T.C.

GEBZE TECHNICAL UNIVERSITY

PHYSICS DEPARTMENT

PHYSICS LABORATORY II

EXPERIMENT REPORT

THE NAME OF THE EXPERIMENT

Magnetic induction

PREPARED BY

NAME AND SURNAME :
STUDENT NUMBER :
DEPARTMENT :
GROUP NO :
TEACHING ASSISTANT :
DATE OF THE EXPERIMENT : ….. / ….. / ……….
DATE : ….. / ….. / ……….

Signature:

Experimental Procedure:

Before starting the experiment, install the setup as in Figure 8.1 except coil 2 part. Function generator does not have a display screen, therefore you will need two auxiliary devices to determine the intensity and the frequency of the current. To measure the intensity, you will have an analog ammeter. Set it to 100 mA scale and don't change it during the experiment. To determine the frequency of the signal, set the counter to frequency mode by pushing MODE button once.

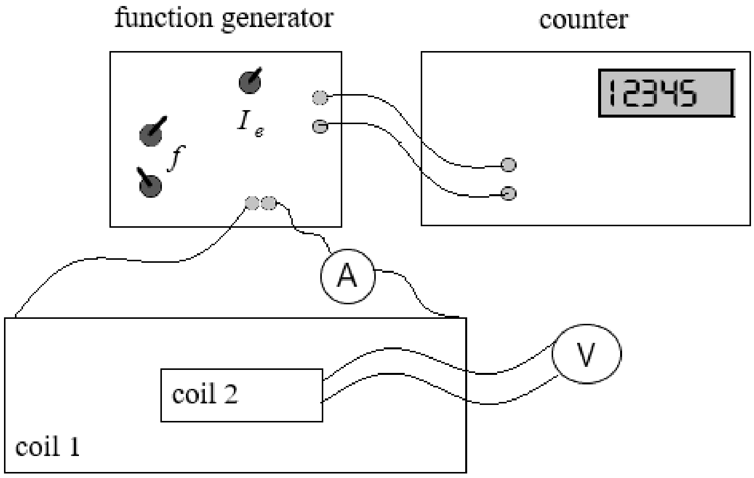


Figure 8.1. Schematic of experimental setup.

A) Induced voltage as a function of I_e:

In the first part, we will investigate the current strength dependence of induced voltage. For this purpose, follow the instructions:

1. For coil 2 use one with 5×5 cm^2 cross-sectional area. Firstly, plug two cables into two holes placed on two sides of stamp 100 Wdg and put the coil inside the solenoid.

2. Turn on the voltmeter and signal generator, and set the letter to 1030 Hz

3. Starting from 0 mA record induced voltage in Table 8.1.

4. Repeat the same procedure for 200 and 300 windings.

5. Fill Table 8.2 with data taken from 50 mA column.

Table 8.1: I_e dependence of U_e for f = 1030 Hz and A = 25 cm^2

N_2 \ I_e	0	10	20	30	40	50
100						
200						
300						

Table 8.2: U_e for I_e = 50 mA taken from Table 8.1.

N_2	100	200	300
U_e			

B) Induced voltage as a function of frequency:

In the second part, we will investigate the frequency dependence of induced voltage. For this purpose, follow the instructions:

1. For coil 2, use one with 2×5 cm^2 cross-sectional area.

2. Set I_e=50 mA and starting from 806 Hz, record induced voltage in Table 8.3.

3. Repeat the same procedure for coils 3×5 cm^2 and 5×5 cm^2

4. Fill Table 8.4 with data taken from 4027 Hz column.

Table 8.3: *f* dependence of U_e for I_e = 50 mA and N_2=300

A \ ***f***	806	2085	4027	6014
10				
15				
25				

Table 8.4: U_e for *f* = 4027 Hz taken from Table 8.3.

A	10	15	25
U_e			

Calculations and Analysis:

In this part, you will derive a similar expression to Equation 8.9 by least squares method. For this purpose, let's assign a general symbol Q for variables I_e, N_2, f, A and suppose that U_e depends on Q as α power:

$$U_e = KQ^{\alpha} \qquad 8.10$$

where K is a proportionality constant. If we take logarithm of two sides, we find,

$$\log U_e = \log K + \alpha \log Q \qquad 8.11$$

As is seen, if we plot $\log U_e - \log Q$ graph instead of $U_e - \mathrm{Q}$ one, we would take a line irrespective of the value. After this plot, associated power, could be found by calculating the slope of $\log U_e - \log Q$ graph. Robust method for this goal is the method of least squares. According to this method, the slope is calculated by the following formula:

$$\alpha = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2} \qquad 8.12$$

Here n is the number of points on the graph, x_i and y_i are the logarithms of independent and dependent variables respectively. For every individual table, you will have to adopt this expression to graphs under investigation. In your calculations you can use a software; it's strongly recommended!

A) I_e dependence of U_e:

Fill Table 8.5 by transforming Table 8.1 after calculating logarithms of I_e and recorded U_e values. Then, for every N_2 calculate α from Equation 8.12 with $x_i = \log I_e$, $y_i = \log U_e$ and $n = 5$.

Table 8.5: $log - log$ form of Table 8.1.

$\log I_e$ / N_2					
100					
200					
300					

Use data from Table 8.5 and calculate the slopes *α's* of the lines that fits the data points on your *log* I_e – *log* U_e graphs by using the linear fitting formulae. In the following sums, the x_i's represent the *log* I_e values on the *x*–axis, while the y_i's represent the *log* U_e values on the *y*–axis of your graphs.

i) N_2 = 100

$$\sum_{i=1}^{5} x_i = \qquad\qquad \sum_{i=1}^{5} y_i =$$

$$\sum_{i=1}^{5} {x_i}^2 = \qquad\qquad \sum_{i=1}^{5} x_i\, y_i =$$

$$\alpha_{100} = \frac{5\sum_{i=1}^{5} x_i y_i - \sum_{i=1}^{5} x_i \sum_{i=1}^{5} y_i}{5\sum_{i=1}^{5} {x_i}^2 - \left(\sum_{i=1}^{5} x_i\right)^2} =$$

ii) N_2 = 200

$$\sum_{i=1}^{5} x_i = \qquad\qquad \sum_{i=1}^{5} y_i =$$

$$\sum_{i=1}^{5} {x_i}^2 = \qquad\qquad \sum_{i=1}^{5} x_i\, y_i =$$

$$\alpha_{200} = \frac{5\sum_{i=1}^{5} x_i y_i - \sum_{i=1}^{5} x_i \sum_{i=1}^{5} y_i}{5\sum_{i=1}^{5} {x_i}^2 - \left(\sum_{i=1}^{5} x_i\right)^2} =$$

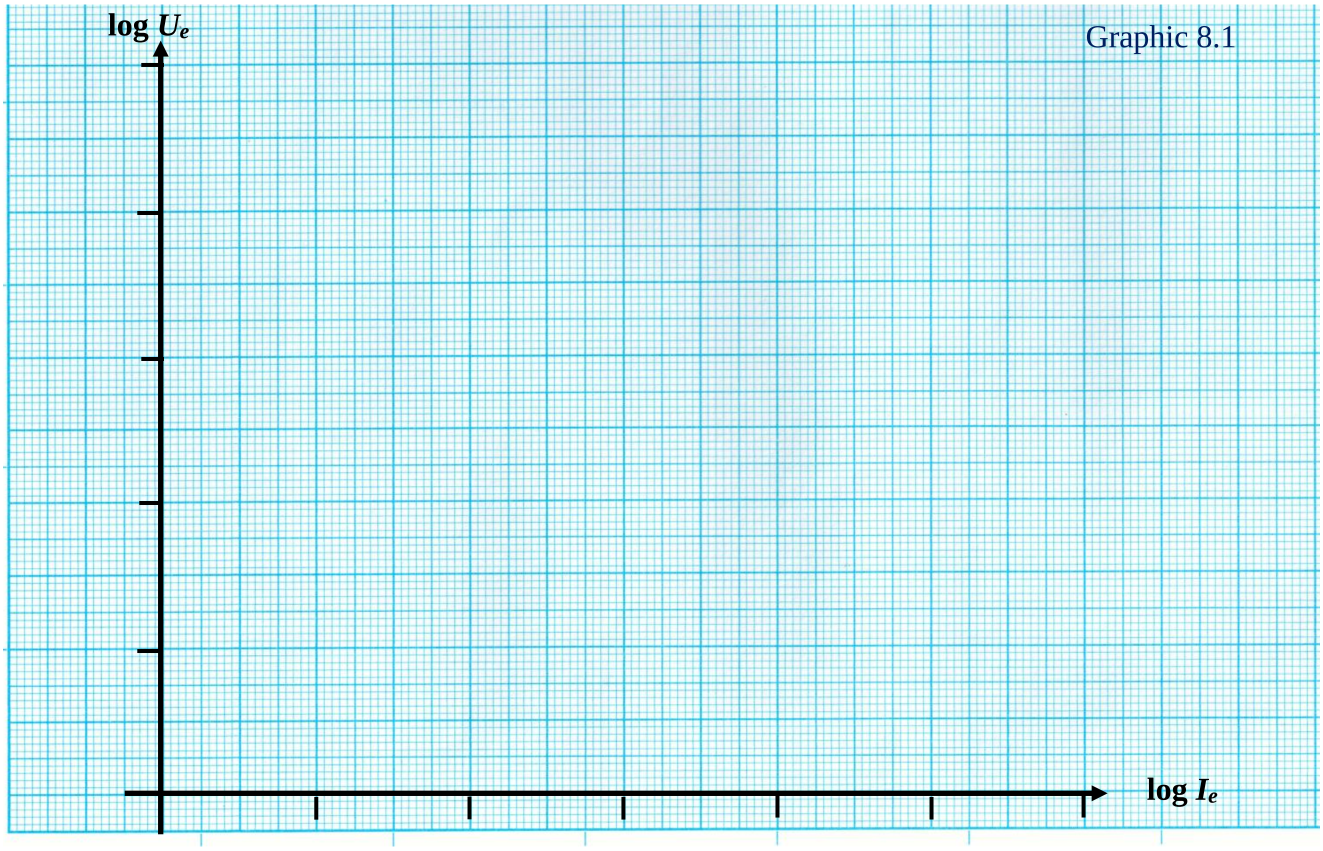
iii) N_2 = 300

$$\sum_{i=1}^{5} x_i = \qquad\qquad \sum_{i=1}^{5} y_i =$$

$$\sum_{i=1}^{5} {x_i}^2 = \qquad\qquad \sum_{i=1}^{5} x_i\, y_i =$$

$$\alpha_{300} = \frac{5\sum_{i=1}^{5} x_i y_i - \sum_{i=1}^{5} x_i \sum_{i=1}^{5} y_i}{5\sum_{i=1}^{5} {x_i}^2 - \left(\sum_{i=1}^{5} x_i\right)^2} =$$

In the following graph, plot $\log I_e - \log U_e$ using $\log I_e$ and $\log U_e$ columns of Table 8.2 as x– and y–axis, respectively. Represent the data as points on your graph and draw the straight line $\log I_e = \alpha \log U_e$



B) N_2 dependence of U_e:

Fill Table 8.6 by transforming Table 8.1 after calculating logarithms of N_2 and recorded U_e values. Then, calculate α from Equation 8.12 with $x_i = \log N_2$, $y_i = \log U_e$ and $n = 3$.

Table 8.6: $log - log$ form of Table 8.2.

$\log N_2$			
$\log U_e$			

Use data from Table 8.6 and calculate the slope α that fits the data points on your $log\ N_2 - log\ U_e$ graph by using the linear fitting formulae. In the following sums, the x_i's represent the $log\ N_2$ values on the x–axis, while the y_i's represent the $log\ U_e$ values on the y–axis of your graphs.

$$\sum_{i=1}^{3} x_i =$$

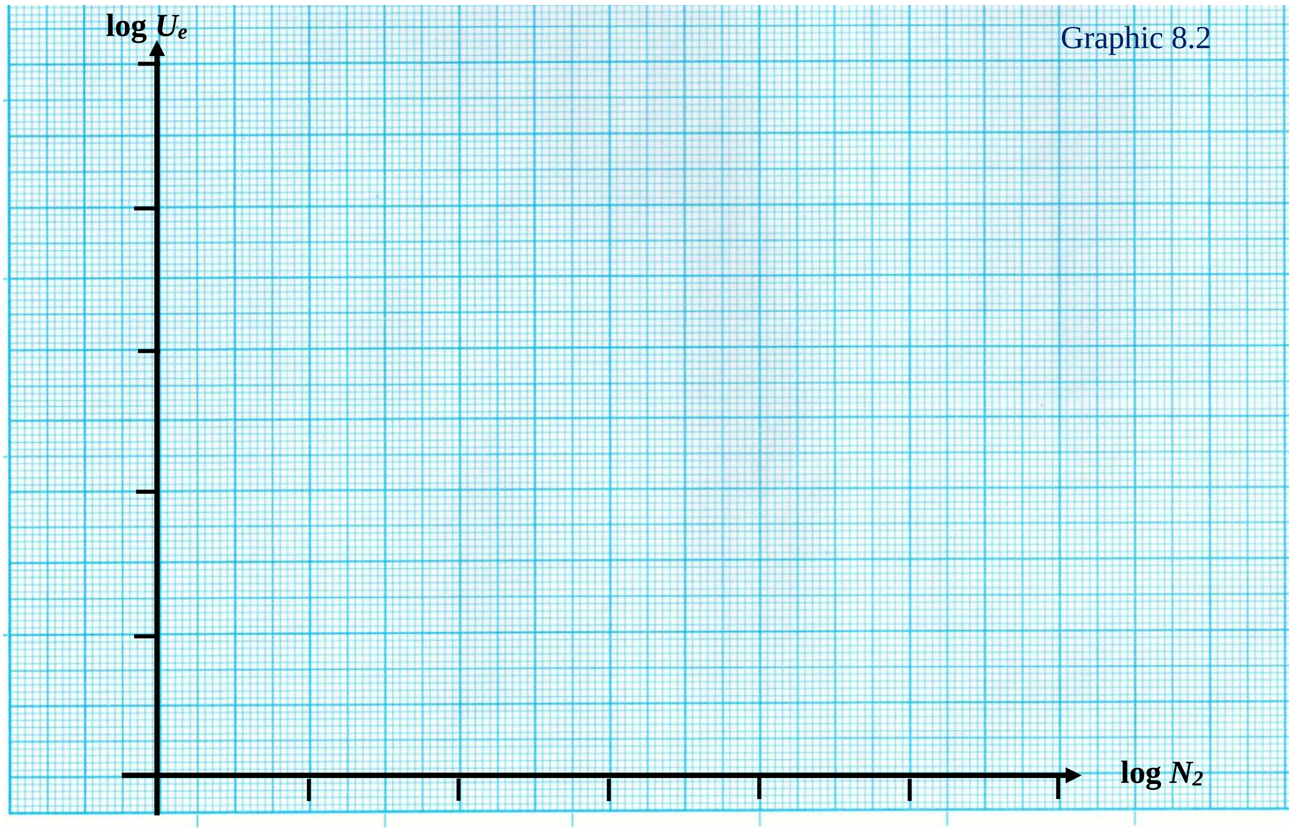
$$\sum_{i=1}^{3} y_i =$$

$$\sum_{i=1}^{3} {x_i}^2 =$$

$$\sum_{i=1}^{3} x_i\, y_i =$$

$$\alpha = \frac{3\sum_{i=1}^{3} x_i y_i - \sum_{i=1}^{3} x_i \sum_{i=1}^{3} y_i}{3\sum_{i=1}^{3} {x_i}^2 - \left(\sum_{i=1}^{3} x_i\right)^2} =$$

In the following graph, plot $log\ N_2 - log\ U_e$ using $log\ N_2$ and $log\ U_e$ columns of Table 8.6 as x– and y–axis, respectively. Represent the data as points on your graph and draw the straight line $log\ U_e = \alpha\ log\ N_2$.



C) f dependence of U_e:

Fill Table 7.7 by transforming Table 7.3 after calculating logarithms of f and recorded U_e values. Then, for every A calculate α from Equation 7.12 with $x_i = \log f$, $y_i = \log U_e$ and $n = 4$.

Table 8.7: $log - log$ form of Table 8.3.

$\log f$ / A				
10				
15				
25				

Use data from Table 8.7 and calculate the slope that fits the data points on your *log f – log Uₑ* graph *by* using the linear fitting formulae. In the following sums, the x_i 's represent the *log f* values on the *x*–axis, while the y_i's represent the *log* U_e values on the *y*–axis of your graphs.

i) *A* = 10 cm²

$$\sum_{i=1}^{4} x_i$$

$$\sum_{i=1}^{4} y_i$$

$$\sum_{i=1}^{4} {x_i}^2 =$$

$$\sum_{i=1}^{4} x_i\, y_i =$$

$$\alpha_{10} = \frac{4\sum_{i=1}^{4} x_i y_i - \sum_{i=1}^{4} x_i \sum_{i=1}^{4} y_i}{4\sum_{i=1}^{4} {x_i}^2 - (\sum_{i=1}^{4} x_i)^2} =$$

ii) *A* = 15 cm²

$$\sum_{i=1}^{4} x_i =$$

$$\sum_{i=1}^{4} y_i =$$

$$\sum_{i=1}^{4} {x_i}^2 =$$

$$\sum_{i=1}^{4} x_i\, y_i =$$

$$\alpha_{15} = \frac{4\sum_{i=1}^{4} x_i y_i - \sum_{i=1}^{4} x_i \sum_{i=1}^{4} y_i}{4\sum_{i=1}^{4} {x_i}^2 - (\sum_{i=1}^{4} x_i)^2} =$$

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iii) $A = 25$ **cm**^{2}

$$\sum_{i=1}^{4} x_i =$$

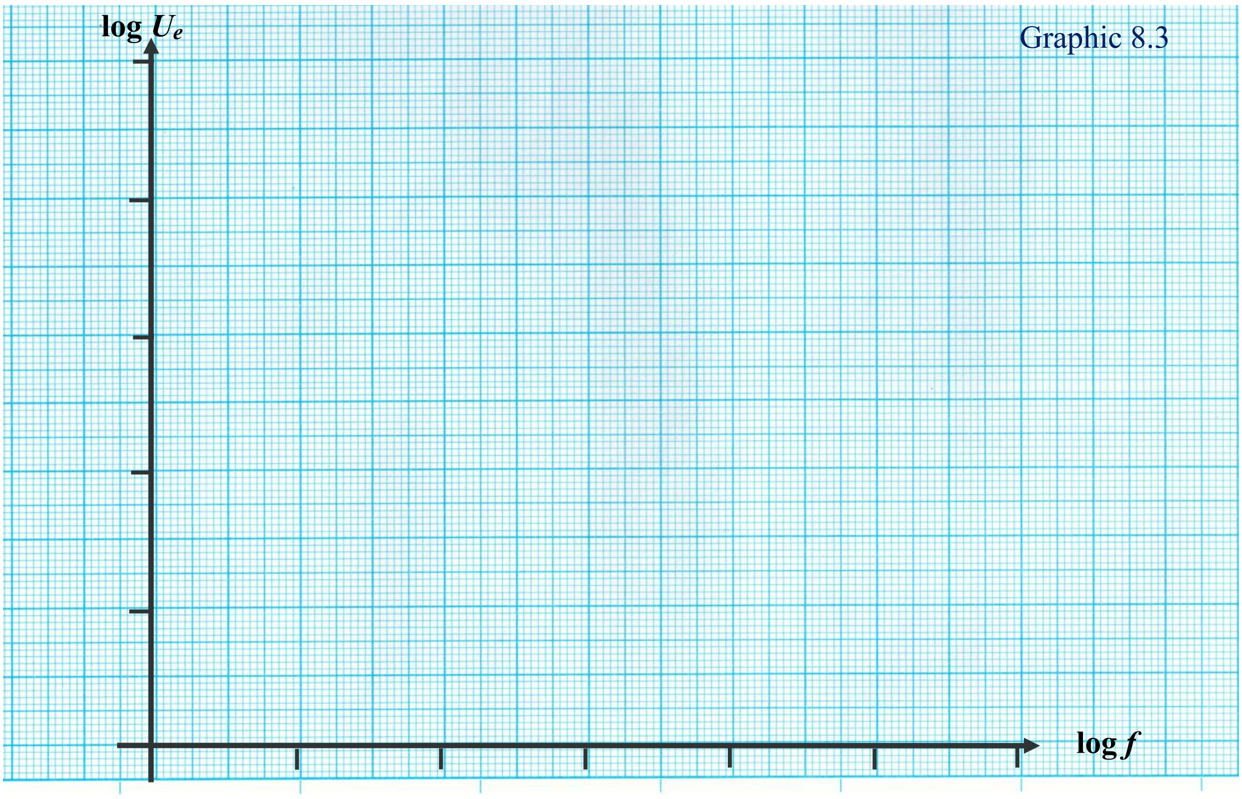
$$\sum_{i=1}^{4} y_i =$$

$$\sum_{i=1}^{4} {x_i}^2 =$$

$$\sum_{i=1}^{4} x_i\, y_i =$$

$$\alpha_{25} = \frac{4\sum_{i=1}^{4} x_i y_i - \sum_{i=1}^{4} x_i \sum_{i=1}^{4} y_i}{4\sum_{i=1}^{4} {x_i}^2 - \left(\sum_{i=1}^{4} x_i\right)^2} =$$

In the following graph, plot *log f – log* U_e by using *log f* and *log* U_e columns of Table 8.7 as *x*– and *y*–axis, respectively. Represent the data as points on your graph and draw the straight line *log* $U_e = \alpha$ *log f*.



D) A dependence of U_e:

Fill Table 8.8 by transforming Table 8.4 after calculating logarithms of A and recorded U_e values. Then, calculate α from Equation 8.12 with $x_i = \log A$, $y_i = \log U_e$ and $n = 3$.

Table 8.8: $log - log$ form of Table 8.4.

$\log N_2$			
$\log U_e$			

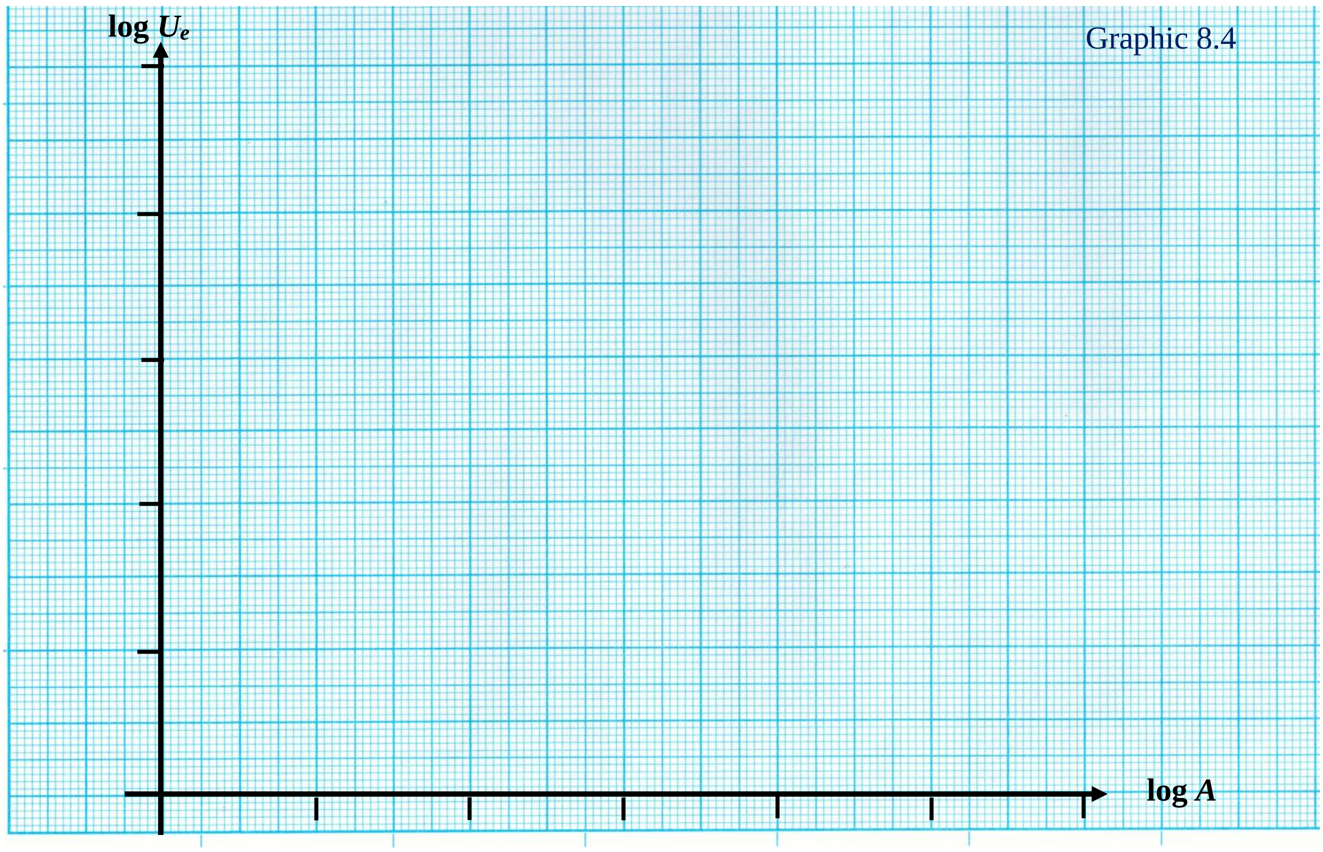
Use data from Table 8.8 and calculate the slope α that fits the data points on your *log A – log* U_e graph by using the linear fitting formulae. In the following sums, the x_i's represent the *log A* values on the x–axis, while the y_i's represent the *log* U_e values on the y–axis of your graphs.

$$\sum_{i=1}^{3} x_i = \qquad\qquad \sum_{i=1}^{3} y_i =$$

$$\sum_{i=1}^{3} {x_i}^2 = \qquad\qquad \sum_{i=1}^{3} x_i\, y_i =$$

$$\alpha = \frac{3\sum_{i=1}^{3} x_i y_i - \sum_{i=1}^{3} x_i \sum_{i=1}^{3} y_i}{3\sum_{i=1}^{3} {x_i}^2 - \left(\sum_{i=1}^{3} x_i\right)^2} =$$

In the following graph, plot *log A – log* U_e by using *log A* and *log* U_e columns of Table 8.8 as x– and y–axis, respectively. Represent the data as points on your graph and draw the straight line *log* $U_e = \alpha$ *log A*.



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Fill the following table with powers calculated by fitting in sections **A**, **B**, **C** and **D**.

Table 8.9: Comparison of powers. Theoretical values are taken from Equation 8.9.

power	I_e	N_2	f	A
theory	1	1	1	1
fitting				

Conclusion, Comment and Discussion:

(Tips: Explain your general observations and experimental findings objectively and scientifically with your original sentences.)

Questions:

1. Derive Equation 8.7.

2. Derive U_e given in Equation 8.9 starting from Equation 8.8.