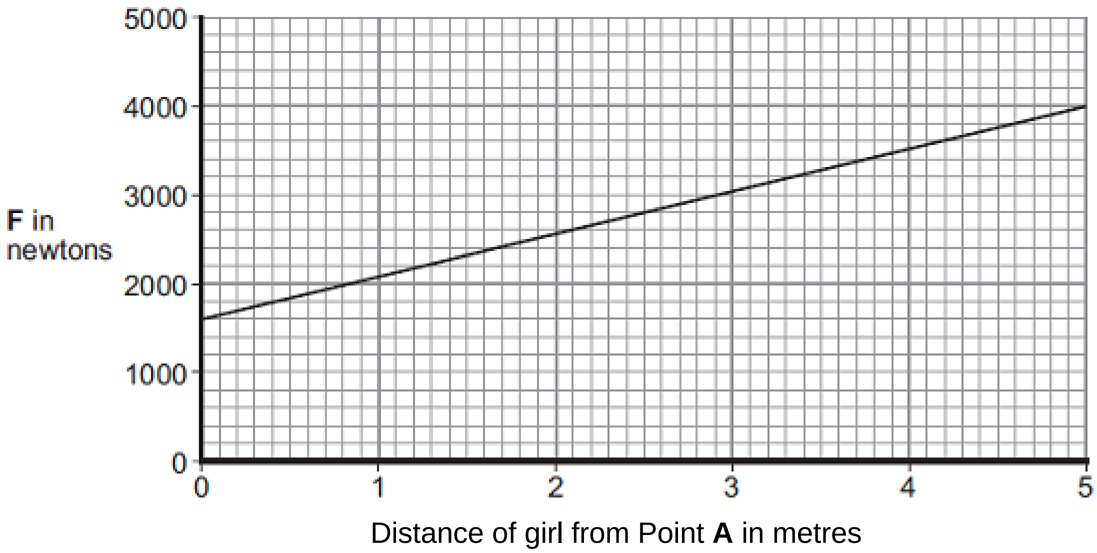


Figure 3 shows how the upward force **F** varies with the distance of the girl from Point **A**.

Figure 3



Explain, in terms of clockwise and anticlockwise moments, why the upward force **F** increases as shown in **Figure 3**.

....

....

....

....

....

....

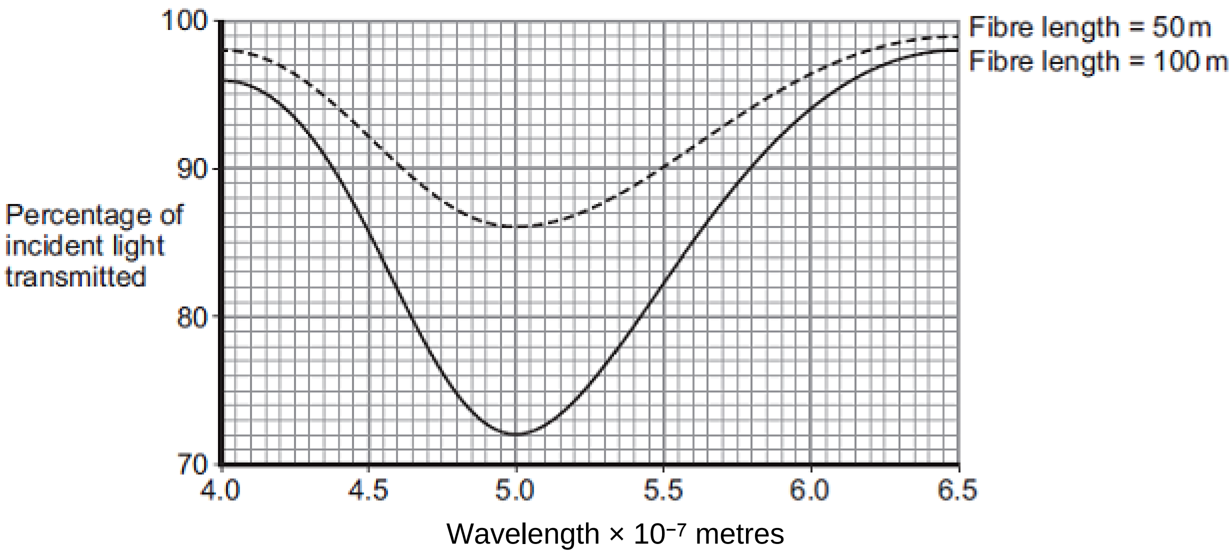
....

....

(3)
(Total 7 marks)

41 Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

....

....

....

....

....

....

....

....

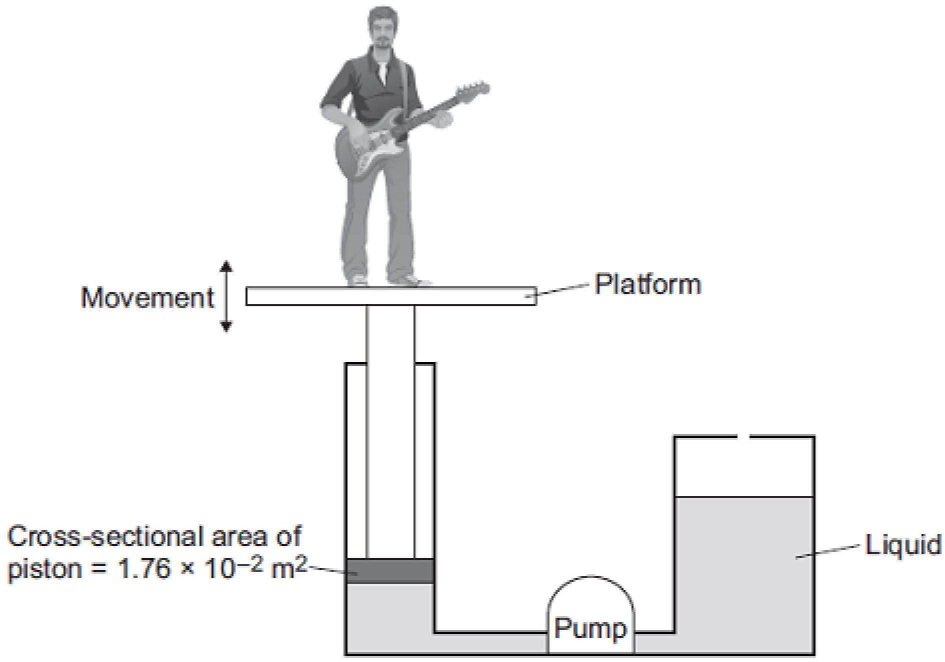
....

(Total 3 marks)

42 Musicians sometimes perform on a moving platform.

Figure 1 shows the parts of the lifting machine used to move the platform up and down.

Figure 1



(a) What type of system uses a liquid to transmit a force?

....

(1)

(b) The pump creates a pressure in the liquid of 8.75×10^4 Pa to move the platform upwards.

Calculate the force that the liquid applies to the piston.

....

....

....

Force = ... N

(2)

(c) The liquid usually used in the machine is made by processing oil from underground wells. A new development is to use plant oil as the liquid.

Extracting plant oil requires less energy than extracting oil from underground wells.

Suggest an environmental advantage of using plant oil.

....

....

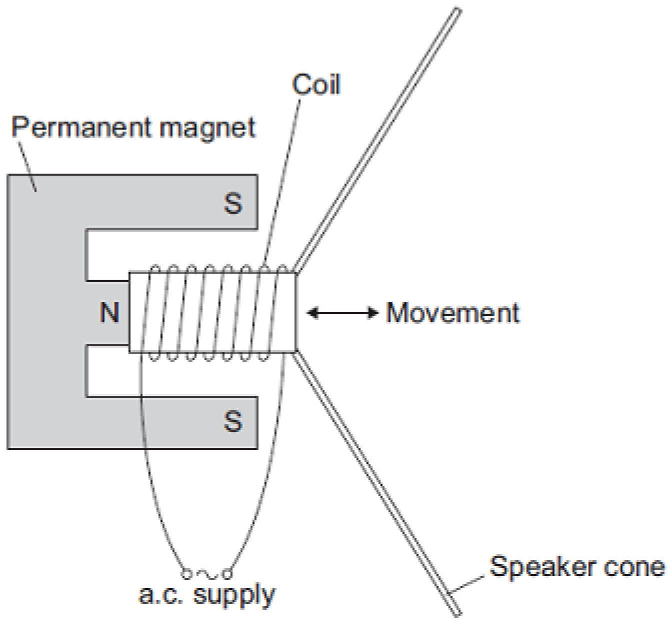
....

(1)

(d) Musicians often use loudspeakers.

Figure 2 shows how a loudspeaker is constructed.

Figure 2



The loudspeaker cone vibrates when an alternating current flows through the coil.

Explain why.

....

....

....

....

....

....

....

....

....

....

(4)
(Total 8 marks)

43 Some students fill an empty plastic bottle with water.
The weight of the water in the bottle is 24 N and the cross-sectional area of the bottom of the bottle is 0.008 m^2.

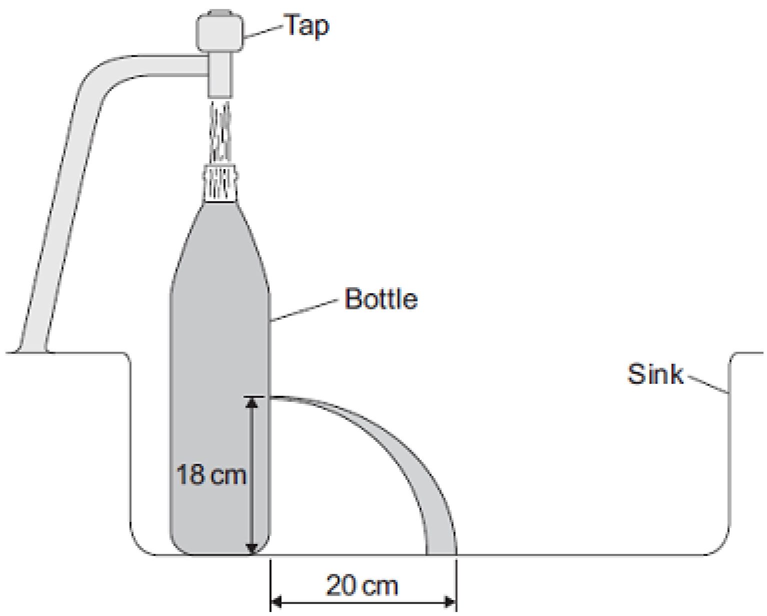
(a) Calculate the pressure of the water on the bottom of the bottle and give the unit.

....

....

Pressure = ...
(3)

(b) The students made four holes in the bottle along a vertical line.
They put the bottle in a sink. They used water from a tap to keep the bottle filled to the top.



The students measured and recorded the vertical heights of the holes above the sink.
They also measured the horizontal distances the water landed away from the bottle.
A pair of measurements for one of the holes is shown in the diagram.

The complete data from the experiment is shown in the table.

Hole	Vertical height in cm	Horizontal distance in cm
J	24	15
K	18	20
L	12	30
M	6	40

(i) Which hole is shown in the diagram?

Draw a ring around the correct answer.

J **K** **L**

(1)

(ii) On the diagram, draw the path of the water coming out of hole **M**.

Use the information in the table to help you.

(2)

(c) Suggest **one** problem that might arise from trying to collect data from a fifth hole with a vertical height of 1 cm above the sink.

....

....

(1)
(Total 7 marks)

44 Forces have different effects.

(a) (i) Use the correct answer from the box to complete the sentence.

slowing	**stretching**	**turning**

The moment of a force is the .... effect of the force.

(1)

(ii) What is meant by the centre of mass of an object?

....

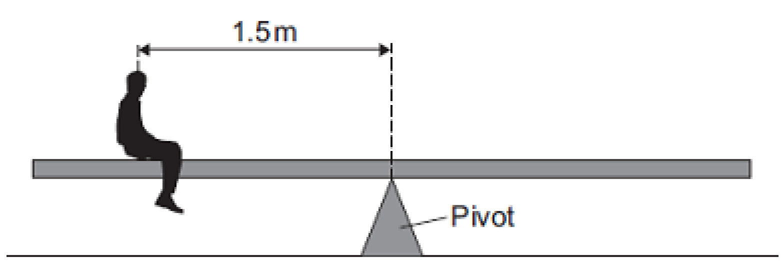
....

(1)

(b) Some children build a see-saw using a plank of wood and a pivot.
The centre of mass of the plank is above the pivot.

Figure 1 shows a boy sitting on the see-saw. His weight is 400 N.

Figure 1



Calculate the anticlockwise moment of the boy in Nm.

....

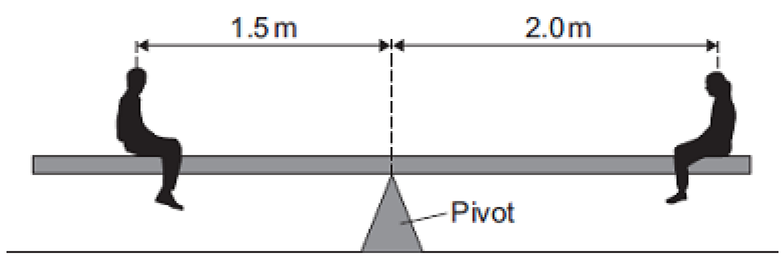
....

Anticlockwise moment = ... Nm

(2)

(c) **Figure 2** shows a girl sitting at the opposite end of the see-saw. Her weight is 300 N.

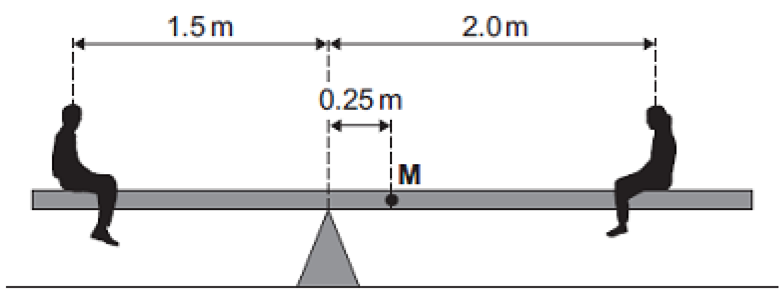
Figure 2



The see-saw is now balanced.

The children move the plank. Its centre of mass, **M**, is now 0.25 m from the pivot as shown in **Figure 3**.

Figure 3



The boy and girl sit on the see-saw as shown in **Figure 3**.

(i) Describe **and** explain the rotation of the see-saw.

....

....

....

....

....

....

....

(3)

(ii) The boy gets off the see-saw and a bigger boy gets on it in the same place. The girl stays in the position shown in **Figure 3**. The plank is balanced. The weight of the plank is 270 N.

Calculate the weight of the bigger boy.

....

....

....

....

....

....

Weight of the bigger boy = ... N

(3)
(Total 10 marks)

45 (a) Human ears can detect a range of sound frequencies.

(i) Use the correct answers from the box to complete the sentence.

2	**20**	**200**	**2000**	**20 000**

The range of human hearing is from about .... Hz to .... Hz.

(2)

(ii) What is ultrasound?

....

....

(1)

(iii) Ultrasound can be used to find the speed of blood flow in an artery.

State **one** other medical use of ultrasound.

....

(1)

(b) The speed of an ultrasound wave in soft tissue in the human body is 1.5×10^3 m / s and the frequency of the wave is 2.0×10^6 Hz.

Calculate the wavelength of the ultrasound wave.

....

....

Wavelength = ... m

(2)

(c) When ultrasound is used to find the speed of blood flow in an artery:

- an ultrasound transducer is placed on a person's arm
- ultrasound is emitted by the transducer
- the ultrasound is reflected from blood cells moving **away** from the transducer
- the reflected ultrasound is detected at the transducer.

Describe the differences between the ultrasound waves emitted by the transducer and the reflected waves detected at the transducer.

....

....

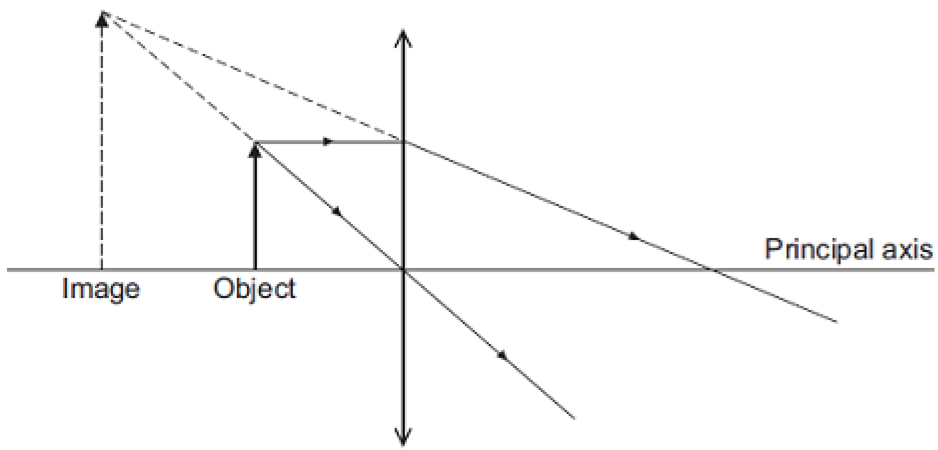
....

....

(2)
(Total 8 marks)

46 (a) The diagram shows how a convex lens forms an image of an object.

This diagram is **not** drawn to scale.



(i) Which **two** words describe the image?

Draw a ring around each correct answer.

diminished **inverted** **magnified** **real** **upright**

(2)

(ii) The object is 4 cm from the lens. The lens has a focal length of 12 cm.

Calculate the image distance.

....

....

....

Image distance = ... cm

(3)

(b) What does a minus sign for an image distance tell us about the nature of the image?

....

(1)
(Total 6 marks)

47 Solar panels are often seen on the roofs of houses.

(a) Describe the action and purpose of a solar panel.

....

....

....

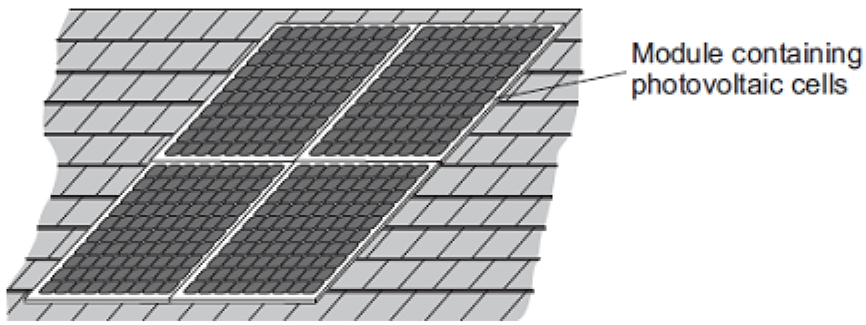
....

(2)

(b) Photovoltaic cells transfer light energy to electrical energy.

In the UK, some householders have fitted modules containing photovoltaic cells on the roofs of their houses.

Four modules are shown in the diagram.



The electricity company pays the householder for the energy transferred.

The maximum power available from the photovoltaic cells shown in the diagram is 1.4×10^3 W.

How long, in minutes, does it take to transfer 168 kJ of energy?

....

....

....

....

....

.... Time = ... minutes

(3)

(c) When the modules are fitted on a roof, the householder gets an extra electricity meter to measure the amount of energy transferred by the photovoltaic cells.

(i) The diagram shows two readings of this electricity meter taken three months apart. The readings are in kilowatt-hours (kWh).

21 November	0	0	0	4	4
21 February	0	0	1	9	4

Calculate the energy transferred by the photovoltaic cells during this time period.

....

Energy transferred = ... kWh

(1)

(ii) The electricity company pays 40p for each kWh of energy transferred.

Calculate the money the electricity company would pay the householder.

....

....

Money paid = ...

(2)

(iii) The cost of the four modules is £6000.

Calculate the payback time in years for the modules.

....

....

Payback time = ... years

(3)

(iv) State an assumption you have made in your calculation in part **(iii)**.

....

....

(1)

(d) In the northern hemisphere, the modules should always face south for the maximum transfer of energy.

State **one** other factor that would affect the amount of energy transferred during daylight hours.

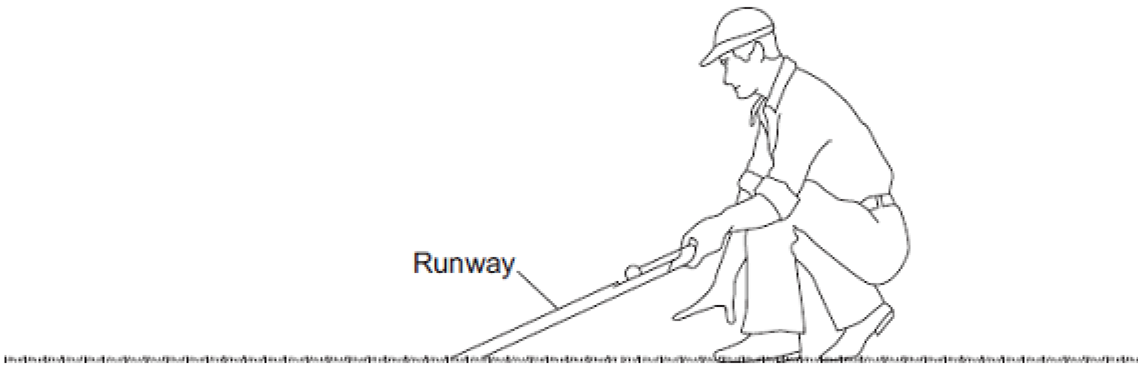
....

....

(1)
(Total 13 marks)

48 **Figure 1** shows a golfer using a runway for testing how far a golf ball travels on grass.
One end of the runway is placed on the grass surface.
The other end of the runway is lifted up and a golf ball is put at the top.
The golf ball goes down the runway and along the grass surface.

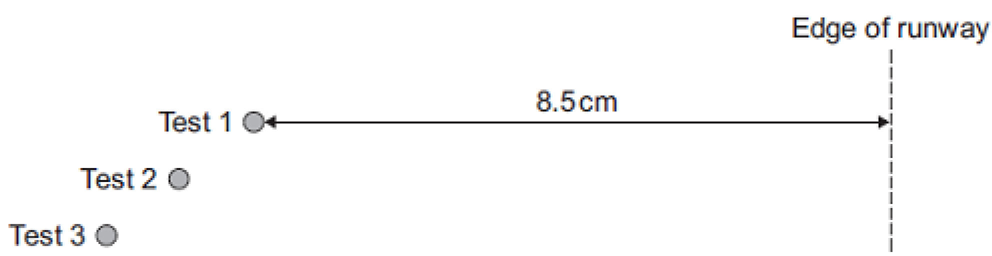
Figure 1



(a) A test was done three times with the same golf ball.

The results are shown in **Figure 2**.

Figure 2



(i) Make measurements on **Figure 2** to complete **Table 1**.

Table 1

Test	Distance measured in centimetres
1	8.5
2	
3	

(2)

(ii) Calculate the mean distance, in centimetres, between the ball and the edge of the runway in **Figure 2**.

....

Mean distance = ... cm

(1)

(iii) **Figure 2** is drawn to scale.
Scale: 1 cm = 20 cm on the grass.

Calculate the mean distance, in centimetres, the golf ball travels on the grass surface.

....

Mean distance on the grass surface = ... cm

(1)

(iv) The distance the ball travels along the grass surface is used to estimate the 'speed' of the grass surface.

The words used to describe the 'speed' of a grass surface are given in **Table 2**.

Table 2

'Speed' of grass surface	Mean distance the golf ball travels in centimetres
Fast	250
Medium fast	220
Medium	190
Medium Slow	160
Slow	130

Use **Table 2** and your answer in part **(iii)** to describe the 'speed' of the grass surface.

....

(1)

(b) The shorter the grass, the greater the distance the golf ball will travel.
A student uses the runway on the grass in her local park to measure the distance the golf ball travels.

(i) Suggest **two** variables the student should control.

....

....

....
(2)

(ii) She carried out the test five times.
Her measurements, in centimetres, are shown below.

75 **95** **84** **74** **79**

What can she conclude about the length of the grass in the park?

....

....
(1)

(c) Another student suggests that the 'speed' of a grass surface depends on factors other than grass length.

She wants to test the hypothesis that 'speed' depends on relative humidity.

Relative humidity is the percentage of water in the air compared to the maximum amount of water the air can hold. Relative humidity can have values between 1% and 100%.

The student obtains the data in **Table 3** from the Internet.

Table 3

Relative humidity expressed as a percentage	Mean distance the golf ball travels in centimetres
71	180
79	162
87	147

(i) Describe the pattern shown in **Table 3**.

....

....
(1)

(ii) The student writes the following hypothesis:
'The mean distance the golf ball travels is inversely proportional to relative humidity.'

Use calculations to test this hypothesis and state your conclusion.

....

....

....

....

....

....

(3)

(iii) The data in **Table 3** does **not** allow a conclusion to be made with confidence.

Give a reason why.

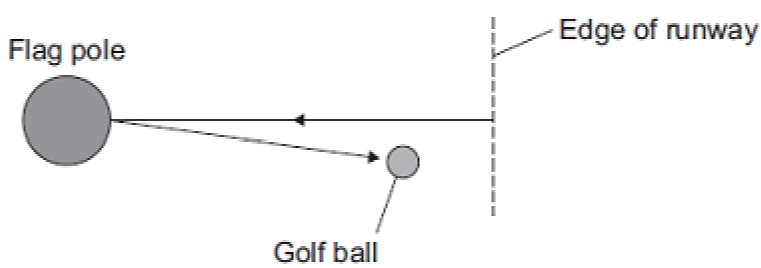
....

....

(1)

(d) In a test, a golf ball hits a flag pole on the golf course and travels back towards the edge of the runway as shown in **Figure 3**.

Figure 3



The distance the ball travels and the displacement of the ball are **not** the same.

What is the difference between distance and displacement?

....

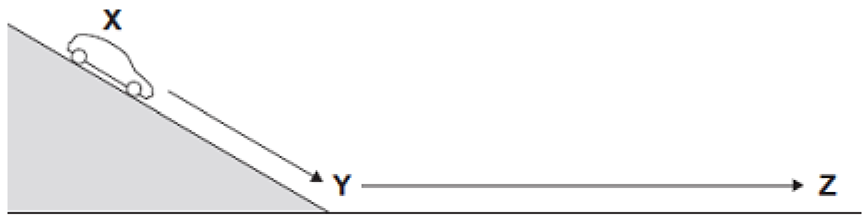
....

....

....

(2)
(Total 15 marks)

49 (a) The diagram shows a car at position **X**.



The handbrake is released and the car rolls down the slope to **Y**.
The car continues to roll along a horizontal surface before stopping at **Z**.
The brakes have **not** been used during this time.

(i) What type of energy does the car have at **X**?

....

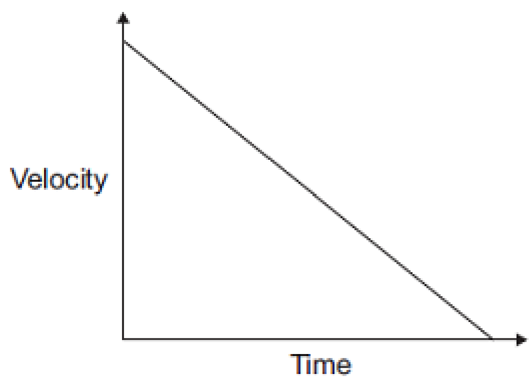
(1)

(ii) What type of energy does the car have at **Y**?

....

(1)

(b) The graph shows how the velocity of the car changes with time between **Y** and **Z**.



(i) Which feature of the graph represents the negative acceleration between **Y** and **Z**?

....

(1)

(ii) Which feature of the graph represents the distance travelled between **Y** and **Z**?

....

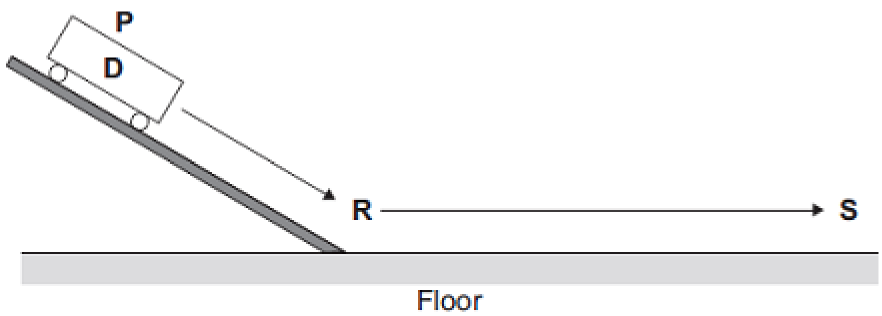
(1)

(iii) The car starts again at position **X** and rolls down the slope as before. This time the brakes are applied lightly at **Y** until the car stops.

Draw on the graph another straight line to show the motion of the car between **Y** and **Z**.

(2)

(c) Three students carry out an investigation. The students put trolley **D** at position **P** on a slope. They release the trolley. The trolley rolls down the slope and along the floor as shown in the diagram.



The students measure the distance from **R** at the bottom of the slope to **S** where the trolley stops. They also measure the time taken for the trolley to travel the distance **RS**.
They repeat the investigation with another trolley, **E**.

Their results are shown in the table.

Trolley	Distance RS in centimetres	Time taken in seconds	Average velocity in centimetres per second
D	65	2.1	
E	80	2.6	

(i) Calculate the average velocity, in centimetres per second, between **R** and **S** for trolleys **D** and **E**. Write your answers in the table.

....

....

....

(3)

(ii) Before the investigation, each student made a prediction.

- Student **1** predicted that the two trolleys would travel the same distance.
- Student **2** predicted that the average velocity of the two trolleys would be the same.
- Student **3** predicted that the negative acceleration of the two trolleys would be the same.

Is each prediction correct?

Justify your answers.

....

....

....

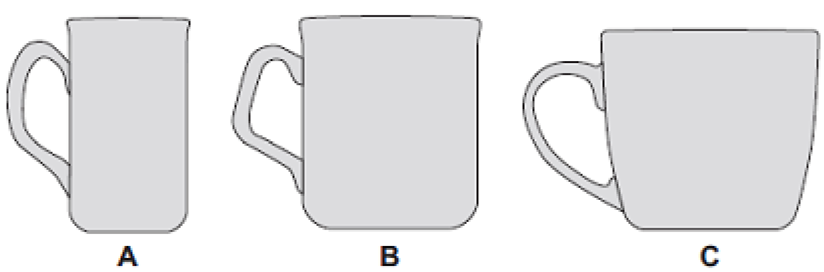
....

....

....

(3)
(Total 12 marks)

50 The diagram shows three cups **A**, **B** and **C**.



Energy is transferred from hot water in the cups to the surroundings.

(a) Use the correct answer from the box to complete each sentence.

condensation	**conduction**	**convection**

Energy is transferred through the walls of the cup by ....

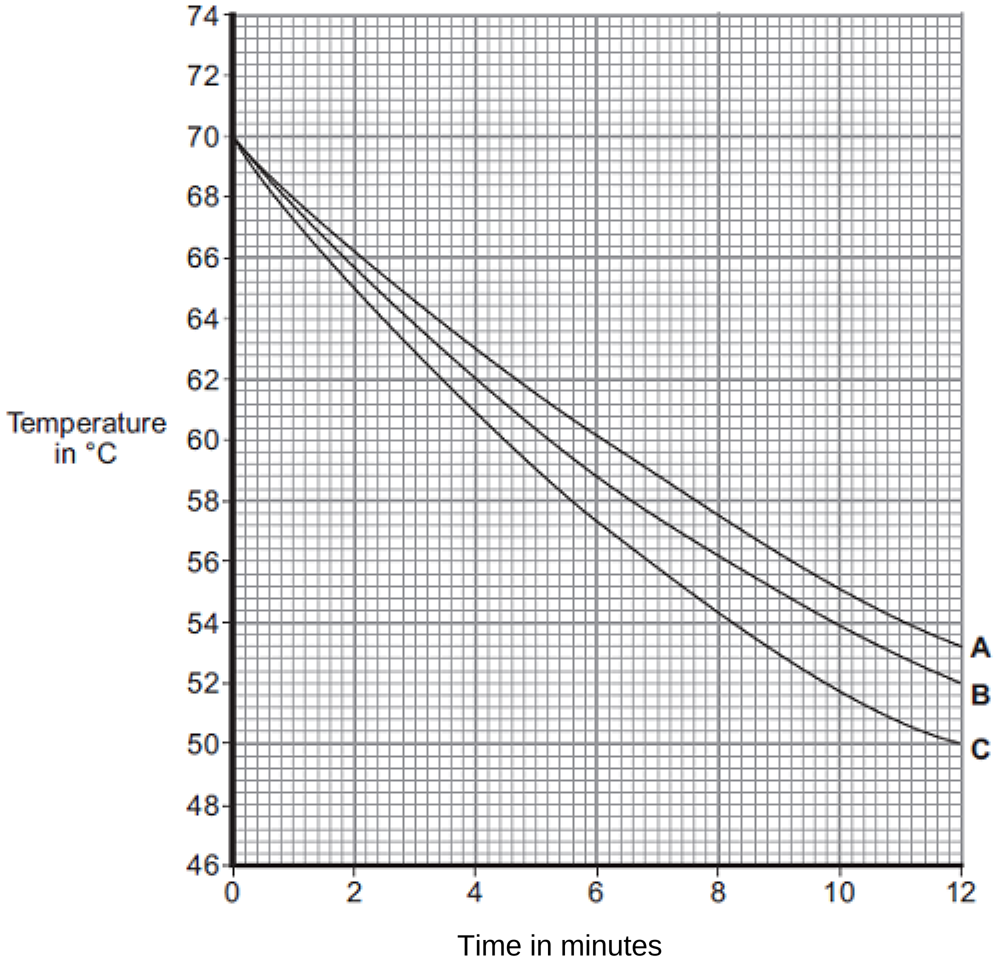
In the air around the cup, energy is transferred by ....

(2)

(b) Some students investigated how the rate of cooling of water in a cup depends on the surface area of the water in contact with the air.

They used cups **A**, **B** and **C**. They poured the same volume of hot water into each cup and recorded the temperature of the water at regular time intervals.

The results are shown on the graph.



(i) What was the starting temperature of the water for each cup?

Starting temperature = ... °C

(1)

(ii) Calculate the temperature fall of the water in cup **B** in the first 9 minutes.

....

Temperature fall = ... °C

(2)

(iii) Which cup, **A**, **B** or **C**, has the greatest rate of cooling? ☐

Using the graph, give a reason for your answer.

....

....

(2)

(iv) The investigation was repeated using the bowl shown in the diagram.

The same starting temperature and volume of water were used.

Draw on the graph in part **(b)** another line to show the expected result.

(1)

(v) After 4 hours, the temperature of the water in each of the cups and the bowl was 20°C.

Suggest why the temperature does **not** fall below 20°C.

....

(1)

(c) (i) The mass of water in each cup is 200 g.

Calculate the energy, in joules, transferred from the water in a cup when the temperature of the water falls by 8°C.

Specific heat capacity of water = 4200 J / kg°C.

....

....

....

Energy transferred = ... J

(3)

(ii) Explain, in terms of particles, how evaporation causes the cooling of water.

....

....

....

....

....

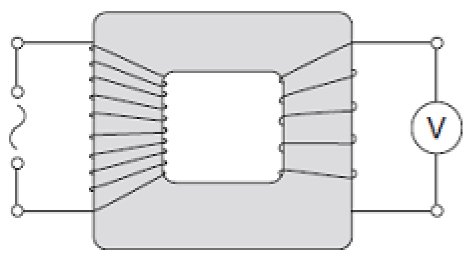
....

....

....

(4)
(Total 16 marks)

51 The diagram shows a transformer with a 50 Hz (a.c.) supply connected to 10 turns of insulated wire wrapped around one side of the iron core.
A voltmeter is connected to 5 turns wrapped around the other side of the iron core.



(a) What type of transformer is shown in the diagram?

Draw a ring around the correct answer.

step-down **step-up** **switch mode**

(1)

(b) The table shows values for the potential difference (p.d.) of the supply and the voltmeter reading.

p.d. of the supply in volts	**Voltmeter reading in volts**
6.4	3.2
3.2	
	6.4

(i) Complete the table.

(2)

(ii) Transformers are used as part of the National Grid.

How are the values of p.d. in the table different to the values produced by the National Grid?

....

....

(1)

(c) Transformers will work with an alternating current (a.c.) supply but will **not** work with a direct current (d.c.) supply.

(i) Describe the difference between a.c. and d.c.

....

....

....

....

(2)

(ii) Explain how a transformer works.

....

....

....

....

....

....

....

....

(4)
(Total 10 marks)

Mark schemes

1 (a) (i) C

1

(ii) The speed of star **B** is less than the speed of star **D**.

1

(b) 300 000 000

*allow **1** mark for correct substitution ie 200 000 × 1500 provided no subsequent step shown*

2

m / s

allow unit correctly indicated in list if not written in answer space

1

[5]

2 (a) (i) infrared (radiation)

accept IR (radiation)

1

(ii) (heated) water turns to steam

ignore reference to fossil fuels

*do **not** accept water evaporates to steam*

1

steam turns a turbine

1

turbine turns a generator

accept turbine connected to a generator

1

(b) (i) (so the molten salts) can store large amounts of energy

accept there is a small temperature change for a large energy transfer

accept heat for energy

1

(ii) 16 (hours)

*an answer that rounds to 16 gains **2** marks eg 15.71*

*allow **1** mark for a correct substitution ie 2 200 000 = 140 000 × t*

3

(iii) the number of daylight hours varies

less sunlight is insufficient

1

the (mean) power (received from the Sun per square metre) varies

*accept an answer in terms of maximum possible electrical output only possible during Summer for **1** mark*

1

(c) (i) non-renewable power stations have higher Capacity Factors than renewable power stations

1

fuel (for non-renewable power stations) is always available

reference to non-renewable power stations operating all the time is insufficient
non-renewable energy sources are reliable is insufficient

1

(most) renewable energy sources are unpredictable / unreliable

accept (most) renewable energy sources depend on the weather

1

(ii) the (proportion of) time that solar storage power stations can generate electricity is greater (than for other renewable energy sources)

1

[14]

3 (a) 4200

*allow **2** marks for correct substitution*
ie 6930 = 0.330 × c × 5.0

*answers of 1050 **or** 840*

or

correctly calculated answer from correct substitution of incorrect temperature change

or

identification of temperature change ie 5 °C
*gain **1** mark*

3

J / kg°C

accept J / kg K

1

(b) (in a metal) free electrons

to gain full credit the answer must be in terms of free electrons

1

gain kinetic energy

accept move faster

1

(free electrons) transfer energy to other electrons / ions / atoms

*do **not** accept particles*

1

by collision

*allow a maximum of **2** marks for answers in terms of atoms / ions / particles*

- *gaining kinetic energy or vibrating faster / more*
- *transferring energy by collisions*

1

(c) (air) particles spread out

1

(which causes the) air to become less dense / expand

*do **not** accept particles become less dense*

1

(so the) warm air rises

*do **not** accept heat rises*
particles rise is insufficient

1

(d) large surface area

ignore references to type of metal or external conditions

1

black / dark (colour)

1

[13]

4 (a) 3 (.0)

*allow **1** mark for correct substitution i.e. 25 × 0.12 provided no subsequent step*

2

(b) (i) elastic potential

correct order only

1

kinetic

1

(ii) increases

1

to 80 (mm) (or more)

accept any number greater than 75

an answer 'it (more than) doubles' gains both marks

1

(c) (i) weight

1

(ii) downward speed increases

1

[8]

5 (a) (i) distance travelled under the braking force

accept distance travelled between applying the brakes and stopping

1

(ii) any **one** from:

- icy / wet roads

  accept weather (conditions)
- (worn) tyres
- road surface

  accept gradient of road
- mass (of car and passengers)

  accept number of passengers
- (efficiency / condition of the) brakes.

  friction / traction is insufficient

1

(iii) greater the speed the greater the braking force (required)

must mention both speed and force

1

(b) 22.5

*allow **1** mark for showing correct use of the graph with misread figures*

or

for showing e.g. 90÷4

*an answer 17 gains **1** mark*

any answer such as 17.4 or 17.5 scores 0

2

(c) (i) momentum before = momentum after

or

(total) momentum stays the same

accept no momentum is lost

accept no momentum is gained

ignore statements referring to energy

1

(ii) 5

*allow **2** marks for correctly obtaining momentum before as 12 000*

or

*allow **2** marks for*

1500 × 8 = 2400 × v

or

*allow **1** mark for a relevant statement re conservation of momentum*

or

*allow **1** mark for momentum before = 1500 × 8*

3

(d) the seat belt stretches

1

driver takes a longer (*impact*) time to slow down and stop (than a driver hitting a hard surface / windscreen / steering wheel)

1

for the (same) change of momentum

accept so smaller deceleration / negative acceleration

1

a smaller force is exerted (so driver less likely to have serious injury than driver without seat belt)

or

the seat belt stretches ***(1)***

do not accept impact for force

driver travels a greater distance while slowing down and stopping (than a driver hitting a hard surface / windscreen / steering wheel) ***(1)***

for (same) amount of work done ***(1)***

accept for (same) change of KE

a smaller force is exerted (so driver less likely to have serious injury than driver without seat belt) ***(1)***

do not accept impact for force

1

[13]

6 (a) refraction

1

(b) towards the normal

1

(c) (i) convex

1

(ii) principal focus

accept focal point

1

(d) parallel on left

1

refracted towards the normal at first surface

1

refraction away from normal at second surface

1

passes through or heads towards principal focus

1

(e) refractive index

accept material from which it is made

1

(radius of) curvature (of the sides)

accept shape / radius

*do **not** accept power of lens*

ignore thickness / length

1

[10]

7 (a) (i) 150

1

(ii) transferred to the surroundings by heating

reference to sound negates mark

1

(iii) 0.75

*450 / 600 gains **1** mark*

*accept 75% for **2** marks*

*maximum of **1** mark awarded if a unit is given*

2

(iv) 20 (s)

*correct answer with or without working gains **2** marks*

*correct substitution of 600 / 30 gains **1** mark*

2

(b) (i) to avoid bias

1

(ii) use less power and last longer

1

1 LED costs £16, 40 filament bulbs cost £80

or

filament costs (5 times) more in energy consumption

1

(iii) any **one** from:

- availability of bulbs
- colour output
- temperature of bulb surface

1

[10]

8 (a) **solid**

particles vibrate about fixed positions

1

closely packed

accept regular

1

gas

<u>particles</u> move randomly

accept particles move faster

accept freely for randomly

1

far apart

1

(b) amount of energy required to change the state of a substance from liquid to gas (vapour)

1

unit mass / 1 kg

dependent on first marking point

1

(c) 41000 **or** 4.1×10^4 (J)

accept

41400 or 4.14×10^4

correct substitution of

$0.018 \times 2.3 \times 10^6$ *gains* ***1*** *mark*

2

(d) **AB**

changing state from solid to liquid / melting

1

at steady temperature

dependent on first ***AB*** *mark*

1

BC

temperature of liquid rises

1

until it reaches boiling point

dependent on first ***BC*** *mark*

1

[12]

9 (a) terminal

1

(b) 5.4 (kg)

correct substitution of 54 = m × 10 gains ***1*** *mark*

2

(c) (i) 0< a <10 1

some upward force

accept some drag / air resistance 1

reduced resultant force 1

(ii) 0 1

upward force = weight (gravity) 1

resultant force zero 1

[9]

10 (a) increases 1

increases 1

(b) 23 (m)

*accept 43 circled for **1** mark*

*accept 9 + 14 for **1** mark* 2

(c) (i) all points correctly plotted

all to ± ½ small square

*one error = **1** mark*

*two or more errors = **0** marks* 2

line of best fit 1

(ii) correct value from their graph (± ½ small square) 1

(d) (i) 70

*½ × 35 × 4 gains **2** marks*

*attempt to estimate area under the graph for **1** mark* 3

(ii) line from (0.6,35) 1

sloping downwards with a less steep line than the first line 1 cutting time axis at time > 4.6 s

accept cutting x-axis at 6

1

(e) (i) 42 000

*1200 × 35 gains **1** mark*

2

kgm / s

Ns

1

(ii) 10 500 (N)

*42 000 / 4 gains **1** mark*

alternatively:

$a = 35 / 4 = 8.75$ m / s^2

$F = 1200 \times 8.75$

2

[19]

11 (a) wavelength correctly shown

1

(b) (i) increased

1

decreased

1

(ii) 17-18 inclusive

1

evidence of measurement divided by 3 or mean of 3 separate measurements

1

mm

accept cm if consistent with answer

1

(c) (i) red shift

1

(ii) moving away

1

(iii) the furthest galaxies show the biggest red shift

1

(meaning that) the furthest galaxies are moving fastest

1

(so the) Universe is expanding

1

(extrapolating backwards this suggests that) the Universe started from an initial point

1

(iv) cosmic microwave background radiation

allow CMBR

1

[13]

12 (a) (i) any **six** from:

- switch on
- read both ammeter and voltmeter

  allow read the meters
- adjust variable resistor to change the current
- take further readings
- draw graph
- (of) V against I

  allow take mean
- R = V / I

  allow take the gradient of the graph

6

(ii) resistor would get hot if current left on

1

so its resistance would increase

1

(iii) 12 (V)

*0.75 × 16 gains **1** mark*

2

(iv) 15 (Ω)

1

16 is nearer to that value than any other

1

(b) if current is above 5 A / value of fuse

1

fuse melts

allow blows / breaks

*do **not** accept exploded*

1

breaks circuit

1

[15]

13 (a) (i) **X** placed at 50 cm mark

1

(ii) point at which mass of object may be (thought to be) concentrated

1

(b) (i) **Y** placed between the centre of the rule and the upper part of mass

1

(ii) 16.5

*allow for **1** mark*
(16.5 + 16.6 +16.5) / 3

2

1.65

value consistent with mean value given

only penalise significant figures once

1

(iii) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
A description of a method which would provide results which may not be valid

Level 2 (3 – 4 marks)
A clear description of a method enabling some valid results to be obtained. A safety factor is mentioned

Level 3 (5 – 6 marks)
A clear and detailed description of experiment. A safety factor is mentioned. Uncertainty is mentioned

examples of the physics points made in the response:

additional apparatus

- stopwatch

use of apparatus

- measure from hole to centre of the mass
- pull rule to one side, release
- time for 10 swings and repeat
- divide mean by 10
- change position of mass and repeat

fair test

- keep other factors constant
- time to same point on swing

risk assessment

- injury from sharp nail
- stand topple over
- rule hit someone

accuracy

- take more than 4 values of *d*
- estimate position of centre of slotted mass
- small amplitudes
- discard anomalous results
- use of fiducial marker

6

(c) (i) initial reduction in *T* (reaching minimum value) as *d* increases

1

after 30 cm T increases for higher value of d

1

(ii) (no)

any **two** from:

- fourth reading is close to mean
- range of data 0.2 s / very small
- variation in data is expected

2

[16]

14 (a) (i) 100 (m)

1

(ii) stationary

1

(iii) accelerating

1

(iv) tangent drawn at t = 45 s

1

attempt to determine slope

1

speed in the range 3.2 – 4.2 (m / s)

dependent on 1st marking point

1

(b) (i) 500 000 (J)

ignore negative sign

1

(ii) 20 000 (N)

ignore negative sign

*allow **1** mark for correct substitution, ie*

500 000 = F × 25

***or** their part (b)(i) = F × 25*

provided no subsequent step

2

(iii) *(kinetic) energy* transferred by heating

1

to the brakes

ignore references to sound energy

*if no other marks scored allow k.e. decreases for **1** mark*

1

[11]

15 (a) (i) infrared / *IR*

1

(ii) *UV / X-rays / gamma rays*

1

appropriate use corresponding with given wave:

dependent on first marking point

- UV: security marking ***or*** *tanning*
- X-rays: medical imaging ***or*** *checking baggage*
- gamma rays: sterilising surgical instruments ***or*** killing harmful bacteria in food

accept any sensible alternative uses

1

(b) D

1

gap must be comparable to wavelength

accept converse

1

can create gap of that size in classroom

dependent on first marking point

1

(c) (i) Q

1

(ii) sound waves reflected

accept 'it' for sound waves

ignore bounce

1

at EF

1

angle of incidence equal to angle of reflection

1

(iii) stop sound going direct from clock to ear

1

(iv) 22 (m)

*allow **1** mark for correct substitution, ie*

*$330 = 15 \times \lambda$ scores **1** mark*

2

(v) outside audible range

1

[14]

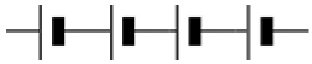
16 (a) *attempt to draw four cells in series*

1

correct circuit symbols

circuit symbol should show a long line and a short line, correctly joined together

example of correct circuit symbol:



1

(b) (i) 6 (V)

*allow **1** mark for correct substitution, ie*

*V = 3 × 2 scores **1** mark*

provided no subsequent step

2

(ii) 12 (V)

ecf from part (b)(i)

18 – 6

or

*18 – their part (b)(i) scores **1** mark*

2

(iii) 9 (Ω)

ecf from part (b)(ii) correctly calculated

3 + their part (b)(ii) / 2

or

*18 / 2 scores **1** mark*

provided no subsequent step

2

(c) (i) need a.c.

1

battery is d.c.

1

(ii) 3 (A)

*allow **1** mark for correct substitution, ie*

*18 × 2 = 12 × I_s scores **1** mark*

2

[12]

17 (a) *there is a* magnetic field *(around the magnet)*

1

(this magnetic field) changes / moves

1

and cuts through coil

accept links with coil

1

so a p.d. *induced* across coil 1

the coil forms *a* complete circuit 1

so a current (*is* induced) 1

(b) ammeter reading does not change

must be in this order

accept ammeter has a small reading / shows a current 1

zero 1

greater than before

accept a large(r) reading 1

same as originally but in the opposite direction

accept a small reading in the opposite direction 1

(c) 0.30

allow ***1*** *mark for correct substitution, ie 0.05 = Q / 6* 2

C / coulomb

allow A s 1

[13]

18 (a) pitch 1

loudness 1

(b) (i) as length (of prongs) decreases frequency / pitch increases

accept converse

accept negative correlation

ignore inversely proportional 1

(ii) 8.3 (cm)

accept 8.3 ± 0.1 cm 1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)

ecf from part ***(ii)*** 1

(so *f* must be) between 384 (Hz) and 480 (Hz)

1

410 (Hz) ≤ *f* ≤ 450 (Hz)

*if only the estimated frequency given, accept for **1** mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high

accept frequency above

*20 000 (Hz) **or** audible range*

1

so tuning fork ***or*** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)

accept any correct rounding 286, 290, 300

*allow **2** marks for 285*

*allow **2** marks for correct substitution 0.0035 = 1 / f*

*allow **1** mark for T = 0.0035 s*

*allow **1** mark for an answer of 2000*

3

[13]

19 (a) (black) is a good absorber of (infrared) radiation

1

(b) (i) amount of energy required to change (the state of a substance) from solid to liquid (with no change in temperature)

melt is insufficient

1

unit mass / 1kg

1

(ii) 5.1×10^6 (J)

accept 5×10^6

*allow **1** mark for correct substitution ie $E = 15 \times 3.4 \times 10^5$*

2

(c) (i) mass of <u>*ice*</u>

allow volume / weight / amount / quantity of <u>ice</u>

1

(ii) to distribute the salt throughout the ice

1

to keep all the ice at the same temperature

1

(iii) melting point decreases as the mass of salt is increased

allow concentration for mass

accept negative correlation

*do **not** accept inversely proportional*

1

(d) 60 000 (J)

accept 60 KJ

*allow **2** marks for correct substitution ie E = 500 × 2.0 × 60*

*allow **2** marks for an answer of 1000 **or** 60*

*allow **1** mark for correct substitution ie*

*E = 500 × 2.0 **or** 0.50 × 2.0 × 60*

*allow **1** mark for an answer of 1*

3

(e) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is *an attempt at a description of some advantages or disadvantages.*

Level 2 (3–4 marks)
There is a basic description of *some advantages* ***and / or*** *disadvantages for some of the methods*

Level 3 (5–6 marks)
There is a clear description of the advantages and disadvantages of all the methods.

examples of the points made in the response

extra information

energy storage

advantages:

- no fuel costs
- no environmental effects

disadvantages:

- expensive to set up and maintain
- need to dig deep under road
- dependent on (summer) weather
- digging up earth and disrupting habitats

salt spreading

advantages:

- easily available
- cheap

disadvantages:

- can damage trees / plants / drinking water / cars
- needs to be cleaned away

undersoil heating

advantages:

- not dependent on weather
- can be switched on and off

disadvantages:

- costly
- bad for environment

6

[18]

20 (a) (i) any **two** from:

- length of coils increased
- coils have tilted
- length of loop(s) increased
- increased gap between coils
- *spring has stretched / got longer*
- *spring has got thinner*

2

(ii) remove mass

accept remove force / weight

1

observe if the spring returns to its original length / shape *(then* it is behaving elastically)

1

(b) (i) 8.0 (cm)

1

extension is directly proportional to force *(up to 4 N)*

for every 1.0 N extension increases by 4.0 cm (up to 4 N)

evidence of processing figures eg 8.0 *cm* is half way between 4.0 *cm* and 12.0 *cm*

1

allow spring constant (k) goes from to $\frac{1}{4}$ to $\frac{5}{22}$

1

(ii) any value greater than 4.0 N and less than or equal to 5.0 N

1

the increase in extension is greater than 4 cm per 1.0 N (of force) added

dependent on first mark

1

(c) (i) elastic potential energy

1

(ii) misread stopwatch

1

timed too many complete oscillations

1

(iii) 4.3 (s)

accept 4.33 (s)

1

(iv) stopwatch reads to 0.01 s

1

reaction time is about 0.2 s
or
reaction time is less precise than stopwatch

1

(v) use more masses

1

smaller masses eg 50 g

not exceeding limit of proportionality

1

[17]

21 (a) (i) electrical

correct order only

1

kinetic

1

sound

1

(ii) transferred into surroundings / atmosphere

accept warms the surroundings

allow released into the environment

becomes heat or sound is insufficient

1

(b) 0.7 / 70 %

an answer of 70 without % or with the wrong unit ***or*** *0.7 with a unit gains* ***1*** *mark*

2

[6]

22 (a) (i) any **two** from:

- mass (of block)

  accept weight for mass
- starting temperature
- final / increase in temperature

  temperature is insufficient
- voltage / p.d.

  same power supply insufficient
- power (supplied to each block)
- type / thickness of insulation

  same insulation insufficient

2

(ii) one of variables is categoric

or

(type of) material is categoric

accept the data is categoric

accept a description of categoric

*do **not** accept temp rise is categoric*

1

(iii) concrete

reason only scores if concrete chosen

1

(heater on for) longest / longer time

a long time or quoting a time is insufficient

*do **not** accept it is the highest bar*

1

(iv) 4500 (J)

*allow **1** mark for correct substitution ie*

2 × 450 × 5 provided no subsequent step shown

2

(b) (i) point at 10 minutes identified

1

(ii) line through all points except anomalous

line must go from at least first to last point

1

(iii) 20 (°C)

if 20°C is given, award the mark.

If an answer other than 20°C is given, look at the graph. If the graph shows a correct extrapolation of the candidate's best-fit line and the intercept value has been correctly stated, allow 1 mark.

1

(iv) 2 (minutes)

1

[11]

23 (a) advantage

any **one** from:

- produce no / little greenhouse gases / carbon dioxide

  allow produces no / little polluting gases

  allow doesn't contribute to global warming / climate change

  allow produce no acid rain / sulphur dioxide

  reference to atmospheric pollution is insufficient

  produce no harmful gases is insufficient
- high(er) energy density in fuel

  accept one nuclear power station produces as much power as several gas power stations

  nuclear power stations can supply a lot of or more energy is insufficient
- long(er) operating life

  allow saves using reserves of fossil fuels or gas

1

disadvantage

any **one** from:

- produce (long term) radioactive waste

  accept waste is toxic

  accept nuclear for radioactive
- accidents at nuclear power stations may have far reaching or long term consequences
- high(er) decommissioning costs

  accept high(er) building costs
- long(er) start up time

1

(b) (i) 12 000 (kWh)

*allow **1** mark for correct substitution eg*

2000 × 6

or

2 000 000 × 6

or

$\frac{12\,000\,000}{1000}$

*an answer of 12 000 000 scores **1** mark*

2

(ii) any idea of unreliability, eg

- wind is unreliable

  reference to weather alone is insufficient
- shut down if wind too strong / weak
- wind is variable

1

(c) any **one** from:

- cannot be seen
- no hazard to (low flying) aircraft / helicopters
- unlikely to be or not damaged / affected by (severe) weather

  unlikely to be damaged is insufficient
- (normally) no / reduced shock hazard

  safer is insufficient

  less maintenance is insufficient

  installed in urban areas is insufficient

1

[6]

24 (a) (i) 440 (sound) waves produced in one second

accept vibrations / oscillations for waves

1

(ii) 0.773 (metres)

*allow **2** marks for an answer that rounds to 0.773*

*allow **2** marks for an answer of* $0.7\dot{7}\dot{2}$

*allow **2** marks for an answer of 0.772*

*allow **1** mark for correct substitution ie 340 = 440 × λ*

3

(b) (sound is) louder

*do **not** accept the converse*

1

as amplitude is larger

waves are taller is insufficient

1

higher pitch / frequency

1

as more waves are seen

reference to wavelengths alone is insufficient

waves are closer together is insufficient

1

[8]

25 (a) conduction

1

(b) 35 000

1

(c) 500

*their (b) = 2 x c x 35 correctly calculated scores **2** marks*

*allow **1** mark for correct substitution,*

ie 35000 = 2 x c x 35
or
their (b) = 2 x c x 35

2

J / kg°C

1

(d) energy lost to surroundings
or
energy needed to warm heater

accept there is no insulation (on the copper block)

*do **not** accept answers in terms of human error or poor results or defective equipment*

1

[6]

26 (a) (i) not moving

1

(ii) straight line from origin to (200,500)

ignore a horizontal line after (200,500)

1

(b) 35 000

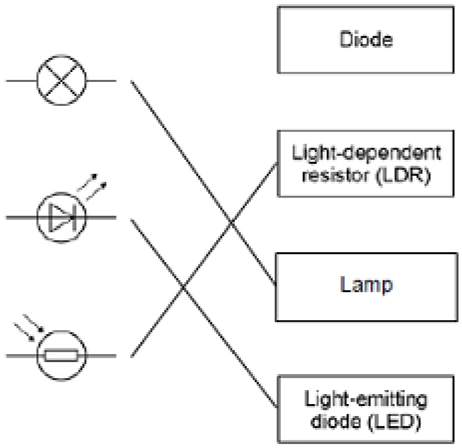
*allow **1** mark for correct substitution, ie 14 000 × 2.5 provided no subsequent step*

an answer of 87 500 indicates acceleration (2.5) has been squared and so scores zero

2

[4]

27 (a)



*allow **1** mark for each correct line if more than one line is drawn from any symbol then all of those lines are wrong*

3

(b) (i) half

1

(ii) 3(V)

1

(iii) V_1

1

(c) (i) potential difference / voltage of the power supply

accept the power supply

accept the voltage / volts

accept number of cells / batteries

accept (same) cells / batteries

do not accept same ammeter / switch / wires

1

(ii) bar drawn – height 1.(00)A

ignore width of bar

*allow **1** mark for bar shorter than 3rd bar*

2

(iii) as the number of resistors increases the current decreases

1

[10]

28 (a) Zero / 0

Accept none

Nothing is insufficent

1

velocity / speed = 0

accept it is not moving

paintball has not been fired is insufficient

1

(b) 0.27

*allow **1** mark for correct substitution, ie p = 0.003(0) × 90 provided no subsequent step*

2

(c) equal to

1

[5]

29 (a) (i)

Wire	**Plug terminal**
Live	C
Neutral	A
Earth	B

*all 3 correct for **2** marks*

*allow **1** mark for 1 correct*

2

(ii) plastic
or
rubber

accept:

ABS
UF / urea formaldehyde
nylon
PVC

1

(b) (i) 600

*allow **1** mark for correct substitution,*

ie $P = \frac{30\,000}{50}$

provided no subsequent step

2

(ii) power is greater than 820 (W)

power is 1200 W is insufficient

1

the lead /cable / wire <u>will</u> overheat / get (too) hot

accept lead / cable will melt

may overheat / get hot is insufficient

1

so there is a risk of fire

accept causing a fire

1

(c) X

any **one** from:

- most / more efficient
- smallest energy input (per second)
- cheapest to operate

mark only scores if X is chosen

mark is for the reason

accept smallest input (power) for same output (power)

accept wastes least energy

smallest (power) input is insufficient

uses least electricity is insufficient

1

[9]

30 (a) 450

*allow **1** mark for correct substitution,*

ie 18 × 10 × 2.5 provided no subsequent step shown

2

(b) (i) friction between child ('s clothing) and slide

accept friction between two insulators

accept child rubs against the slide

accept when two insulators rub (together)

1

causes electron / charge transfer (between child and slide)

accept specific reference, eg electrons move onto / off the child / slide

reference to positive electrons / protons / positive charge / atoms transfer negates this mark

answers in terms of the slide being initially charged score zero

1

(ii) all the charges (on the hair) are the same (polarity)

accept (all) the charge/hair is negative / positive

accept it is positive/negative

1

charges / hairs are repelling

both parts should be marked together

1

(iii) charge would pass through the metal (to earth)

accept metal is a conductor

accept metal is not an insulator

accept there is no charge / electron transfer

accept the slide is earthed

accept metals contain free electrons

1

[7]

31 (a) (i) friction

1

(ii) air resistance

accept drag

friction is insufficient

1

(iii) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content.

Level 1 (1–2 marks)
There is an attempt to explain in terms of forces A and B why the velocity of the cyclist changes between any two points
or
a description of how the velocity changes between any two points.

Level 2 (3–4 marks)
There is an explanation in terms of forces A and B of how the velocity changes between X and Y and between Y and Z
or
a complete description of how the velocity changes from X to Z.
or
an explanation and description of velocity change for either X to Y or Y to Z

Level 3 (5–6 marks)
There is a clear explanation in terms of forces A and B of how the velocity changes between X and Z
and
a description of the change in velocity between X and Z.

examples of the points made in the response

extra information

X to Y

- at X force A is greater than force B
- cyclist accelerates
- and velocity increases
- as cyclist moves toward Y, force B (air resistance) increases (with increasing velocity)
- resultant force decreases
- cyclist continues to accelerate but at a smaller value
- so velocity continues to increase but at a lower rate

Y to Z

- from Y to Z force B (air resistance) increases
- acceleration decreases
- force B becomes equal to force A
- resultant force is now zero
- acceleration becomes zero

- velocity increases until…
- cyclist travels at constant / terminal velocity

accept speed for velocity throughout

6

(b) (i) 3360

*allow **1** mark for correct substitution,*

ie 140 × 24 provided no subsequent step

*accept 3400 for **2** marks if correct substitution is shown*

2

joule / J

*do **not** accept j*

*do **not** accept Nm*

1

(ii) decreases

accept an alternative word / description for decrease

do not accept slows down

1

temperature

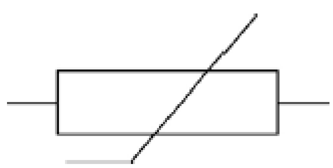
accept thermal energy

accept heat

1

[13]

32 (a) (i)



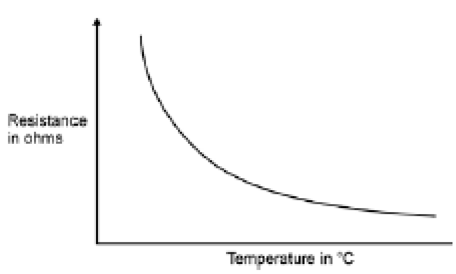
1

(ii) 360

*allow **1** mark for correct substitution, ie 9 = 0.025 × R*

2

(iii) sketch graph of correct shape, ie



1

(iv) An automatic circuit to switch a heating system on and off.

1

(b) so ammeter reduces / affects current as little as possible

accept so does not reduce / change the current (it is measuring)

accurate reading is insufficient

not change the resistance is insufficient

1

(c) gives a common understanding

accept is easier to share results

accept can compare results

do not need to be converted is insufficient

prevent errors is insufficient

1

(d) replace Bunsen (and water) with a lamp

accept any way of changing light level

1

replace thermometer with light sensor

accept any way of measuring a change in light level

datalogger alone is insufficient

1

[9]

33 (a) momentum before (jumping) = momentum after (jumping)

accept momentum (of the skateboard and skateboarder) is conserved

1

before (jumping) momentum of skateboard and skateboarder is zero

accept before (jumping) momentum of skateboard is zero

accept before (jumping) total momentum is zero

1

after (jumping) skateboarder has momentum (forwards) so skateboard must have (equal) momentum (backwards)

answers only in terms of equal and opposite forces are insufficient

1

(b) 7

*accept –7 for **3** marks*

*allow **2** marks for momentum of skateboarder equals 12.6*

or

$0 = 42 \times 0.3 + (1.8 \times -v)$

or

*allow **1** mark for stating use of conservation of momentum*

3

[6]

34 (a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) <u>reactor</u>

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve

or

(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive

*allow **1** mark for correctly calculating number remaining as 20 000*

or

*allow **1** mark for number of*

80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

35 (a) transmits

correct order

1

absorbs

1

(b) light

*allow ultra violet **or** UV **or** infrared **or** IR **or** gamma*

1

(c) 20

*allow **1** mark for correct working, ie $\frac{60}{3}$ provided no subsequent step*

2

(d) Killing cancer cells

1

[6]

36 (a) 3000

*allow **1** mark for correct substitution, ie 600 × 5 provided no subsequent step*

2

(b) anticlockwise moment

must be both words

1

(c) (i) 3400

allow 3.4 kilo (newtons)

1

(ii) as the distance (of the girl from point A) increases, force F increases

allow gets bigger for increases

force is (directly) proportional to distance will negate any correct response

1

[5]

37 (a) long

1

(b) lens A

1

it is a concave / diverging lens

this mark is only gained if lens A is stated

any reference to lens material or mass of lens negates this mark

allow it will focus light onto the retina

1

(c) The refractive index of the lens material

1

(d) 4

ignore any signs

*allow **1** mark for correct substitution, ie* $\frac{1}{0.25}$ *provided no subsequent step*

2

(e) Cauterising open blood vessels

1

(f) 5

*allow **1** mark for correct substitution, ie* $\frac{70}{14}$ *provided no subsequent step*

2

[9]

38 (a) hydraulic

1

(b) 9

*allow **1** mark for a correct substitution, ie* $\frac{1800}{200}$ *provided no subsequent step*

2

(c) an environmental

1

[4]

39 (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans
or
a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$
provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

  damage cells is insufficient
- shielding is needed

  can be dangerous (to human health) unqualified, is insufficient

1

[7]

40 (a) 3800

*allow **1** mark for 2000*

*allow **1** mark for 1800*

*if neither of above scored, allow correct substitution for **1** mark (800 × 2.5) + (600 × 3)*

if moments have been calculated incorrectly, allow 1 mark for adding their two moment values correctly

3

newton metres **or** Nm

*do **not** allow nm **or** NM*

1

(b) as the girl increases her distance (from the pivot) the clockwise moment increases

1

(F must increase) as the anticlockwise moment must increase

1

so (the anticlockwise moment) is equalled / balanced by the clockwise moment
or
so resultant / overall moment (on the board) is zero

accept to balance / equal the moments

to balance the board is insufficient

1

[7]

41 (for both fibres) increasing the <u>wavelength</u> of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*

(for both fibres) increasing the <u>wavelength</u> (of light) to 5 (x 10^{-7} metres), decreases the (percentage) transmission

1

(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres)
or
maximum transmission occurs at 6.5 (x 10^{-7} metres)

*accept for a further **1** mark:*

(for both fibres) increasing the wavelength of the light from 5 (x 10^{-7} metres) increases the amount of light transmitted

increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark:*
Any statement that correctly processes data to compare the fibres

1

[3]

42 (a) hydraulic (system)

1

(b) 15.40 $\times 10^2$
or
1540

*allow **1** mark for correct substitution, ie*

$$8.75 \times 10^4 = \frac{F}{1.76 \times 10^{-2}}$$

or

$$87\,500 = \frac{F}{0.0176}$$

or

$F = 8.75 \times 10^4 \times 1.76 \times 10^{-2}$

or

$F = 87\,500 \times 0.0176$

2

(c) any **one** environmental **advantage**:

stating a converse statement is insufficient, or a disadvantage of the usual oil, ie the usual oil is non-renewable

plant oil is renewable

using plant oil will conserve (limited) supplies **or** extend lifetime of the usual / crude oil.

plant oil releases less carbon dioxide (when it is being produced / processed)

plant oil will add less carbon dioxide to the atmosphere (when it is being produced / processed, than the usual oil)

plant oil removes carbon dioxide from **or** adds oxygen to the air when it is growing

stating that plant oil is carbon neutral is insufficient

1

(d) (the current flowing through the coil) creates a magnetic field (around the coil)

1

(this magnetic field) interacts with the permanent magnetic field
or
current carrying conductor is in a (permanent) magnetic field

it must be clear which magnetic field is which

1

this produces a (resultant) force (and coil / cone moves)

1

when the direction of the current changes, the direction of the force changes to the opposite direction

*accept for **2** marks the magnetic field of the coil interacts with the permanent magnetic field*

1

[8]

43 (a) 3000

*correct substitution of 24 / 0.008 gains **1** mark provided no subsequent steps are shown*

2

N / m^2 or Pa

1

(b) (i) K

accept ringed K in table

1

(ii) water exiting bottle one-third of vertical height of K

allow less than half vertical height of spout shown, judged by eye

1

water landing twice the distance of the spout shown in the diagram

accept at least one and a half times further out than spout shown, judged by eye

*do **not** accept water hitting the side of the sink*

ignore trajectory

1

(c) water will land on the (vertical) side of the sink

*accept sink **not** long / wide / big enough*

or

water will dribble down very close to the bottle

or

that part of the bottle is curved

*do **not** accept goes out of the sink*

1

[7]

44 (a) (i) turning

accept turning ringed in the box

1

(ii) point at which mass (or weight) may be thought to be concentrated

accept the point from which the weight appears to act

allow focused for concentrated

*do **not** accept most / some of the mass*

*do **not** accept region / area for point*

1

(b) 600 (Nm)

*400 × 1.5 gains **1** mark provided no subsequent steps shown*

2

(c) (i) plank rotates clockwise

accept girl moves downwards

*do **not** accept rotates to the right*

1

(total) CM > (total) ACM

accept moment is larger on the girl's side

1

weight of see-saw provides CM

answer must be in terms of moment

*maximum of **2** marks if there is no reference to the weight of the see-saw*

1

(ii) W = 445 (N)

W × 1.5 = (270 × 0.25) + (300 × 2.0) gains ***2*** *marks*

allow for ***1*** *mark:*

total CM = total ACM either stated or implied

or

(270 × 0.25) + (300 × 2.0)

if no other marks given

3

[10]

45 (a) (i) 20

1

20 000

either order

accept ringed answers in box

1

(ii) (frequency) above human range

accept pitch for frequency

or

(frequency) above 20 000 (Hz)

do ***not*** *accept outside human range*

allow ecf from incorrect value in ***(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning

  accept any other appropriate scanning use

  do ***not*** *accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  accept curing prostate cancer or killing prostate cancer cells
- removing plaque from teeth

  cleaning teeth is insufficient

1

(b) 7.5×10^{-4} (m)

$1.5 \times 10^{3} = 2.0 \times 10^{6} \times \lambda$ gains ***1*** *mark*

2

(c) for reflected waves

must be clear whether referring to emitted or detected / reflected waves

if not specified assume it refers to reflected wave

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased

allow amplitude / energy has decreased
allow the beam is weaker

2

[8]

46 (a) (i) magnified

1

upright

1

(ii) v = −6(cm)

*max **2** marks if no minus sign*

*6(cm) gains **2** marks*

1/v = 1/12 − 1/4 = −1/6
*gains **2** marks*

1/12 = 1/4 + 1/v
*gains **1** mark*

−5.99(cm)
*using decimals gains **3** marks*

3

(b) it is virtual

1

[6]

47 (a) water heated by radiation (from the Sun)

accept IR / energy for radiation

1

water used to heat buildings / provide hot water

*allow for **1** mark heat from the Sun heats water if no other marks given*

*references to photovoltaic cells / electricity scores **0** marks*

1

(b) 2 (minutes)

$1.4 \times 10^3 = \frac{168 \times 10^3}{t}$

*gains **1** mark*

*calculation of time of 120 (seconds) scores **2** marks*

3

(c) (i) 150 (kWh)

1

(ii) £60(.00) or 6000 (p)

*an answer of £6000 gains **1** mark*

*allow **1** mark for 150 × 0.4(0) 150 × 40*

*allow ecf from **(c)(i)***

2

(iii) 25 (years)

an answer of 6000 / 240
or
*6000 / their **(c)(ii)** × 4*
*gains **2** marks*

an answer of 6000 / 60
or
*6000 / their **(c)(ii)** gains **1** mark, ignore any other multiplier of **(c)(ii)***

3

(iv) any **one** from:

- will get £240 per year
  *accept value consistent with calculated value in **(c)(iii)***
- amount of light is constant throughout the year
- price per unit stays the same
- condition of cells does not deteriorate

1

(d) any **one** from:

- angle of tilt of cells
- cloud cover
- season / shade by trees
- amount of dirt

1

[13]

48 (a) (i) 9.5

accept ±1 mm

1

10.5

1

(ii) 9.5

*ecf from **(a)(i)***

1

(iii) 190

*20 × **(a)(ii)** ecf*

1

(iv) medium

*ecf from **(a)(iii)***

1

(b) (i) any **two** from:

- position of ball before release
- same angle **or** height of runway
- same ball
- same strip of grass

2

(ii) long

or

longer than in part **(a)**

or

uneven

*do **not** allow reference to speed*

1

(c) (i) as humidity increases mean distance decreases

accept speed for distance

1

(ii) 71 × 180 = 12780

79 × 162 = 12798

87 × 147 = 12789

*all three calculations correct with a valid conclusion gains **3** marks*

or

find k from R = k / d

*all three calculations correct gains **2** marks*

or

87 / 71 × 147 = 180.1 ~ 180

87 / 79 × 147 = 161.9 ~ 162

*two calculations correct with a valid conclusion gains **2** marks*

conclusion based on calculation

*one correct calculation of k gains **1** mark*

3

(iii) only three readings **or** small range for humidity

accept not enough readings

accept data from Internet could be unreliable

ignore reference to repeats

1

(d) distance is a scalar **or** has no direction **or** has magnitude only

allow measurements from diagram of distance and displacement

1

displacement is a vector **or** has direction

1

[15]

49 (a) (i) gravitational potential (energy)

1

(ii) kinetic (energy)

1

(b) (i) slope or gradient

1

(ii) area (under graph)

*do **not** accept region*

1

(iii) starts at same y−intercept

1

steeper slope than original and cuts time axis before original

the entire line must be below the given line

allow curve

1

(c) (i) 31

and

31

*correct answers to 2 significant figures gains **3** marks even if no working shown*

*both values to more than 2 significant figures gains **2** marks:*
30.952……
30.769….

65 / 2.1 and / or
*80 / 2.6 gains **1** mark*

*if incorrect answers given but if both are to 2 significant figures allow **1** mark*

3

(ii) student 1 incorrect because 80 ≠ 65

1

student 2 correct because average velocities similar

*ecf from **(c)(i)***

1

student 3 incorrect because times are different

1

[12]

50 (a) conduction

must be in correct order

1

convection

1

(b) (i) 70

accept ± half a square
(69.8 to 70.2)

1

(ii) 15

*accept 14.6 to 15.4 for **2** marks*

*allow for **1** mark 70 − 55*

ecf from (b)(i) ± half a square

2

(iii) C

1

biggest drop in temperature during a given time

accept it has the steepest gradient this is a dependent

1

(iv) starting at 70 °C and below graph for C
must be a curve up to at least 8 minutes

1

(v) because 20 °C is room temperature

accept same temperature as surroundings

1

(c) (i) 6720

*correct answer with or without working gains **3** marks*

*6 720 000 gains **2** marks*

*correct substitution of E = 0.2 × 4200 × 8 gains **2** marks*

*correct substitution of E = 200 × 4200 × 8 gains **1** mark*

3

(ii) the fastest particles have enough energy

accept molecules for particles

1

to escape from the surface of the water

1

therefore the mean energy of the remaining particles decreases

accept speed for energy

1

the lower the mean energy of particles the lower the temperature (of the water)

accept speed for energy

1

[16]

51 (a) step-down

1

(b) (i) 1.6

correct order only

1

12.8

1

(ii) values of p.d. are smaller than 230 V

1

(c) (i) a.c. is constantly changing direction

accept a.c. flows in two / both directions

accept a.c. changes direction(s)

a.c. travels in different directions is insufficient

1

d.c. flows in one direction only

1

(ii) an alternating current / p.d. in the primary creates a changing / alternating magnetic field

1

(magnetic field) in the (iron) core

current in the core negates this mark

accept voltage for p.d.

1

(and so) an alternating p.d.

1

(p.d.) is induced across secondary coil

1

[10]

Examiner reports

1

(a) (i) The majority of students correctly identified star C as being the one that is moving away from the Earth. However, a large number of students thought that it was star D.

(ii) A large number of students incorrectly thought that the speed of star B is greater than the speed of star D, although just less than half of students answered correctly.

(b) Most students gave the correct substitution but many failed to derive a correct answer, often being out by a factor of 10. Sometimes this may have been caused by students not using comma separators and therefore being unsure of the number of zeroes they had put in their answer.

Almost half of students scored all three marks; many only scored 2 marks either because of a miscalculation or because of choosing the wrong unit.

A significant number of students made no attempt at the calculation, although some of these did manage to circle one of the units in the question.

2 (a) (i) Almost half of students scored a mark by identifying infra-red radiation. Common incorrect answers were ultra-violet, visible light or the Sun.

(ii) Many good answers were seen, with about a quarter of students scoring all 3 marks. A number of students thought that water evaporates to form steam which is incorrect and therefore negated the first marking point. A minority of students thought that water turned the turbine which negated the first and second marking points. Some students thought the turbine generated electricity negating the third marking point.

(b) (i) Almost a third of students understood that a high specific heat capacity meant lots of energy could be stored. Most incorrect answers referred to the salts melting (they were already molten) or changing state, which was insufficient.

(ii) The majority of students gained 2 or 3 marks for this question. The most common mistake was to incorrectly round their answer to 15 or to ignore the instruction about significant figures and give an answer of '15.7' or a similar un-rounded figure.

(iii) Many students failed to realise that the table for this part question held the information needed to answer it. Many students thought that the weather or other associated problems were responsible, when in fact summer is the only time when the power station can operate at maximum capacity because of the highest power per m^2 and the longest number of daylight hours. Some students answered with the expected response that the power varies and so do the number of daylight hours, but these were few.

(c) (i) Most students scored the first marking point, comparing the Capacity Factor for renewable with non-renewable sources. Many scored the third marking point for the unreliability of non-renewable sources.

Few students scored the 2^{nd} marking point for stating that non-renewable fuels were always available. Many students just stated that non-renewable sources were reliable which was insufficient.

(ii) Very few students scored this mark. The idea that for the Capacity Factor to be higher the solar storage power station was generating electricity for more time was needed. It was insufficient to say that the Sun is reliable or it is in a hot desert or that it stores energy.

3

(a) This question was well answered with over half of students scoring 3 or 4 marks. The incorrect use of a calculator caused most problems, with the absence of brackets around part of the calculation, which resulted in an answer of 105 000. This would have gained 1 mark only for the temperature change being identified. A difficult unit, but many students had either learned it or worked it out from the information given in the question.

(b) Students found this question difficult with only a small minority of students scoring 3 or 4 marks. Lots of incorrect physics was seen which negated some marking points, electrons vibrating, rather than gaining kinetic energy or moving faster, for example. For students who described conduction by describing vibrations of atoms (or ions) a maximum of 2 marks was available. However, credit was given to students who made correct statements about both parts of the conduction explanation. Some students described the energy gained as ‘heat’ which is incorrect at an atomic level. If students failed to mention that the electrons were free, they were limited to scoring 3 marks.

Many answers were seen in which ‘cold’, ‘cold particles’ or ‘cold energy’ were being conducted. Some reasonable but incomplete answers were given in terms of ‘particles’; in such answers, a common mistake was to say that the particles would start to vibrate when given energy. Whilst a large number knew that conduction through metals involved ‘free electrons’, it was obvious that many did not understand the role which these played. Many answers gave a description relating to ‘particles’ then added that ‘free electrons also help the energy to be conducted’, without further explanation.

(c) Students found this question difficult with only a minority scoring 2 of the 3 marks available. Students who only discussed the air were generally more successful, gaining 2 marks for the idea that the warmed air becomes less dense and rises. Students who started their answer by talking about particle separation (first marking point) usually negated the second marking point by incorrectly describing particle density changing, then ‘warmer’ particles rising, which was insufficient for the third marking point; as convection is a bulk process it was necessary to say that the warmer air rises.

(d) Almost half of the students scored 1 mark. Many students referred to a large surface area, but there was confusion amongst some students relating to the colour of the cooling fins, many opting for ‘light and shiny to reflect the heat away’.

Any reference to external conditions was insufficient - temperature difference, for example. Fans were ignored as separate from the fins, as was the amount of air flow. Large surface to area volume was accepted also, but ‘thin’ was insufficient. Some students stated factors like ‘surface area’ without describing it as ‘large’ or ‘small’, etc.

4

(a) The majority of the students scored both marks for this calculation. There was some evidence that students may not have been equipped with calculators as a correct substitution had been written down but no subsequent answer provided.

(b) (i) This was answered well with just over three quarters of the students scoring both marks.

(ii) Nearly three quarters of the students recognised from the graph that the extension would increase and so the band would extend further. Only a quarter of the students were able to extrapolate the graph to give an acceptable value for the final extension. Unfortunately, some students incorrectly answered the question by describing the likely flight pattern of the glider when the accelerating force had been increased.

(c) (i) Perhaps surprisingly only around two thirds of the students identified the force to be 'weight'. The most frequent incorrect answer was 'drag'.

(ii) Most of the students knew that the downward speed would increase.

5 (a) (i) Less than half of the students scored this mark. A large number of students incorrectly stated that it was the time taken to stop under braking force. A small number of responses related braking distance to the total stopping distance or thinking distance, without answering the question asked.

(ii) Almost all of the students could state one correct factor. Incorrect answers generally related to thinking distance, such as the driver was tired, distracted or under the influence of alcohol. Despite being given speed in the question, some of the students still gave various versions of speed − how fast etc. as their answer.

(iii) Where students did not give a correct response it was clear that they had not read the question correctly. Many comments related increased speed to increased braking distance or increased time it would take to stop. Just fewer than half of the students scored this mark.

(b) Only a small proportion of the students correctly calculated the maximum speed of the car from the graph. Many chose to calculate the average speed. Those that calculated average speed often made errors in reading data from the graph, taking the distance to be 174 m. A few students calculated speed incorrectly by multiplying distance and time.

(c) (i) For a straight recall question this was surprisingly poorly answered with only about half of the students scoring the mark. Many incorrect responses suggested that momentum stopped or momentum is added. Some answers were in terms of conservation of energy and others simply stated that momentum is mass x velocity. A minority of the students confused momentum with moments, referring to clockwise and anticlockwise moments.

(ii) There were some well-presented correct answers with one third of the students scoring all three marks. However, a further eighth of the students did not understand how to complete the calculation and so scored two marks. Students who did correctly calculate the initial momentum often failed to calculate the combined mass of the two cars when substituting into the final equation. Other students were unable to correctly rearrange the equation. In some cases the wrong equation was used.

(d) Just over half of the students scored zero and only a very small proportion of the students scored all four marks.

The most common correct points given by students were that the time taken to slow down increased and that there was a smaller force exerted on the driver. The vast majority of incorrect responses were descriptive answers that did not contain any physics. Students often stated that without a seatbelt the driver would go through the windscreen. Some students incorrectly wrote about slowing down the time of impact. A significant minority of students wrote about how the seat belt spreads the force out across your body in an attempt to discuss reducing pressure rather than force. Very few students knew that seat belts stretch, although some did refer to them being elasticated or similar.

14 (a) (i) Almost all students answered this question correctly.

(ii) Almost all students answered this question correctly.

(iii) Almost all students answered this question correctly.

(iv) Just over a fifth of students drew a tangent and correctly calculated its gradient. Nearly two-thirds scored no marks, with the most common incorrect answer being to find the average speed by dividing total distance travelled by time.

(b) (i) The vast majoriy of students answered this questiion correctly.

(ii) Almost all students scored full marks for this question.

(iii) Whilst the majority of students correctly identified the transfer of energy taking place, only about a fifth stated the effect that this would have on heating up the brakes. The most common response was to indicate that the energy was transferred 'to the surroundings'.

15 (a) (i) This question was answered well with over three-quarters of students scoring the mark.

(ii) This question was answered well with most students scoring both marks.

(b) Whilst around three-quarters of students correctly chose wave **D**, less than a third were able to link the choice to the size of the gap needed for diffraction. A common incorrect response was that the wavelength itself was too long to fit in a classroom.

(c) (i) Around three-quarters of students correctly chose position **Q**.

(ii) Most students were able to gain one mark for the sound wave reflecting however, less than a fifth scored all three marks.

(iii) Less than half of responses were correct. There was evidence that students had not looked at the diagram in detail, and answered in terms of surface **EF** rather than **GH**.

(iv) Nearly all students correctly calculated the wavelength and scored both marks.

(v) Over two-thirds of students correctly linked the given frequency with the range of human hearing.

16

(a) Of the whole exam paper, this question had the highest percentage of students who did not attempt an answer. Around three-quarters of students correctly identified that four cells would be needed and drew the correct symbols. However, these were often joined by dotted lines, or not joined at all.

(b) The calculations were very well answered with nearly all students scoring both marks for part (i) and more than three-quarters scoring full marks for parts (ii) and (iii).

(c) (i) Around half of students had the correct idea. However, some failed to score both marks by just referring to either the fact that the transformer needs alternating current to work, or that the battery supplies direct current, but not referring to both. Incorrect answers commonly referred to the voltage being too high, or too low.

(ii) This calculation question was well answered, with around three-quarters of students scoring both marks.

17

(a) This question was quite well done, with some almost 'text-book' answers. Although only a small minority scored all six marks, around three-quarters of students scored at least two marks, usually for mentioning the 'magnetic field' and the 'current produced'. There were, however, a small number of confused answers relating to the motor effect. Having answered the question, a significant number of students went on to explain what would happen if the magnet were withdrawn / moved faster / moved slower etc.

(b) Half of the students scored at least two of the four marks. A common mistake was not relating the actions to the original movement of the magnet, so that comparisons of size and direction of current were not made.

(c) This was answered well, with nearly all students achieving both marks for the calculation, and nearly two-thirds scoring the mark for the correct unit.

18

(a) Nearly all students knew that frequency determines the pitch of a sound and that amplitude determines the loudness of a sound.

(b) (i) Nearly all students correctly described the trend shown in the table of length of tuning fork prong and frequency.

(ii) Nearly all students correctly measured the length of a tuning fork prong.

(iii) Over half of the students were able to correctly estimate the frequency of the tuning fork measured in part (i) from a table listing prong lengths and frequency. Some students mistakenly assumed a relationship of direct proportionality between prong length and frequency.

(c) (i) Nearly all students knew that ultrasound waves were produced by electronic systems.

(ii) Less than half of the students could explain that ultrasound waves could not be produced by a tuning fork because the very high frequency would require an extremely small fork according to the evidence given. Many wrote that ‘tuning forks can only produce frequencies within the human audible range’ so scored neither mark.

(d) Just under half of the students scored full marks for correctly determining a frequency from a trace on an oscilloscope screen. Many calculated frequency from 1 / 0.0005 instead of from 1 / (7 × 0.0005).

19

(a) Three-quarters of students knew why an energy storage system would work if the road surface was black. Many answers stated that 'black surfaces absorb heat' rather than 'absorb heat well'.

(b) (i) A quarter of students gave a correct definition of specific latent heat of fusion. However, many incorrect responses referred to melting rather than a change from solid to liquid.

(ii) Nearly all students correctly calculated the amount of energy required to melt the ice.

(c) (i) Two-thirds of students correctly stated that the variable to be controlled was mass of ice. The remainder stated that the mass of salt had to be controlled.

(ii) Two-thirds of students correctly ticked two boxes with suggestions as to why the student stirred the crushed ice.

(iii) Nearly all students could correctly describe the pattern of how mass of salt added to some crushed ice affected the melting point of the ice.

(d) Just under half of students scored full marks for a calculation of energy transferred given values of power and time in non-SI units. Conversion from: kW to W; and minutes to seconds, was required. The spread of marks demonstrated this, with a third of students dropping one mark.

(e) The Quality of Communication question brought together the elements of the entire question and asked for advantages and disadvantages of using energy storage, salt and undersoil heating for keeping a road free from ice in the winter. Most students used the available space and many used additional pages.

Three-quarters of students scored four marks or more. Some excellent work was seen, but many students wasted time by repeating much of what was in the question. Also they ended a very good account with an unnecessary summary. Some very well written work only addressed either an advantage or a disadvantage of each system.

20 (a) (i) Over three-quarters of students correctly described two ways in which a spring changed shape when a mass was suspended from it. Some stated the same thing twice with 'got longer' and 'extended' or 'bigger distance between the loops'.

(ii) Nearly three-quarters of students correctly described how the spring could be tested to see if it behaved elastically.

(b) (i) Nearly all students were able to score at least two out of three marks for completing **Table 1** with a value of extension and explaining their value.

(ii) Just less than half of the students correctly suggested a value of force at which the spring exceeded its limit of proportionality and gave a reason.

(c) (i) Nearly all students knew that the type of energy stored in the loaded spring was elastic potential energy.

(ii) Less than a third of students gave the correct two reasons out of five stating why a value in **Table 2** was anomalous.

(iii) Over four-fifths of students calculated the correct mean value of time in **Table 2** leaving out the anomalous value.

(iv) Hardly any students scored a mark where they were asked why raw values of time were given to three significant figures and mean values given to two significant figures. Instead of referring to the precision of a stopwatch and comparing this with human reaction time, they thought that it was something to do with making the plotting of a graph easier.

(v) Just under three-quarters of students correctly suggested that extra masses would be needed to get more results, but relatively few stated that that they should be smaller masses eg 50 g. Many of those who scored both marks also correctly referred to the value of force beyond which the spring may no longer behave elastically.

21 (a) (i) Just over a half of all students correctly identified the energy transfers for an electric car.

(ii) Just under two fifths of the students were able to state that waste energy is transferred into the surroundings. Weaker students forgot that the question was about an electric car and confused the wasted energy with exhaust gases. Others thought the waste energy is recycled and used again.

(b) The majority of students were able to substitute the energy values given in the question into a correct equation. Most tried to express the answer as a percentage, but about one third of students failed to gain maximum marks because they either neglected to insert the % sign after the number 70 or they quoted the efficiency as 0.7 but then put either a % sign or a unit after the number.

22 (a) (i) About one third of the students correctly chose two control variables, a further quarter were able to identify one control variable. A common reason for not gaining marks was not being specific with their answers, e.g. simply saying ‘temperature’ rather than ‘starting temperature’.

When a control variable is asked for, credit is not normally given for saying that the same equipment should be used, e.g. ‘use the same thermometer each time’.

(ii) A low proportion of students appreciated that bar graphs are used when one of the sets of data is categoric. Most simply referred to the ease of comparing results or the ease of drawing bar graphs.

(iii) About half of the students identified that concrete needed the most energy to increase its temperature by 5°C. The majority of these recognised this was because the heater had been on for longer. Students were expected to compare the time for heating concrete with the times for the other materials and not simply state that the bar was higher or that it took a long time.

(iv) Three quarters of the students could correctly substitute into the appropriate equation and calculate the correct energy transfer.

(b) (i) Four fifths of the students correctly identified the anomalous result as the one after 10 minutes.

(ii) Many students did not appreciate that when a line of best fit is required any anomalous results are ignored. A line of best fit should have as many points below the line as above the line. Just over a half of students drew an acceptable line of best fit.

(iii) A third of the students appreciated that the block was at room temperature when the heater was switched on and were able to extrapolate their line of best fit back to the temperature axis and correctly record the intercept. Common incorrect responses were the lowest and highest plotted temperatures plotted on the graph.

(iv) About three fifths of the students knew that the interval is the time between each reading.

23 (a) A low proportion of students could give an advantage and a disadvantage of a nuclear power station compared with a gas-fired power station. A further quarter could give either an advantage or a disadvantage. Too many answers were vague and referred simply to pollution, rather than naming a gas. A common misunderstanding was to say that nuclear power stations give out carbon dioxide gas. A common misreading of the question was to give an advantage for a nuclear power station and a disadvantage for a gas-fired power station.

(b) (i) Nearly two thirds of the students were able to substitute a power and time value into the correct equation. A low proportion of students were able to convert the given power into kilowatts.

(ii) Just over a half of students were able to state that the wind is a variable and unreliable source of energy. The figure of 30% proved a distractor for weaker students who often quoted that 70% of the energy was wasted. Those students who mentioned that the output was weather-dependent were not given credit. The key aspect is variation in wind speed or power. Some students appear to believe that wind turbines are operated by supplying them with electrical energy, and are shut down to conserve energy.

(c) Two fifths of the students were able to give an advantage of underground cables compared with overhead cables. Too many statements were vague, students were expected to give some detail of why underground cables are less likely to be damaged. There are still a large number of students who believe that birds will be electrocuted if they land on overhead power cables.

24 (a) (i) This was a standard demand question. Around a third of students correctly answered the question asked. Many students answered the question ‘what does frequency mean?’

(ii) This was a high demand question. Around one-quarter of students achieved all three marks. Nearly two-thirds were able to carry out the calculation correctly, but either failed to see the instruction to give their answer to three significant figures, or did not understand what this meant.

(b) This was a standard demand question. Although around a half of students scored one or two marks out of the four available, very few achieved all four. Many students seemed confused as to what the question was asking, and stated a fact about the first wave for ‘Conclusion 1’ and a fact about the second wave for ‘Conclusion 2’. It was common to see ‘a louder sound’ linked to ‘increased wavelength’. Whilst many correctly identified the second wave as having a greater frequency, the reason often referred to a shorter wavelength, instead of more waves in the same time. Students need to recall that the horizontal axis on a CRO represents time.

25 (a) A very small amount of students did not identify conduction as the process by which energy is transferred through copper.

(b) The majority of students answered correctly, of those who did not score the mark, the most common error was misreading the number on the x-axis (for a temperature increase of 35°C) as 30,500 instead of 35,000.

(c) Around half of students scored two of the three marks available. This was usually for performing the calculation correctly, but failing to give the correct unit.

(d) A very low proportion of students did not attempt this question, with less than a fifth scoring the mark. The most common incorrect answers referred to faulty apparatus, incorrect measurements or values not as stated in the question, e.g. the block was not 2kg.

26 (a) (i) Just over three quarters of the students scored this mark. The most common error was to give the answer ‘Moving at constant speed’.

(ii) Just over two fifths of the students were able to draw the correct line. The most common errors were; to join the line for the fullest extent available from (0,0) to (300,500); draw their line from (0,0) to (200,400) or to add a horizontal step to the line. A small proportion of students made no attempt at all.

(b) The correct answer was given by nearly four fifths of the students. Unfortunately, a number of students did not understand that it is the unit of acceleration that includes a square and not the numerical value that needs to be squared. These students wrote out the correct numerical equation included the units, then went on to square the numerical value for acceleration.

27

(a) This was well answered with three fifths of the students scoring all three marks. There seemed no real pattern to the errors that were made.

(b) (i) Just over three fifths of the students scored this mark.

(ii) Only just over half of the students were able to correctly add the potential differences of the two cells. Many of the incorrect answers resulted from the students multiplying the potential differences together.

(iii) Nearly three fifths of the students scored this mark.

(c) (i) Only about a third of the students scored this mark. Many students failed to realise that the bar graph indicated both the number of resistors and current had changed and gave either of these quantities as the answer. Using the same ammeter was another common incorrect answer. A minority of students stated that the control variable does not change without actually identifying a control variable.

(ii) A majority of the students could see the pattern of reducing current and scored one mark for drawing a bar of reduced height. About a fifth of the students were able to score the second mark by accurately drawing this bar at the value of 1.0 amps.

(iii) Over four fifths of the students were able to express an answer in terms of ‘as the number of resistors increases, the current decreases’. Common errors were to have the two functions both increasing or both decreasing. Other unacceptable answers were that the number of resistors changed or affected the current without writing in which direction the change would be.

28

(a) Many students did not appreciate that the question simply wanted an answer of zero and the simple reason that the paintball was not moving. Many students tried to explain how the gun worked or give an answer in terms of forces.

(b) The correct numerical value was given by the majority of the students. Those students not scoring both marks generally made the error of multiplying or dividing their correct answer by a factor of 10.

(c) Only a small proportion of the students scored this mark. Most students thought that the momentum would be ‘greater than’, presumably these students did not know the law of conservation of momentum or did not appreciate that the question referred to both the gun and paintball.

29 (a) (i) Most students could correctly identify one of the plug terminals but surprisingly, fewer than half of the students could correctly identify all three.

(ii) Virtually all of the students were aware that a suitable insulating material was needed for the casing of a three-pin plug. Most students gave the answer ‘plastic’ or an acceptable named plastic.

(b) (i) About four fifths of the students were able to substitute into the correct equation chosen from the Physics Equation Sheet and to calculate the power of the drill.

(ii) Very few of the students scored all of the three marks available. Many of the students were able to deduce from the information provided about the 1200W drill that it would cause the cable inside the casing to be overloaded but fewer of the students stated that this would definitely result in heating with the possibility of a fire developing. Some students thought that the extension cable provided the power and so the 1200W drill would not work. A significant number of students answered in terms of fuses blowing and there are still many students that state that anything electrical will blow up if there is a problem of any kind.

(c) Although many of the students correctly identified X as the best drill, under half of the students were able to give the reason for their choice in terms of the increased efficiency or smallest energy input or least money to operate.

30 (a) This was well answered with just over four fifths of the students scoring both marks. A small number of students used the correct equation but changed the mass into grams. Some of the students were unsure of the positioning of the decimal point after their multiplication of the values provided.

(b) (i) Less than half of the students indicated that the electrical charge was due to the friction between the slide and the child. There were few answers indicating that this charge would be transferred between the child and the slide. Unfortunately many answers were in terms of positive charge movement or ‘positive electrons’.

(ii) This part question provided few answers which deserved any marks, the majority of the students writing that the child's hair stood on end due to attractive forces or repulsion from the slide.

(iii) Again poorly answered with only a quarter of the students scoring the mark. Some of the students realised that a metal slide would result in the charges going to earth, but most of the students scored the mark for simply stating that metal is a conductor of electricity.

31 (a) (i) Just over two thirds of the students scored this mark.

(ii) Nearly half of the students gave an acceptable answer to score this mark.

(iii) There was generally a lack of detail in the answers with most marks being achieved by a description of the velocity changes occurring with little reference to the forces involved. Popular misconceptions were that the graph represented a hill that the cyclist had to ascend or that the graph was a distance-time graph and the cyclist would become stationary at point Z. Many of the students described in great detail practical details of cycling and the fatigue of the cyclist without referring to the question asked. Many of the students used the term speed to refer to the constant force applied to the pedals resulting in answers such as ‘he moves at constant speed causing velocity to increase’. A significant number of the students answered in terms of direction changing, many doing so at the same time as mentioning that the cyclist was on a straight road. Few of the students realised that the graph indicates that the acceleration was decreasing but that the velocity was still increasing but at a slower rate to become steady between Y and Z with the forces being balanced. Most students achieved Level 1 to score 1 or 2 marks.

(b) (i) The calculation was relatively straightforward with four fifths of the students arriving at a correct answer. However only a quarter of the students were able to give the correct unit.

(ii) Nearly three fifths of the students scored one mark, generally for identifying that the kinetic energy would decrease. Only a small proportion of the students scored both marks. A common incorrect answer to the second part was friction.

32 (a) (i) Fewer than two fifths of the students drew the correct thermistor symbol. Some of the students drew a symbol for an incorrect component, often a variable resistor, LED or LDR. Drawings of bead thermistors were quite common, as were a box or circle with just the letter T in it.

(ii) The majority of the students substituted the data and calculated the correct answer. There were very few calculation errors, but a number of the students did not rearrange the equation correctly. The most common mistake was to use the temperature value, 20°C, for either current or potential difference.

(iii) This question was poorly answered with only a small proportion of students scoring the mark. The majority of the students drew an upwards sloping straight line.

(iv) The majority of the students were able to answer this question correctly.

(b) Only a quarter of the students answered this question correctly. There were some high quality explanations of why the ammeter in series should have low resistance so as not to affect the current it is measuring. Many of the students scored zero with answers such as ‘it lets the current flow easily’, ‘it lets more current go through’ and ‘it stops it overheating’.

(c) This question was well answered by just over half of the students. Some students failed to score the mark because they merely threw in a word from the ‘How Science Works’ lexicon, for example ‘it makes it more accurate / reliable / valid / fair’. A few misunderstood the question and explained why scientists in different countries use different temperature scales or stated that it made it easier to convert the units.

(d) Nearly half of the students scored one mark, usually for recognising that a light source was needed to replace the Bunsen burner. A smaller number of the students went on to gain the second mark for realising that the thermometer was redundant and a light meter was required. Some did not know the name of the scientific apparatus but gave an acceptable description of ‘a device that measures the amount of light’. Many of the students missed marks because they gave answers like ‘use light not heat’ but did not refer to the specific apparatus. Others stated what needed removing but not what should replace it, or vice versa. There were a few totally wrong ideas e.g. ‘use a better thermometer’, ‘increase / decrease the battery voltage’ and ‘add / remove change the ammeter / voltmeter’. It was clear that many students did not make good use of the example given in the stem of the question.

33 (a) A large proportion of the students scored zero on this question, many because of their failure to use the idea of momentum. The majority of these answers included reference to forces, commonly beginning ‘every action has an equal and opposite reaction’ etc. Some of the students picked up marks for stating that momentum is conserved or words to that effect and a smaller number picked up a mark for realising that the initial momentum was zero. Some students related the situation to an explosion but still struggled to score more than one mark. However, those who understood the situation were able to give clear answers gaining full marks.

(b) Over half of the students scored zero on this calculation. Many added the masses together before attempting to calculate any momentum, and there was a general lack of clear understanding. Very few of the students scored a mark for stating that momentum was conserved but some compensation marks were scored for finding the final momentum of the skateboarder.

34

(a) Nearly three fifths of the students gave the correct answer, 'number of protons'. Many of the students did not understand the term 'in common' and instead, wrote about the differences between isotopes.

(b) (i) About two fifths of the students correctly stated that nuclei are split in nuclear fission. Most of the remaining students had an idea of what happens but used ambiguous and vague terminology, using 'break apart', 'divide' 'particles' without supporting explanation and thus lacked sufficient clarity to obtain the mark.

(ii) A lack of clarity again stopped students obtaining this mark with only about two fifths naming the reactor as the part where molybdenum is produced.

(c) About two thirds of the students identified the radiation as beta. However the reasons given were often confused, imprecise and sometimes contradictory. Examples seen include: 'atomic number stays the same but number of protons goes up', 'nucleus loses a proton and gains a neutron', 'nucleus loses a neutron but gains a proton and an electron', etc. Less than a third of the students gave complete answers that correctly gave the marking points in the mark scheme.

(d) Only less than a third of the students gave answers sufficient to score the mark. A small proportion of the students gave an answer in terms of the count rate halving.

(e) (i) About two thirds of the students recognised that the number remaining was 20,000 but then less than half of these students used the graph to correctly identify 6.2-6.3 days as the time required. A small amount of students drew lines on the graph at 80,000 and identified 0.8 days but half of them, then carried out further calculations on this and consequently lost the compensation mark.

(ii) Fewer than a third of the students scored the mark for the ionising effect of radiation; of those who did, they usually went on to score the second mark. Most of the students that scored the second mark did so for general terms about radiation 'causing cancer' or some form of harm. Few students linked the ionising effect of radiation to damage or harm to individual cells or DNA.

(iii) Many of the students reiterated statements from part e(ii) about the dangers of radiation rather than answering the question asked. Students' phrasing of their response was often confused with only about a fifth being able to describe that the benefits outweighed the risks.

35

(a) A very low proportion of students scored both marks, with a fifth of the students gaining 1 mark. Over two thirds of students scored zero.

(b) Just under a third of students gained the mark for identifying light.

(c) Most students gained 2 marks for completing this calculation successfully.

(d) Just under two thirds of students identified the correct answer of killing cancer cells.

36

(a) Students were able to select and use the correct equation successfully and scored both marks for this calculation.

(b) Just over a quarter of the students correctly stated anti-clockwise moment.

(c) (i) Three quarters of the students accurately determined the force from the graph.

(ii) Only a tenth of the students failed to state the correct conclusion from the graph.

37

(a) This was poorly answered with very few students able to identify that short-sight can be caused by the eyeball being too long.

(b) Over half of the students failed to identify lens A, and so scored zero. Of those students that did select lens A, only half stated the correct reason. Some students referred to the properties of the material rather than the optics here.

(c) Over two thirds of the students gained the mark.

(d) Most students gained both marks in this calculation.

(e) Only a fifth of the students failed to gain the mark.

(f) The majority of students were able to select and apply the correct equation but then inverted the calculation when using the calculator, ie 14 / 70.

38

(a) The vast majority of students could identify the system as hydraulic.

(b) The majority of students scored both marks for the calculation.

(c) Most students correctly identified the advantage as environmental.

39

(a) Many students attempted to describe how ultrasound is used rather than defining it. Other answers were vague, eg ‘cannot be heard’ but without further qualification. Some thought ultrasound was an electromagnetic wave and some thought ultrasound was the gel applied when a scan is carried out.

(b) Few students gained all 3 marks for this calculation. Over two thirds of the students failed to take the echo into account and so scored 2 marks. About one student in ten failed to gain any marks.

(c) Just under two thirds of the students stated a correct medical use of ultrasound scanning. Many students who did not gain the mark were often not specific enough in their answer; ‘baby scanning’ was a common response that was not sufficient.

(d) Many students did not read the question carefully, so the advantages and disadvantages given were not comparative. Many responses were about patient perceptions or cost. A number of students reversed their responses giving the advantages as disadvantages.

40 (a) Almost two thirds of the students correctly calculated the total moment. Some added the weights and distances prior to multiplying them. Only half of the students who correctly calculated the moment could correctly state the unit. A number of students lost the unit mark by mixing upper and lower case letters.

(b) Many students failed to follow the instruction in the question that clockwise and anticlockwise moments are needed in the explanation, with a third of students scoring zero. A further third scored one mark. Many students referred to forces rather than moments, or simply used the word ‘balanced’ without relating it to the moments.

41 Many students failed to process the information supplied in the graph, and often just stated values. Less than one student in twenty gained all 3 marks.

42 (a) Over four fifths of students recalled it was a hydraulic system, but there was a range of misspellings used.

(b) About four fifths of the students gained full marks for the calculation using standard form.

(c) Half of the students gained 1 mark in this societal aspects of science question. Many did not score as their answer was too vague or because they gave a disadvantage of the usual oil. A small number wrote correctly about the conservation of fossil fuels but most who answered in terms of fossil fuels wrote about the negative side of using them.

(d) Students struggled to apply their knowledge to the given situation of a loudspeaker. Written responses often failed to show a logical progression. A small proportion of students scored 3 or 4 marks. There was widespread confusion with the transformer. Few students referred to a force or to the direction of the force changing as the direction of the current changes. Very few mentioned ‘force’ but some stated ‘attraction / repulsion’. Descriptions often did not include the direction of the force changing when then current changed direction.

43 (a) About two-thirds of the students scored full marks for the calculation of pressure when given values for force and cross-sectional area. The remainder lost a mark for giving an incorrect unit for pressure.

(b) (i) Nearly all students were able to match the dimensions given on a diagram with those in a table of results.

(ii) Nearly all students were able to draw the trajectory of water from a bottle giving both the vertical and horizontal distances of the trajectory.

(c) About half of the students were able to suggest a problem that might arise from trying to collect data from a hole close to the bottom of the bottle.

44 (a) (i) Nearly all students knew that the moment of a force is the turning effect of the force.

(ii) Less than half of the students were able to state what is meant by centre of mass of an object. Many referred to a region within the object rather than a point.

(b) Almost all students were able to calculate a moment of a force.

(c) (i) Very few students scored the three marks for describing and explaining the movement of a previously-balanced plank whose pivot had been moved away from the centre of mass of the plank. The idea that the weight of the plank now provided a moment was not understood.

(ii) This high-demand calculation was successfully performed by about a quarter of the students.

45 (a) (i) Three-quarters of the students knew the frequency range of human hearing.

(ii) Three-quarters of students knew what ultrasound is.

(iii) Nearly all students could state a medical use of ultrasound. Most referred to viewing a fetus but other statements such as 'pregnancy testing' and 'looking at babies' did not score the mark.

(b) The calculation which involved rearranging the wave equation and using data given in standard form was very well answered by the vast majority of students.

(c) Ultrasound waves were emitted and the reflected waves from an object, moving away, were detected. Less than one-fifth of the students could correctly describe the differences between the emitted and reflected waves because it was often not clear which wave was being referred to in the answers.

46 (a) (i) Less than three-quarters of students identified the image in the ray diagram as being magnified and upright.

(ii) More than half of the students gained full marks for a calculation using the lens formula that required a minus sign in the answer. Most of the remaining students forgot to invert the value for the final answer.

(b) Most students knew that a minus sign meant that the image was virtual.

47 (a) Only a tenth of students correctly described the action of a solar panel. The remainder described a photovoltaic cell which is not in the specification.

(b) The remainder of the question concerned photovoltaic cells which were introduced here.

The calculation to find the time to transfer a certain amount of energy, given a certain value of power available gained full marks from a quarter of the students. The calculation involved the interpretation of data given in standard form, the conversion of kJ to J and the final answer given in minutes. Another quarter of the students only dropped one mark for leaving the answer in seconds.

(c) (i) Students were required to take the difference between two meter readings in this part

(ii) multiply the answer by 40p in this part

(iii) work out a payback time for some photovoltaic cells in this part.

The two readings were three months apart and many students had problems relating this time to the correct fraction of a whole year. Although nine-tenths of students correctly completed the first two steps far less scored the marks in this part.

(iv) Almost two-thirds of students correctly stated the assumption behind the calculation of payback time.

(d) Most students knew that specific weather conditions such as cloud cover would affect the energy transferred during daylight hours.

48 (a) (i) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(ii) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(iii) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(iv) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(b) (i) Only half of the students could name two variables that had to be controlled when using the runway elsewhere. The most common non-scoring answer was ‘keep the length of the runway the same’.

(ii) Eight-tenths of students correctly interpreted the results of a test using the runway in a park showing the grass to be long and uneven.

(c) (i) Nearly all students correctly described the pattern in a table of relative humidity and distance travelled by the ball.

(ii) Less than a quarter of students were able to show that the data in the table showed inverse proportionality.

(iii) Three quarters of students were able to give a reason why the data used in part **(ii)** might not allow a conclusion to be made. The answer ‘it is from the Internet so might be unreliable’ was accepted, but the more astute answer was that the data was taken from a very small range of values of relative humidity.

(d) The question ‘What is the difference between distance and displacement?’ alone might have produced better answers than was seen here. Because it was set in the context of the question, students mostly forgot to state that one is scalar and one is a vector. More than half of the students scored zero.

49 (a) (i) Three-quarters of students knew that the energy possessed by a car at the top of a slope is gravitational potential.

(ii) Nearly all students knew that the energy the car possessed after rolling down the slope was kinetic.

(b) (i) Just over half of the students knew that the acceleration on a velocity-time graph of the car slowing down on a horizontal surface, was represented by its slope. There were many vague statements like 'the line'.

(ii) Three quarters of students knew that the distance travelled on a velocity-time graph was represented by the area under the graph.

(iii) Students were asked to draw a second line on the velocity-time graph to show the motion of the car if its brakes had been lightly applied when it reached the bottom of the slope. This was very well answered with three-quarters of the students gaining full marks.

(c) (i) Students had to calculate two values of average speed for two trolleys from two sets of values of distance and time.

Three-quarters of the students were able to calculate the average speeds, but only a fifth of them gave the answers to two significant figures. In such situations students, are expected to give the answers to a suitable number of significant figures to match the other data in the table.

(ii) Students had to state and justify whether the distances, velocities and accelerations for the two trolleys were the same.

The distances were not the same because two different values had been given.

The speeds were the same to two significant figures. Because students usually had correct values of 31.0 and 30.8 for the velocities, they often argued that these values were not the same. In future, students will be expected to exercise better judgment in experimental situations and consider whether values are, more than, for example, 5% apart.

Despite the trolleys slowing down from the same initial velocity in different times and distances, many students stated that there was not enough evidence to judge whether the negative accelerations were the same.

Despite that, a third of the students did score full marks.

50 (a) Nearly all students recognised two situations that represented conduction and convection.

(b) (i) Almost all students were able to read the starting value of temperature from a cooling curve.

(ii) Nearly all students correctly calculated the temperature fall from the cooling curve. Those who got it wrong gave the value of the temperature reached rather than the change in temperature.

(iii) The given graph showed the cooling curves for three cups of different cross-sectional areas. Students were asked which cup showed the greatest rate of cooling. Only half of the students were able to give a reason because they did not refer to temperature drop in a given time.

(iv) A diagram of a fourth container was given and students had to draw the expected cooling curve on the same axes. This was well done with four-fifths of students scoring full marks.

(v) Nearly all students recognised that the lowest temperature reached after four hours was also room temperature.

(c) (i) The calculation of energy transferred from the water, where the mass of water was given in grams, was correctly done by two-thirds of the students.

(ii) The explanation of evaporation causing the cooling of water was very poorly answered with half of the students scoring zero marks. Many students described convection and very few referred to the reduction in the mean energy of the particles when the most energetic had escaped from the surface of the water. Only a tenth of students scored three or four marks.

51 (a) Most students recognised the transformer illustrated as being a step-down transformer.

(b) (i) Most students were able to complete a table with values of potential difference from the input and output of the transformer.

(ii) Most students knew that the values of potential difference produced by the National Grid were larger than those given in the question.

(c) (i) Only half of the students gave an adequate description of the difference between a.c and d.c., for example, ‘a.c. flows in two directions whereas d.c. only flows in one direction’. A quarter of students scored zero. Their explanations often used ‘ways’ instead of ‘directions’ and referred to ‘positive’ and ‘negative’.

(ii) The explanation of how a transformer works was poorly answered with more than a third of students scoring zero out of four.

Many answers only referred to the number of turns on each coil. Very few students mentioned the changing magnetic field in the primary coil and others stated that there was a current in the core.