

- 1 A ball rolls forwards and backwards on a curved track as shown in Fig. 1.1.

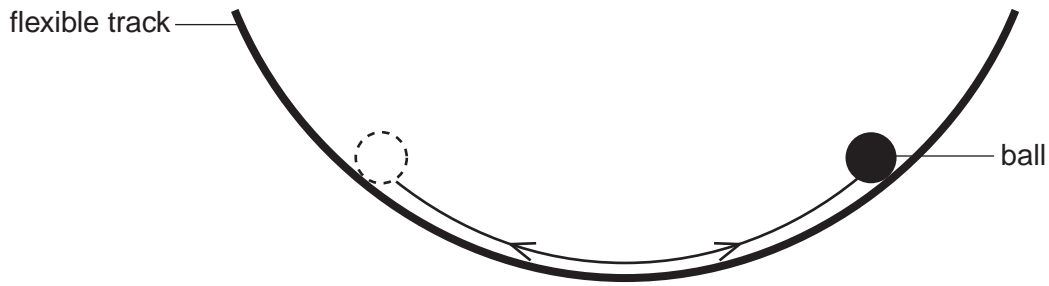


Fig. 1.1

It is suggested that the period T of the oscillations is related to the radius r of the ball and the radius of curvature C of the track by the relationship

$$T^2 = \frac{28\pi^2}{5g} (C - r)$$

where g is the acceleration of free fall.

You are provided with a flexible track. Design a laboratory experiment to test the relationship between T and r . Explain how your results could be used to determine a value for C . 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]

- 2 A student is investigating a circuit containing an operational amplifier (op-amp).

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

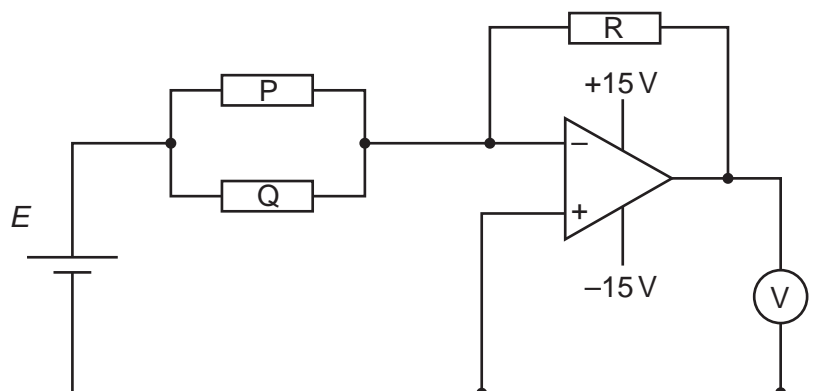


Fig. 2.1

The op-amp is connected to a +15V and –15V power supply.

An experiment is carried out to investigate how the reading V on the voltmeter varies with the resistance Q of resistor Q .

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

$$V = -ER \left(\frac{1}{P} + \frac{1}{Q} \right)$$

where E is the e.m.f. of the cell, P is the resistance of resistor P and R is the resistance of resistor R .

- (a) A graph is plotted of $\frac{V}{E}$ on the y -axis against $\frac{1}{Q}$ on the x -axis.

Determine expressions for the gradient and the y -intercept in terms of P and R .

gradient =

y -intercept =

[1]



- (b) The e.m.f. E of the cell has a value of $1.6 \pm 0.1\text{V}$.

Values of V and Q are given in Fig. 2.2.

$Q/10^3 \Omega$	V/V	$\frac{1}{Q}/10^{-3}\Omega^{-1}$	$\frac{V}{E}$
0.15	-8.2 ± 0.1		
0.22	-6.0 ± 0.1		
0.33	-4.4 ± 0.1		
0.50	-3.3 ± 0.1		
0.66	-2.8 ± 0.1		
0.90	-2.4 ± 0.1		

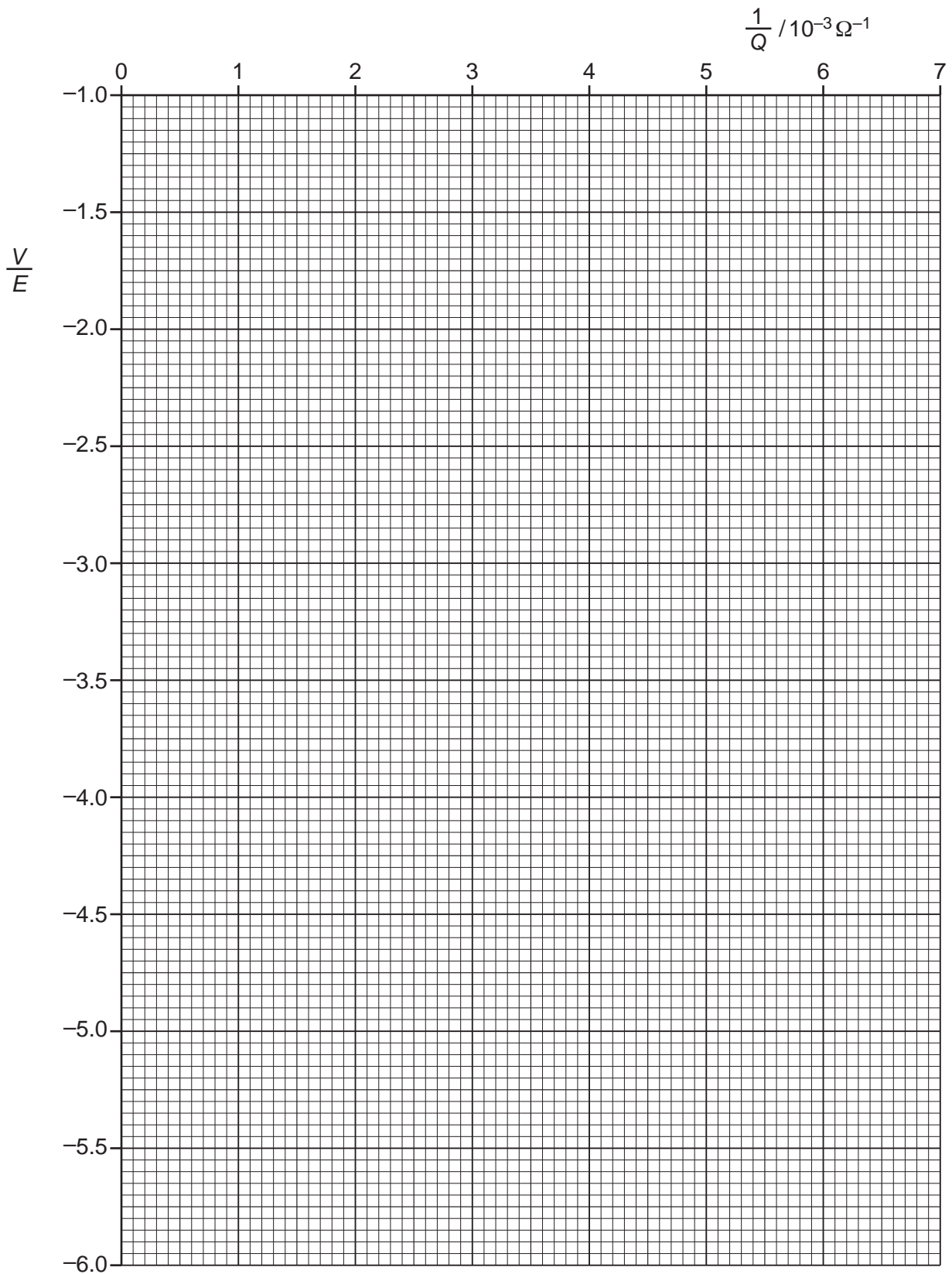
Fig. 2.2

Calculate and record values of $\frac{1}{Q}/10^{-3}\Omega^{-1}$ 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 $\frac{1}{Q}/10^{-3}\Omega^{-1}$. 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]



- (iv) Determine the y -intercept of the line of best fit. Include the uncertainty in your answer.

y -intercept = [2]

- (d) (i) Using your answers to (c)(iii) and (c)(iv), determine the values of P and R . Include appropriate units.

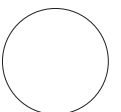
P =

R = [2]

- (ii) Determine the percentage uncertainty in P .

percentage uncertainty =% [1]

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