1 A student carries out an investigation to determine how the resistance of a metal varies with temperature.

A resistor is made from a coil of wire. The resistor is placed in a beaker of hot water as shown in the photograph. The resistance is measured for different temperatures of the water as it cools.

(a) (i) Explain two precautions the student should take to ensure that her results are accurate.

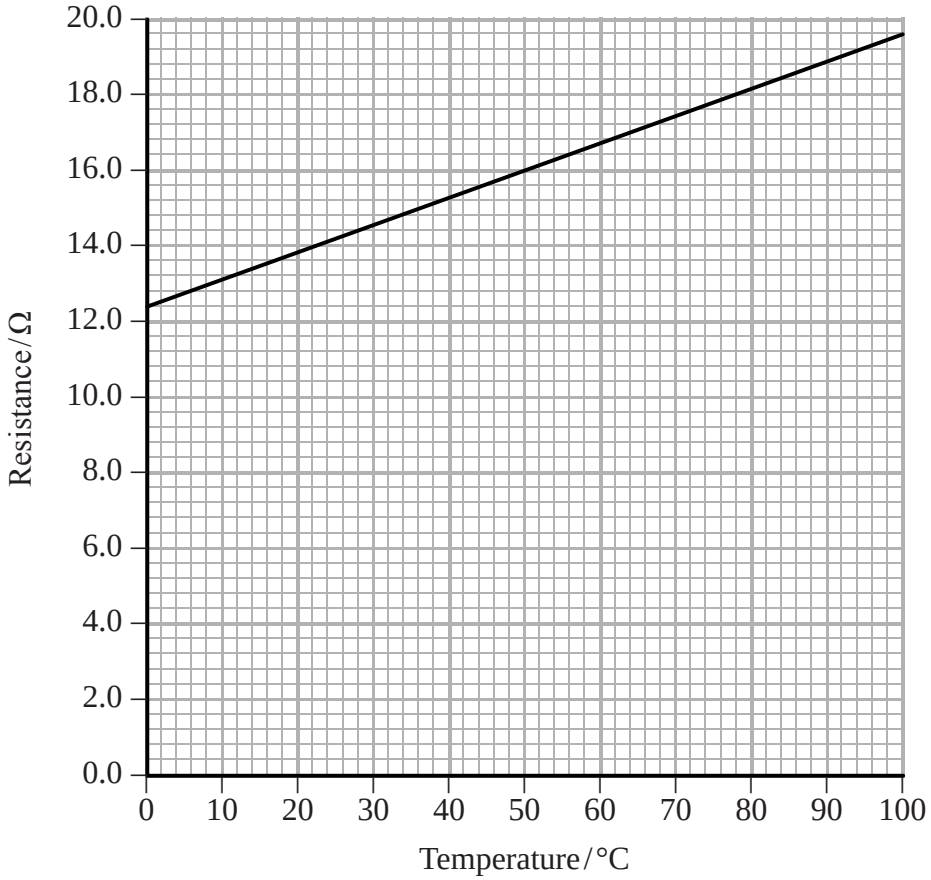
(2)

(ii) The student used a thermometer and ohmmeter.

State why it would have been better to use a temperature sensor and resistance sensor attached to a data logger.

(1)

(b) The results of the investigation are shown in the graph.



(i) The graph shows that resistance is **not** directly proportional to temperature in °C. State how the graph shows this.

(1)

(ii) Explain the graph in terms of the structure of the metal.

(4)

(c) The resistance of the coil of wire is 12.4 Ω at 0 °C.
Calculate the length of wire in the coil.
resistivity of the metal = 9.71×10^{-8} Ω m
diameter of wire = 8.13×10^{-5} m

(3)

Length =

(d) The resistor from the investigation is placed in series with a fixed resistor of resistance 24 Ω. A potential difference of 12 V is applied across the two resistors in series.

Using information from the graph in (b), determine the temperature for which the potential difference across the resistor from the investigation will be 4.5 V.

(3)

Temperature =

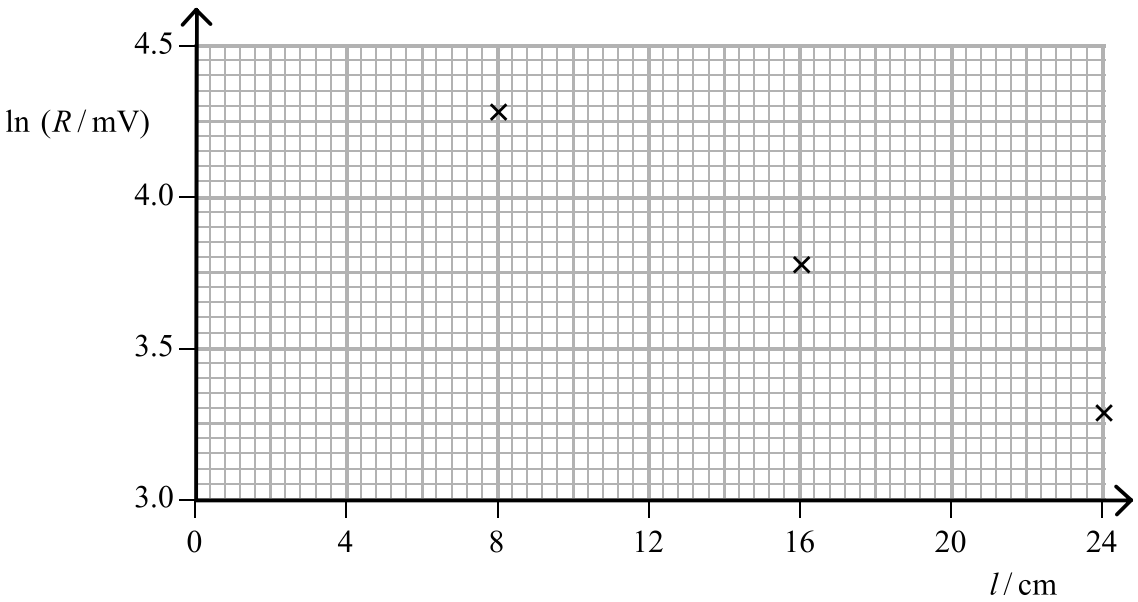
(Total for Question = 14 marks)

2 A student carries out a practical involving a length of jelly. She places an infrared transmitter at one end and a receiver at the other. She obtains the following results.

Length of jelly *l* / cm	**Receiver reading *R* / mV**	**ln (*R* / mV)**
8.0	72	4.28
12.0	57	
16.0	43	3.76
20.0	33	
24.0	26	3.26

(a) Complete the table above and the graph below.

(2)



(b) The student reads that infrared light in jelly can be mathematically modelled using the equation $R = R_0 e^{-\mu l}$ where μ is a constant.

Use your graph to determine a value of μ for the jelly.

(2)

$\mu =$

(Total for Question = 4 marks)

3 A student is investigating the physics of an electric guitar. When a string on a guitar is plucked, a standing wave is produced with one antinode.

The student finds that the speed of a wave, v, in a stretched string is given by

$$v \quad \sqrt{\frac{T}{\mu}}$$

where T is the tension in the string and μ is the mass per unit length of the string.

The student decides to measure the diameters of the strings and the frequency of the fundamental note produced when each string is plucked. She then constructs a spreadsheet to record these results and to calculate v, μ and T for each string.

The strings are made of a material of density (mass per unit volume) 7800 kg m^{-3}.

	A	**B**	**C**	**D**	**E**	**F**	**G**
1	Length / m	Frequency / Hz	Speed / m s^{-1}	Diameter / mm	Volume of a 1 metre length / 10^{-6} m^3	Mass per unit length / 10^{-3} kg m^{-1}	Tension / N
2	0.655	82	107	1.240	1.210	9.42	108
3	0.655	110	144	0.914	0.656		106
4	0.655	147	193	0.711	0.397	3.10	115
5	0.655	196	257	0.457	0.164	1.28	84
6	0.655	247	324	0.356	0.100	0.78	
7	0.655	330	432	0.279	0.061	0.48	90

(a) (i) The formula to calculate the value of cell C3 is

= 2*A3*B3

Explain why this is the correct formula.

(2)

(ii) Write the formula to calculate the value of cell E3.

(1)

(iii) Write the formula to calculate the value of cell F4.

(1)

(iv) Hence calculate the value of cell F3.

(1)

(v) Calculate the value of cell G6.

(2)

(b) The student decides to verify the equation $v \sqrt{\frac{T}{\mu}}$ by using one string.

She removes a string from the guitar and clamps one end in a support. She varies the tension by hanging known weights on the other end of the string. The speed of the wave is calculated from the length of the string and the measured frequency of the fundamental note when the string is plucked.

Describe how the student could use a graph to verify the equation.

(3)

(Total for Question = 10 marks)

4 A student carries out an experiment to investigate how the volume occupied by a gas depends upon the temperature.

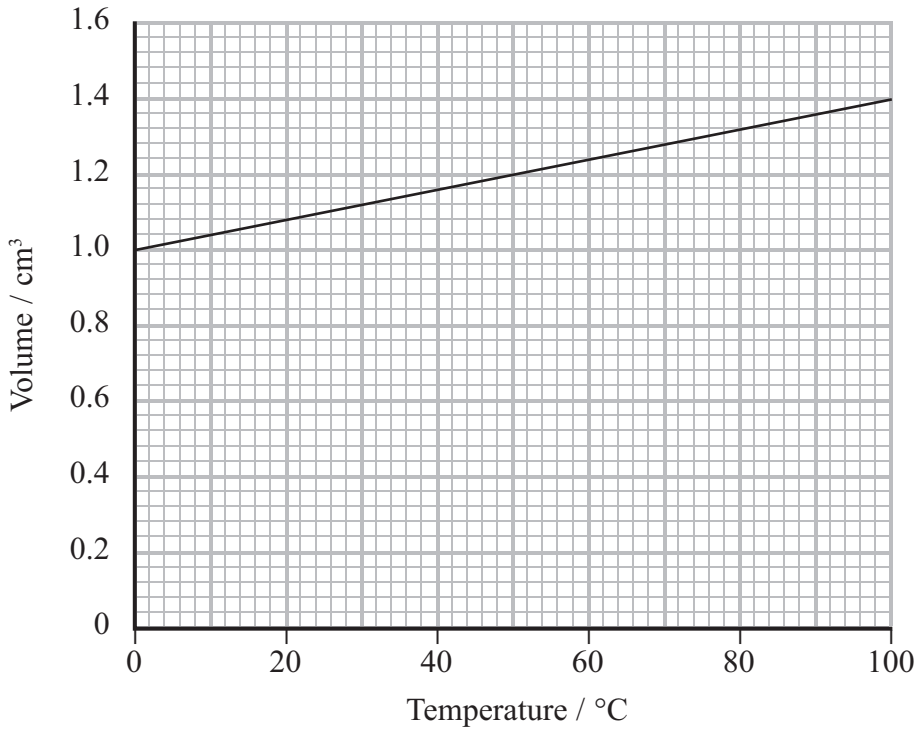
(a) What variables must the student control in this investigation?

(2)

.....

.....

(b) The following graph is obtained.



Explain how graphs such as this provide evidence for an absolute zero of temperature.

(2)

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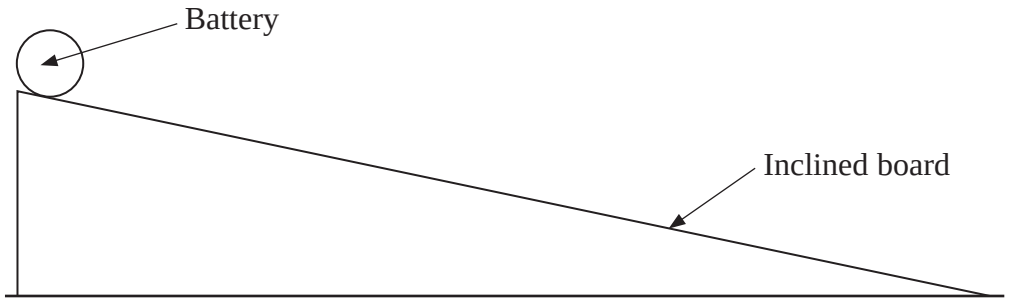
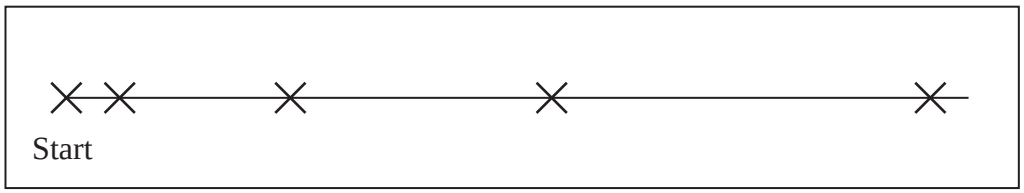
(Total for Question 4 marks)

5 A group of students was asked to find how the velocity of a cylindrical battery changes as it rolls down an inclined board.



The group marked the position of the battery on the board every second with an X.



(a) These markings were used to obtain the following results table.

(i) Complete the table.

(3)

		A	**B**
Time / s	**Distance from start position / m**	**Average velocity in previous second / m s^{-1}**	**Average velocity from the start / m s^{-1}**
0.0	0.00	0	0
1.0	0.18	0.18	0.18
2.0	0.84		
3.0	1.75		
4.0	3.14	1.39	0.79

(ii) Justify which of the columns, A or B, gives a more accurate value for the velocity of the battery at the bottom of the inclined board.

(1)

(b) The only two pieces of equipment that the students used were a measuring tape and a manual stopwatch.

Give a possible source of error and suggest changes to the equipment and method used to make the values in column A more accurate.

(3)

Source of error

Changes

(Total for Question = 7 marks)

6 Physical quantities can be vectors or scalars.

(a) Describe what is wrong with each of the following statements.

(3)

A car has a mass of 10 000 N acting vertically downwards.

.....

.....

The velocity of light from the Sun is 3×10^8 m s ^{1}.

.....

.....

The car slowed down with an acceleration of 2.5 m s ^{2}.

.....

.....

(b) A car travels 45 km due north and then 30 km due east.

(i) Calculate the total distance travelled by the car.

(1)

.....

Total distance travelled .....

(ii) Calculate the displacement of the car.

(3)

.....

.....

.....

.....

Magnitude of displacement .....

Direction .....

(Total for Question 7 marks)

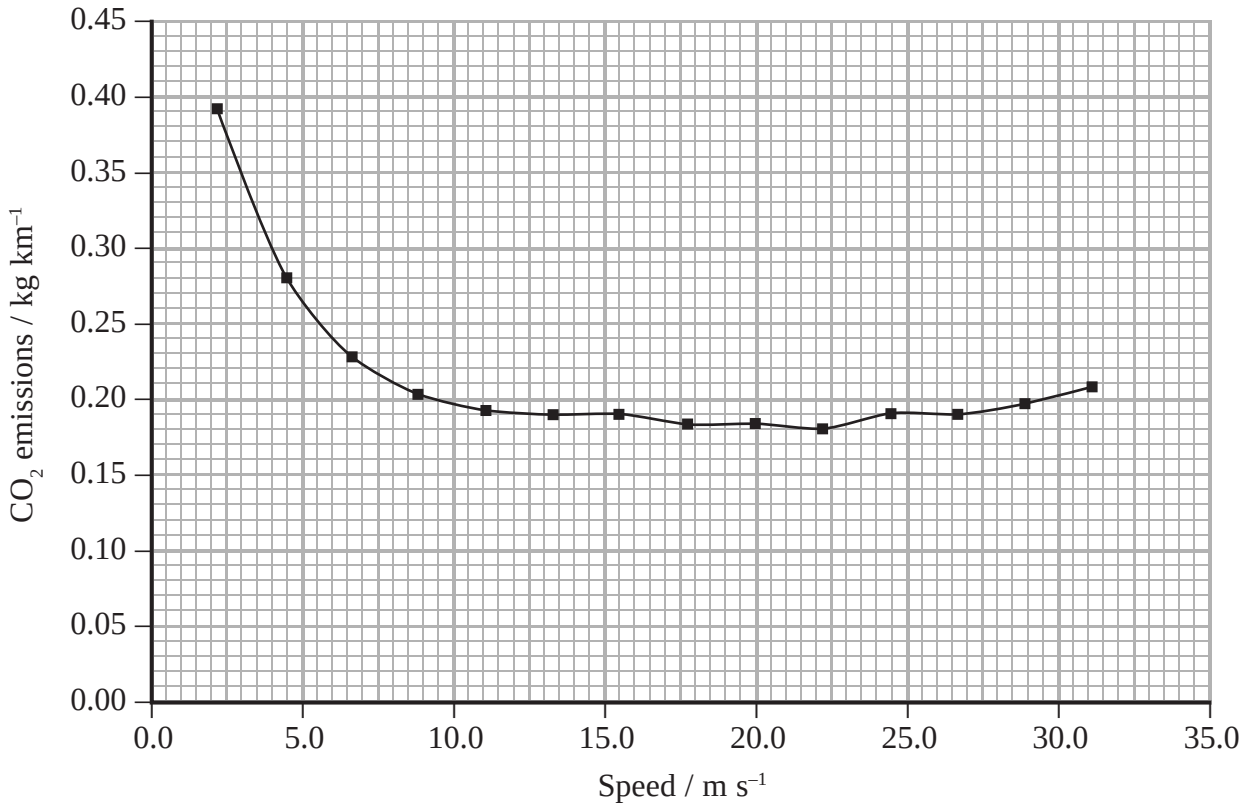
7 Queues of cars often form behind cyclists on narrow, rural roads.

Sometimes cars that would normally travel at 65 km hour^{-1} may be limited to about 20 km hour^{-1} by a cyclist.

(a) Show that 65 km hour^{-1} is about 18 m s^{-1}.

(1)

(b) The graph shows the amount of carbon dioxide emitted per kilometre by a typical car at different speeds.



During a 10 minute journey a cyclist, travelling at 5 m s^{-1}, has an average of three cars queuing behind him. The cars would otherwise be travelling at 18 m s^{-1}. The cars emit more carbon dioxide because they are travelling slowly.

(i) Calculate the extra carbon dioxide emitted by the 3 cars due to travelling at this reduced speed for 10 minutes.

(4)

Extra carbon dioxide emitted =

(ii) If the cyclist had made the same journey in his car at 18 m s^{-1}, his car would have emitted 0.54 kg of carbon dioxide. Comment on the significance of this.

(1)

(Total for Question 13 = 6 marks)

8 (a) Explain the difference between scalar and vector quantities.

(1)

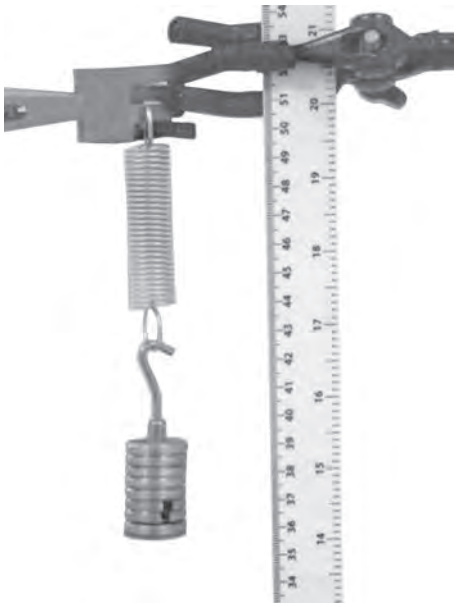
(b) When asked to run one complete lap around a track, a student says, “However fast I run, my average velocity for the lap will be zero”.

Comment on his statement.

(3)

(Total for Question = 4 marks)

9 The apparatus shown can be used to determine the spring constant k of a spring.



*(a) Describe how the apparatus can be used to accurately obtain the measurements needed.

(4)

(b) Describe how the measurements would be used to determine a reliable value of *k*.

(3)

(c) State why it is important not to exceed the limit of proportionality of the spring.

(1)

(Total for Question = 8 marks)