UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

8358883018

PHYSICS **9702/43**

Paper 4 A2 Structured Questions **May/June 2011**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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Answer **all** questions.
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Total	

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[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\frac{Gm}{r}$
hydrostatic pressure,	$p = \rho gh$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
simple harmonic motion,	$a = -\omega^2 x$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $v = \pm \omega\sqrt{(x_0^2 - x^2)}$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
alternating current/voltage,	$x = x_0 \sin \omega t$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** State what is meant by a *field of force*.

....

.... [1]

(b) Gravitational fields and electric fields are two examples of fields of force.
State one similarity and one difference between these two fields of force.

similarity: ....

....

difference: ....

....

....
[3]

(c) Two protons are isolated in space. Their centres are separated by a distance *R*.
Each proton may be considered to be a point mass with point charge.
Determine the magnitude of the ratio

$$\frac{\text{force between protons due to electric field}}{\text{force between protons due to gravitational field}}.$$

ratio = ... [3]

For Examiner's Use

2 **(a)** State what is meant by a *mole*.

....

....

.... [2]

(b) Two containers A and B are joined by a tube of negligible volume, as illustrated in Fig. 2.1.

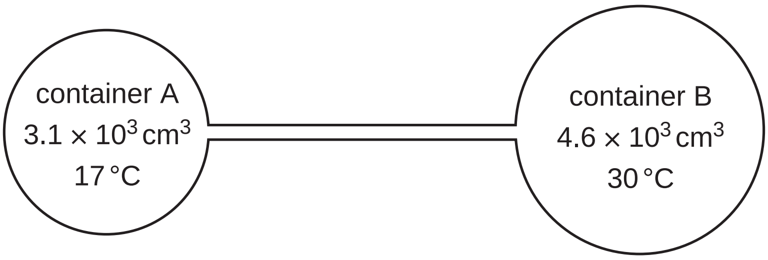

Fig. 2.1

The containers are filled with an ideal gas at a pressure of 2.3×10^5 Pa.
The gas in container A has volume $3.1 \times 10^3\,cm^3$ and is at a temperature of 17 °C.
The gas in container B has volume $4.6 \times 10^3\,cm^3$ and is at a temperature of 30 °C.

Calculate the total amount of gas, in mol, in the containers.

amount = ... mol [4]

3 A capacitor consists of two metal plates separated by an insulator, as shown in Fig. 3.1.

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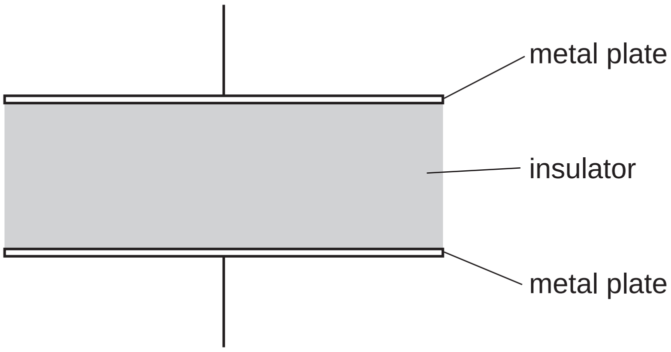

Fig. 3.1

The potential difference between the plates is *V*. The variation with *V* of the magnitude of the charge *Q* on one plate is shown in Fig. 3.2.

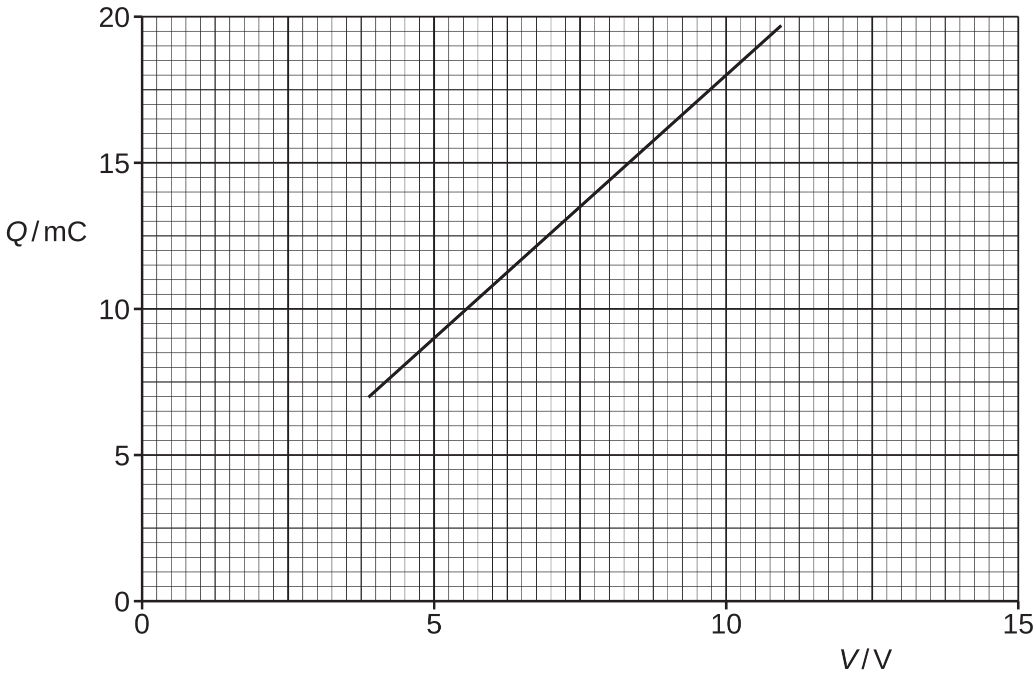

Fig. 3.2

(a) Explain why the capacitor stores energy but not charge.

....

....

....

.... [3]

(b) Use Fig. 3.2 to determine

For Examiner's Use

(i) the capacitance of the capacitor,

capacitance = ... μF [2]

(ii) the loss in energy stored in the capacitor when the potential difference *V* is reduced from 10.0 V to 7.5 V.

energy = ... mJ [2]

(c) Three capacitors X, Y and Z, each of capacitance 10 μF, are connected as shown in Fig. 3.3.

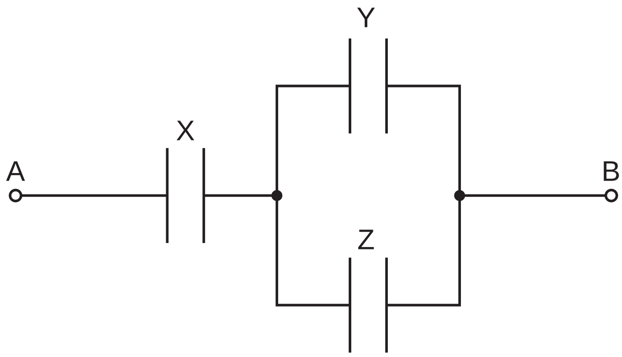

Fig. 3.3

Initially, the capacitors are uncharged.
A potential difference of 12 V is applied between points A and B.
Determine the magnitude of the charge on one plate of capacitor X.

charge = ... μC [3]

For Examiner's Use

4 **(a)** The first law of thermodynamics may be expressed in the form

$$\Delta U = q + w.$$

Explain the symbols in this expression.

+ ΔU ....

+ q ....

+ w .... [3]

(b) **(i)** State what is meant by *specific latent heat*.

....

....

....

.... [3]

(ii) Use the first law of thermodynamics to explain why the specific latent heat of vaporisation is greater than the specific latent heat of fusion for a particular substance.

....

....

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.... [3]

5 A bar magnet is suspended vertically from the free end of a helical spring, as shown in Fig. 5.1.

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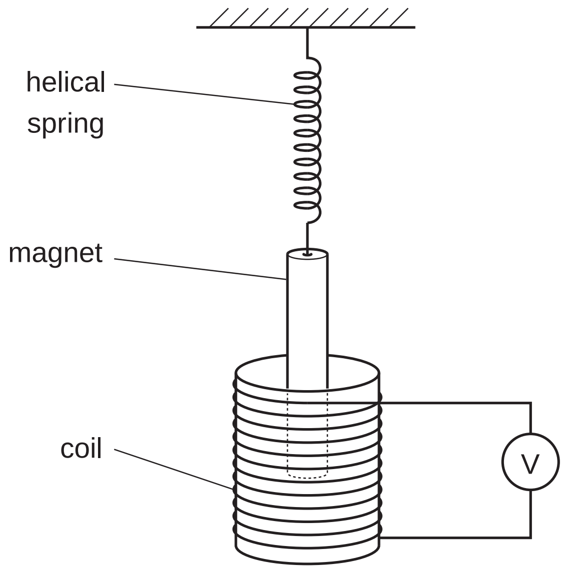


Fig. 5.1

One pole of the magnet is situated in a coil. The coil is connected in series with a high-resistance voltmeter.
The magnet is displaced vertically and then released.
The variation with time *t* of the reading *V* of the voltmeter is shown in Fig. 5.2.

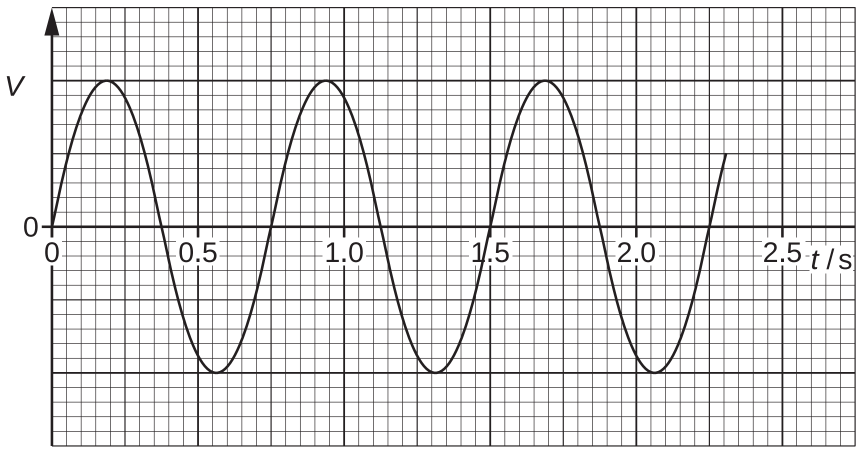


Fig. 5.2

(a) **(i)** State Faraday's law of electromagnetic induction.

....

....

.... [2]

(ii) Use Faraday's law to explain why

1. there is a reading on the voltmeter,

....

.... [1]

2. this reading varies in magnitude,

....

.... [1]

3. the reading has both positive and negative values.

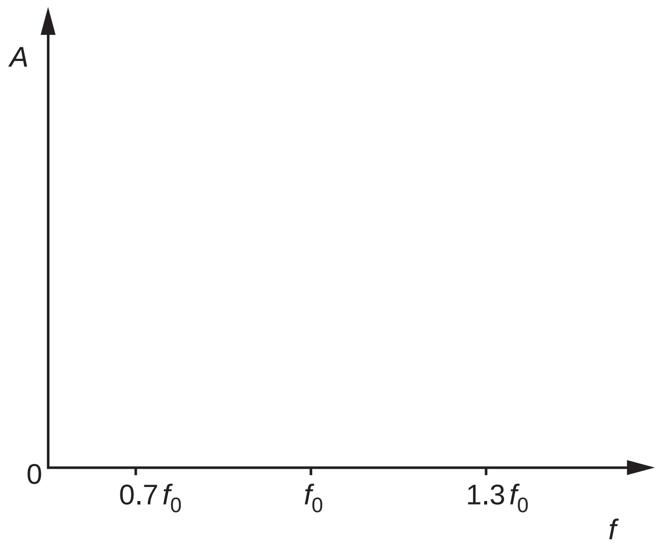
....

.... [1]

(b) Use Fig. 5.2 to determine the frequency f_0 of the oscillations of the magnet.

f_0 = ... Hz [2]

(c) The magnet is now brought to rest and the voltmeter is replaced by a variable frequency alternating current supply that produces a constant r.m.s. current in the coil.
The frequency of the supply is gradually increased from $0.7f_0$ to $1.3f_0$, where f_0 is the frequency calculated in **(b)**.
On the axes of Fig. 5.3, sketch a graph to show the variation with frequency f of the amplitude A of the new oscillations of the bar magnet.



[2]

Fig. 5.3

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(d) **(i)** Name the phenomenon illustrated on your completed graph of Fig. 5.3.

.... [1]

(ii) State one situation where the phenomenon named in **(i)** is useful.

....

.... [1]

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Please turn over for Question 6.

6 An alternating current supply is connected in series with a resistor R, as shown in Fig. 6.1.

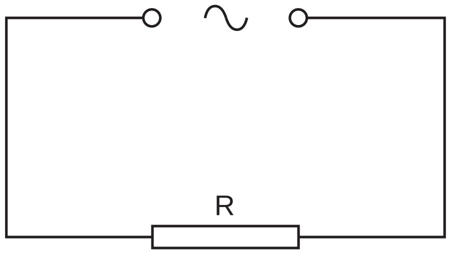

Fig. 6.1

The variation with time *t* (measured in seconds) of the current *I* (measured in amps) in the resistor is given by the expression

$$I = 9.9\sin(380t).$$

(a) For the current in the resistor R, determine

(i) the frequency,

frequency = ... Hz [2]

(ii) the r.m.s. current.

r.m.s. current = ... A [2]

For Examiner's Use

(b) To prevent over-heating, the mean power dissipated in resistor R must not exceed 400 W.
Calculate the minimum resistance of R.

resistance = ... Ω [2]

For Examiner's Use

7 **(a)** State what is meant by the *de Broglie wavelength*.

....

....

.... [2]

(b) An electron is accelerated in a vacuum from rest through a potential difference of 850 V.

(i) Show that the final momentum of the electron is 1.6×10^{-23} N s.

[2]

(ii) Calculate the de Broglie wavelength of this electron.

wavelength = ... m [2]

(c) Describe an experiment to demonstrate the wave nature of electrons.
You may draw a diagram if you wish.

....

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....

.... [5]

8 **(a)** State what is meant by the *binding energy* of a nucleus.

....

....

.... [2]

(b) Show that the energy equivalence of 1.0 u is 930 MeV.

[3]

(c) Data for the masses of some particles and nuclei are given in Fig. 8.1.

	mass / u
proton	1.0073
neutron	1.0087
deuterium ($^{2}_{1}H$)	2.0141
zirconium ($^{97}_{40}Zr$)	97.0980

Fig. 8.1

Use data from Fig. 8.1 and information from **(b)** to determine, in MeV,

(i) the binding energy of deuterium,

binding energy = ... MeV [2]

(ii) the binding energy **per nucleon** of zirconium.

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binding energy per nucleon = ... MeV [3]

For Examiner's Use

Section B

Answer **all** the questions in the spaces provided.

9 **(a)** Describe the structure of a metal wire strain gauge. You may draw a diagram if you wish.

....

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.... [3]

(b) A strain gauge S is connected into the circuit of Fig. 9.1.

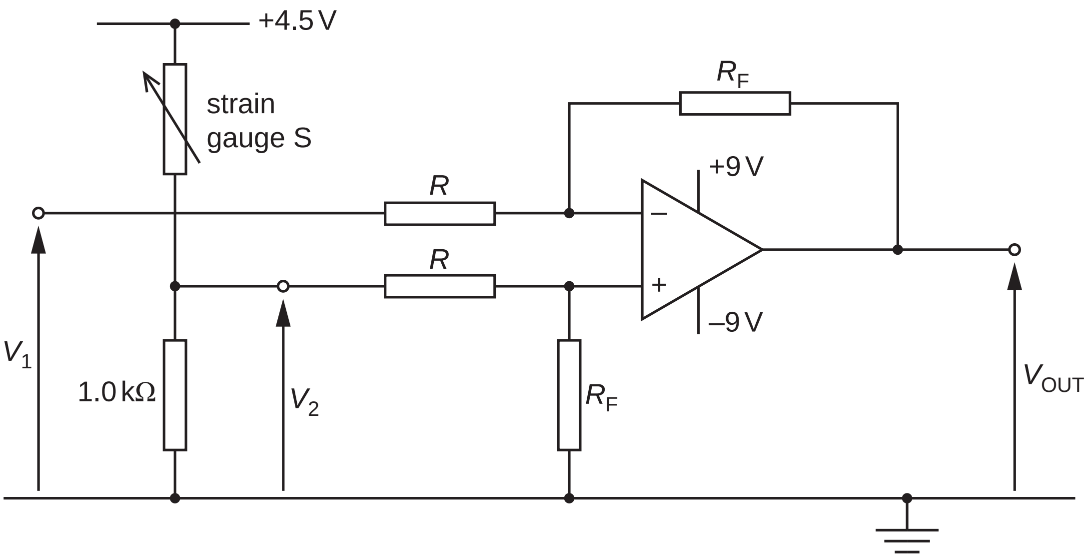

Fig. 9.1

The operational amplifier (op-amp) is ideal.
The output potential V_{OUT} of the circuit is given by the expression

$$V_{OUT} = \frac{R_F}{R} \times (V_2 - V_1).$$

(i) State the name given to the ratio $\frac{R_F}{R}$.

.... [1]

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(ii) The strain gauge S has resistance 125 Ω when not under strain.
Calculate the magnitude of V_1 such that, when the strain gauge S is not strained, the output V_{OUT} is zero.

V_1 = ... V [3]

(iii) In a particular test, the resistance of S increases to 128 Ω. V_1 is unchanged.
The ratio $\frac{R_F}{R}$ is 12.
Calculate the magnitude of V_{OUT}.

V_{OUT} = ... V [2]

10 Explain briefly the main principles of the use of magnetic resonance to obtain diagnostic information about internal body structures.

For Examiner's Use

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.... [8]

For Examiner's Use

11 The use of ionospheric reflection of radio waves for long-distance communication has, to a great extent, been replaced by satellite communication.

(a) State and explain two reasons why this change has occurred.

1. ....

....

....

2. ....

....

....
[4]

(b) The radio link between a geostationary satellite and Earth may be attenuated by as much as 190 dB.
Suggest why, as a result of this attenuation, the uplink and downlink frequencies must be different.

....

....

....

.... [2]

12 **(a)** The signal-to-noise ratio in an optic fibre must not fall below 24 dB. The average noise power in the fibre is 5.6×10^{-19} W.

For Examiner's Use

(i) Calculate the minimum effective signal power in the optic fibre.

power = ... W [3]

(ii) The fibre has an attenuation per unit length of 1.9 dB km^{-1}.
Calculate the maximum uninterrupted length of fibre for an input signal of power 3.5 mW.

length = ... km [3]

(b) Suggest why infra-red radiation, rather than ultraviolet radiation, is used for long-distance communication using optic fibres.

....

.... [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME				
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PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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For Examiner's Use

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]

Diagram

For Examiner's Use

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For Examiner's Use

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating how a volume of nitrogen gas is affected by the pressure exerted on it.

A sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a small volume of oil. Pressure is applied by a pump. The applied pressure is measured on a gauge, as shown in Fig. 2.1.

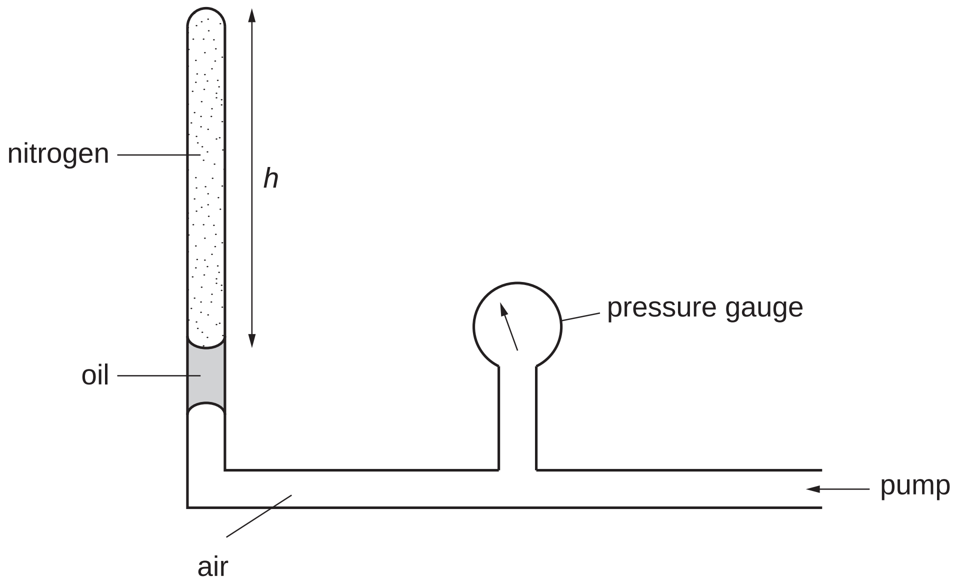


Fig. 2.1

The temperature T of the nitrogen is 290 K.

An experiment is carried out to investigate how the height h of nitrogen trapped in the tube varies with the pressure p.

Question 2 continues on the next page.

It is suggested that p and h are related by the equation

$$pAh = NkT$$

where A is the cross-sectional area of the tube, k is the Boltzmann constant and N is the number of molecules of nitrogen gas.

For Examiner's Use

(a) A graph is plotted of p on the y-axis against $\frac{1}{h}$ on the x-axis. Express the gradient in terms of N.

gradient = ...[1]

(b) Values of p and h are given in Fig. 2.2.

p / 10^5 Pa	h / 10^{-3} m	
1.10	400 ± 5	
1.22	360 ± 5	
1.38	320 ± 5	
1.57	280 ± 5	
1.83	240 ± 5	
2.09	210 ± 5	

Fig. 2.2

Calculate and record values of $\frac{1}{h}$ in Fig. 2.2. Include the absolute uncertainties in $\frac{1}{h}$.

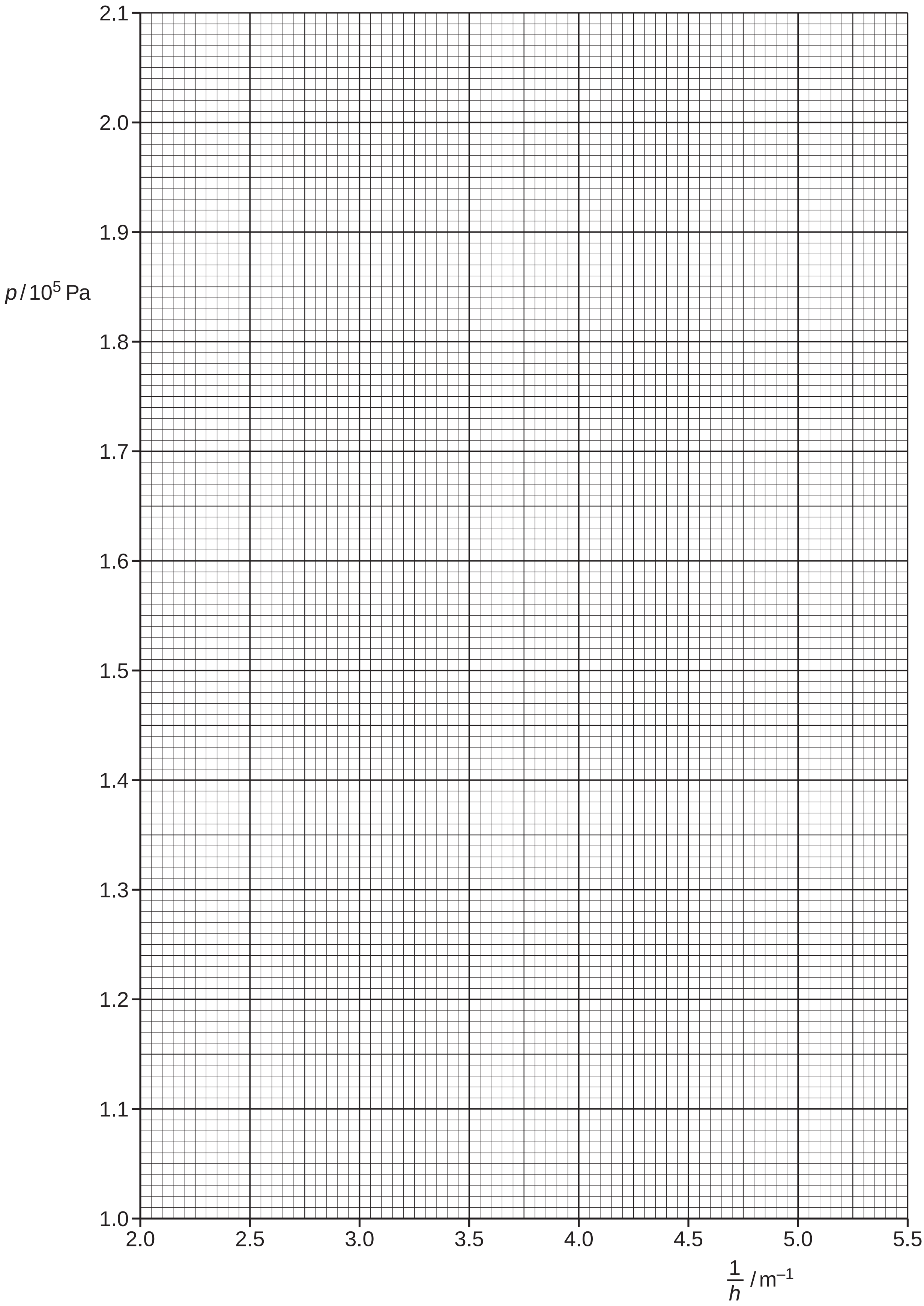
[3]

(c) (i) Plot a graph of p / 10^5 Pa against $\frac{1}{h}$ / m^{-1}. Include error bars for $\frac{1}{h}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient = ...[2]



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(d) In this experiment, $A = 3.14 \times 10^{-6}\,m^2$ and $k = 1.38 \times 10^{-23}\,J\,K^{-1}$. Using your answer in **(c)(iii)**, determine the value of N. Include the absolute uncertainty in your value.

For Examiner's Use

N = ...[2]

(e) **(i)** The pressure is reduced so that $p = 1.10 \times 10^5$ Pa and the temperature decreases by 12 ±1 K.

Determine h using the relationship given and your answer in **(d)**.

h = ...[2]

(ii) Determine the percentage uncertainty in your value of h.

percentage uncertainty = ... % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

6655069171

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

1 hour 15 minutes

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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.

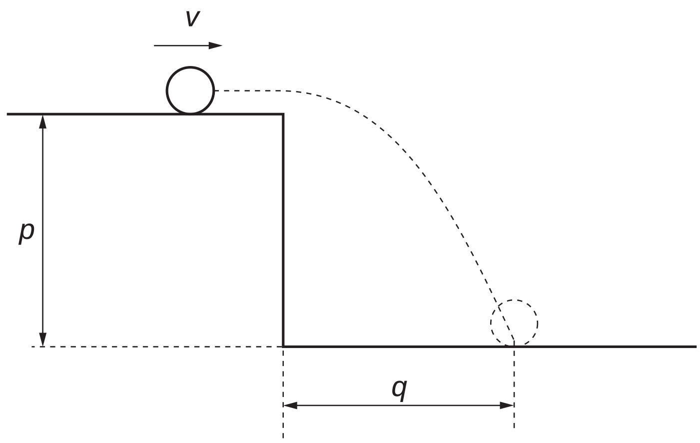

Fig. 1.1

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]

Diagram

For Examiner's Use

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For Examiner's Use

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating a non-inverting operational amplifier (op-amp) circuit.

The circuit is set up as shown in Fig. 2.1.

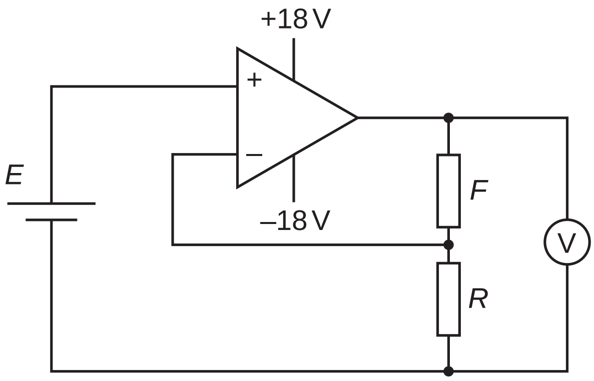


Fig. 2.1

The op-amp is connected to a +18 V and –18 V power supply.

E is the e.m.f. of the cell, which has a value of 1.6 ± 0.1 V.

An experiment is carried out to investigate how the reading *V* on the voltmeter varies with resistance *R*.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that V and R are related by the equation

$$V = \frac{F}{R}E + E$$

where F is the resistance of the fixed resistor in the circuit.

(a) A graph is plotted of $\frac{V}{E}$ on the y-axis against $\frac{1}{R}$ on the x-axis. Express the gradient in terms of F.

gradient = ...[1]

(b) Values of R and V are given in Fig. 2.2.

$R\,/\,\Omega$	$V\,/\,\mathrm{V}$	$\frac{1}{R}\,/\,10^{-3}\,\Omega^{-1}$	$\frac{V}{E}$
150	14.4 ± 0.1		
220	10.4 ± 0.1		
330	7.4 ± 0.1		
470	5.6 ± 0.1		
680	4.4 ± 0.1		
860	3.8 ± 0.1		

Fig. 2.2

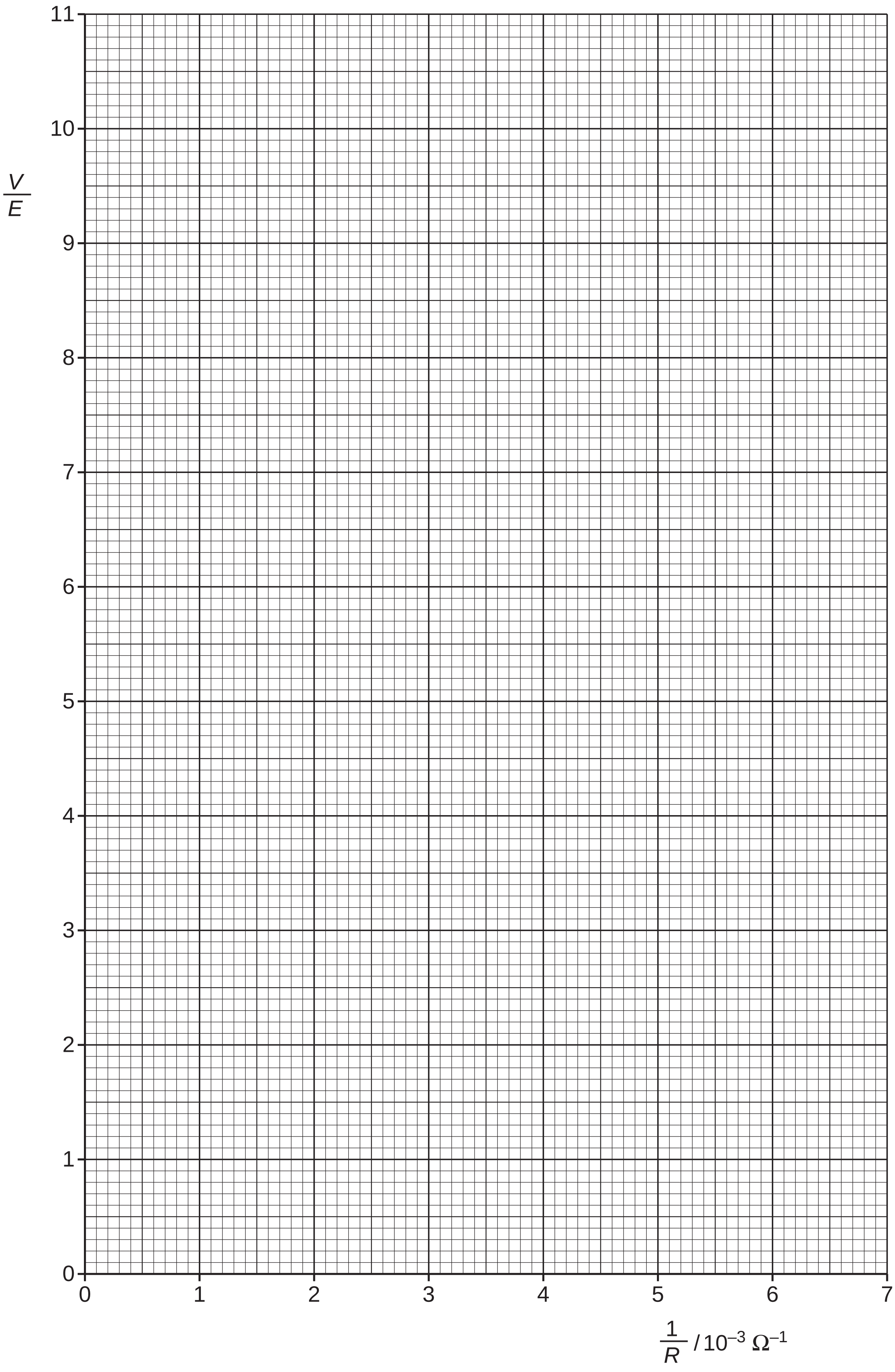
Calculate and record values of $\frac{1}{R}\,/\,10^{-3}\,\Omega^{-1}$ and $\frac{V}{E}$ in Fig. 2.2. Include the absolute uncertainties in $\frac{V}{E}$. [3]

(c) (i) Plot a graph of $\frac{V}{E}$ against $\frac{1}{R}\,/\,10^{-3}\,\Omega^{-1}$. Include error bars for $\frac{V}{E}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient = ...[2]



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(d) Using your answer in **(c)(iii)**, determine the value of *F*. Include the absolute uncertainty in your value and an appropriate unit.

For Examiner's Use

F = ...[2]

(e) For one measurement, *R* has a value of 120 Ω ± 5%.

(i) Determine the value of $\frac{V}{E}$ using the relationship given and your answer in **(d)**.

Include the absolute uncertainty in your answer.

$\frac{V}{E}$ = ...[2]

(ii) Determine the expected voltmeter reading.

voltmeter reading = ... V [1]

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General Certificate of Education Advanced Level

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PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

1 hour 15 minutes

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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.

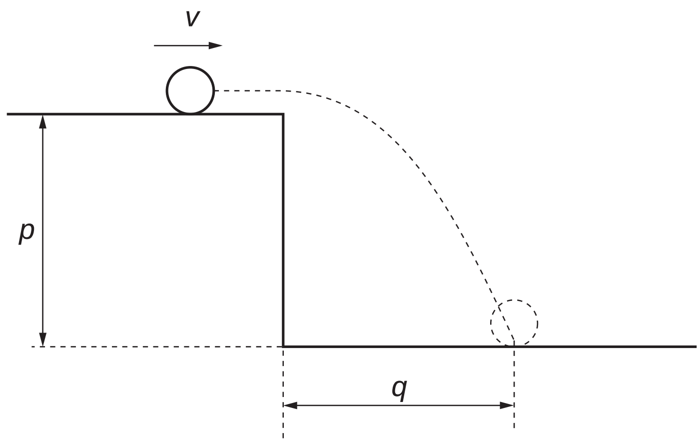

Fig. 1.1

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]

Diagram

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For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

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2 A student is investigating a non-inverting operational amplifier (op-amp) circuit.

The circuit is set up as shown in Fig. 2.1.

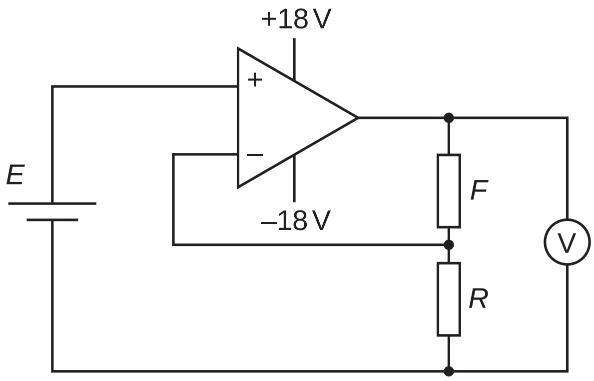

Fig. 2.1

The op-amp is connected to a +18 V and –18 V power supply.

E is the e.m.f. of the cell, which has a value of 1.6 ± 0.1 V.

An experiment is carried out to investigate how the reading *V* on the voltmeter varies with resistance *R*.

Question 2 continues on the next page.

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It is suggested that V and R are related by the equation

$$V = \frac{F}{R}E + E$$

where F is the resistance of the fixed resistor in the circuit.

(a) A graph is plotted of $\frac{V}{E}$ on the y-axis against $\frac{1}{R}$ on the x-axis. Express the gradient in terms of F.

gradient = ...[1]

(b) Values of R and V are given in Fig. 2.2.

$R\,/\,\Omega$	V / V	$\frac{1}{R}\,/\,10^{-3}\,\Omega^{-1}$	$\frac{V}{E}$
150	14.4 ± 0.1		
220	10.4 ± 0.1		
330	7.4 ± 0.1		
470	5.6 ± 0.1		
680	4.4 ± 0.1		
860	3.8 ± 0.1		

Fig. 2.2

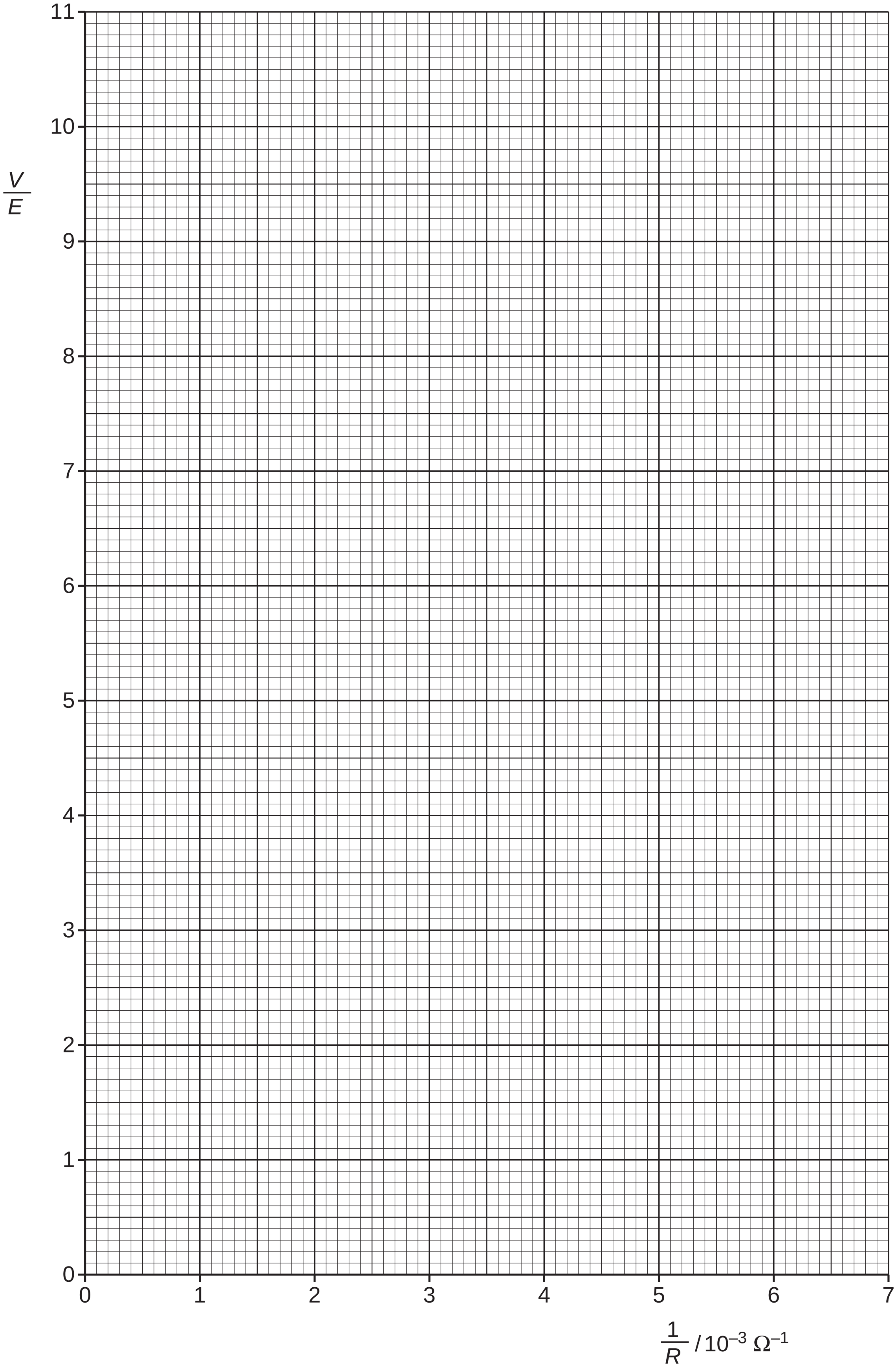
Calculate and record values of $\frac{1}{R}\,/\,10^{-3}\,\Omega^{-1}$ and $\frac{V}{E}$ in Fig. 2.2. Include the absolute uncertainties in $\frac{V}{E}$. [3]

(c) (i) Plot a graph of $\frac{V}{E}$ against $\frac{1}{R}\,/\,10^{-3}\,\Omega^{-1}$. Include error bars for $\frac{V}{E}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient = ...[2]



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(d) Using your answer in **(c)(iii)**, determine the value of *F*. Include the absolute uncertainty in your value and an appropriate unit.

F = ...[2]

(e) For one measurement, *R* has a value of 120 Ω ± 5%.

(i) Determine the value of $\frac{V}{E}$ using the relationship given and your answer in **(d)**.

Include the absolute uncertainty in your answer.

$\frac{V}{E}$ = ...[2]

(ii) Determine the expected voltmeter reading.

voltmeter reading = ... V [1]