1 Fig. 1.1 shows a bar magnet attached to a spring.

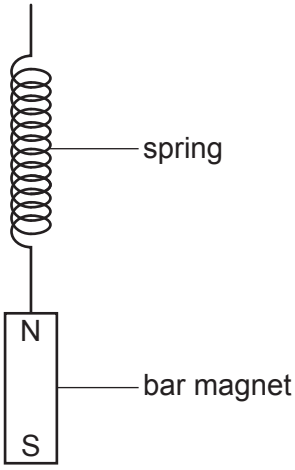

Fig. 1.1

The bar magnet is displaced a distance x from its equilibrium position and released. It then oscillates vertically.

A student investigates how the maximum induced electromotive force (e.m.f.) E in a coil placed below the magnet depends on x.

It is suggested that the relationship between E and x is

$$E = \alpha BNx\sqrt{\frac{k}{m}}$$

where B is the magnetic flux density at one of the poles of the bar magnet, N is the number of turns on the coil, k is the spring constant, m is the mass of the magnet and α is a constant.

Design a laboratory experiment to test the relationship between E and x.
Explain how your results could be used to determine a value for α.

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

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

[15]

2 A student investigates the discharge of a capacitor through a resistor as shown in Fig. 2.1.

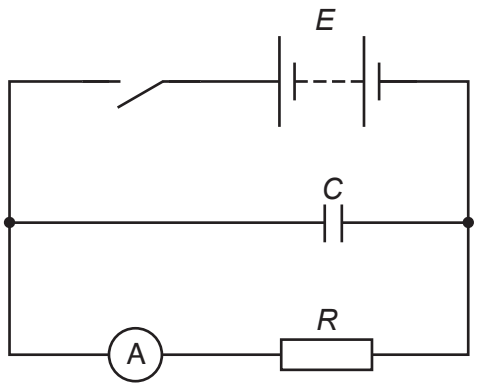

Fig. 2.1

The student initially closes the switch and charges the capacitor. The switch is then opened and a stop-watch is started. The capacitor discharges through the resistor. At different times t the current I is measured.

It is suggested that I and t are related by the equation

$$I = \frac{E}{R}e^{-\left(\frac{t}{RC}\right)}$$

where E is the e.m.f. of the power supply, C is the capacitance of the capacitor and R is the resistance of the resistor.

(a) A graph is plotted of $\ln I$ on the y-axis against t on the x-axis.

Determine expressions for the gradient and the y-intercept.

gradient = ...

y-intercept = ...

[1]

(b) Values of t and I are given in Table 2.1.

Table 2.1

t/s	I/μA	ln(I/μA)
0	46 ± 2	
12	40 ± 2	
24	34 ± 2	
36	28 ± 2	
48	24 ± 2	
60	20 ± 2	

Calculate and record values of ln(I/μA) in Table 2.1.
Include the absolute uncertainties in ln(I/μA). [2]

(c) **(i)** Plot a graph of ln(I/μA) against t/s.
Include error bars for ln(I/μA). [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 absolute uncertainty in your answer.

gradient = ... [2]