PHYSICS PAPER 5 (PLANNING QUESTION)

EXAMPLE OF AN ACCEPTABLE FORMAT (GENERAL GUIDELINES)

DEFINE (3 marks)

1.) Independent variable: ________________

2.) Dependent variable: _________________

3.) Variable to be kept constant: ___________________

PROCEDURE (5 marks)

1.) Draw a workable diagram (if it is a circuit diagram, sometimes – 2 marks)

2.) Describe independent variable: how to vary it

3.) Describe independent variable: how to measure / what instruments used

3.) Describe dependent variable: how to measure / what instruments used

4.) Describe how to control & maintain the variable that should be kept constant.

5.) Repeat the experiment by changing the independent variable (mention the range / interval of change)

ANALYSIS (2 marks)

1.) A graph of ____ vs ______ is plotted.

2.) If the graph is a straight line (passing through origin), then ______________________

3.) Identify gradient & y-intercept

SAFETY / PRECAUTION (1 mark)

1.) Safety boots, safety goggles, rubber gloves, do not look into light source directly, use lead box (radioactive)

DETAILS (4 marks)

Improvements / good physics / detail explanation of the experiment.

1.) Show equation in the form of y = mx + c.

2.) Repeat experiment for each (fill in the blank with the independent variable) and find average.

3.) Identify the use of better equipment.

4.) Conducting a preliminary experiment if necessary.

2 The properties of many magnetic materials are affected by temperature. One effect is the loss of permanent magnetism when the temperature of a magnetic material exceeds a particular value. This temperature is known as the Curie point.

Design an experiment to investigate how the magnetic field strength of a magnet depends on the temperature of the magnet in the range from 0 °C to 200 °C.

In your account you should pay particular attention to

(a) the method of measuring the magnetic field strength (magnetic flux density),

(b) how the temperature of the magnet would be measured in the given range,

(c) the method of ensuring that the temperature of the magnet is uniform,

(d) the procedure to be followed,

(e) the control of variables.

Mark scheme:

A1	Use a Hall probe/search coil/current balance/magnetic field sensor <u>with</u> datalogger or meter to measure magnetic field	1
A2	Hall probe connected to a galvanometer/microammeter/voltmeter/<u>calibrated</u> Hall probe/datalogger. Search coil connected to ballistic galvanometer/datalogger. Current balance and measure force or current (n/a Newton meter) If magnetic field sensor used then the meter must be specified. Allow datalogger	1
A3	Insert/remove search coil from field Arrange plane of Hall probe to be perpendicular to field. Current balance with some detail (e.g. wire perpendicular to field or adjust current until balance)	1
B1	Use an appropriate thermometer to measure temperature in the range 0 – 200°C e.g. thermocouple thermometer/digital thermometer/thermistor thermometer resistance thermometer/electric thermometer Do not allow vague 'thermometer'. If mercury-in-glass thermometer employed, then the range must be specified.	1
B2	Method of heating the magnet uniformly e.g. oven/constant temperature enclosure/heat in oil Do not allow the magnet to be heated in boiling water/use of Bunsen flame Do not allow vague answers such as 'heat source'. Do not allow magnet to be heated in coil.	1
B3	Leave magnet for a 'long time' in order to achieve uniform temperature	1
C1	Vary temperature of magnet and measure B and θ Only apply to workable arrangements such as Hall probe/search coil/induced e.m.f./ induced current/current balance/force on current-carrying wire. Do not allow iron filings methods/paper clips/force on a nearby magnet	1
C2	Keep the distance of the Hall probe to the magnet constant Allow 'distance from magnet to 'detector' is the same'. Allow 'move magnet at same speed' (if magnet has been inserted into coil). Unworkable methods cannot score this mark.	1
D	Any good further design features. Some of these might be: Perform the experiment away from other magnetic materials Use datalogger to record/display results (possible three marks for good description) Awareness that Hall probe must not become hot during the experiment Allow magnet to reach thermal equilibrium and then quickly place Hall probe next to magnet; record B and then quickly remove the probe. Attach thermocouple to magnet/thermocouple detail. Detail relating to calibration of Hall probe. Use fridge/freezer/ice bath to achieve 0 °C. Any good safety point. Allow other valid points. 11 marking points, but only **10 marks maximum can be scored.**	3

2 Many musical instruments contain wires which are stretched between two fixed supports. These wires are often made to resonate in their fundamental mode of vibration, as shown in Fig. 2.1.

Fig. 2.1

The frequency of the note produced by the wire when it vibrates depends on

(i) the length of the wire between the supports,

(ii) the tension in the wire,

(iii) the mass per unit length of the wire.

Design an experiment to investigate how the resonant frequency of a wire vibrating in its fundamental mode depends on the tension in the wire.

You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the method by which the wire would be made to vibrate at a known frequency,

(b) how the resonant frequency and the tension would be measured,

(c) the procedure to be followed,

(d) control of variables,

(e) any safety precautions which you would take.

Mark Scheme:

A1	Workable arrangement and correct kit Do not allow this mark if the method of investigation is invalid. E.g. Do not allow d.c. with magnet or d.c. with vibration generator. Do not allow stopwatch methods Do not allow if no method given for changing frequency Do not allow if no method of finding tension (e.g. turning pegs on a guitar) Allow microphone + CRO for frequency measurement Allow tuning fork placed on sonometer + paper rider on wire	**1**
A2	Procedure (determine *T* and *f*, change *T* and measure new *f*) This mark may be scored even if the arrangement is unworkable Could be given for table headings. If *l* varies then this mark cannot be scored.	**1**
B1	Method of measuring tension (e.g. weight of mass on wire/Newton meter) Do not accept methods involving measurement of extension	**1**
B2	Method of measuring frequency (e.g. read scale from SG or strobe) Allow microphone connected to CRO to be placed near to the wire and 'find the frequency from the CRO'. Allow frequency from the fork to be given. Allow use of 'high speed photography' if sensible Do not accept 'frequency sensor'. Do not accept 'camera' or 'video'	**1**
C1	Method of achieving resonance of wire (e.g. adjust output freq. of SG until large amplitude oscillations are seen) Allow 'pluck the wire'	**1**
C2	Any one safety precaution (e.g. wear safety goggles (in case the wire snaps); safety screens; keep feet away from the load in case the wire snaps; use a bucket of sand below load; do not look directly into strobe). Do not allow 'gloves'.	**1**
C3	Use constant length of wire or same mass per unit length of wire	**1**
D1/2/3	Any further good design features. Some of these might be: Place white card behind vibrating wire so it can be seen easily. Check frequency scale of SG/calibration ideas Good description for finding resonance position Use top pan balance/electronic scales to find mass Do preliminary experimentation to determine suitable loads Detail relating to how the frequency would be found from the CRO trace Check uniformity of wire (1 mark) Use screw gauge to check the uniformity (1 mark) Sensible ideas relating to the elastic limit Perform the experiment in a quiet place if using microphone and CRO Check the wire to ensure that it is free from kinks Accept 'smooth pulley' or 'smooth rod' ideas Do not accept 'repeat readings' ideas	**3**

10 marks in total.

June 2003

2 One type of radiation detector known as a Geiger-Müller tube is shown in Fig. 2.1.

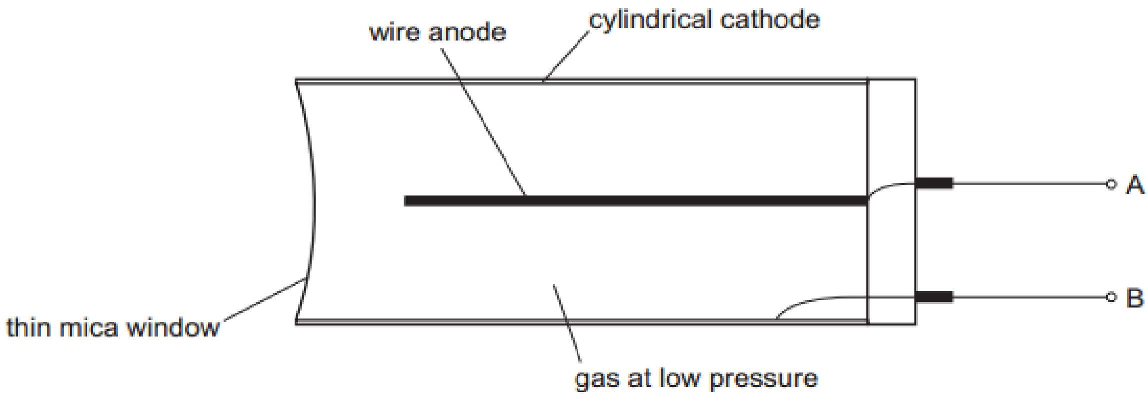

Fig. 2.1

In order for the tube to function, a potential difference V_{AB} has to be applied between A and B. The count rate registered by an instrument connected to the tube depends on several factors such as the distance from the radioactive source to the thin mica window, the activity of the source and V_{AB}. The tube can detect α, β and γ-radiation.

Design a laboratory experiment to investigate how the count rate due to γ-radiation **only** depends upon the potential difference V_{AB}. You have access to three different radioactive sources only. Information relating to each of these sources is given in the table below.

source	type of radiation emitted	half-life of source
Radium-226	α, β and γ	1600 years
Bismuth-214	β and γ only	20 minutes
Cobalt-60	β and γ only	5 years

You may assume that the following equipment is available, together with any other apparatus that may be found in a school or college science laboratory.

Aluminium plates of different thicknesses
Ammeter
Connecting wires
Datalogger
Geiger-Müller tube
Lead plates of different thicknesses
Metre rule
Oscilloscope
Ratemeter
Scaler
Signal generator
Source handling tool
Variable d.c. power supply
Voltmeter

You should draw a diagram showing the arrangement of your apparatus. In your account you should pay particular attention to

(a) which source you would use, giving a reason for your choice,

(b) the procedure to be followed, including how the count rate would be measured,

(c) the control of variables,

(d) any safety precautions you would take.

Mark Scheme:

2	**A1**	Sensible choice of equipment and procedure OK (i.e. measure count rate and p.d.; change p.d. and measure new count rate) Unworkable methods/inappropriate choice of apparatus cannot score this mark	1
	A2	Voltmeter shown in parallel with the GM tube or the supply	1
	A3	Ratemeter/scalar/datalogger connected to terminals A and B of GM tube	1
	B1	Radium or Cobalt source used	1
	B2	Reason for choice Answer must relate to half-life. This mark cannot be scored if **B1 = 0**	1
	B3	Method of removing α or β radiation (depending on source used) Appropriate absorber is expected. Accept 'aluminium' or <u>thin</u> lead Could be shown on the diagram. Allow electric or magnetic deflection	1
	C1/2	Any two safety precautions e.g. use source handling tool store source in lead lined box when not in use do not point source at people/do not look directly at source Do not allow 'protective clothing', 'lead suits', 'lead gloves', 'goggles', etc.	2
	D1/2	Any good/further detail Examples of creditworthy points might be: Repeat readings (to allow for randomness of activity) or scalar + long time Sensible value of p.d. applied to GM tube (i.e. 50 V to 1000 V) Keep distance from source to GM tube <u>constant</u>/<u>fixed</u>/<u>same</u>, etc. <u>Subtract</u> count rate due to background radiation Aluminium sheets must be mm or cm thickness Allow other valid points. Any two, one mark each	2
		10 marks in total	

2 Modern day lifts in tall buildings are of a relatively simple design. A passenger car is connected to a counterweight by a steel cable which passes over a system of pulleys at the top of the lift shaft, as shown in Fig. 2.1.

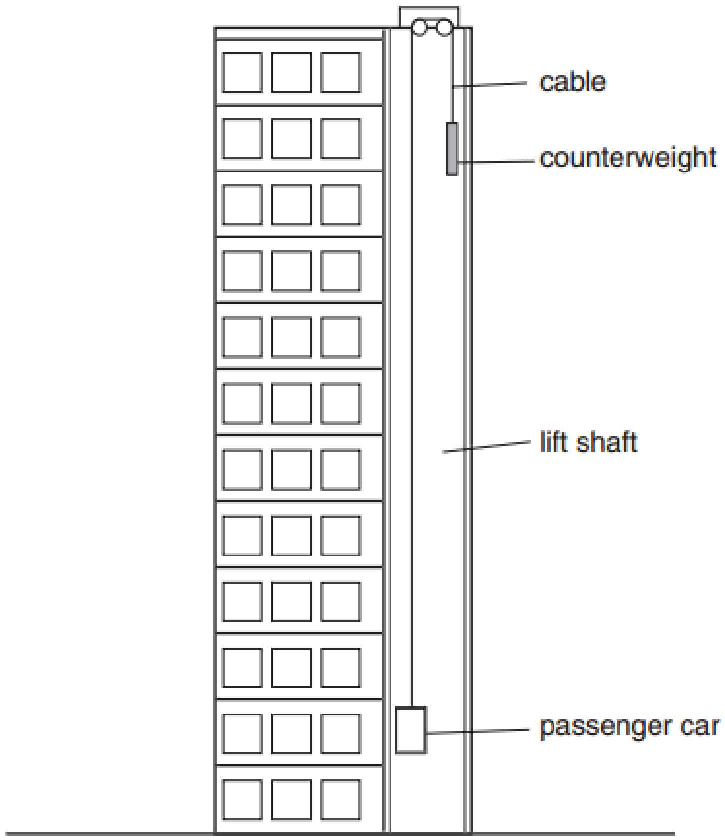

Fig. 2.1

The passenger car and the counterweight are of similar mass. A motor, which is connected to the pulley system, is used to raise and lower the passenger car. A braking system enables the passenger car to come to rest at any desired position. If the motor and the braking system were to fail, the passenger car and counterweight would move under the action of gravity until one of several safety features incorporated in the design of the system (not shown on Fig. 2.1) brings the passenger car and counterweight to rest.

A failure of the motor and braking system may be simulated in the laboratory by connecting two objects A and B of mass m_A and m_B respectively by a thin steel wire which passes over a pulley, as shown in Fig. 2.2.

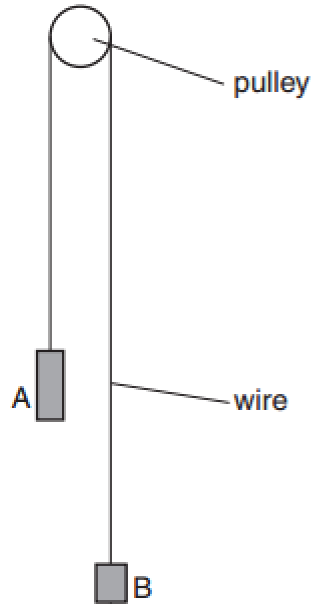

Fig. 2.2

Design a laboratory experiment to investigate how the acceleration of object A depends on the mass m_B of object B when the system is allowed to move freely under the action of gravity. You may assume that m_A is constant throughout and that $m_A > m_B$. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements that would be taken,

(c) how the acceleration of object A would be determined,

(d) any safety precautions that you would take.

Mark Scheme:

Question 2

A1	Procedure OK (i.e. find m_B and acc^n of A or B; <u>change</u> m_B and repeat). An experiment must have been described for this mark to be awarded. **This mark can be scored even if the method is unworkable.**	**1**
A2	Diagram of <u>workable</u> arrangement to find acceleration (e.g. object falls between two markers/light gates/smart pulley at top) If the diagram is not very detailed refer to text.	**1**
A3	Measurement of mass m_B (e.g. using balance/Newton meter/calibrations on masses)	**1**
B1	<u>Valid</u> <u>method</u> of measuring time Accept stopwatch; ticker-tape; light gates; motion sensors and dataloggers; smart pulley etc.. **Unworkable methods will not score this mark**.	**1**
B2	Correct measurements taken to find acceleration (e.g. measure a distance and u = 0 (if distance/time method used) spacing of successive dots on ticker-tape some detail of sampling rate if motion sensor/datalogger used)	**1**
B3	Use of results to calculate acceleration (e.g. substitute into $s = ut + ½at^2$; a = $25(x_2 - x_1)$ etc..) If motion sensor used then acceleration obtained from monitor.	**1**
C1	Any one safety precaution (e.g. Catch falling mass in bucket of sand Care needed to prevent mass B from coming over the top of the pulley Whiplash from breaking wires etc. Clamp retort stand to prevent it from falling over. Do not allow vague 'safety goggles'. Insist on a reason being given.	**1**
D1/2/3	Any further good design features Some of these might be: Method of supporting the pulley Mention of friction in the pulley/oil pulley/smooth pulley Use large distance (to reduce percentage uncertainty) Limitations of stopwatch methods Vary s and measure t; use graph to find a Repeat the experiment to find values of a for each value of m_B Some detail about the timing circuit (e.g. stop terminals on timer connected to double pole switch and electromagnet).	**3**

10 marks in total.

June 2004

2 Beta particles can be deflected by magnetic fields.

Design a laboratory experiment to investigate how magnetic flux density affects the angle through which beta particles are deflected when they pass through a uniform magnetic field. The only radioactive source that is available to you is a Radium-226 source which emits α, β and γ radiation.

You should draw a diagram showing the arrangement of your apparatus. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the method by which beta particles **only** would be detected,

(c) the method of measuring the angle of deflection,

(d) how the magnetic field would be produced, measured and changed,

(e) any safety precautions you would take.

Mark Scheme:

2	A1	Use of <u>alpha</u> <u>emitter</u> as source (one mark), with a reason (strongly ionising) (one mark). These are independent marks. Do not award these marks if the source is not sensible (e.g. smoke producing alpha particles)	[2]
	A2	Correct circuit showing milliammeter/microammeter/galvanometer Do not allow ammeter. Accept 'sensitive ammeter'. A power supply must be shown.	[1]
	A3	Use of Bourdon gauge/pressure gauge/manometer/barometer Accept pressure sensor + datalogger. Do not allow vague 'pressure metre'. Could be shown on the diagram.	[1]
	B1	Change air pressure using <u>pump</u> (could be shown on diagram)	[1]
	B2	Diagram showing 'closed box' surrounding the equipment. do not award this mark if the gauge is not measuring the pressure in the box.	[1]
	B3	Procedure <u>Measure</u> ionisation current and *P*; change air pressure (and measure new pressure and ionisation current). This mark can be scored even if the design is unworkable. Accept a table.	[1]
	C1/C2	Two safety precautions e.g. use source handling tool store source in lead lined box when not in use do not point source at people/do not look directly at source use safety goggles when dealing with low/high pressures Do not allow vague 'safety goggles' without clarification container must be strong enough to withstand high/low pressure use safety screens in case of implosion/explosion Do not allow lead suits/lead lined rooms/lead gloves/lead lined expt. etc. One mark for safety relating to radiation. One mark for safety relating to pressure.	[2]
	D	Any good/further detail Examples of creditworthy points might be: Use high voltage as current is small Use GM tube and scalar/ratemeter to monitor activity to ensure that it does not change Use of source of long half-life Place source close to plates (as range of alpha in air is small) Tap gauge when taking readings (in case needle sticks) Fix position of source relative to plates Separation of plates constant Allow other valid points.	[1]

[Total: 10 marks]

Nov 2004

2 Two students are having a discussion about an experiment in which the air inside a bell jar is gradually removed. The sound of a ringing bell inside the jar is heard to diminish in intensity during this process. One student suggests that the frequency of the sound changes as the pressure changes; the other student thinks that the frequency remains constant as the air is removed.

Design a laboratory experiment to investigate how the frequency of a sound wave depends on the pressure of air. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements that would be taken,

(c) how the frequency of the sound would be measured using a cathode ray oscilloscope,

(d) the control of variables,

(e) any safety precautions that you would take.

Mark Scheme:

A1 Procedure OK (i.e. measure *P* and *f;* change *P* and repeat). **1**

This mark can be scored even if the method is unworkable.

A2 Diagram of workable arrangement **2**

Source of sound + pump (1 mark); microphone + CRO (1 mark)

Allow ½ if all apparatus is inside the bell jar.

Allow ½ if the container is open.

A3 Measurement of *P* **1**

(e.g. Bourdon gauge/pressure gauge/manometer/barometer). Must be shown correctly on the diagram.

B1 Correct measurements taken to find frequency using CRO **1**

Length of trace on screen + timebase setting

B2 Use of measurements to calculate frequency, or $f = 1/T$ **1**

B3 Maintain constant temperature whilst pressure is reduced **1**

OR maintain constant frequency as pressure is reduced

OR close tap before taking readings

C Safety precaution **1**

Safety screens/goggles

D1/2 Any further good design features **2**

Some of these might be:

Difficulty with detecting sounds of low intensity at low pressures

Use a signal generator connected to speaker

Vacuum grease the wires to the speaker

Allow time between readings for apparatus to warm up/cool down

Monitor temperature with thermometer during experiment

Avoid unwanted sounds/use soundproof room

Source of sound and microphone both inside the chamber

Increase *P* as well as decrease *P* to give wide spread of readings

10 marks in total

2 Many homes have smoke detectors fitted to the ceilings of certain rooms to provide an early warning of a fire. These detectors contain a weak radioactive source that ionises the air between two metal plates. See Fig. 2.1.

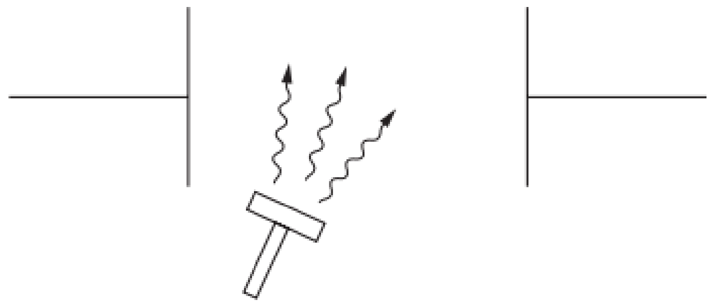

Fig. 2.1

A low voltage battery in the detector causes the ions to move. This produces a very small ionisation current in a circuit containing the battery and the plates. Any reduction in this ionisation current due to smoke is detected and an alarm sounds.

An airline company wishes to install some of these smoke detectors in its aircraft and needs to know if changes in air pressure will affect the ionisation current.

Design a laboratory experiment to investigate how the ionisation current depends on air pressure. You should draw a detailed labelled diagram showing the arrangement of your apparatus. In your account you should pay particular attention to

(a) the type of source used in the investigation (i.e. whether it is an alpha, beta or gamma emitter) giving a reason for your choice,

(b) how the ionisation current would be measured (given that it is very small),

(c) the method of changing and measuring the air pressure,

(d) the procedure to be followed,

(e) any safety precautions that you would take.

Mark Scheme:

2	**A1**	Use of <u>alpha</u> <u>emitter</u> as source (one mark), with a reason (strongly ionising) (one mark). These are independent marks. Do not award these marks if the source is not sensible (e.g. smoke producing alpha particles)	**[2]**
	A2	Correct circuit showing milliammeter/microammeter/galvanometer Do not allow ammeter. Accept 'sensitive ammeter'. A power supply must be shown.	**[1]**
	A3	Use of Bourdon gauge/pressure gauge/manometer/barometer Accept pressure sensor + datalogger. Do not allow vague 'pressure metre'. Could be shown on the diagram.	**[1]**
	B1	Change air pressure using <u>pump</u> (could be shown on diagram)	**[1]**
	B2	Diagram showing 'closed box' surrounding the equipment. do not award this mark if the gauge is not measuring the pressure in the box.	**[1]**
	B3	Procedure <u>Measure</u> ionisation current and *P*; change air pressure (and measure new pressure and ionisation current). This mark can be scored even if the design is unworkable. Accept a table.	**[1]**
	C1/C2	Two safety precautions e.g. use source handling tool store source in lead lined box when not in use do not point source at people/do not look directly at source use safety goggles when dealing with low/high pressures Do not allow vague 'safety goggles' without clarification container must be strong enough to withstand high/low pressure use safety screens in case of implosion/explosion Do not allow lead suits/lead lined rooms/lead gloves/lead lined expt. etc. One mark for safety relating to radiation. One mark for safety relating to pressure.	**[2]**
	D	Any good/further detail Examples of creditworthy points might be: Use high voltage as current is small Use GM tube and scalar/ratemeter to monitor activity to ensure that it does not change Use of source of long half-life Place source close to plates (as range of alpha in air is small) Tap gauge when taking readings (in case needle sticks) Fix position of source relative to plates Separation of plates constant Allow other valid points.	**[1]**

[Total: 10 marks]

2 A hot wire in air loses energy. Some of the energy is lost to the air particles that hit the wire. This energy lost depends on the number of particles hitting the wire per second, and hence on the air pressure.

If the temperature of the wire is constant then the total energy lost per second is equal to the electrical energy supplied per second.

Design a laboratory experiment to investigate how the total energy lost per second from a wire depends on the air pressure. You should draw a detailed labelled diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) how the electrical energy supplied to the wire per second would be measured,

(c) the type of thermometer used to check that the temperature of the wire remains constant during the experiment,

(d) how the pressure would be changed and measured,

(e) any safety precautions that you would take.

Mark Scheme:

2 **A1** Procedure OK (i.e. measure pressure and electrical power; change pressure and measure new power and repeat). **[1]**
This mark can be scored even if the method is unworkable.

A2 Diagram of workable arrangement **[2]**
e.g. wire connected to joulemeter and power supply. A stopwatch must be used if this method is employed. Allow alternative circuit using ammeter and voltmeter.
The wire must be shown inside a closed container with some means of changing and measuring the pressure.
One mark for the electrical arrangement; one mark for the mechanical arrangement.

A3 Measurement of pressure **[1]**
(e.g. Bourdon gauge/pressure gauge/manometer)

B1 Change setting on the power supply to keep the wire at the same temperature when the pressure is changed. **[1]**

B2 Power supplied to wire = $V \times I$ (or reading on joulemeter ÷ time) **[1]**

B3 Use of thermocouple thermometer to monitor temperature whilst pressure is changed or adjust V or I to keep R (and hence T) constant **[1]**

C Any one safety precaution **[1]**
e.g. safety screens/goggles/wire mesh surrounding vacuum chamber

D1/2 Any further good design features **[2]**
Some of these might be:
Thermocouple thermometer shown attached to the wire to monitor temperature.
Light spot galvanometer connected to thermocouple.
Use of a needle valve to control pressure.
Vacuum grease the connecting wires to the heater wire.
Allow time between readings for experiment to stabilise.
Do not allow the wire to become too hot or the thermocouple may melt.

10 marks in total

June 2006

2 A fine wire mesh has individual wires that are spaced very close together. See Fig. 2.1.

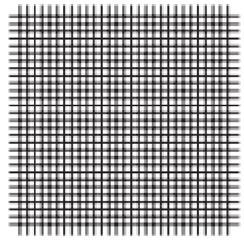

Fig. 2.1

The mesh behaves like two diffraction gratings placed at right angles to each other. The diffraction grating formula is $d \sin\theta = n\lambda$.

The spacing between the wires of the mesh is to be found accurately. Design a laboratory experiment using light of a single wavelength to determine the spacing between the wires. You may assume that the wavelength of the light is known.

You should draw a detailed labelled diagram showing the arrangement of your apparatus. In your account you should pay particular attention to

(a) the type of light source to be used, giving a reason for your choice,

(b) the procedure to be followed and the measurements that would be taken,

(c) how the measurements would be used to find values of θ,

(d) how the spacing between the wires would be deduced,

(e) any safety precautions you may take.

Mark Scheme:

A1	Diagram of arrangement (light source/mesh/screen or collimator/mesh/telescope)	**[1]**
A2	Fringes or dots shown on screen. May be shown on diagram.	**[1]**
A3	Some sensible discussion of <u>coherence</u>	**[1]**
A4	Use of <u>laser</u> or <u>single slit</u> (and lens) in collimator	**[1]**
B1	Measurements: distance from mesh to screen and separation between fringes OR measure an angle from the spectrometer table	**[1]**
B2	n = 1; find separation between central fringe and first bright fringe OR measure angle between central bright beam and first order beam using scale on table	**[1]**
B3	Use of $n\lambda = \sin\theta$ to find d. n must be clearly identified	**[1]**
C	Any safety precaution e.g. use goggles/do not look directly into laser beam/cover over sodium lamp do not touch the bulb	**[1]**
D	Any good/further detail Examples of creditworthy points might be: Take readings with mesh in different positions to average d Sketch/suggestion of <u>two-dimensional</u> array of dots on screen Laser + mesh + screen all at same height λ = 589 nm for sodium lamp or about λ = 630 nm for He/Ne laser/semiconductor laser D of the order of 1 m to 4 m (laser method) Measure 2θ and divide by two to reduce uncertainty in θ Repeat experiment with 2nd order (3rd order etc.) beams Detail relating to setup/use of spectrometer Allow other valid points.	**[2]**

[Total: 10 marks]

2 A simple air-spaced capacitor can be made by placing two metal plates close to each other. When the capacitor is charged the plates have equal and opposite charges as shown in Fig. 2.1.

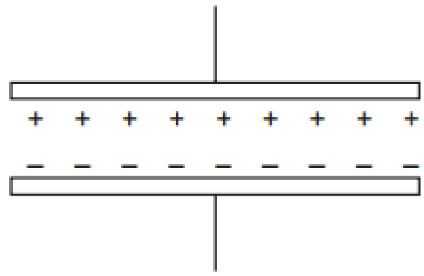

Fig. 2.1

The plates attract each other because they have opposite charges. This force of attraction can be small and therefore difficult to measure.

Design a laboratory experiment to investigate how the force of attraction between the plates depends on the potential difference between the plates. You should draw a detailed labelled diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) how the plates would be charged,

(c) how the potential difference between the plates would be measured,

(d) how the equipment would be arranged so that the force between the plates is made as large as possible,

(e) how the force of attraction between the plates would be measured,

(f) any safety precautions that you would take.

Mark Scheme:

Question 2

A1	(Measure) p.d. and find a force (could be in a table or graph). Change p.d. and repeat. i.e. correct procedure. Do not give for only identifying the variables. This mark can be scored if the method is unworkable.	1
A2	Measurement of p.d. – voltmeter connected in parallel with capacitor or power supply on diagram or voltage read from power supply in text. Wrong diag loses this mark.	1
A3	Workable electrical arrangement: d.c. power supply on diag or in text. Ignore Voltmeter in series. Ammeter in parallel loses this mark. Do not allow discharge of circuit while measuring force. If diagram wrong this loses this mark.	1
A4	Method of changing the p.d. (diag or text). Variable power supply or potential divider circuit. Do no allow variable resistor in series. Do not allow changing distance.	1
B1	Measure the force/(mass) with tpb or force with newtonmeter. Or measure force from a mass/lever/pulley system.	1
B2	Workable mechanical arrangement to measure force on diag. Allow workable loading/lever/pulley system.	1
B3	**Plates** close together/large surface area or HT/EHT/hight voltage to make force large/measurable.	1
C	Any one safety precaution with reason. e.g. wear insulating/rubber gloves: earth/insulate one plate wrt top pan balance or newtonmeter; discharge before touching plates to avoid/prevent shock/short circuit. Do not allow not touching plates (precaution needed).	1
D1/2	Any further good design features. Some of these might be: Two fixed points shown on the diagram (appropriate clamps or supports). Distance between the plates should be kept constant. Method of achieving constant separation of plates (spacers or measurement; no insulators or dielectrics)/adjust newtonmeter position to give same separation. Force = mg Force is the change in readings. Calibrate springs to give force reading. Approx. p.d (greater than 100 V)/distance (less than 1 cm)/Area (greater than 400 cm2)	2

10 marks in total.

1 It is useful to know how the speed of an object is affected by its size when it moves through liquid in a confined space. In a laboratory this can be modelled by dropping small steel balls through oil.

It is suggested that the terminal velocity v is related to the radius r of a steel ball by the equation

$$v = kr^2$$

where k is a constant.

Design a laboratory experiment to investigate whether v is related to r as indicated in the above equation. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) how the radius of the steel ball would be measured,

(c) how the terminal velocity of the steel ball in oil would be measured,

(d) the control of variables,

(e) how the data would be analysed,

(f) any safety precautions that you would take.

[15]

1 ***Planning (15 marks)***

Defining the problem (3 marks)

P1 r is the independent variable or vary r (accept diameter but not mass or size). [1]

P2 v is the dependent variable or determine v (accept speed) [1]

P3 A controlled variable – accept temperature, [1]
distance when time is measured, or time when distance measured.
Do not accept volume/height of oil.

Methods of data collection (5 marks)

M1 Diagram of a workable arrangement including a deep container of oil, ball and some measurement indicated for either time or distance. [1]

M2 Measure diameter by using a micrometer (screw gauge)/vernier callipers (and halving to obtain radius). Accept from diagram. Accept travelling microscope. [1]

M3 Measure the time for the ball to fall a set distance in oil (or distance for a set time). [1]

M4 Measure the (constant) distance fallen (constant time) and show how v is calculated. [1]

M5 Evidence that ball has reached terminal velocity (e.g. starting mark well below surface of oil) [1]
Reject equations of uniform acceleration ideas.

Method of analysis (2 marks)

A1 Plot a graph of v against r^2 or logarithmic equivalent. [1]

A2 Relationship is correct if graph is a straight line through the origin. [1]
An explicit statement is required.
If lg v against lg r is plotted gradient should equal 2.

Safety considerations (1 mark)

S1 Relevant safety precaution related to the oil, [1]
e.g. mop up spillages of oil/wear gloves with reason/keep away from flames.
Do not accept vague answers e.g. goggles/spills/washing hands but allow credit for detailed reasoning e.g. drop ball near surface to avoid splashing.

Additional detail (4 marks)

D1/2/3/4 Relevant points might include: [4]
Allow oil to stand so that air bubbles escape/ball may trap air bubbles.
Wash and dry steel balls/handle steel balls with tweezers/gloves.
Distance marks should be as far apart as possible or use long tube.
Large distance to reduce percentage uncertainty.
Wide tube to reduce edge effects/method to keep long tube vertical.
Discussion of parallax for stop watch methods.
Method of ensuring that terminal velocity has been reached.
Retrieve steel balls using a magnet.
Use clear oil.
Repeat diameter measurements and average.
An additional variable kept constant.

[Total: 15]

1 Double glazing can be used for sound insulation. Double-glazed windows consist of two panes of glass with air in the space between them. Manufacturers reduce the air pressure in the space between the panes of glass to reduce the amplitude of sound transmitted through the window.

It is suggested that the amplitude A of sound transmitted through a double-glazed window is related to the air pressure p in the space between the panes by the equation

$$A = k\sqrt{p}$$

where k is a constant.

Fig. 1.1 shows a laboratory model of a double-glazed window. It consists of two panes of glass. There is a tube connected to the space between the two panes so that air may be removed.

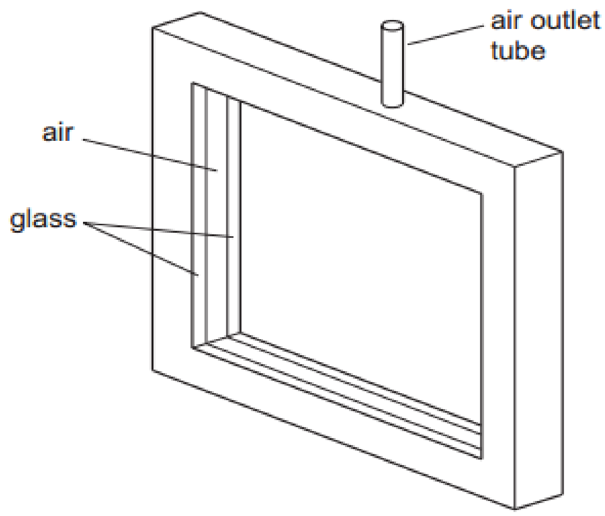

Fig. 1.1

Design a laboratory experiment to investigate whether A is related to p as indicated in the above equation when p is reduced. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) how the air pressure between the panes of glass would be measured,

(c) how the amplitude of the sound would be measured,

(d) the control of variables,

(e) how the data would be analysed,

(f) any safety precautions that you would take.

[15]

Mark Scheme:

Planning (15 marks)

Defining the problem (3 marks)

P1 p is the independent variable <u>or</u> vary p. [1]

P2 A is the dependent variable <u>or</u> determine A for different p. [1]

P3 Keep the incident amplitude constant (allow volume of sound or power/intensity output). [1]

Methods of data collection (5 marks)

M1 <u>Labelled</u> diagram of a workable arrangement including source of sound – glass window – detector of sound. [1]
Allowed sources: loudspeaker, bell, buzzer, siren but not musical instruments.
Allowed detectors: microphone, sound meter, sound detector.

M2 Method of measuring pressure. Use bourdon gauge/manometer or pressure gauge [1]
Do not allow barometer or pressure meter.

M3 Method of <u>reducing</u> pressure. Use (vacuum) pump to withdraw air from glass window. [1]

M4 Method of measuring amplitude. Measure amplitude from oscilloscope. [1]

M5 Perform experiment in quiet room. [1]

Method of analysis (2 marks)

A1 Appropriate quantities plotted i.e. A^2 against p; or lg A against lg p or A against $\sqrt{p}$. [1]

A2 Relationship to be correct i.e. graph is a straight line <u>through the origin</u>. [1]
Gradient should equal 0.5 if lg A against lg p plotted.
An explicit statement is required.

Safety considerations (1 mark)

S1 Relevant safety precaution related to either the use of glass or intensity of sound, [1]
e.g. wear ear defenders, switch on sound source for short period of time.
Protection (goggles/safety screen) <u>in case glass breaks</u>.
Awareness of low pressures in glass.
Do not allow gloves because glass is sharp.

Additional detail (4 marks).

D1/2/3/4 Relevant points might include: [4]
Method of ensuring that output from speaker is constant.
Method of reducing sound reflections from e.g. foam/speaker & microphone close to glass.
Window perpendicular to sound source.
Detail explaining use of oscilloscope to measure amplitude.
Difficulty in measuring amplitude at small pressures/use a loud incident source.
Control (or monitoring) of one additional variable e.g. temperature, frequency, distances.
Allow time for the temperature/pressure between the glass to stabilise.
Discussion of attenuation in air/frame/glass.

[Total: 15]

1 A student wishes to measure the resistivity of glass. A teacher suggests that its resistivity is of the order of $10^6\,\Omega\,m$ which is very large.

Resistivity ρ is defined by the equation

$$\rho = \frac{RA}{l}$$

where R is resistance, A is cross-sectional area and l is the length of the material.

The student is given a number of sheets of glass of the same thickness and of different areas.

Design a laboratory experiment to determine the resistivity of glass. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) how the glass would be connected to the circuit,

(c) the measurements that would be taken,

(d) the control of variables,

(e) how the data would be analysed,

(f) any safety precautions that you would take. [15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 A is the independent variable or vary A. [1]
P2 R is the dependent variable or determine R for different A. [1]
P3 Keep the temperature (of glass) constant. Do not allow "controlled variable". [1]

Methods of data collection (5 marks)

M1 Basic circuit diagram. [1]
Ammeter and voltmeter with power supply, or
ohmmeter without power supply, or
bridge methods.
M2 Correct orientation of glass between electrodes – largest cross-sectional area. [1]
M3 A distance (thickness) measured using a micrometer/vernier scale/vernier callipers. [1]
M4 Method of determining area perpendicular to current flow. [1]
Distances measured and multiplied together.
This mark may only be scored if it is clear that the correct dimensions are being used.
M5 Method of determining resistance. [1]
Ohmmeter.
$R = V/I$ justified.
Description of balancing bridge with correct equation.

Method of analysis (2 marks)

A1	A2
R against $1/A$	ρ = gradient/l
R against l/A	ρ = gradient
$1/A$ against R or $1/R$ against A	$\rho = 1/(\text{gradient} \times l)$
l/A against R or l/R against A	ρ = 1/gradient
lg R against lg A	$\rho = 10^{l \times \text{y-intercept}}$

[2]

Safety considerations (1 mark)

S1 Relevant safety precaution related to: [1]
EHT power supply (>100 V) – switch off before changing circuit/use of rubber gloves;
or handling glass – wear (thick) gloves.

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]
Calculation of typical resistance of glass using value of resistivity given.
Range of ammeter or ohmmeter with reasoning.
Use of EHT or power supply >1000 V or microammeter/galvanometer.
Take many readings of thickness and average.
Good contact between circuit and glass e.g. metal plates, foil, conducting putty.
Metal plates/foil/conducting putty to cover all of the cross-sectional area in use.
Method of securing good contact between circuit and glass, e.g. g clamps, weights.
Clean/dry the glass.

1 A student wishes to investigate how the resistance R of a light-dependent resistor varies with the distance d from an intense light source.

It is believed that the relationship between R and d is

$$R = kd^n$$

where k and n are constants.

Design a laboratory experiment to test the above relationship. The light-dependent resistor has a resistance of $100\,\Omega$ when it is in bright light and a resistance of $500\,\text{k}\Omega$ when no light falls on it.

You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements that would be taken,

(c) the control of variables,

(d) how the data would be analysed,

(e) any safety precautions that you would take.

[15]

Mark Scheme:

Planning (15 marks)

Defining the problem (3 marks)

P1	*d* is the independent variable or vary *d* (allow in table if numbers given)	[1]
P2	*R* is the dependent variable or measure *R* as *d* varied (allow in table)	[1]
P3	Keep output of light source constant (allow constant current / e.m.f. / voltage / power)	[1]

Methods of data collection (5 marks)

M1	Diagram showing an LDR in a circuit and an independent lamp.	[1]
M2	Diagram showing ruler measuring appropriate distance or *d* labelled correctly.	[1]
M3	Correct circuit diagram for LDR using conventional symbols; allow labelled diagram Ammeter and voltmeter with power supply, or potential divider methods ohmmeter without power supply, or bridge methods.	[1]
M4	Method of determining *R*. Ohmmeter. $R = V/I$ justified. Potential divider equation Description of balancing bridge with correct equation.	[1]
M5	Perform experiment in a dark room/tube	[1]

Method of analysis (2 marks)

A1	Plot a graph of log *R* against log *d*	[1]
A2	Relationship is correct if log *R* against log *d* graph is a straight line	[1]

Safety considerations (1 mark)

S1	Do not look directly at bright light source / do not touch hot light source. Allow safety glasses with reference to light source.	[1]

Additional detail (4 marks)

D1/2/3/4	Relevant points might include Detail on measuring the distance Keep orientation of LDR with respect to the light source constant Reasoned method for keeping light and LDR in correct orientation. (E.g. use of set square, fix to rule, optical bench or equivalent) Determination of a typical current Range of ammeter / ohmmeter Control (or monitoring) of an additional variable e.g. temperature Reason for performing experiment in a dark room related to the LDR Method for checking the output of the light source is constant. Identifies gradient = *n* and/or *y*-intercept = log *k* for log *R* against log *d* graph Do not allow parallax when reading ruler, or reflectors.	[4]

[Total: 15]

1 A student wishes to determine the Young modulus E of wood from the period of oscillation of a loaded wooden rule, as shown in Fig. 1.1.

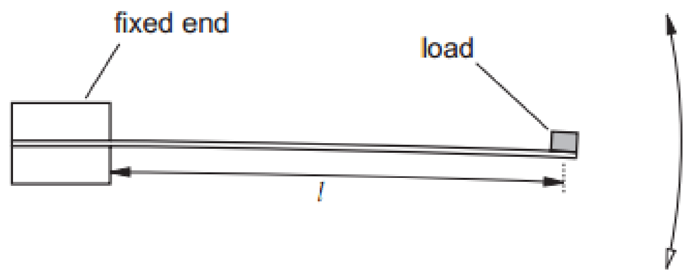

Fig. 1.1

An equation relating the period of oscillation T to the overhanging length l of the rule is

$$T^2 = \frac{kl^3}{E}.$$

The constant k is given by

$$k = \frac{16\pi^2 M}{wd^3}$$

where M is the mass of the load, w is the width of the rule and d is the thickness of the rule.

Design a laboratory experiment to determine the Young modulus of wood. You should draw a diagram showing the arrangement of your equipment. In your account, you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) how to analyse the data,

(e) how to determine E,

(f) the safety precautions to be taken.

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 Vary l or l is the independent variable [Allow M] [1]
P2 Determine the period T (for each l [M]) or T is the dependent variable [1]
P3 M is kept constant [l is kept constant] [1]

Methods of data collection (5 marks)

M1 Diagram showing the cantilever is fixed e.g. g-clamp & bench, retort stand & clamp [1]
M2 Many oscillations repeated to determine average T ($n \geqslant 10$ or $t \geqslant 10$ s for stopwatch) [1]
M3 Weigh M using balance [1]
M4 Measure w and d and measure/record l [1]
M5 Use of vernier caliper/micrometer to measure d and/or w [1]

Method of analysis (2 marks)

A1 Appropriate graph plotted i.e. T^2 against l^3; [T^2 against M] or lg T against lg l or lg M [1]

A2 $$E = \frac{16\pi^2 M}{wd^3 \times gradient} = \frac{k}{gradient} \quad E = \frac{16\pi^2 l^3}{wd^3 \times gradient}$$

Allow logarithmic solutions e.g. $E = \dfrac{k}{10^{2xy\text{-intercept}}} = \dfrac{k}{100^{y\text{-intercept}}}$ [1]

Safety considerations (1 mark)

S1 Relevant safety precaution related to the use of loads [1]
e.g. cushion/sand in case load falls, keep feet away, keep distance from experiment.

Additional detail (4 marks)

D Relevant points might include [4]

1. Use same rule or keep w and/or d constant.
2. Repeat measurements of d and/or w along rule and average.
3. Discussion of use of motion sensor e.g. orientation or light gates with detail.
4. Use small amplitude or small angle oscillations (to ensure equation is valid).
5. Method of securing load to rule e.g. with tape/glue.
6. Discussion of magnitude of load: large enough to make T large enough.
7. Use of fiducial marker to help to time.
8. Start timing after oscillations have settled.

Do not allow vague use of computers/light gates, video cameras, dataloggers.

[Total: 15]

1 The volume of air in a bottle affects its resonant frequency.

It is suggested that the resonant frequency f is related to the volume V by the equation

$$f^2 = \frac{k}{V}$$

where k is a constant.

Design a laboratory experiment to determine whether this equation is correct. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) how to analyse the data,

(e) the safety precautions to be taken. [15]

Mark Scheme:

Planning (15 marks)

Defining the problem (3 marks)

P1 Vary V or f [1]

P2 Measure f for different V or measure V for different f [1]

P3 Keep temperature constant [1]

Methods of data collection (5 marks)

M1 labelled diagram including source of sound adjacent to the opening e.g. loudspeaker/tuning fork [1]

M2 Method of producing sound of different frequencies e.g. several tuning forks or signal generator [1]

M3 Method of measuring volume of air – volume of container - volume of water or find total volume of each different container [1]

M4 Method of determining resonant frequency e.g. largest sound heard or displayed [1]

M5 Perform experiment in quiet room or avoid other noise [1]

Method of analysis (2 marks)

A1 Plot a graph of f^2 against $1/V$ or lg f against lg V or or lg f against lg $1/V$ [1]

A2 Relationship is correct if graph is a straight line through the origin or straight line for log-log graph [1]

Safety considerations (1 mark)

S Switch off power supply when not in use/ ear defenders for loudspeaker method [1]

Additional detail (4 marks)

D Relevant points might include [4]

1. Detail on measuring volume – use of measuring cylinder/burette
2. Determination of frequency using oscilloscope/read off tuning fork or signal generator
3. Detailed timebase calculation
4. Detail determining resonance e.g. adding/subtracting small amounts of water/changing signal generator to create resonance
5. Discussion of container e.g. end correction/shape of mouth of bottle
6. Gradient = k or lg f = -0.5 lg V + 0.5 lg k or lg f = 0.5 lg $1/V$ + 0.5 lg k
7. Constant amplitude/intensity of source of sound
8. Method to check fundamental frequency.

15 marks can be scored in total.

1 When a current passes through a wire, the wire becomes hot and expands.

This can be investigated in a laboratory by passing a current through a wire of diameter *d* and measuring the displacement *y*, as shown in Fig. 1.1.

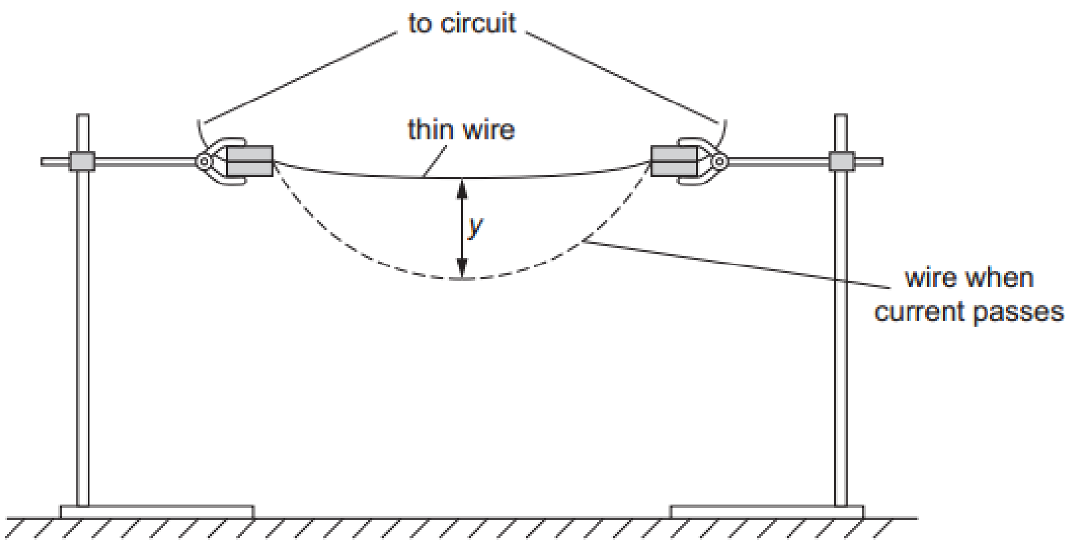

Fig. 1.1

It is suggested that the diameter *d* of the wire is related to *y* by the equation

$$y = pd^q$$

where *p* and *q* are constants.

Design a laboratory experiment to investigate the relationship between *d* and *y*, so as to determine a value for *q*. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

Question 1

Planning (15 marks)

Defining the problem (3 marks)

P1 Vary *d* and measure *y* or *d* is the independent variable and *y* is the dependent variable [1]

P2 Keep current constant [1]

P3 Keep length of wire constant [1]

Methods of data collection (5 marks)

M1 Diagram showing ruler positioned and power supply connected to wire or diagram showing initial and final marks on screen and power supply connected to wire [1]

M2 Use of ammeter to check current – penalise incorrect circuit diagrams [1]

M3 Measurement of *d* using micrometer [1]

M4 Allow time for displacement of wire to stabilise [1]

M5 Detail on measuring *y*; final reading - initial reading [1]

Method of analysis (2 marks)

A1 Plot a graph of log *y* against log *d* [1]

A2 q = gradient [1]

Safety considerations (1 mark)

S Safety related to hot wire – use of gloves, wait to cool down/switch off before changing wire, do not touch hot wire [1]

Additional detail (4 marks)

D Relevant points might include [4]

1. Use of vernier scale to measure *y* /well described optical method/use of set square
2. Method for keeping current constant e.g. use of rheostat
3. Check starting position for *y* for same wire
4. $\lg y = q \lg d + \lg p$
5. Repeat measurements of *d* at different points along the wire and determine average
6. Control of additional variables e.g. separation between supports, room temperature
7. Use of protective resistor (either labelled or explained).

15 marks can be scored in total.

1 A hammer is often used to force a nail into wood. The faster the hammer moves, the deeper the nail moves into the wood.

This can be represented in a laboratory by a mass falling vertically onto a nail.

It is suggested that the depth d of the nail in the wood (see Fig. 1.1) is related to the velocity v of the mass at the instant it hits the nail by the equation

$$d = kv^n$$

where k and n are constants.

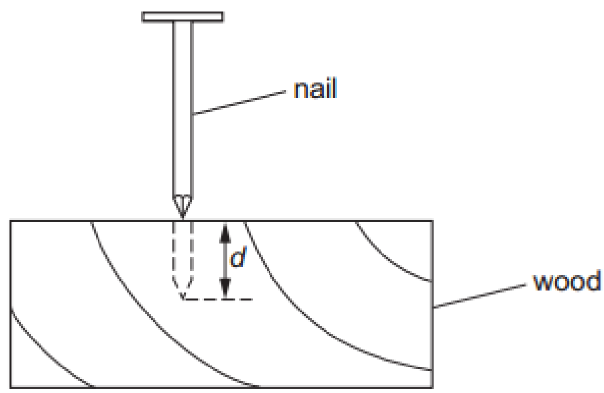

Fig. 1.1

Design a laboratory experiment to investigate the relationship between v and d so as to determine a value for n. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

Planning (15 marks)

Defining the problem (3 marks)

P1	Vary v and measure d, or v is the independent variable and d is the dependent variable	[1]
P2	Keep mass constant	[1]
P3	Keep the wood constant/keep same type of nails	[1]

Methods of data collection (5 marks)

M1	Diagram of apparatus showing mass falling onto centre of nail	[1]
M2	Change height of falling mass (to change v)	[1]
M3	Measurement(s) from which v can be determined, e.g. measure height fallen; light gate(s) connected to timer/data-logger measuring time, and ticker tape/motion sensor. Do not award stopwatch methods.	[1]
M4	Appropriate equation to determine v (the velocity of the mass at the instant it hits the nail)	[1]
M5	Detail on measuring d ; subtract, needle, mark nail, depth gauge	[1]

Method of analysis (2 marks)

A1	Plot a graph of log d against log v	[1]
A2	n = gradient	[1]

Safety considerations (1 mark)

S1	Precaution linked to falling masses, e.g. keep well away/sand trays	[1]

Additional detail (4 marks)

D 1/2/3/4	Relevant points might include	[4]

1. Method to create a large d, e.g. large mass, thin nails, soft wood
2. Use of a guide for falling mass/guide for nail
3. Use of vernier scale to measure d
4. Repeat experiment and determine an average
5. Use different part of wood for each test
6. Method to make nail vertical e.g. set square
7. Discussion / preliminary experiment about thin nails going totally into wood
8. $\lg d = n \lg v + \lg k$

[Total: 15]

1 A current in a flat circular coil produces a magnetic field.

A student suggests that the strength B of the magnetic field is related to the distance x from the centre of the coil (see Fig. 1.1) by the equation

$$B = B_0 e^{-px}$$

where B_0 is the strength of the magnetic field for $x = 0$, and p is a constant.

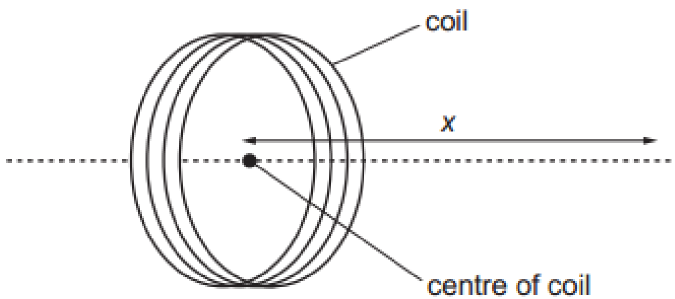

Fig. 1.1

Design a laboratory experiment that uses a Hall probe to investigate the relationship between B and x. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1	x is the independent variable, B is the dependent variable or vary x and measure B	[1]
P2	Keep the number of turns on the coil/radius of the coil <u>constant</u> Do not accept same coil – 'coil' is not a variable	[1]
P3	Keep the <u>current</u> (in the coil) <u>constant</u>	[1]

Methods of data collection (5 marks)

M1	Diagram showing coil and Hall probe with a means of read out appropriately positioned along axis	[1]
M2	Coil connected to a power supply	[1]
M3	Measure x with a ruler	[1]
M4	Hall probe at right angles to direction of magnetic field or gives maximum output for each reading	[1]
M5	Method to determine axis of coil or to find $x = 0$	[1]

Method of analysis (2 marks)

A1	Plot a graph of ln B against x	[1]
A2	Relationship <u>valid</u> if a straight line is produced (ignore reference to y-intercept)	[1]

Safety considerations (1 mark)

S1	Precaution linked to (large) current in <u>coil</u>/heating, e.g. switch off when not in use to avoid overheating coil; do not touch because it is hot	[1]

Additional detail (4 marks)

D 1/2/3/4 Relevant points might include [4]

1. Method to create a large magnetic field, e.g. use large current or large number of turns.
2. <u>Reasoned method</u> to keep current constant.
3. <u>Reasoned method</u> to keep Hall probe in same orientation (e.g. use of set square, fix to rule, optical bench or equivalent).
4. B is proportional to voltage across Hall probe/calibrate Hall probe (in a known magnetic field).
5. Repeat experiment with Hall probe reversed or equivalent.
6. Identifies logarithmic equation i.e. $\ln B = -p\,x + \ln B_0$
7. Avoid external magnetic fields.
8. Method to keep Hall probe along axis.

Do not allow vague computer methods.

[Total: 15]

1 Fig. 1.1 shows a coil (coil X).

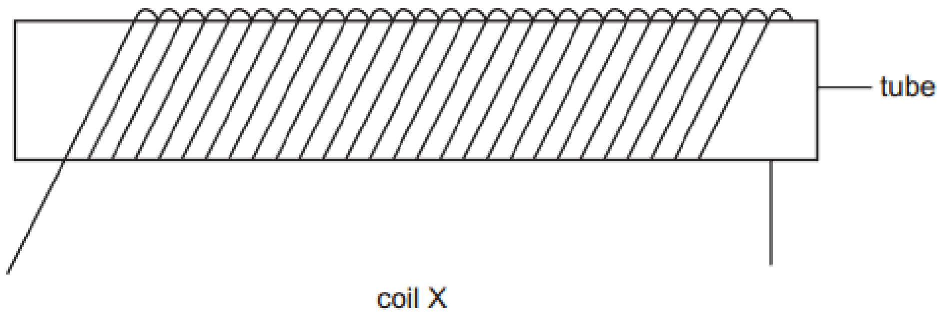

Fig. 1.1

A student winds another coil (coil Y) tightly around coil X.

A changing e.m.f. in coil X induces an e.m.f. in coil Y.

The student wishes to investigate how the e.m.f. *V* in coil Y depends on the frequency *f* of the current in coil X.

It is suggested that *V* is directly proportional to *f*.

Design a laboratory experiment to investigate the suggested relationship. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 *f* is the independent variable and *V* is the dependent variable or vary *f* and measure *V* [1]
P2 Keep the current in coil X constant [1]
P3 Keep the number of turns on coil (Y)/area of coil Y constant
Do not credit reference to coil X only. [1]

Methods of data collection (5 marks)

M1 Two independent coils labelled X and Y. [1]
M2 Alternating power supply/signal generator connected to coil X in a workable circuit. [1]
M3 Coil Y connected to voltmeter/c.r.o. in a workable circuit. [1]
M4 Use c.r.o. to determine period/frequency or read off signal generator. [1]
M5 Method to keep current constant in coil X: adjust signal generator/use of rheostat. [1]

Method of analysis (2 marks)

A1 Plot a graph of *V* against *f*. [1]
A2 Relationship valid if straight line through origin [1]

Safety considerations (1 mark)

S1 Reference to hot coils – switch off when not in use/use gloves/do not touch coils. Must refer to hot coils. [1]

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]

1. Use large current in coil X/large number of coils on coil Y (to increase emf).
2. Use iron core (to increase emf).
3. Detail on measuring emf e.g. height × *y*-gain.
4. Avoid other alternating magnetic fields.
5. Detail on measuring frequency from c.r.o. to determine period and hence *f*.
6. Use of ammeter/c.r.o. and resistor to check current is constant
7. Use insulated wire for coils.
8. Keep coil Y and coil X in the same relative positions.

Do not allow vague computer methods.

[Total: 15]

1 A student wishes to determine the resistivity of aluminium.

The resistivity ρ of a conductor is defined as

$$\rho = \frac{RA}{l}$$

for a conductor of resistance R, cross-sectional area A and length l.

Fig. 1.1 shows the typical dimensions of a strip of aluminium of lengths c, d and t. The resistivity of aluminium is about $10^{-8}\,\Omega\text{m}$.

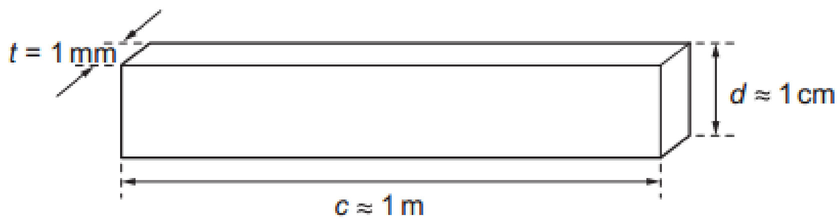

Fig. 1.1 (not to scale)

Design a laboratory experiment to determine the resistivity of aluminium using this strip. The usual apparatus of a school laboratory is available, including a metal cutter.

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 *c*, *d* or *A* is the independent variable and *R* is the dependent variable or vary *c*, *d* or *A* and measure *R*. [1]

P2 If *c* varied then (*t* and) *d* or *A* kept constant, if *d* varied then (*t* and) *c* or *A* kept constant, if *A* varied then *c* or *d* kept constant. [1]

P3 Keep temperature constant. [1]

Methods of data collection (5 marks)

M1 Circuit diagram to measure resistance. [1]

M2 Use micrometer screw gauge to measure *d* or *t*. (Allow digital or vernier callipers) [1]

M3 Measure *c* with a ruler/metre rule. [1]

M4 Method of making contact with the strip e.g. use electrodes of at least same dimension as *c* or *d* or *t* or conducting paint methods. Do not allow crocodile clips, unless it is clear that the whole area of the end of the strip is covered. [1]

M5 Method to determine resistance. [1]

Method of analysis (2 marks)

A1 Plot a graph of *R* against *c*, 1/*d* or 1/*A* depending on orientation. Other alternatives possible, e.g. *R* against 1/*c* depending on orientation [1]

A2 Must be consistent with A1: $\rho = A \times$ gradient or $t \times$ gradient/c [1]
Other alternatives possible, e.g. $\rho = d \times$ gradient/t

Safety considerations (1 mark)

S1 Reference sharp edges or cutting metals, e.g. wear gloves. [1]

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]

1. Insulate aluminium strip
2. Take many readings of *t* or *d* and average
3. Use a protective resistor/circuit designed to reduce current
4. Rearrange equation to determine graph using *c*, *d* and *t* or A
5. Determine typical resistance of aluminium strip
6. Likely meter range of ammeter/voltmeter/ohmmeter
7. Detail on cutting strip e.g. mark using set square

Do not allow vague computer methods.

[Total: 15]

1 When light is incident on the front of a photocell, an e.m.f. is generated in the photocell.

A student wishes to investigate the effect of adding various thicknesses of glass in front of a photocell. This may be carried out in the laboratory by varying the number of identical thin glass sheets between a light source and the front of the photocell.

It is suggested that the e.m.f. V is related to the number n of glass sheets by the equation

$$V = V_0 e^{-\alpha n t}$$

where t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the e.m.f. for $n = 0$.

Design a laboratory experiment to determine the absorption coefficient of glass. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 n is the independent variable and V is the dependent variable or vary n and measure V [1]
P2 Keep distance from light to photocell constant [1]
P3 Keep intensity of light constant. Allow constant voltage across lamp/current through lamp/brightness. Do not allow 'same lamp/output'. [1]

Methods of data collection (5 marks)

M1 Labelled diagram of apparatus: lamp, glass sheet and photocell in line. [1]
M2 Voltmeter connected to photocell. Penalise unworkable photocell circuit. [1]
M3 Use micrometer (screw gauge) to measure thickness of glass sheet. [1]
M4 Take many readings of thickness and average. [1]
M5 Perform experiment in a dark room or shield apparatus. [1]

Method of analysis (2 marks)

A1 Plot a graph of $\ln V$ against n. Allow $\ln V$ against nt [1]
A2 α = (–)gradient / t. ($\ln V$ against nt then α = (–)gradient) [1]

Safety considerations (1 mark)

S Reasoned method to prevent burns from hot source, e.g. use gloves
Reasoned method to prevent eye damage from bright/intense source, e.g. shield lamp/ dark glasses/do not look at source directly
Reasoned method to prevent cuts from glass e.g. use gloves. [1]

Additional detail (4 marks)

D Relevant points might include [4]
1 Use small distance/high intensity to gain large reading.
2 Method to check output of lamp is constant e.g. measure current through/p.d. across lamp/regularly check V_0 with no glass.
3 Reasoned method to ensure output of lamp is constant e.g. workable circuit diagram with variable resistor or variable power supply.
4 Clean sheets of glass before use.
5 Direction of light is perpendicular to glass sheets/constant orientation.
6 $\ln V = -\alpha nt + \ln V_0$.
7 Further safety consideration.

Do not allow vague computer methods.

[Total: 15]

1 A student wishes to investigate projectile motion.

A small ball is rolled with velocity v along a horizontal surface. When the ball reaches the end of the horizontal surface, it falls and lands on a lower horizontal surface. The vertical displacement of the ball is p and the horizontal displacement of the ball is q, as shown in Fig 1.1.

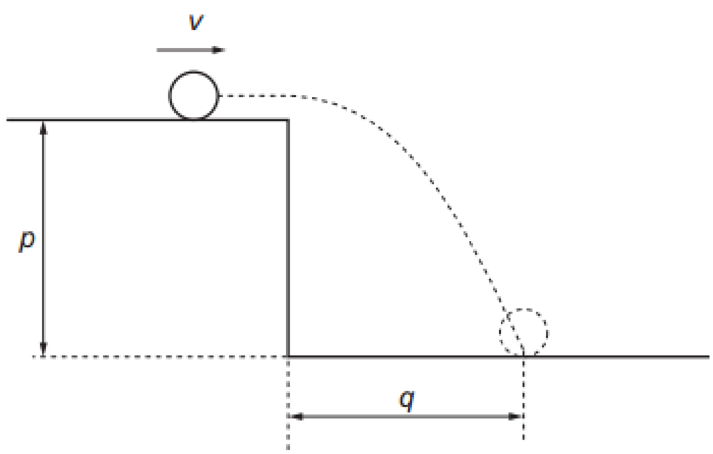

Fig. 1.1

It is suggested that

$$gq^2 = 2pv^2$$

where g is the acceleration of free fall.

Design a laboratory experiment to investigate how q is related to p and how v may be determined from the results. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 p is the independent variable or vary p [1]
P2 q is the dependent variable or measure q [1]
P3 Keep (horizontal) velocity (v) constant [1]

Methods of data collection (5 marks)

M1 Labelled diagram of apparatus including method to vary p. [1]
M2 Method to determine position of ball on surface e.g. carbon paper/dye/video/sand. [1]
M3 Use ruler/caliper to measure p and/or q. [1]
M4 Method to ensure velocity is constant e.g. releasing ball from same height on a track/ spring loaded device or impulse device set to a constant value. [1]
M5 Method to ensure that the moved surface remains horizontal, e.g. spirit level/check height at different places. [1]

Method of analysis (2 marks)

A1 q^2 against p $\quad$ q against $\sqrt{p}$ $\quad$ p against q^2 $\quad$ $\sqrt{p}$ against q [1]

A2 $v = \sqrt{\dfrac{g \times \text{gradient}}{2}}$ $\quad$ $v = \text{gradient} \times \sqrt{\dfrac{g}{2}}$ $\quad$ $v = \sqrt{\dfrac{g}{2 \times \text{gradient}}}$ $\quad$ $v = \dfrac{1}{\text{gradient}} \times \sqrt{\dfrac{g}{2}}$ [1]

Allow valid logarithmic graph e.g. lg q against lg p, lg $2p$, lg $2p/g$ and valid calculation of v from y-intercept.

Safety considerations (1 mark)

S Reasoned method to prevent ball rolling on floor e.g. box below/storage box for balls/ sand box.
Reasoned method to prevent ball causing injury e.g. goggles/safety screen [1]

Additional detail (4 marks)

D Relevant points might include [4]
1 Method to ensure that velocity of ball is horizontal only when it reaches table, e.g. curved track.
2 Ensure that the ball leaves the table at 90°, e.g. set square/protractor on upper surface.
3 Detail on measuring q – location of landing position e.g. centre of crater/start of track.
4 Detail on determining location of zero position for p and q e.g. set square, plumb line.
5 Detail on method of determining position of ball e.g. slow motion playback including scale.
6 Take many readings of q for each p and average.
7 Straight line through the origin shows that p is proportional to q^2/relationship is valid – this mark may only be awarded when A1 is given.
8 Use of high density ball to minimise the effects of air resistance.

Do not allow vague computer methods.

[Total: 15]

1 A current-carrying coil produces a magnetic field.

It is suggested that the strength B of the magnetic field at the centre of a flat circular coil is inversely proportional to the radius r of the coil.

Design a laboratory experiment that uses a Hall probe to test the relationship between B and r. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P *r* is the independent variable, *B* is the dependent variable or vary *r* and measure *B*. [1]
P Keep the number of turns on the coil(s) <u>constant</u>. [1]
Do not accept same coil.
P Keep the current in the coil <u>constant</u>. [1]

Methods of data collection (5 marks)

M1 Diagram showing coil and labelled Hall probe positioned in the centre of a coil. Solenoids will not be credited. [1]
M2 Circuit diagram for coil connected to a (<u>d.c.</u>) power supply. [1]
M3 Connect Hall probe to voltmeter/c.r.o.
Allow galvanometer but do not allow ammeter. [1]
M4 Measure diameter or radius with a ruler/vernier callipers. [1]
M5 Method to locate centre of coil.
e.g. determine max V_H; cross rules; projection [1]

Method of analysis (2 marks)

A Plot a graph of *B* against 1/*r* [allow lg *B* against lg *r* or other valid graph] [1]
A Relationship is valid if the graph is a straight line passing through the origin
[if lg-lg then straight line with gradient = –1 (ignore reference to *y*-intercept)] [1]

Safety considerations (1 mark)

S Precaution linked to (large) heating of <u>coil</u>, e.g. switch off when not in use to avoid overheating coil; do not touch coil because it is hot. [1]

Additional detail (4 marks)

D Relevant points might include [4]
1 Use large current/large number of turns to create a large magnetic field.
2 Use of rheostat to keep current constant in coil.
3 Monitor constant current with ammeter to check current is constant.
4 Hall probe at right angles to direction of magnetic field/plane of coil.
5 <u>Reasoned method</u> to keep Hall probe in constant orientation (e.g. use of set square, fix to rule, optical bench or equivalent).
6 *B* is proportional to voltage across Hall probe/calibrate Hall probe in a known magnetic field.
7 Repeat experiment with Hall probe reversed and average.
8 Repeat measurement for *r* or *d* and average.

Do not allow vague computer methods.

[Total: 15]

1 A changing e.m.f. in a coil can induce an e.m.f. in another coil.

Fig. 1.1 shows a coil (coil X), which is wound on a cardboard tube.

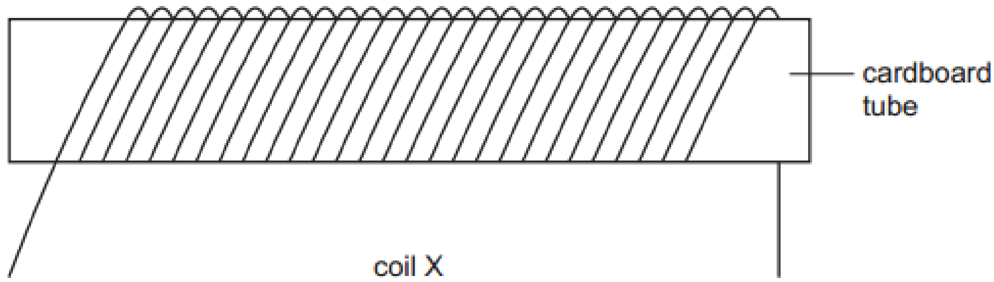

Fig. 1.1

Coil X has cross-sectional area *A*.

A student winds another coil (coil Y) tightly around coil X. The student wishes to investigate how the e.m.f. *V* in coil Y depends on *A*.

It is suggested that *V* is directly proportional to *A*.

Design a laboratory experiment to investigate the suggested relationship. You should draw, on page 3, a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P	*A* is the independent variable and *V* is the dependent variable or vary *A* and measure *V*.	[1]
P	Keep the number of turns on coil Y or coil X constant.	[1]
P	Keep the current in coil X constant.	[1]

Methods of data collection (5 marks)

M1	Two independent coils labelled X and Y; coil Y wound over coil X.	[1]
M2	Alternating power supply/signal generator connected to coil X.	[1]
M3	Coil Y connected to voltmeter/c.r.o. in a workable circuit.	[1]
M4	Measure diameter/radius/lengths with a ruler/vernier callipers.	[1]
M5	Method to determine area.	[1]

Method of analysis (2 marks)

A	Plot a graph of *V* against *A*.	[1]
A	Relationship valid if straight line through origin.	[1]

Safety considerations (1 mark)

S Precaution linked to (large) current in coil/heating, e.g. switch off when not in use to avoid overheating coil; do not touch coil because it is hot. [1]

Additional detail (4 marks)

D Relevant points might include [4]

1 Use large current in coil X/large number of turns/high frequency a.c. to produce measurable e.m.f.
2 Detail on measuring e.m.f., e.g. height × *y*-gain on CRO.
3 Keep frequency of power supply constant.
4 Use of rheostat to keep current constant in coil X.
5 Monitor with a.c. ammeter.
6 Avoid other alternating magnetic fields.
7 Repeat measurement for *r* or *d* or lengths and average.

Do not allow vague computer methods.

[Total: 15]

1 A fairground ride carries passengers in chairs which are attached by metal rods to a rotating central pole, as shown in Fig 1.1. When the pole rotates with angular velocity ω, the rods make an angle θ to the vertical.

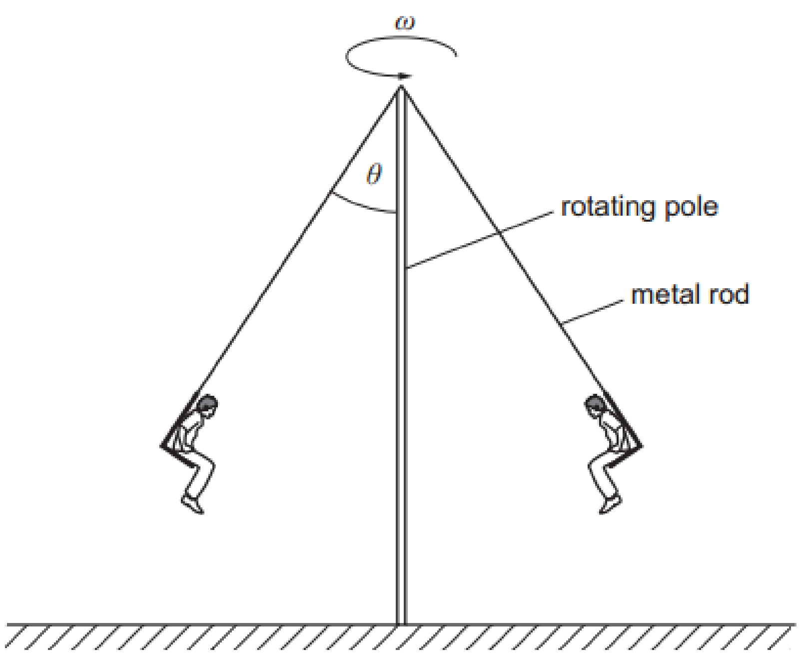

Fig 1.1

It is suggested that $\cos\theta$ is inversely proportional to ω^2.

Design a laboratory experiment, using a small object to represent an occupied chair, to test the relationship between θ and ω. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 Frequency or period of rotation or ω is the independent variable and θ is the dependent variable or vary f or T or ω and measure θ. [1]

P2 $\omega = 2\pi f = 2\pi/T$ [1]

P3 Keep the length of the rigid rod <u>constant</u>; ignore reference to mass. [1]

Methods of data collection (5 marks)

M1 Labelled diagram of apparatus: small <u>object</u>, pole attached to a <u>rotating device</u> (motor, turntable). [1]

M2 Method to change the speed of the rotating device. [1]

M3 Method to determine frequency or time period (e.g. stop watch to time a number of rotations, rev counter/tachometer, light gates connected to a timer/frequency meter). [1]

M4 Use fiducial mark or light gates perpendicular to motion of object. [1]

M5 Method to measure angle – use protractor or rule for measurements for trigonometry methods. This must be shown correctly on diagram or explained in text. [1]

Method of analysis (2 marks)

A1 Plot a graph of cos θ against $1/\omega^2$. [1]

A2 Relationship is valid if straight line through the origin [1]

Safety considerations (1 mark)

S1 Use a protective screen in case mass detaches from the pole. Do not use goggles. [1]

Additional detail (4 marks)

Relevant points might include [4]

1. Large motor speed to produce measurable θ.
2. Additional detail on measuring angle e.g. <u>large</u> protractor fixed to pole.
3. Projection method, slow motion freeze frame video, camera <u>with detail</u>.
4. $\cos \theta = h/l$ or equivalent.
5. Method of checking pole is vertical – use a set square.
6. Additional detail on measuring angular velocity, e.g. time at least 10 rotations.
7. Wait for motion to become stable.

Do not allow vague computer methods.

[Total: 15]

1 A hot air balloon is tied to the ground using a rope. As the wind blows with speed v, the rope makes an angle θ to the horizontal, as shown in Fig 1.1.

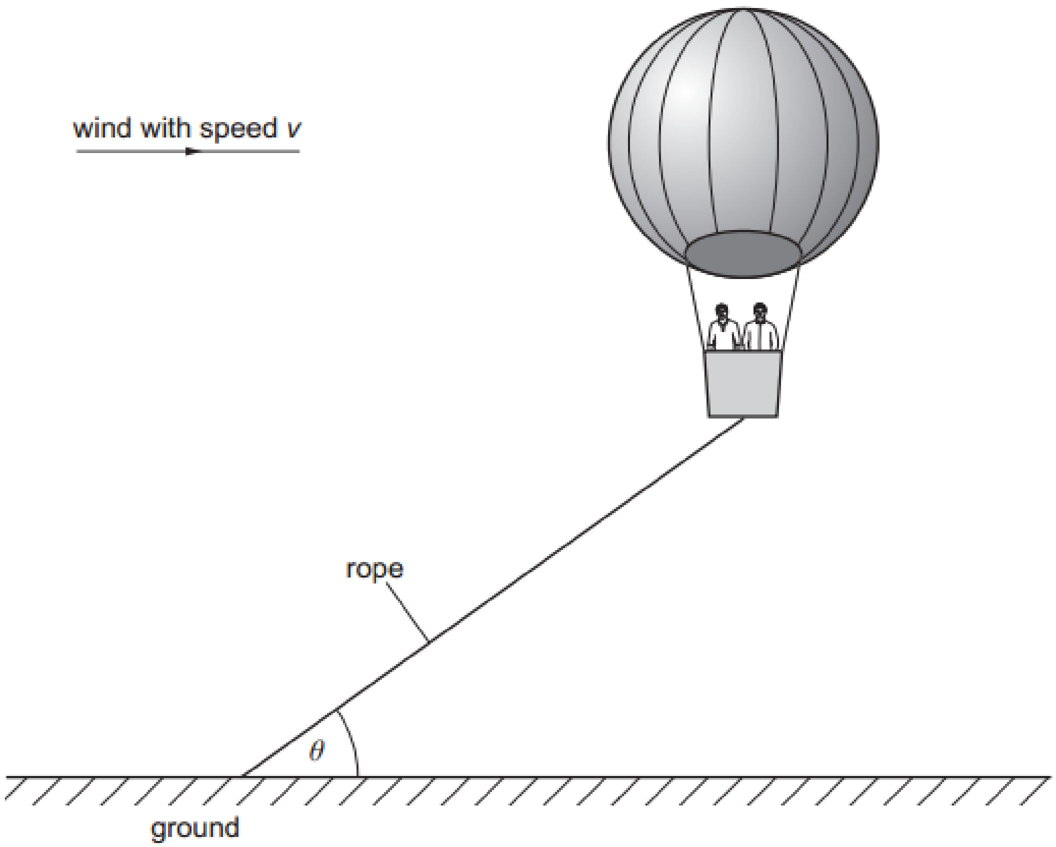

Fig 1.1

It is suggested that $\tan\theta$ is inversely proportional to v^2.

To model the hot air balloon in the laboratory, a balloon filled with helium is used. Design a laboratory experiment using a small helium-filled balloon to test the relationship between θ and v. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P1 *v* is the independent variable and θ is the dependent variable or vary *v* and measure θ. [1]

P2 Keep the (shape and) size/volume/surface area/mass of balloon/helium constant [1]
Do not credit 'same balloon'.

P3 Keep the temperature (air/helium/balloon) constant. [1]

Methods of data collection (5 marks)

M1 Labelled diagram of apparatus: balloon, string fixed and method of producing wind. Method of producing wind to be approximately horizontal to balloon. [1]

M2 Suspend mass from balloon. [1]

M3 Method to change wind speed, e.g. change setting, variable power supply/resistor/change distance from fan. [1]

M4 Method to measure wind speed, e.g. wind speed indicator/detector, anemometer [1]

M5 Method to measure angle – use protractor or rule for measurements for trigonometry methods. This must be shown correctly on diagram or explained in text. [1]

Method of analysis (2 marks)

A1 Plot a graph of tan θ against $1/v^2$. [1]

A2 Relationship valid if straight line through origin [1]

Safety considerations (1 mark)

S1 Avoid the moving blades of the fan (safety screen, switch off when changing experiment); goggles to avoid air stream into eye. [1]

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]

1. Large wind speed to produce measurable deflection/large cross-sectional area of balloon.
2. Additional detail on measuring angle e.g. use a large protractor, projection method.
3. tan $\theta = h/l$.
4. Measuring air speed at point where balloon is positioned.
5. Adjust height of fan so that air flow is horizontally aligned to the balloon.
6. Reason for adding mass to increase stability/deflection.
7. Keep windows shut/air conditioning switched off/use of wind tunnel to avoid draughts.
8. Wait for the balloon to become stable.

Do not allow vague computer methods.

[Total: 15]

1 As a bar magnet is dropped through a coil, an e.m.f. is induced in the coil. The maximum e.m.f. E is induced as the magnet leaves the coil with speed v.

It is suggested that E is directly proportional to v.

Design a laboratory experiment to test the relationship between E and v. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P v is the independent variable or vary v. [1]

P E is the dependent variable or measure E. [1]

P Keep the number of turns on the coil constant. [1]

Methods of data collection (5 marks)

M1 Labelled diagram showing magnet falling vertically through coil. [1]

M2 Voltmeter or c.r.o. connected to the coil. Allow voltage sensor connected to datalogger. [1]

M3 Method to change speed e.g. change height. [1]

M4 Measurements to determine v. Use metre rule to measure distance magnet falls to the bottom of the coil or metre rule/ruler to measure length of coil or ruler to measure length of the magnet. [Allow timing instrument to measure the time of the fall from the start to the bottom of the coil.] [1]

M5 Method of determining v corresponding to appropriate distance e.g. $v = \sqrt{2gh}$ or $v=2h/t$ (for height method) or $v = L/t$ for length of magnet or coil and by stopwatch, timer or lightgate(s) connected to datalogger. [Allow $v = gt$ for timing fall to bottom of coil.] [1]

Method of analysis (2 marks)
A Plot a graph of E against v. [Allow lg E against lg v] [1]

A Relationship valid if straight line through origin. [1]
[If lg-lg then straight line with gradient = (+)1 (ignore reference to y-intercept)]

Safety considerations (1 mark)
S Keep away from falling magnet/use sand tray/cushion to catch magnet. [1]

Additional detail (4 marks)
D1/2/3/4 Relevant points might include [4]
Use coil with large number of turns/drop magnet from large heights/strong magnet
1 Detailed use of datalogger/storage oscilloscope to determine maximum E; allow video camera including slow motion play back
2 Use same magnet or magnet of same strength.
3 Use of short magnet so that v is (nearly) constant
4 Use short/thin coil so that v is (nearly) constant
5 Use a non-metallic vertical guide/tube
6 Method to support vertical coil or guide/tube
7 Repeat experiment for each v and average

Do not allow vague computer methods.

[Total: 15]

1 Two identical light sources are viewed from a distance, as shown in Fig 1.1. When the angle θ between the light sources is large, they are seen as separate.

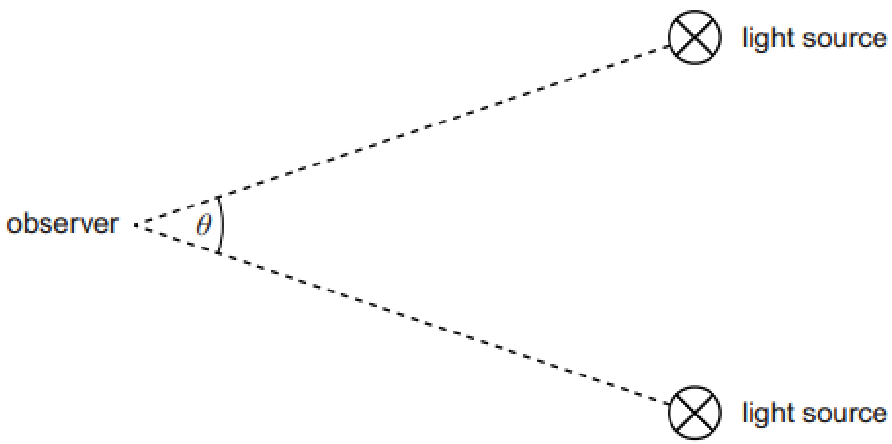

Fig 1.1 (not to scale)

The sources are moved closer together. At a particular angle θ_1 the two sources appear as a single source.

It is suggested that θ_1 is directly proportional to the wavelength λ of the light from the sources.

Design a laboratory experiment using two light sources to test the relationship between θ_1 and λ. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P λ is the independent variable or vary λ. [1]
P θ is the dependent variable or measure θ (for each λ). [1]
P Light sources to be of similar intensity/brightness. [1]

Methods of data collection (5 marks)

M1 Labelled diagram showing observer, light sources with method of producing monochromatic light e.g. filter/coloured LED. [1]
M2 Method to measure wavelength: record from filter/LED or Young's slit/diffraction grating method. [1]
M3 Use a rule to measure the distances. [1]
M4 Method to determine θ, e.g. θ (or sin θ or tan θ) = separation/distance or

$$\tan\left(\theta/2\right)=\frac{\text{separation}}{2\times\text{distance}}$$

Do not allow protractor methods. [1]

M5 Carry out the experiment in a dark room. [1]

Method of analysis (2 marks)

A Plot a graph of θ against λ. [Allow lg θ against lg λ]. [1]
A Relationship valid if straight line <u>through origin</u>. [1]
[If lg-lg then straight line with gradient = (+)1 (ignore reference to *y*-intercept)]

Safety considerations (1 mark)

S Lamp becomes hot, therefore do not touch/switch off when not in use or use gloves when moving hot lamp.
OR Light may damage eyes, therefore wear dark glasses or do not look at unprotected lamps.
[1]

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]
1 Use vertical filament lamps. Allow vertical slits.
2 Additional detail on measuring λ e.g. use of equation for Young's slit/diffraction grating method.
3 Use of vernier calipers to measure the separation of light sources.
4 Use large distances/separations.
5 θ = sin θ = tan θ for small angles.
6 View with the same eye.
7 Method to ensure distances are perpendicular or observer <u>equidistant</u> from pair of lamps.
8 Repeat experiment for each λ <u>and</u> average.
Do not allow vague computer methods.

[Total: 15]

1 A student is investigating the flow of water through a horizontal tube.

The rate Q (volume per unit time) at which water flows through a tube depends on the pressure difference per unit length across the tube.

The student has the use of a metal can with two holes. A narrow horizontal tube goes through the hole in the side of the can. The can is continuously supplied with water from a tap. The level of water in the can is kept constant by the position of a wide vertical tube which passes through the hole in the bottom of the can as shown in Fig. 1.1. Both tubes may be moved along the holes.

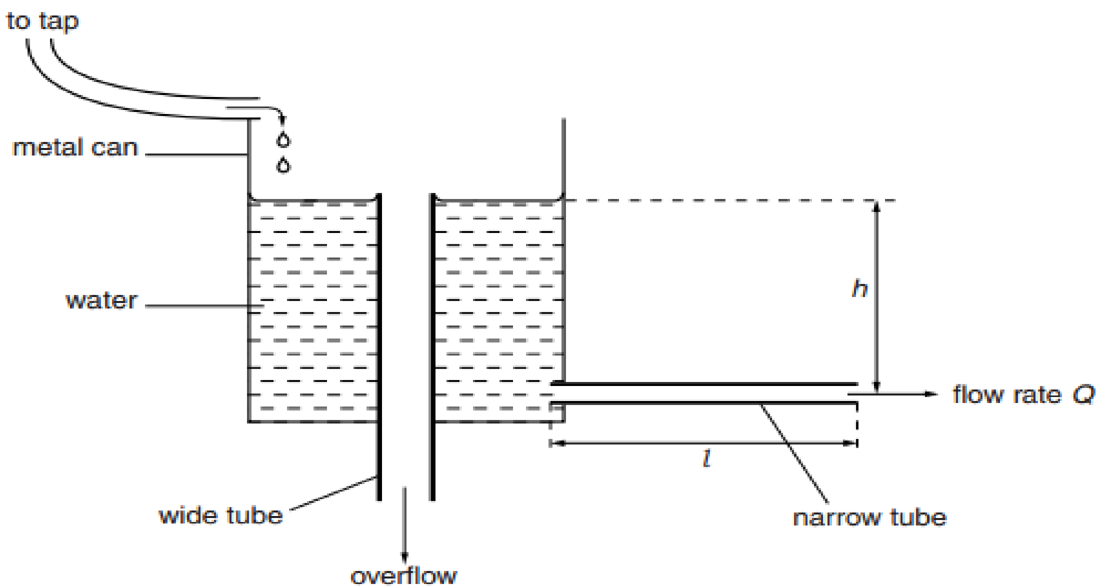

Fig. 1.1

It is suggested that the relationship between the flow rate Q of water through the narrow horizontal tube and the vertical height h is

$$Q = \frac{2\pi\rho g h d^4}{l\eta}$$

where ρ is the density of water, g is the acceleration of free fall, d is the internal diameter of the tube, l is the length of the tube and η is a constant.

Design a laboratory experiment to test the relationship between Q and h and determine a value for η. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

Planning (15 marks)

Defining the problem (3 marks)

P *h* is the independent variable or vary *h*. [1]

P *Q* is the dependent variable or measure *Q* (allow *t*). [1]

P Keep *l* constant. [1]

Methods of data collection (5 marks)

M Labelled diagram of apparatus: including labelled measuring cylinder/calibrated beaker to receive water. (Measurement may be credited in the text.) [1]

M Vary position of vertical/larger tube. [1]

M Measure *h* and *l* with a rule/caliper. [1]

M Measure *d* with a travelling microscope or vernier calipers. [1]

M Measure *t* with stopwatch. [1]

Method of analysis (2 marks)

A Plot a graph of *Q* against *h*. [Allow lg *Q* against lg *h*] [1]

A $\eta = \dfrac{2\pi\rho g d^4}{l \times \text{gradient}}$

Must include gradient and η must be subject of formula. [1]

Safety considerations (1 mark)

S Reasoned method to prevent spills, e.g. use tray/sink/cloths on floor. Reasoned method to prevent injury when adjusting metal/glass tubes by wearing protective gloves. Mark may not be scored from the diagram. [1]

Additional detail (4 marks)

D Relevant points might include [4]

1 Repeat experiment for same *h* and average
2 Method to determine the density of water including method to measure mass and volume and equation
3 Take many readings of *d* and average
4 Relationship is valid if straight line passing through origin [if lg-lg graph allow straight line with gradient = 1]
5 Method to check that tube is horizontal
6 Detail on measuring *h* to the centre of the horizontal tube e.g. add radius of tube
7 Keep temperature of water constant

Do not allow vague computer methods.

[Total: 15]

1 A student is investigating how the peak alternating current I_0 varies with frequency f in a circuit containing a coil of wire.

It is suggested that

$$\left(\frac{V_0}{I_0}\right)^2 = R^2 + 4\pi^2 f^2 L^2$$

where R is the resistance of the coil, V_0 is the peak voltage and L is a constant.

Design a laboratory experiment to test the relationship between I_0 and f and determine a value for L. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Mark Scheme:

1 Planning (15 marks)

Defining the problem (3 marks)

P f is the independent variable or vary f. [1]

P I_0 is the dependent variable or measure I_0. [1]

P Keep V_0 constant. [1]

Methods of data collection (5 marks)

M Labelled/ workable circuit diagram of apparatus: including coil connected to power supply/signal generator. [1]

M Variable frequency ac power supply or signal generator (method of varying frequency). [1]

M Measure current using ammeter or p.d. across resistor. [1]

M Measure V across power supply or across coil e.g. voltmeter or c.r.o. explained. [1]

M Measure f using oscilloscope/read off signal generator. [1]

Method of analysis (2 marks)

A Plot a graph of $1/I_0^2$ against f^2 or V_0^2/I_0^2 against f^2 or equivalent.
Do not allow log-log graph. [1]

A $L = \sqrt{\dfrac{V_0^2 \text{gradient}}{4\pi^2}} = \dfrac{V_0}{2\pi}\sqrt{\text{gradient}}$ or $L = \sqrt{\dfrac{\text{gradient}}{4\pi^2}}$ [1]

Safety considerations (1 mark)

S Reasoned method to prevent overheating of coil or burns from coil. [1]

Additional detail (4 marks)

D Relevant points might include [4]
1 Use lower frequencies to produce larger currents
2 Keep resistance of circuit/coil constant
3 Additional detail on measuring T using timebase
4 $f = 1$ / period
5 Additional detail on measuring V_0 using y-gain
6 Relationship is valid if straight line, provided plotted graph is correct
7 Relationship is valid if straight line not passing through origin, provided plotted graph is correct (any quoted expression must be correct)
8 Detail on changing r.m.s. to peak

Do not allow vague computer methods. Ignore reference to iron core / other magnetic fields.

[Total: 15]