Leaving Certificate Physics

Experiment Book

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Mechanics

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The variation of the Resistance ***R*** of a Thermistor with Temperature ***d***
NOTE: could be a metal wire instead of thermistor

Acceleration Due to Gravity ï Pendulum Method

A student investigated the relationship between the period and the length of a simple pendulum. The student measured the length ***l*** of the pendulum. The pendulum was then allowed to swing through a small angle and the time ***t*** for 30 oscillations was measured. This procedure was repeated for different values of the length of the pendulum.

The student recorded the following data.

l /cm	40.0	50.0	60.0	70.0	80.0	90.0	100.0
t /s	38.4	42.6	47.4	51.6	54.6	57.9	60.0

Why did the student measure the time for 30 oscillations instead of measuring the time for one?

The pendulum used consisted of a small heavy bob attached to a length of inextensible string.

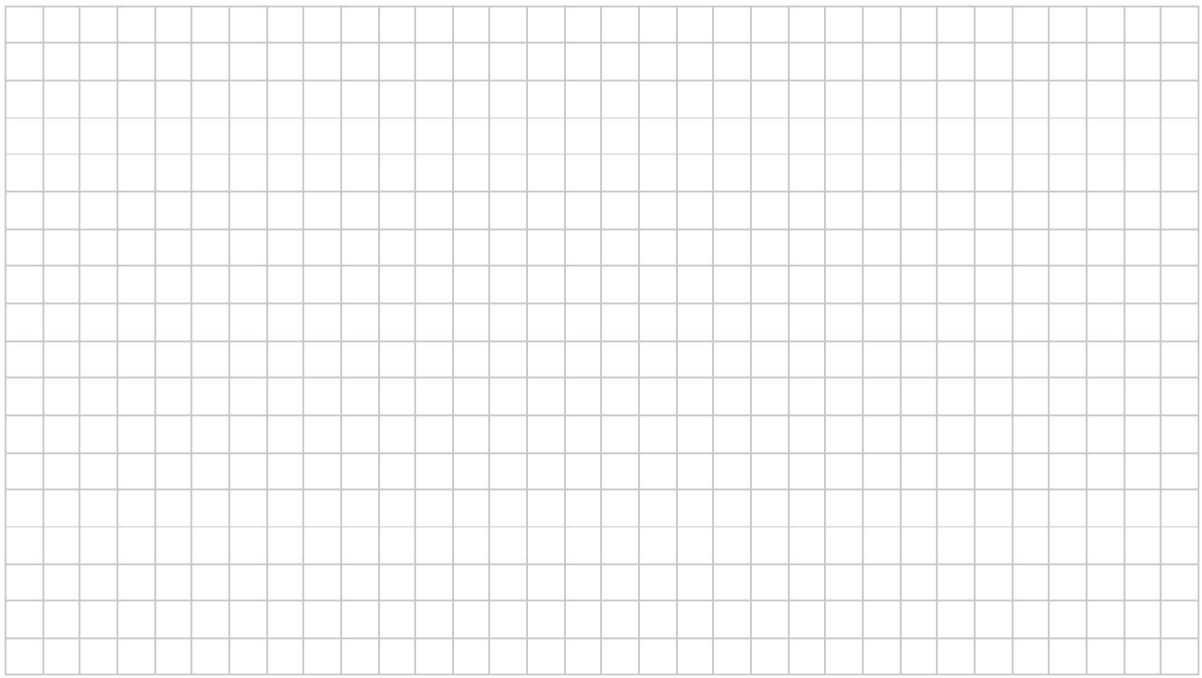
Explain

(i) why a small heavy bob was used;

(ii) why the string was inextensible.

How did the student ensure that the length of the pendulum remained constant when the pendulum was swinging?

Describe how the pendulum was set up so that it swung freely about a fixed point. Include a diagram in your answer.



Give two precautions taken when allowing the pendulum to swing.

Using the recorded data draw a suitable graph to show the relationship between the period and the length of a simple pendulum.

Use your graph to calculate the acceleration due to gravity.

What is the relationship between the period and length of a simple pendulum and how does your graph show this relationship?

Graph

Acceleration Due to Gravity ï Free Fall method

In an experiment to measure the acceleration due to gravity, the time ***t*** for an object to fall from rest through a distance ***s*** was measured. The procedure was repeated for a series of values of the distance ***s***. The table shows the recorded data.

s/cm	30	50	70	90	110	130	150
t/ms	247	310	377	435	473	514	540

Draw a labelled diagram of the apparatus used in the experiment.

Describe how the time interval ***t*** was measured.

Calculate a value for the acceleration due to gravity by drawing a suitable graph based on the recorded data.

Give two ways of minimising the effect of air resistance in the experiment.

Graph

Measurement of Velocity and Acceleration

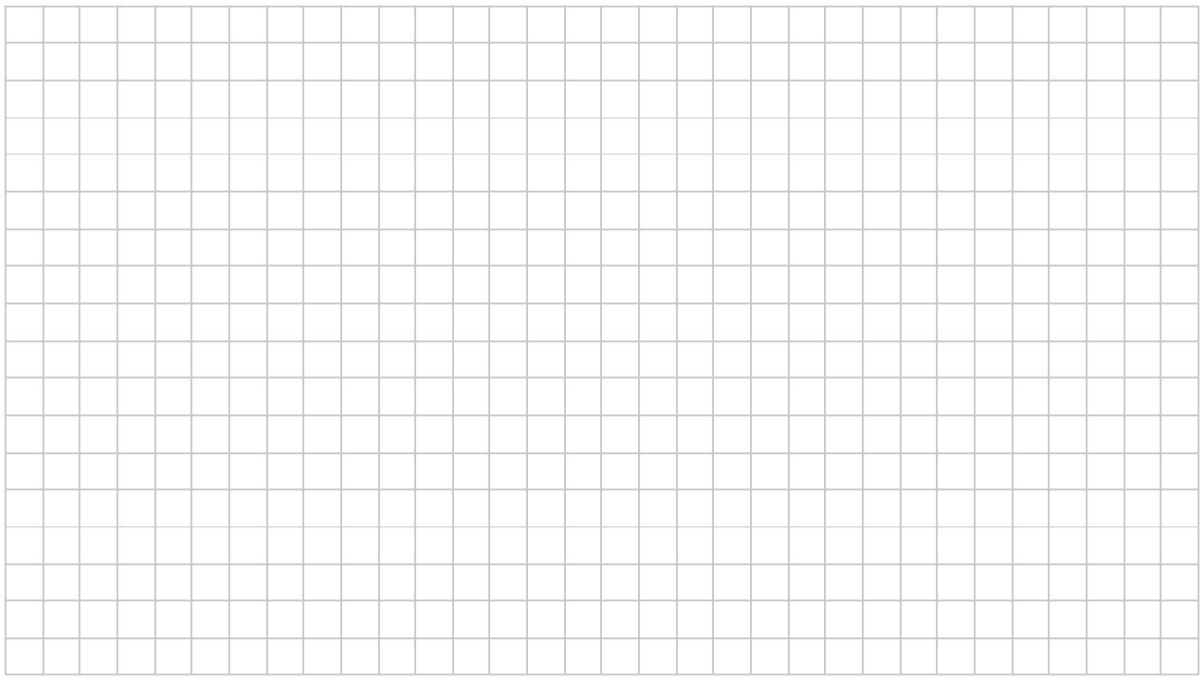
A student set up an apparatus to measure the constant velocity of a trolley along a track.

Draw a diagram of the apparatus used in this experiment.

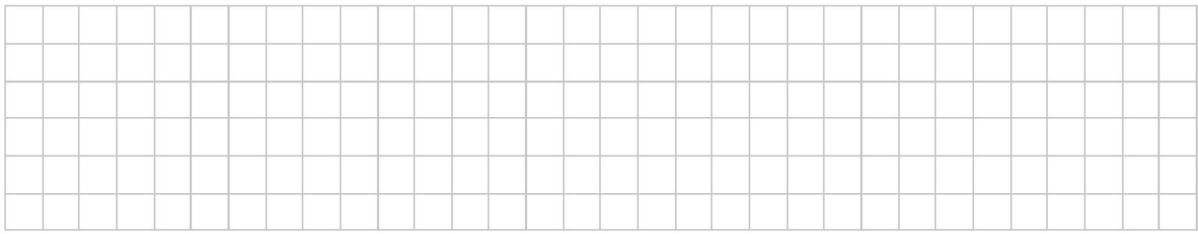
How did the student set up the track so that the trolley moved at a constant velocity.

What measurements did the student need to take to ensure the trolley moved at a constant velocity?

Describe how the student took these measurements.

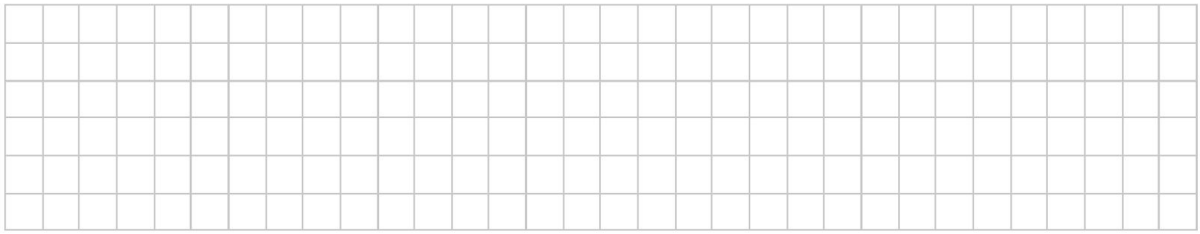


When the trolley moved at a constant velocity along the track, what was the net force acting on the trolley?

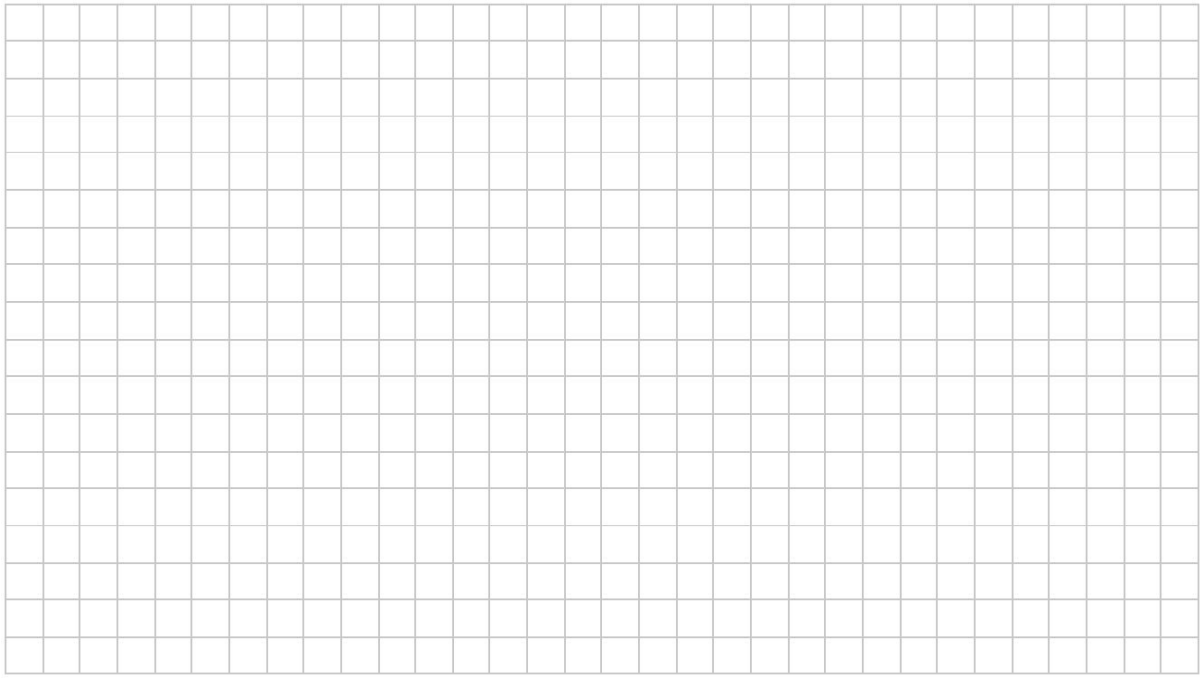


The student then adjusted the track so that the trolley would accelerate as it moved. What adjustments did she make to the track?

What measurements did she need to take to measure the acceleration of the trolley?



Describe how these measurements can be used to find the acceleration of the trolley.



Investigation of the Laws of Equilibrium for a Set of Coplanar Forces

A student investigated the laws of equilibrium for a set of coplanar forces acting on a metre stick. The student found that the centre of gravity of the metre stick was at the 50.4 cm mark and its weight was 1.2 N.

The student recorded the following data.

position on metre stick/cm	11.5	26.2	38.3	70.4	80.2
magnitude of force/N	2.0	4.5	3.0	5.7	4.0
direction of force	down	up	down	up	down

Explain how the centre of gravity was found.

Explain how the weight of the metre stick was found.

Explain how the upward forces and downward forces were determined.

Why is the centre of gravity of the metre stick not at the 50.0 cm mark?

The student applied vertical forces to the metre stick and adjusted them until the metre stick was in equilibrium. How did the student know that the metre stick was in equilibrium?

Calculate:

(i) the net force acting on the metre stick

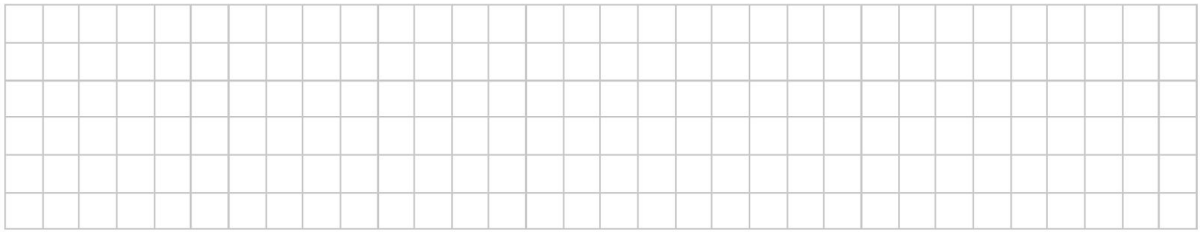
(ii) the total clockwise moment about a vertical axis of the metre stick

(iii) the total anti-clockwise moment about a vertical axis of the metre stick.

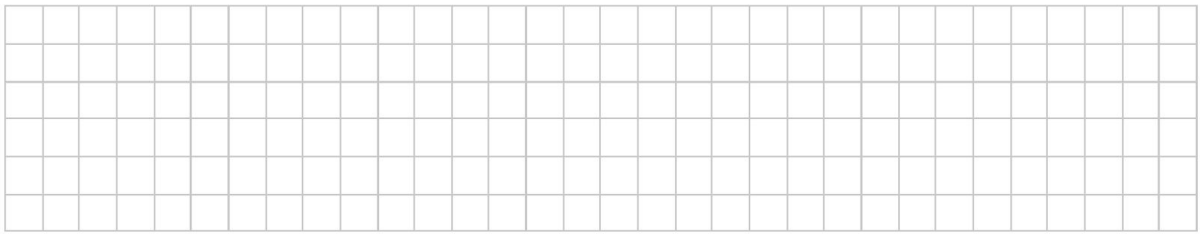
(iv) Use these results to verify the laws of equilibrium.

Calculate the sum of the clockwise moments and the sum of the anticlockwise moments about an axis through the 10 cm mark on the metre stick.

Explain how these experimental values verify the second law of equilibrium for a set of coplanar forces.



Why was it important to have the spring balances hanging vertically?

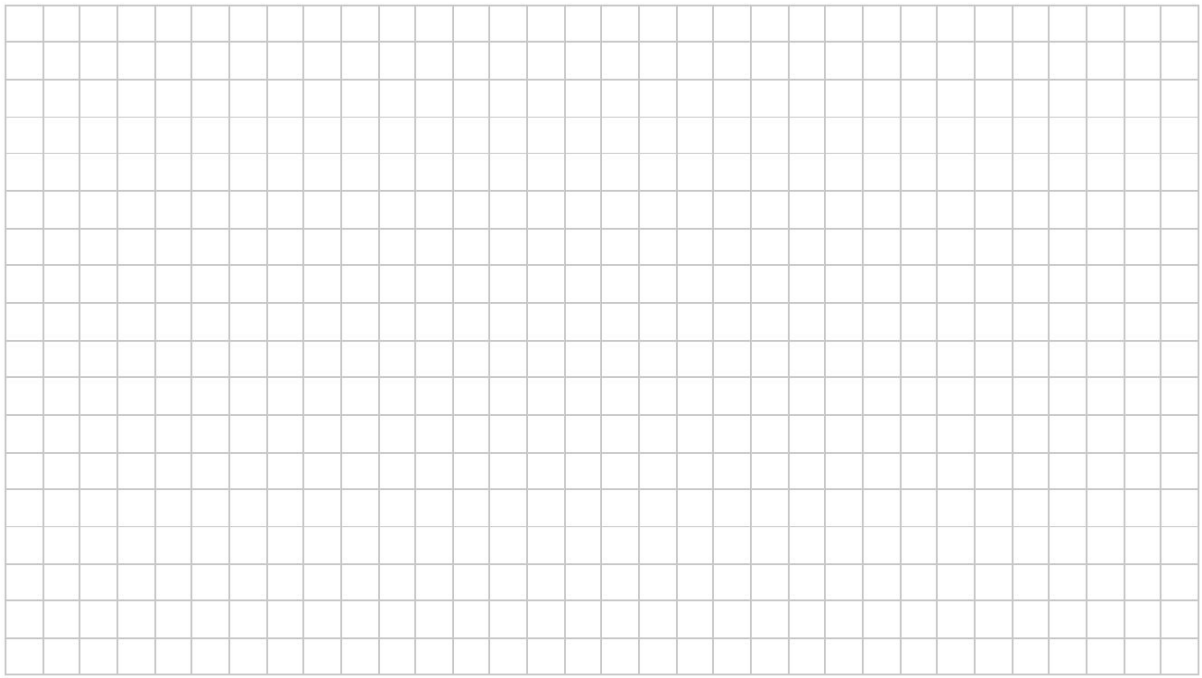


Relationship between Force and Acceleration ï Force = mass x acceleration

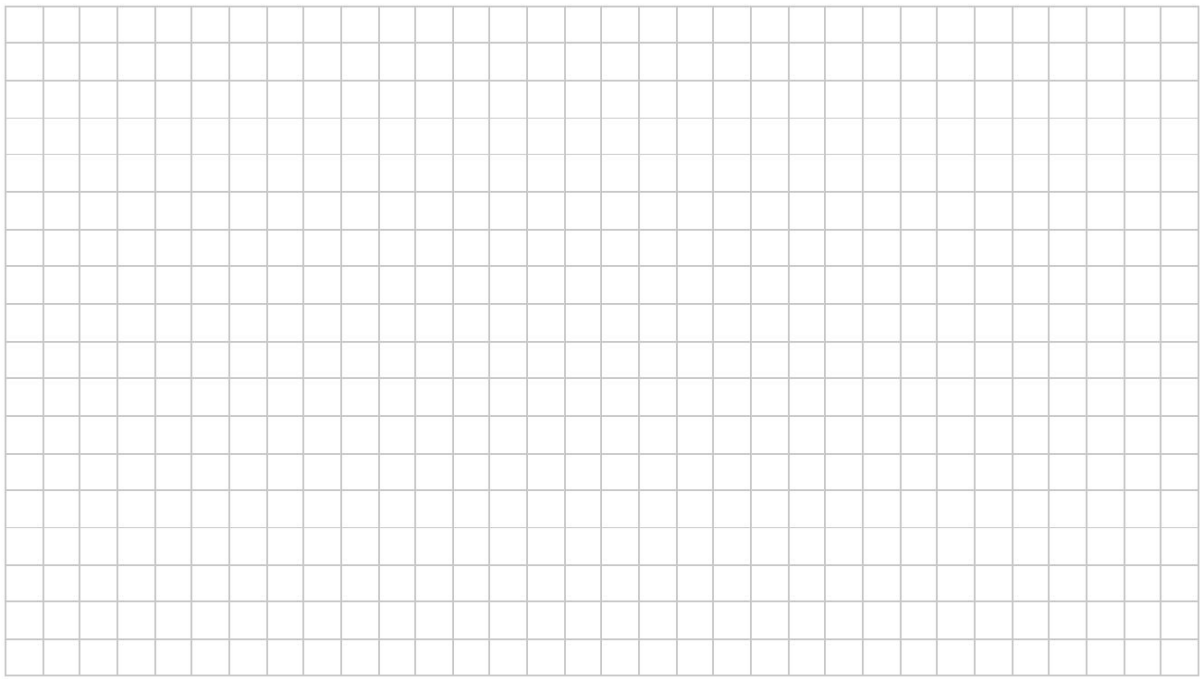
In an experiment to investigate the relationship between force and acceleration a student applied a force to a body and measured the resulting acceleration. The table shows the measurements recorded by the student.

Force /N	0.1	0.2	0.3	0.4	0.5	0.6	0.7
acceleration /m s^{-2}	0.10	0.22	0.32	0.44	0.55	0.65	0.76

Draw a labelled diagram of the apparatus used in the experiment.



Describe how the student measured the applied force.



Draw a suitable graph on graph paper to show the relationship between acceleration and applied force.

What is the relationship?

How does your graph verify this?

Calculate the slope of your graph and hence determine the mass of the body.

Give two precautions that the student took during the experiment.

How was the effect of friction reduced in the experiment?

Graph

Principle of Conservation of Momentum

In an experiment to verify the principle of conservation of momentum, a body A was set in motion with a constant velocity. It was then allowed to collide with a second body B, which was initially at rest and the bodies moved off together at constant velocity.

The following data was recorded.

Mass of body A = 520.1 g
Mass of body B = 490.0 g
Distance travelled by A for 0.2 s before the collision = 10.1 cm
Distance travelled by A and B together for 0.2 s after the collision = 5.1 cm

Draw a diagram of the apparatus used in the experiment.

How did the student measure the mass of the trolleys?

State what measurements the student took and how these measurements were used to calculate the velocities.

Describe how the time interval of 0.2 s was measured.

When carrying out this experiment the student ensures that there is no net external force acting on the bodies. What are the two forces that the student needs to take account of to ensure this?

Using the data,

(i) calculate the velocity of the body A (i) before, (ii) after, the collision;

(ii) show how the experiment verifies the principle of conservation of momentum.

How were the effects of friction and gravity minimised in the experiment?

Boyle's Law – Pressure x Volume = constant

In an experiment to verify Boyle's law, a student measured the volume ***V*** of a gas at different values of the pressure ***p***. The mass of the gas was not allowed to change and its temperature was kept constant.

The table shows the data recorded by the student.

p/ kPa	120	180	220	280	320	380	440
V/cm3	9.0	6.0	5.0	4.0	3.5	3.0	2.5

Describe with the aid of a diagram how the student obtained this data.

Draw a suitable graph on graph paper to show the relationship between the pressure of the gas and its volume.

What is the relationship between pressure of a gas and volume?

Explain how your graph verifies Boyle's law.

Use your graph to estimate the pressure of the gas at a volume of 4.7 cm^3.

Describe how the student ensured that the temperature of the gas was kept constant.

Why might the temperature of the gas have changed significantly during the experiment?

Give two precautions that the student took in carrying out the experiment.

Name the units used when measuring pressure and volume.

Graph

Specific Heat Capacity of Water

The specific heat capacity of water was found by adding hot copper to water in a copper calorimeter. The following data was recorded.

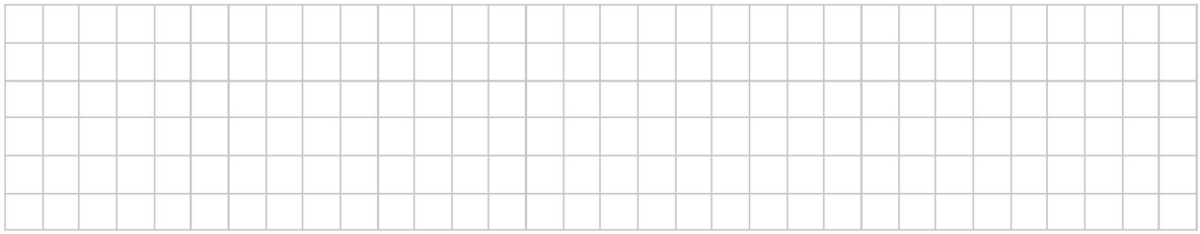
mass of calorimeter	55.7 g
mass of calorimeter + water	101.2 g
mass of copper + calorimeter + water	131.4 g
initial temperature of water	16.5 ºC
temperature of hot copper	99.5 ºC
final temperature of water	21.0 ºC
Specific Heat Capacity of Copper =	390 J / Kg / k

Describe how the copper was heated and how its temperature was measured.

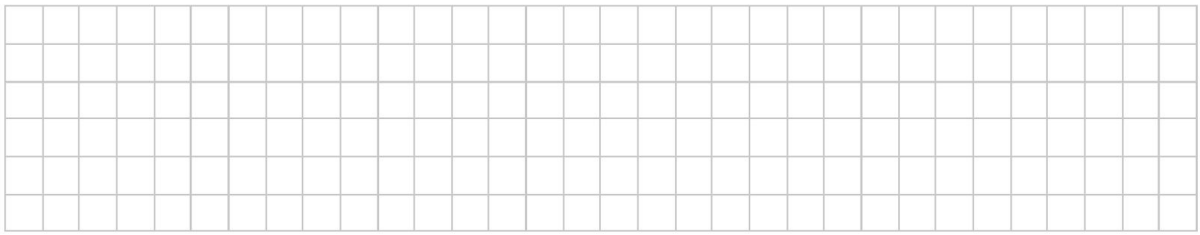
Using the data, calculate the energy lost by the hot copper.

Using the data, calculate the specific heat capacity of water.

Give two precautions that were taken to minimise heat loss to the surroundings.



Explain why adding a larger mass of copper would improve the accuracy of the experiment.



Specific Latent Heat of Fusion of Ice

In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in a copper calorimeter. Dried, melting ice was added to the warm water and the following data was recorded.

mass of calorimeter	60.5 g
mass of calorimeter + water	118.8 g
temperature of warm water	30.5 °C
mass of ice	15.1 g
temperature of water after adding ice	10.2 °C
Specific Heat Capacity of Water =	4200 J / Kg / K
Specific Heat Capacity of Copper =	390 J / kg / K

Explain why warm water was used.

Why was dried, melting ice used?

What was the advantage of having the room temperature approximately halfway between the initial temperature of the water and the final temperature of the water?

Describe how the mass of the ice was found.

How did the student prepare the ice for the experiment?

How did the student know the ice was at 0 ^{o}C?

Why did the student use warm water in the experiment?

What should be the approximate room temperature to minimise experimental error?

Calculate the energy lost by the calorimeter and the warm water.

Calculate the specific latent heat of fusion of ice.

The accepted value for the specific latent heat of fusion of ice is 3.3×10^5 J kg^{-1}, suggest two reasons why your answer is not this value.

Specific Latent Heat of Vaporisation of Water

In an experiment to measure the specific latent heat of vaporisation of water, cool water was placed in an insulated copper calorimeter. Dry steam was added to the calorimeter.

The following data was recorded.

Mass of calorimeter =	50.5 g
Mass of calorimeter + water =	91.2 g
Initial temperature of water =	10 °C
Temperature of steam =	100 °C
Mass of calorimeter + water + steam =	92.3 g
Final temperature of water =	25 °C
Specific Heat Capacity of Water =	4200 J / Kg / K
Specific Heat Capacity of Copper =	390 J / kg / K

Draw a labelled diagram of the apparatus used in this experiment.

Why was dry steam used? How was the steam dried?

Why is the rise in temperature the least accurate value?

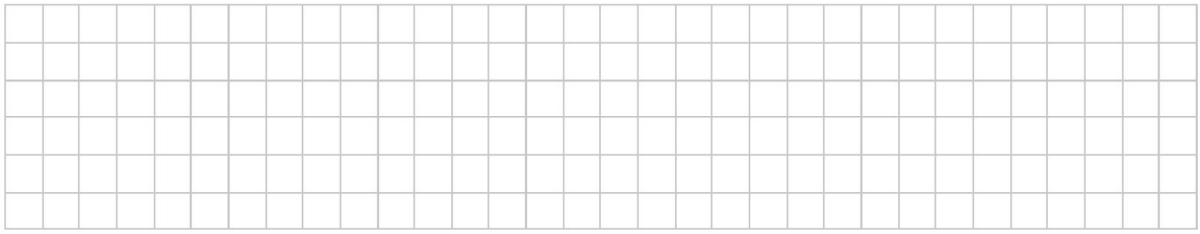
Describe how the mass of the steam was found.

Calculate a value for the specific latent heat of vaporisation of water.

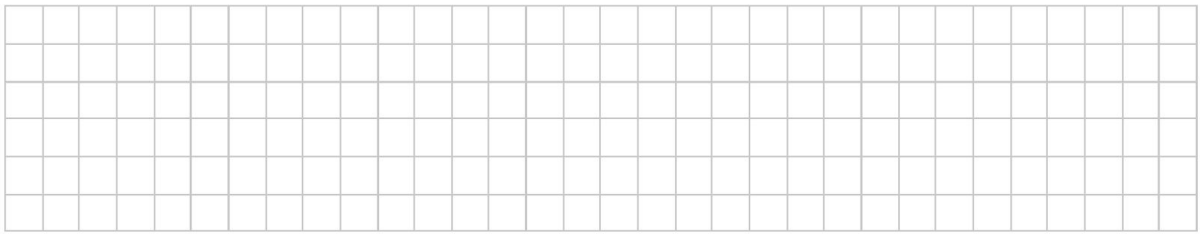
Give two ways of improving the accuracy of this value.

A thermometer with a low heat capacity was used to ensure accuracy. Explain why.

State why it was necessary to ensure that the steam did not condense before it entered the calorimeter and explain how this was achieved.



What was the advantage of having cold water in the calorimeter initially?



True or false? ‘Heat lost or gained = energy lost or gained?’

Calibration Curve of a Thermometer

A student carried out an experiment to obtain the calibration curve of a thermometer.

The following is an extract from her report.

"I placed the thermometer I was calibrating in a beaker of water along with a mercury thermometer which I used as the standard. I recorded the value of the thermometric property of my thermometer and the temperature of the water as shown on the mercury thermometer. I repeated this procedure at different temperatures. The following is the table of results that I obtained."

Temperature/°C	0	20	40	60	80	100
Value of thermometric property	4	12	24	40	64	150

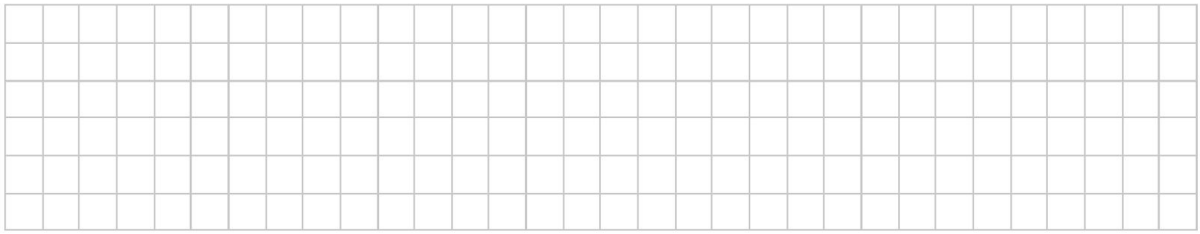
Draw a labelled diagram of the apparatus used in the experiment.

Using the data in the table, draw a graph on graph paper of the value of the thermometric property against its temperature.

Use your graph to estimate the temperature when the value of the thermometric property is 50.

How was the value of this thermometric property measured?

What is the difference between heat and temperature?



What is the S.I. unit of temperature?

What is meant by a thermometric property?

What is the thermometric property that an alcohol in glass tube thermometer is based on?

Graph

Focal Length of Concave Mirror

In an experiment to measure the focal length of a concave mirror, an approximate value for the focal length was found. The image distance ***v*** was then found for a range of values of the object distance ***u***. The following data was recorded.

u/cm	15.0	20.0	25.0	30.0	35.0	40.0
v/cm	60.5	30.0	23.0	20.5	18.0	16.5

Describe how the student could have found an approximate value for the focal length of the mirror before starting the experiment.

What was the advantage of finding the approximate value for the focal length?

Describe, with the aid of a labelled diagram, how the position of the image was found.

Give two sources of error in this experiment.

Calculate the focal length of the concave mirror by drawing a suitable graph based on the recorded data.

Focal Length of Converging Lens

A student was asked to measure the focal length of a converging lens. The student measured the image distance ***v*** for each of three different object distances ***u***.
The following is part of the students report:

"I found the approximate focal length of the lens. I then placed an object at different positions in front of the lens so that a real image was formed in each case."
The student recorded the following data.

u/cm	20.0	30.0	40.0
v/cm	65.2	33.3	25.1

Describe, with the aid of a labelled diagram, how the student found the position of the image.

Why was the experiment repeated several times?

How did the student find an approximate value for the focal length of the lens?

Describe how the image distance was measured.

Give two sources of error in measuring the image distance and state how one of these errors can be reduced.

What difficulty would arise if the student placed the object 10 cm from the lens?

What is meant by a real image and a virtual image?

Using the data above, find an average value for focal length of the lens.

Draw a suitable graph on graph paper and use it to find the focal length of the lens.

Graph

Why does a graph give a more accurate value for focal length?

Snellâs law ï Sin i / Sin r = Constant - Refractive Index of a Material

In an experiment to verify Snell's law, a student measured the angle of incidence ***i*** and the angle of refraction ***r*** for a ray of light entering a substance. This was repeated for different values of the angle of incidence. The following data was recorded.

i/degrees	20	30	40	50	60	70
r/degrees	14	19	26	30	36	40

Describe, with the aid of a diagram, how the student obtained the angle of refraction.

How did the student measure the angle of refraction?

Draw a suitable graph on graph paper and explain how your graph verifies Snell's law.

From your graph, calculate the refractive index of the substance.

How does your graph verify Snell's Law?

The smallest angle of incidence chosen was 20^{o}. Why would smaller values lead to a less accurate result?

Using a graph to calculate a value for the refractive index is a more accurate method than calculating the refractive index for each pair of angles and then finding the mean. Give two reasons for this.

Graph

To Measure the Refractive Index of a Liquid

In an experiment to measure the refractive index of a liquid using the real depth apparent depth method, the following data was recorded.

Real Depth / cm	17.3	14.2	12	9.1
Apparent Depth / cm	13.1	10.7	9.0	6.8

Draw a labelled diagram of the apparatus used in the experiment.

Describe how the student recorded the above measurements.

Using the values given, calculate a value for refractive index of the liquid.

Give two sources of error in this experiment and say how these errors could be avoided.

The Variation of Fundamental Frequency and Tension

A student investigated the variation of the fundamental frequency ***f*** of a stretched string with its tension ***T.*** The following is an extract of the student's account of the experiment.

"I fixed the length of the string at 40 cm. I set a tuning fork of frequency 256 Hz vibrating and placed it by the string. I adjusted the tension of the string until resonance occurred. I recorded the tension in the string. I repeated the experiment using different tuning forks."

The following data were recorded.

f /Hz	256	288	320	341	384	480	512
T /N	2.4	3.3	3.9	4.3	5.7	8.5	9.8

Draw a labelled diagram of the apparatus used in this experiment.

How was the tension measured?

How did the student know that resonance occurred?

What is the relationship between fundamental frequency and tension and how does your graph show this relationship.

Draw a suitable graph to show the relationship between the fundamental frequency of a stretched string and its tension.

Use your graph to

(i) estimate the fundamental frequency of the string when its tension is 11 N;

(ii) calculate the mass per unit length of the string.

From your graph, estimate the tension in the string when its fundamental frequency is 380 Hz.

Why was it necessary to keep the length constant in this experiment?

How did the student know that the string was vibrating at its fundamental frequency?

Graph

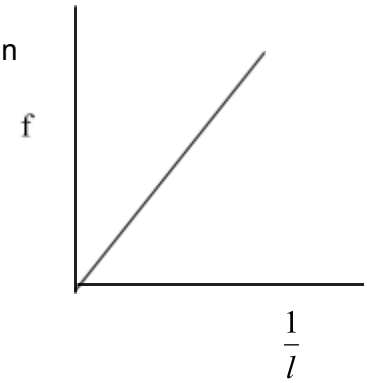
Variation of Fundamental Frequency and Length

A student investigated the variation of the fundamental frequency ***f*** of a stretched string with its length ***l***.

Draw a labelled diagram of the apparatus used in this experiment.

Describe how the student set the string vibrating.

The student drew a graph, as shown, using the data recorded in the experiment, to illustrate the relationship between the Fundamental frequency of the string and its length.



State this relationship and explain how the graph verifies it.

How did the student know that the string was vibrating at its fundamental frequency?

In another experiment, the student got the following results for frequency and length:

f (Hz)	256	288	320	341	384	427	480	512
l (cm)	51.3	42.6	39.2	37.7	34.5	30.3	26.0	25.0

The string was kept at a constant tension of 8.5 N.

Draw a suitable graph to illustrate the relationship between f and l.

State the relationship and explain how the graph verifies it.

Use your graph to calculate (i) the length of the string at a frequency of 192 Hz (ii) the mass per unit length of the string.

Graph

Speed of Sound in Air

A cylindrical column of air closed at one end and three different tuning forks were used in an experiment to measure the speed of sound in air. A tuning fork of frequency ***f*** was set vibrating and held over the column of air. The length of the column of air was adjusted until it was vibrating at its first harmonic and its length ***l*** was then measured. This procedure was repeated for each tuning fork.

Finally, the diameter of the column of air was measured.

The following data was recorded.

f/Hz	512	480	426	
l/cm	16.0	17.2	19.4	Diameter of column of air = 2.05 cm

Describe

(i) how the length of the column of air was adjusted;

(ii) how the frequency of the column of air was measured;

(iii) how the diameter of the column of air was measured.

How was it known that the air column was vibrating at its **first** harmonic?

State what distance the student measured and explain how this measurement was used to find the wavelength.

Write down the equation used to calculate the speed of sound in air.

Using all of the data, calculate an average value for the speed of sound in air.

Give two precautions which should be taken to obtain an accurate value for the speed.

Draw a labelled diagram of the apparatus used in this experiment.

Why was it necessary to measure the diameter of the air column?

Draw a suitable graph on graph paper and use it to find the speed of sound in air.

Wavelength of Monochromatic Light

In an experiment to measure the wavelength of monochromatic light, a diffraction pattern was produced using a diffraction grating with 500 lines per mm. The angle between the first order images was measured. This was repeated for the second and the third order images.

The table shows the recorded data.

Angle between First order images	Angle Between second order images	Angle between third order images
34.2°	71.6°	121.6°

Draw a labelled diagram of the apparatus used in the experiment.

Name a source of monochromatic light.

What is the distance between each line on the diffraction grating? ie the grating constant.

How was a narrow beam of light produced?

Explain how using a diffraction grating of 700 lines per mm / 100 lines per mm leads to a more accurate / less accurate result.

Explain how the first order images were identified. ie describe the experiment.

Describe how the angle between the first order images was measured.

Use the data to calculate the wavelength of the monochromatic light.

Give another way of improving the accuracy of this experiment.

The table shows more recorded data for the experiment.

N	2	1	0	1	2
θ /degrees	36.2	17.1	0	17.2	36.3

The values for the angles on the left of the central image are smaller than the corresponding ones on the right. Suggest a possible reason for this.

Which of the four angles is the most accurate? Suggest a reason for your answer.

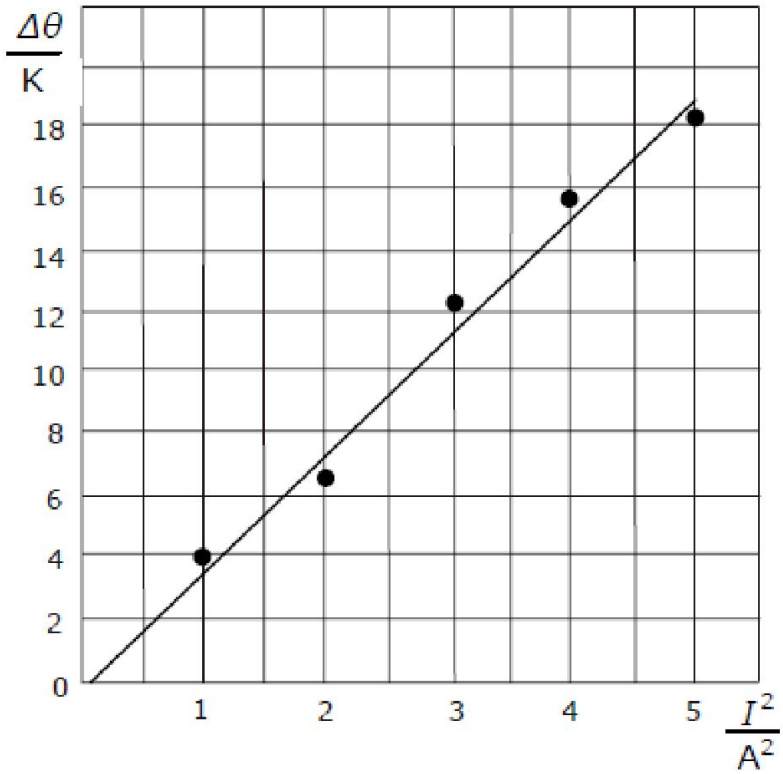
From the second table above, find the wavelength of the light.

From the data, calculate the maximum number of images that could have been observed.

Explain what would happen to the positions of the images if the wavelength of the light was decreased.

Joule's Law

In an experiment to verify Joule's law a student passed a current through a heating coil in a calorimeter containing a fixed mass of water and measured the rise in temperature Δθ for a series of different values of the current ***I***. The student allowed the current to flow for three minutes in each case.



Describe, with the aid of a labelled diagram, how the student arranged the apparatus.

Why was a fixed mass of water used throughout the experiment?

The student drew a graph, as shown. Explain how this graph verifies Joule's law.

Given that the mass of water in the calorimeter was 90 g in each case, and assuming that all of the electrical energy supplied was absorbed by the water, use the graph to determine the resistance of the heating coil. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

In another experiment to verify Joule's law, a heating coil was placed in a fixed mass of water.
The temperature rise Δθ produced for different values of the current ***I*** passed through the coil was recorded. In each case the current was allowed to flow for a fixed length of time.

The table shows the recorded data.

I /A	1.5	2.0	2.5	3.0	3.5	4.0	4.5
Δθ	3.5	7.0	10.8	15.0	21.2	27.5	33.0

Change in temperature is measured in degrees celsius.

Explain why the current was allowed to flow for a fixed length of time in each case.

Apart from using insulation, give one other way of reducing heat losses in the experiment.

Using the given data, draw a suitable graph on graph paper and explain how your graph verifies Joule's law.

Resistivity of a Wire

The following is part of a student's report of an experiment to measure the resistivity of nichrome wire.

"The resistance and length of the nichrome wire were found. The diameter of the wire was then measured at several points along its length."

The following data was recorded.

resistance of wire = 32.1 Ω
length of wire = 90.1 cm
diameter of wire = 0.19 mm, 0.21 mm, 0.20 mm, 0.21 mm, 0.20 mm

Name an instrument to measure the diameter of the wire and describe how it is used.

Why was the diameter of the wire measured at several points along its length?

Give two precautions that should be taken when measuring the length of the wire.

Using the data, calculate a value for the resistivity of nichrome.

Describe the steps involved in finding the average diameter of the wire.

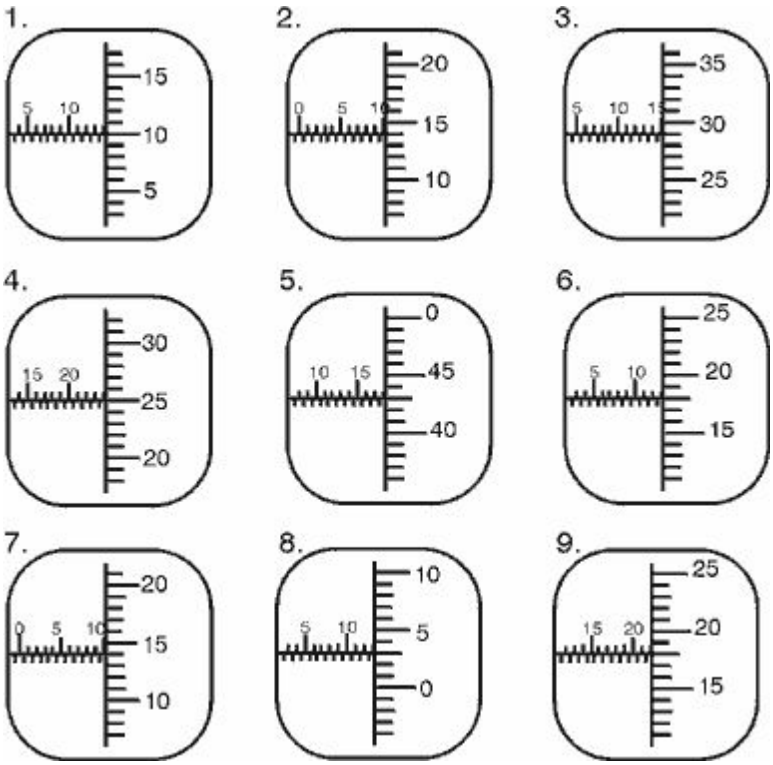
The experiment was repeated on a warmer day. What effect did this have on the measurements?

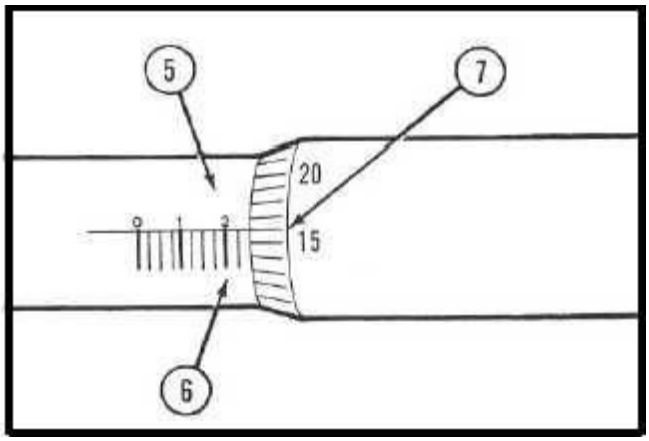
How could the student ensure that the wire was of uniform diameter?

The student then used a piece of this nichrome wire in an experiment to investigate the variation of the resistance of the piece of wire with its temperature.
Draw a labelled diagram of the arrangement of the apparatus used in this experiment.

The student drew a graph to show the relationship between resistance and temperature.
Draw a sketch of the graph. Describe this relationship.

What is the reading on the Micrometers shown?





The Variation of Current ***I*** with Potential Difference ***V*** for a Semiconductor Diode

The following is part of a student's report on an experiment to investigate the variation of the current ***I*** with potential difference ***V*** for a semiconductor diode.
"I set up the apparatus as shown in the circuit diagram. I measured the current flowing through the diode for different values of the potential difference. I recorded the following data."

V/V	0	0.50	0.59	0.65	0.68	0.70	0.72
I /mA	0	3.0	5.4	11.7	17.4	27.3	36.5

(NOTE mA)

Draw a circuit diagram used by the student.

How did the student vary and measure the potential difference?

Using the data, draw a graph to show how the current varies with the potential difference for the semiconductor diode.

Estimate from your graph the junction voltage of the diode.

Does the resistance of the diode remain constant during the investigation? Justify your answer.

The student continued the experiment with the connections to the semiconductor diode reversed.

What adjustments should be made to the circuit to obtain valid readings?

If the diode was replaced with an **(electrolyte, filament bulb, copper sulphate solution with copper electrodes)** how would the graphs change? (or would they – sketch the graphs)

What would be observed at the electrodes as current flowed through the electrolyte?

Graph

The variation of the Resistance ***R*** of a Thermistor with Temperature ***θ*** ***NOTE: could be a metal wire instead of thermistor***

In an experiment to investigate the variation of the resistance ***R*** of a thermistor with its temperature ***θ***, a student measured its resistance at different temperatures.

The following table of results were recorded.

θ/°C	20	30	40	50	60	70	80
R/Ω	2000	1300	800	400	200	90	40

Draw a labelled diagram of the apparatus used.

Describe how the temperature was varied.

In this investigation, why is the thermistor usually immersed in oil rather than in water?

Using the recorded data, plot a graph to show the variation of the resistance of a thermistor with its temperature.

Use your graph to estimate the average variation of resistance per kelvin in the range 45 °C – 55 °C.

Use your graph to estimate the resistance of the metal conductor at a temperature of –20 °C

Explain why the relationship between the resistance of a metallic conductor and its temperature is **not** linear.

Graph