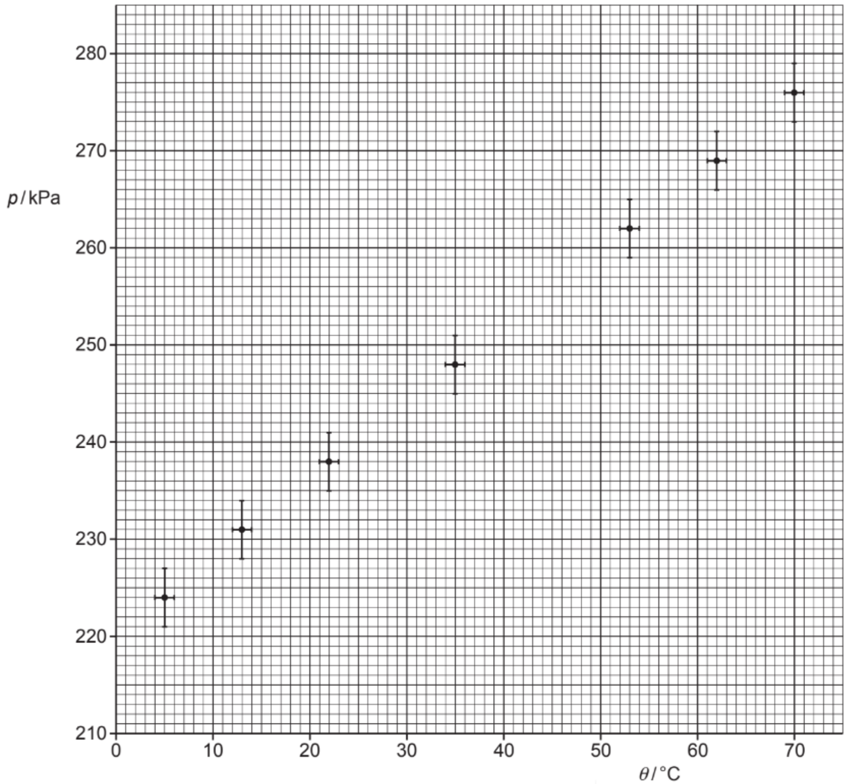
A Level Exam Questions

2017 QP - Paper 1 OCR (A) Physics A-level

17cii – 13A.6.7 Estimating Absolute Zero (PAG 8)



Explain what is meant by absolute zero. Describe how Fig. 17.3 can be used to determine the value of absolute zero.

Determine the value of absolute zero. You may assume that the gas behaves as an ideal gas.

[6]

19b - 13A.5.7 Resonance

Describe with the aid of a labelled diagram how an experiment can be conducted and how the data can be analysed to test the validity of the equation

$$T^2 = \frac{4\pi^2}{g}L$$

for oscillations of small amplitude.

[6]

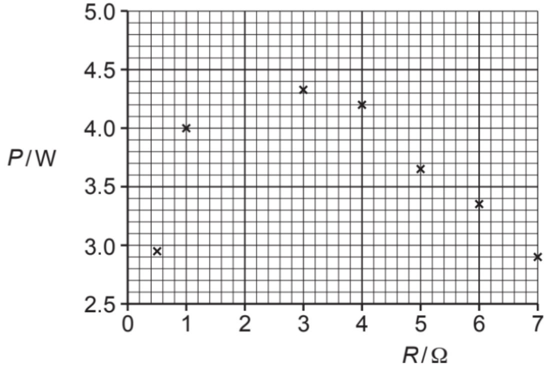
2017 QP - Paper 2 OCR (A) Physics A-level

18b - 12B.2.4 EMF and Power

A group of students are investigating the power dissipated in a variable resistor connected across the terminals of a cell. The cell has e.m.f. 1.5 V.

The students determine the power P dissipated in the variable resistor of resistance R.

Fig. 18.2 shows the data points plotted by the students on a graph of P (y-axis) against R (x-axis).



The group of students know that **maximum power** is dissipated in the variable resistor when R is equal to the internal resistance r of the cell.

Describe, with the help of a suitable circuit diagram, how the students may have determined P and R. Use Fig. 18.2 to estimate the internal resistance r of the cell and discuss any limitations of the data plotted by the group.

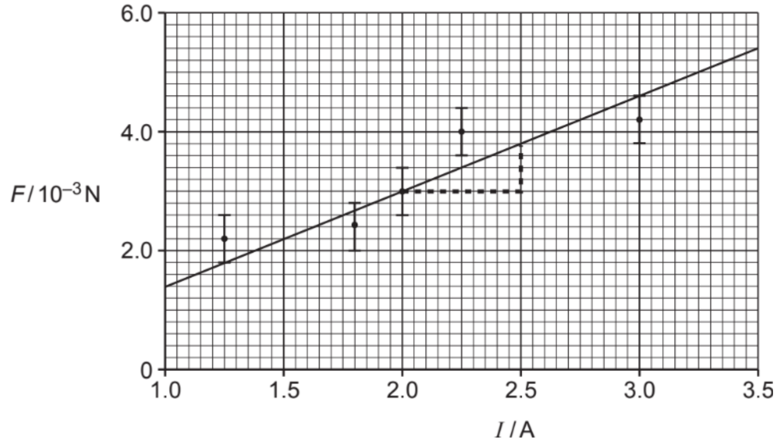
[6]

22a - 13B.5.2 Forces on a Wire in a Magnetic Field

A student conducts an experiment to confirm that the uniform magnetic flux density **B** between the poles of a magnet is 30 mT.

A current-carrying wire of length 5.0 cm is placed perpendicular to the magnetic field.

The current **I** in the wire is changed and the force **F** experienced by the wire is measured. Fig. 22.1 shows the graph plotted by the student.



The student's analysis is shown on the graph of Fig. 22.1 and in the space below.

$F = BIL$

$$gradient = BL = \frac{(3.8 - 3.0) \times 10^{-3}}{2.5 - 2.0} = 0.0016$$

$$B = \frac{0.0016}{0.05} = 0.032\ T = 32\ mT$$

This is just 2 mT out from the 30 mT value given by the manufacturer, so the experiment is very accurate.

Evaluate the information from Fig. 22.1 and the analysis of the data from the experiment. No further calculations are necessary.

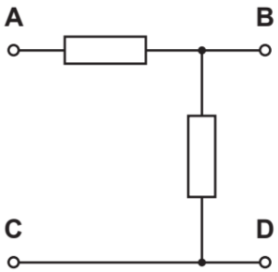
[6]

2017 QP - Paper 3 OCR (A) Physics A-level

4a - 12B.4.2 Potential Dividers

You are given an unmarked sealed square box which has four identical terminals at each corner.

Fig 4.1 shows the circuit diagram for the contents of the box with the four terminals labelled **A**, **B**, **C** and **D**.



One of the resistors in the box has resistance 220 Ω. The other resistor has resistance 470 Ω.

Two of the terminals are connected by a wire.

The four terminals on your unmarked sealed box are not labelled.

You are given a 6.0 V d.c. supply, a 100 Ω resistor (labelled R) and a digital ammeter.

Plan an experiment to determine the arrangement of the components and identify which terminal of your unmarked sealed box is **A**, **B**, **C** and **D**.

A space has been left for you to draw circuit diagrams to illustrate your answer.

[6]

5b - 12.6.2 Two Source Interference

Students are given the equipment in Fig. 5.1 together with a metre rule.

They are also given a second loudspeaker connected to the same signal generator at 1.7 kHz. They are asked to design an experiment where they would need to take just **one** measurement and be able to determine the value of the speed of sound.

They set up the experiment in two different ways as shown in Fig. 5.3(a) and (b).

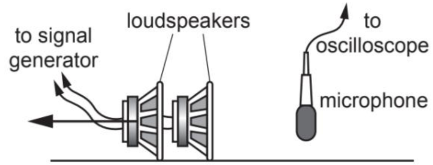
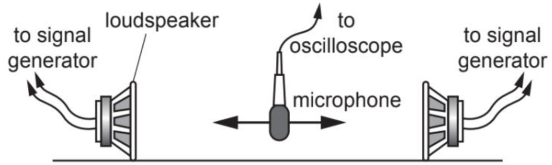


Fig. 5.3(a)



In method (a) the microphone is fixed and one loudspeaker is moved to the left as shown in Fig. 5.3(a).

In method (b) the microphone is moved to the left or to the right with the loudspeakers fixed a certain distance apart as shown in Fig. 5.3(b).

Describe and explain how both methods can be used to accurately determine the speed of sound. In your description, discuss how the uncertainty in the value for the speed of sound can be minimised in one of the methods, without using any other apparatus.

[6]

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16b - 12A.2.4 Projectiles

A metal ball is rolled off the edge of a horizontal laboratory bench. The initial horizontal velocity of the ball is v. The ball travels a horizontal distance x before it hits the level floor.

Use your knowledge of projectile motion to suggest the relationship between v and x. Describe how an experiment can be safely conducted to test this relationship and how the data can be analysed.

[6]

22b - 13A.6.6 The Ideal Gas Equation & Energy of Atoms

There is a lot of helium in the Universe. This was also true of the Earth when it was formed billions of years ago. However, only small traces of helium are now found in the atmosphere of the Earth.

Use the kinetic theory of gases to explain why only small amounts of helium are found in the Earth's atmosphere. Use the information below to do suitable calculations to support your answer.

- typical atmospheric temperature = 10°C
- mass of helium atom = 6.64×10^{-27} kg
- escape velocity from the Earth = 11 kms^{-1}

[6]

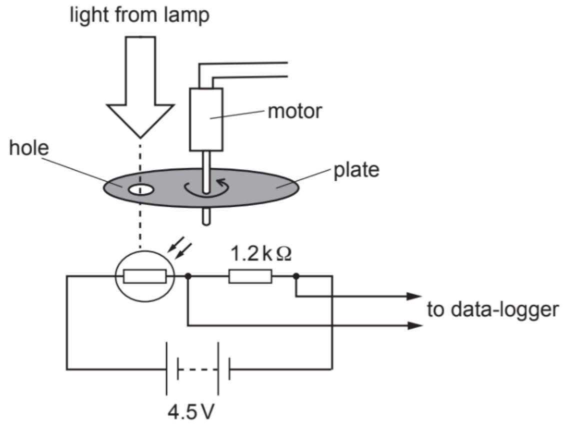
2018 QP - Paper 2 OCR (A) Physics A-level

17 - 12B.4.2 Potential Dividers

A metal circular plate is rotated at a constant frequency by an electric motor.

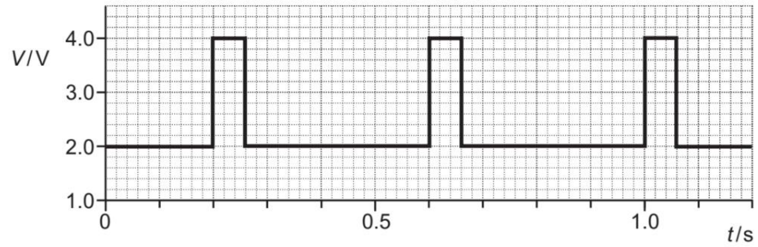
The plate has a small hole close to its rim.

Fig. 17.1 shows an arrangement used by a student to determine the frequency of the rotating plate.



A light-dependent resistor (LDR) and a fixed resistor of resistance 1.2kΩ are connected in series to a battery. The battery has e.m.f. 4.5V and has negligible internal resistance. The potential difference V across the resistor is monitored using a data-logger.

Fig. 17.2 shows the variation of V with time t.



Use your knowledge and understanding of potential divider circuits to explain the shape of the graph shown in Fig. 17.2. Include in your answer the maximum and minimum values of the resistance of the LDR.

Describe how the student can determine the frequency of the rotating plate.

[6]

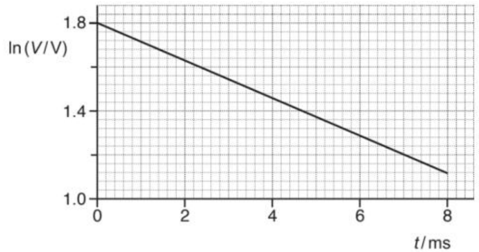
22b - 13B.3.1 Capacitance

A student wishes to determine the permittivity ε of paper using a capacitor made in the laboratory.

The capacitor consists of two large parallel aluminium plates separated by a very thin sheet of paper.

The capacitor is initially charged to a potential difference V_0 using a battery. The capacitor is then discharged through a fixed resistor of resistance 1.0 MΩ.

The potential difference V across the capacitor after a time t is recorded by a data-logger. The student uses the data to draw the ln V against t graph shown in Fig. 22.



Use Fig. 22 to determine the capacitance C of the capacitor. Describe how the student can then use this value of C to determine a value for ε.

In your description, mention any additional measurements required on the capacitor.

[6]

2018 QP - Paper 3 OCR (A) Physics A-level

1a - 12B.3.5 Resistance and Resistivity

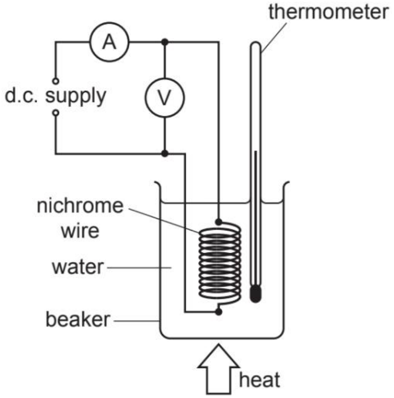
This question is about a resistance wire made of nichrome.

It is suggested that the resistance **R** of a length of nichrome wire varies with temperature θ in °C according to the equation

$$R = R_0 (1 + k\theta)$$

where R_0 is the resistance of the wire at 0°C and k is a constant for the wire.

Fig. 1.1 shows a diagram of the arrangement of apparatus in an experiment to test the relationship between R and θ and to determine the value of k.



The resistance wire is coiled and placed in a water bath.

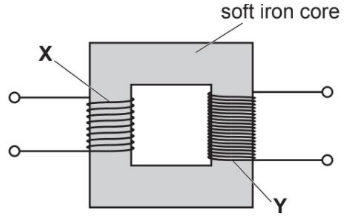
Describe how you would carry out the experiment, analyse the data to verify the relationship between R and θ and determine a value for k.

In your description, state any precautions that you would take to improve the accuracy and precision of the measurements.

[6]

5b - 13B.6.5 Transformers

A student is given a transformer with coils X and Y, as shown in Fig. 5.4.



The student is intending to investigate how the maximum induced e.m.f. V_0 in coil Y depends on the frequency f of the alternating current in coil X.

The changing magnetic flux density in coil X induces an e.m.f. in coil Y. Faraday's law indicates that the maximum induced e.m.f. V_0 should be directly proportional to f.

Describe how you would investigate the suggested relationship between V_0 and f in the laboratory using these coils. In your description include all of the equipment used and how you would analyse the data collected.

Use the space below to draw a suitable diagram.

[6]

2019 QP - Paper 1 OCR (A) Physics A-level

19b - 12A.4.2 KE and GPE

A student rolls a marble at different speeds on a carpet to model the braking of a car.

The student wishes to investigate how the total distance x travelled before the marble stops (braking distance) depends on its initial speed v.

The speed v and distance x are related by the equation

$$\frac{1}{2}mv^2 = Fx$$

where m is the mass of the marble and F is the constant frictional force acting on the marble.

- Describe how an experiment can be conducted in the laboratory to investigate the relationship between v and x.
- Explain how the data can be analysed to determine F.

[6]

23a - 13A.1.4 Wein's and Stefan's Law

In 2017, an ultra-cool star TRAPPIST-1 was discovered with at least five of its own orbiting planets. Astronomers are interested about the possibility of finding life on some of the planets orbiting TRAPPIST-1.

The table below shows some data.

	TRAPPIST-1	Sun
Luminosity L / W	2.0×10^{23}	3.8×10^{26}
Surface temperature T / K	2500	5800
Radius of star / m	R	7.0×10^{8}
Distance between Earth and Sun / m		1.5×10^{11}
Distance between planets and TRAPPIST-1 / m	1.6×10^{9} to 9.0×10^{9}	

The temperature T in kelvin of a planet, its distance d from the star and the luminosity L of the star are related by the expression

$$\frac{T^4 d^2}{L} = constant$$

- The average temperature of the Earth is about 290 K. Explain how life may be possible on some of the planets orbiting TRAPPIST-1.
- Use your knowledge of luminosity to show that the radius R of TRAPPIST-1 is smaller than the Sun.
- Support your answers by calculations.

[6]

2019 QP - Paper 2 OCR (A) Physics A-level

16d - 12A.8.3 Measuring the Mass of the Earth

The speed v of surface water waves in shallow water of depth d is given by the equation

$$v = \sqrt{gd}$$

where g is the acceleration of free fall.

The speed v is about 1 ms^{-1} for a depth of about 10 cm.

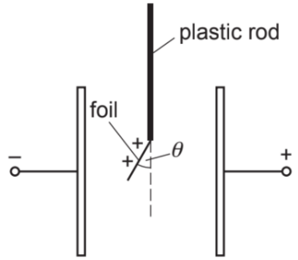
You are provided with a rectangular plastic tray, supply of water and other equipment available in the laboratory.

Describe how an experiment can be conducted in the laboratory to test the validity of the equation above and how the data can be analysed to determine a value for g.

[6]

22c - 13B.3.3 Electric Potential and Electric Potential Energy

Fig. 22.4 shows an arrangement used by a student to investigate the forces experienced by a small length of charged gold foil placed in a uniform electric field.



The two vertical metal plates are connected to a high-voltage supply.

The foil is given a positive charge by briefly touching it to the positive plate.

The angle θ made with the vertical by the foil in the electric field is given by the expression

$$\tan\theta = \frac{qE}{W}$$

where q is the charge on the foil, E is the electric field strength between the plates and W is the weight of the foil.

The angle θ can be determined by taking photographs with the camera of a mobile phone.

Describe how the student can safely conduct an experiment to investigate the relationship between θ and E.

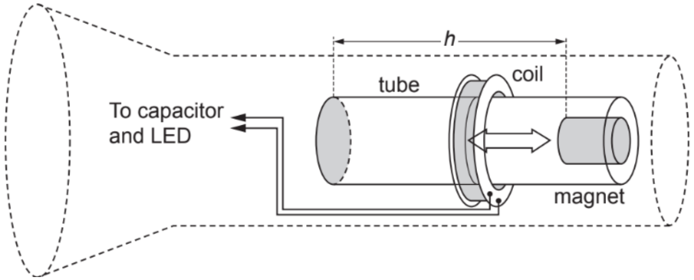
Identify any variables that must be controlled.

[6]

2019 QP - Paper 3 OCR (A) Physics A-level

3c - 13B.6.3 Lenz's Law

Fig. 3.1 shows the design of a 'mechanical' torch.



There is no battery in the torch. Instead, when the torch is inverted, the magnet falls a short vertical distance h through the coil of wire, as shown in Fig. 3.2. This induces an electromotive force (e.m.f.) across the ends of the coil. The e.m.f. is used to store charge in a capacitor, which lights a light-emitting diode (LED) when it discharges.

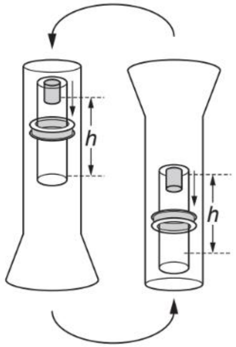
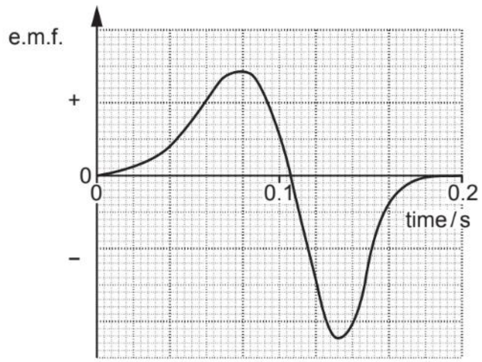


Fig. 3.3 shows the variation with time of the e.m.f. generated as the magnet falls the distance h.



In the torch, the gravitational potential energy of the magnet is converted into electrical energy supplied to the 50 mW LED.

You are asked to investigate whether the efficiency of this energy conversion depends on the number of inversions of the torch.

- Describe how you will make accurate measurements to collect your data. Assume that both the torch and the tube can be opened.
- Explain how you will use the data to reach a conclusion.

[6]

5a - 12B.6.4 Diffraction Grating

Hydrogen atoms excited in a discharge tube only emit four different discrete wavelengths of visible photons.

In a semi-darkened room, a single slit is placed in front of the discharge tube. A student holds a diffraction grating which has 300 lines per millimetre.

The student looks through the grating at a 15 cm plastic ruler placed 0.50 m away, as shown in Fig. 5.1.

The paths of the different colours of light from the slit to the student's eye are shown in Fig. 5.2.

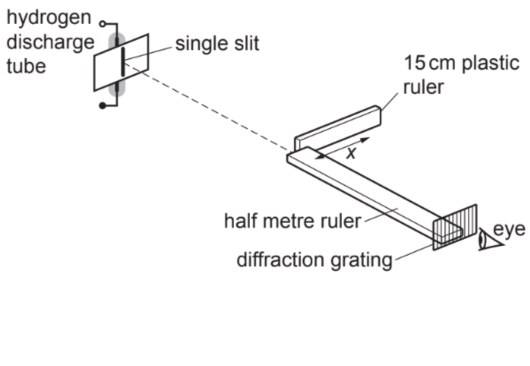


Fig. 5.1 (not to scale)

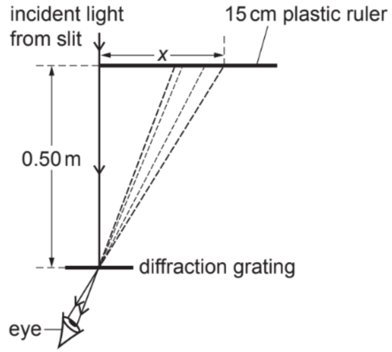


Fig. 5.2 (not to scale)

Four first order images of the slit, one at each photon wavelength, are observed as vertical lines against the background of the plastic ruler, as shown in Fig. 5.3.

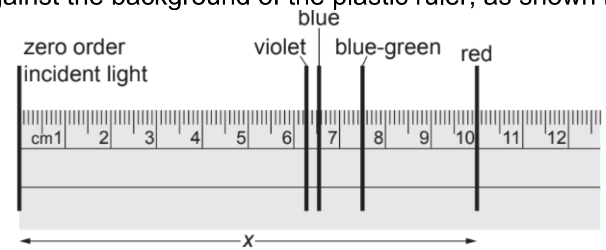


Fig. 5.3

The student decides to determine the wavelength of the photons which form the red line observed at x = 10 cm on the ruler.

- Describe how the information that has been given can be used to determine the wavelength of the red photons.
- Estimate the percentage uncertainty in the measured value of the wavelength.

[6]

2020 QP - Paper 1 OCR (A) Physics A-level

17b - 13A.6.3 Specific Heat Capacity & Specific Latent Heat

A student is carrying out an experiment to determine the specific latent heat of fusion L_f of ice.

The student has two sets of apparatus next to each other on the laboratory bench, as shown in **Fig. 17.1** and **Fig. 17.2**.

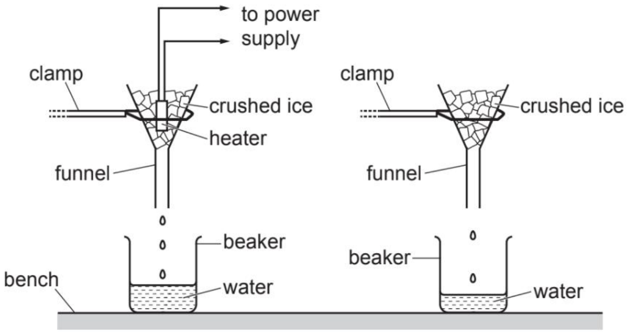
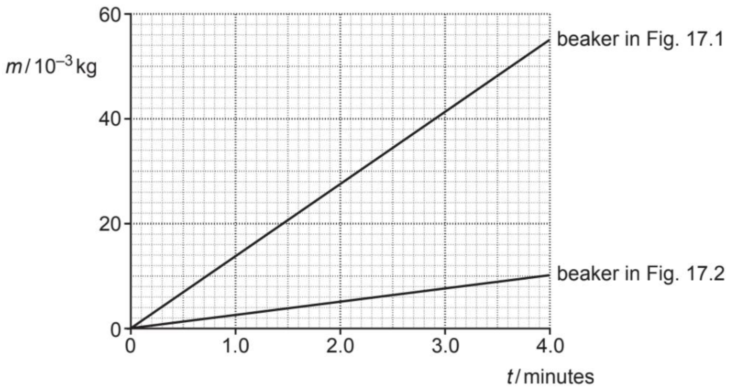


Fig. 17.1 **Fig. 17.2**

Both funnels are identical and have the same mass of crushed ice at 0 °C.

The current in the heater is 5.0 A and the potential difference across it is 12 V.

Fig. 17.3 shows the variation of mass of water m collected in each beaker with time t.



Describe and explain the shape of the two graphs in Fig. 17.3 and use them to determine the specific latent heat of fusion L_f of ice.

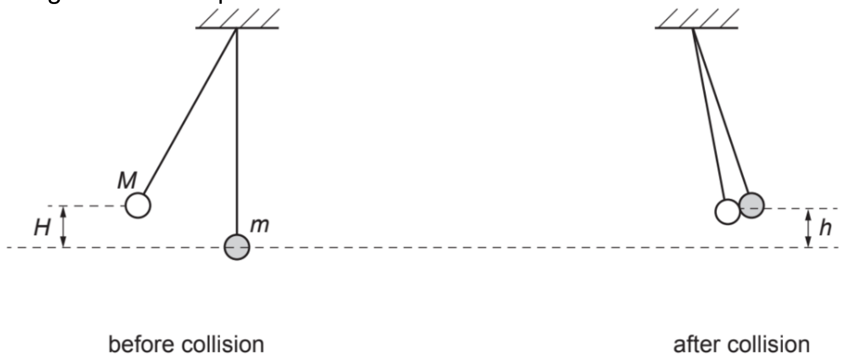
[6]

19 - 13A.5.3 Energy Transfers during Oscillations

A student makes a pendulum using a length of string with a ball of adhesive putty which acts as a bob. The mass of this bob is M.

A similar second pendulum is constructed with the same length of string but with a bob of a smaller mass. The mass of this bob is m.

The arrangement of the pendulums is shown below.



The bob of mass M is pulled back to a vertical height of H from its rest position. It is released and collides with the bob of mass m. The two bobs then stick together and reach a maximum vertical height h from the rest position.

The height h is given by the equation

$$h = \left(\frac{M}{M + m}\right)^2 H$$

Describe how to perform an experiment to test the validity of this equation and how the data can be analysed.

[6]

2020 QP - Paper 2 OCR (A) Physics A-level

18 - 12B.3.6 LDRs and Thermistors

A resistance wire is coiled around a thermistor. The coil of wire will warm the thermistor.

It is suggested that the relationship between the power P dissipated in the coiled wire and the stable resistance R of the thermistor is given by the expression

$$P = kR^n$$

where k and n are constants.

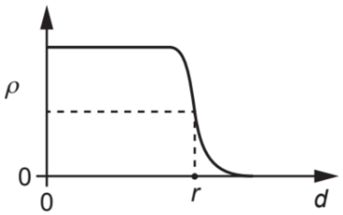
Describe how an experiment can be conducted to assess the validity of this expression and how the data collected can be analysed to determine k and n.

Use the space below for a circuit diagram.

[6]

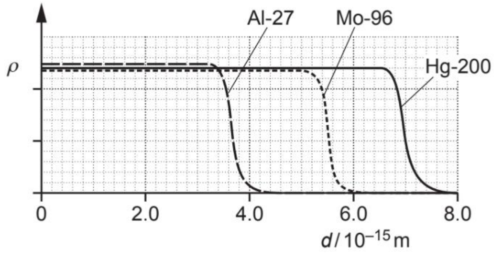
21c - 13B.1.4 Nuclear Forces and Density

A graph of the density ρ of a nucleus against distance d from the centre of the nucleus is shown below.



The radius of the nucleus r is taken as the distance d where the density is half the maximum density.

Fig. 21.1 shows the density ρ variation for three different nuclei and **Table 21.1** shows the nucleon number A of each nucleus.



Nucleus	Nucleon number A
Al-27	27
Mo-96	96
Hg-200	200

Use the information provided opposite to

- describe how the density of a nucleus depends on its nucleon number A
- show numerically that $r \propto A^{1/3}$
- estimate the mean density of the nuclei.

[6]

2020 QP - Paper 3 OCR (A) Physics A-level

3b - 13A.6.6 The Ideal Gas Equation & Energy of Atoms

A student attends a lecture about the Sun and makes the following notes.

1. The Sun loses more than 4 x 10^9 kg of its mass every second to maintain its luminosity.
2. Treating hydrogen nuclei (protons) as an ideal gas, a temperature of 10^{10} K provides a kinetic energy of about 1 MeV, which is necessary for fusion.
3. However, the Sun's core temperature is only 10^7 K, so the chance of protons fusing on collision is very small. This explains why the Sun has such a long lifetime.

Explain the principles of physics which are involved in each of the three points.

You should include relevant formulae, but no numbers or calculations are required.

[6]

5d - 12B.7.1 Standing Waves

This question is about investigations involving an electromagnetic wave.

A vertical transmitter aerial emits a vertically polarised electromagnetic wave which travels towards a vertical receiver aerial. The wavelength of the wave is 0.60 m.

Fig. 5.1 shows a short section of the oscillating electric field of the electromagnetic wave.

A student carries out two investigations with these electromagnetic waves.

In **investigation 1**, the student rotates the receiver aerial about the horizontal axis joining the two aerials, as shown in **Fig. 5.1**.

In **investigation 2**, the student places a metal sheet behind the receiver aerial. The student moves the sheet backwards and forwards along the horizontal axis joining the two aerials, as shown in **Fig. 5.2**.

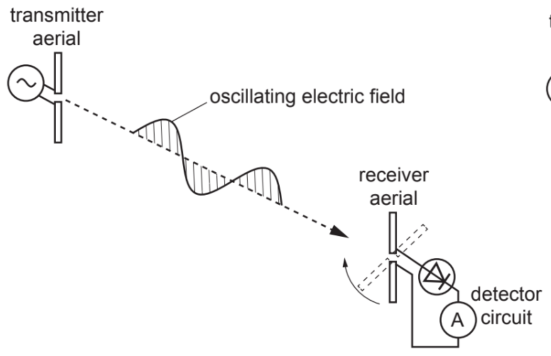


Fig. 5.1

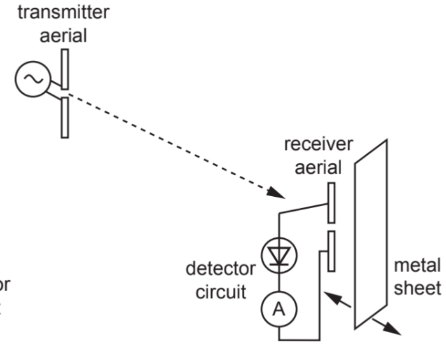


Fig. 5.2

For each of these two investigations:

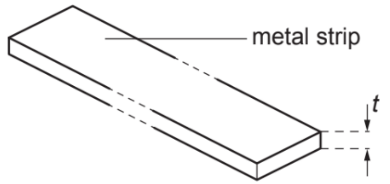
- Explain why the ammeter sometimes gives a maximum reading and sometimes a zero (or near zero) reading.
- State the orientations of the receiver aerial in investigation 1, and the positions of the metal sheet in investigation 2, where these maximum and zero readings would occur.

[6]

2021 QP - Paper 1 OCR (A) Physics A-level

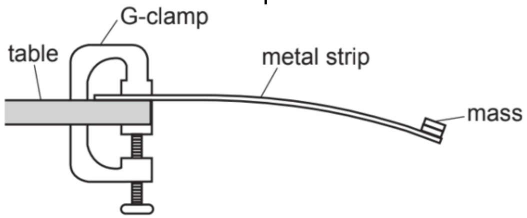
17b - 12A.5.4 Stress and Strain

A metal strip has thickness t, as shown below.



A student wants to determine the Young modulus E of the metal of the strip in **(a)**.

The student clamps the metal strip to the edge of a table using a G-clamp. A mass is **permanently** fixed to the end of the strip as shown.



The mass oscillates freely when it is moved away from its equilibrium position and then released.

The Young modulus E of the metal can be determined using the equation

$$E = \frac{16\pi^2 mL^3}{wt^3T^2}$$

where

m is the mass fixed to the end of the strip, L is the length of the strip from the end of the table to the centre of the mass, w is the width of the strip, t is the thickness of the strip, and T is the period of oscillations.

Describe how an experiment may be safely conducted, and how the data can be analysed to determine an accurate value for E.

[6]

20b - 13A.4.3 Gravitational Potential

A satellite is in a circular geostationary orbit around the centre of the Earth. The satellite has both kinetic energy and gravitational potential energy.

The mass of the satellite is 2500 kg and the radius of its circular orbit is 4.22×10^7 m.

The mass of the Earth is 5.97×10^{24} kg.

- Describe some of the features of a geostationary orbit.
- Calculate the total energy of the satellite in its geostationary orbit.

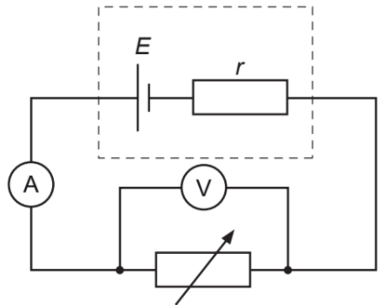
[6]

2021 QP - Paper 2 OCR (A) Physics A-level

18b - 12B.4.3 EMF and Internal Resistance

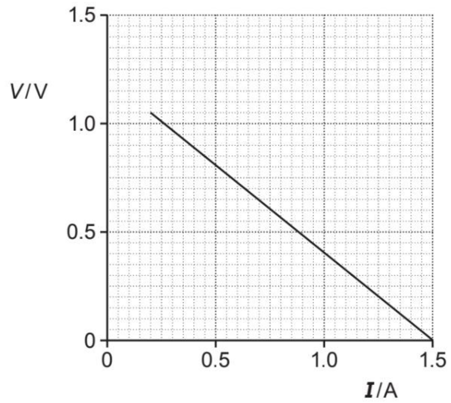
A student is doing an experiment to determine the e.m.f. **E** of a cell and its internal resistance **r**.

The circuit diagram of the arrangement is shown below.



The student changes the resistance of the variable resistor. The potential difference **V** across the variable resistor and the current **I** in the circuit are measured.

The **V** against **I** graph plotted by the student is shown below.



V / V	I / A	R / Ω	P / W
0.20	1.25		
0.40	1.00		
0.60	0.75		
0.80	0.50		
1.00	0.25		

There is an incomplete table next to the graph.

R is the resistance of the variable resistor and **P** is the power dissipated by the variable resistor.

- Use the graph to determine **E** and **r**. Explain your reasoning.
- Calculate **R** and **P** to complete the table. Describe how **P** depends on **R**.

[6]

23b - 13A.2.4 Nuclear Fusion in Stars

Some nuclear fission reactors use uranium-235 as fuel. In the future, there is possibility of using hydrogen-2 as fuel in fusion reactors.

Here is some information and data on fission and fusion reactions.

	Fission reactor	**Fusion reactor**
Typical reaction	${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3{}^{1}_{0}n$	${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + {}^{1}_{1}H$
Approximate energy produced in each reaction	200 MeV	4 MeV
Molar mass of fuel material	uranium-235: 0.235 $kgmol^{-1}$	hydrogen-2: 0.002 $kgmol^{-1}$

- Describe the similarities and the differences between fission and fusion reactions.
- Explain with the help of calculations, which fuel produces more energy per kilogram.

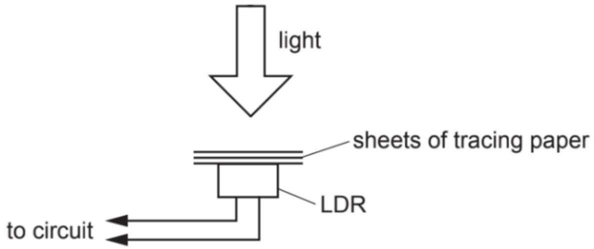
[6]

2021 QP - Paper 3 OCR (A) Physics A-level

2b - 13B.2.3 Exponential Decay

The current in an LDR depends on the intensity of light incident on it.

A student decides to alter the intensity of light incident on an LDR by using sheets of tracing paper and a light source.



The diagram below shows **part** of an arrangement suggested by the student.

It is suggested that the current **I** in the LDR is given by the expression

$$\boldsymbol{I} = ke^{-nx}$$

where x is the **total** thickness of the sheets of tracing paper, and k and n are constants.

Describe how the student could carry out an experiment to verify the validity of this expression and determine k and n. Include in your answer

- a circuit diagram
- a possible table for the results, including the headings
- the graph plotted to determine k and n
- any precautions taken to improve the quality of the results.

[6]

4 - 13A.6.6 The Ideal Gas Equation & Energy of Atoms

This question is about an electric cooker, which consists of an oven and an electromagnetic induction hob.

The oven is not sealed, so the air inside remains at atmospheric pressure of 1.0×10^5 Pa.

The volume of the oven is 0.065 m^3. The air inside the oven behaves as an ideal gas.

The temperature of the oven increases from room temperature to 200 °C.

Show that the internal energy of the air in the oven is the same at all temperatures of the oven. Support your answer with an explanation of the motion of the air molecules in terms of kinetic theory.

[6]