

EXP.3: Force Between Current Carrying Wires

Lab Report

Complete this report YOURSELF except DATA taking parts! This report will not be submitted (except the very last page), but you should carefully complete it as preparation for the applied exam.

Suggested Pre-Lab Questions

Q1. In your OWN WORDS, give a definition of μ_0 in ONE SENTENCE!

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Q2. Explain the meaning of μ_0 in your OWN WORDS! Why do we need μ_0 ?

Q3. Show the dimensional Analysis for μ_0 .

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Experiment

OBJECTIVE : To measure the force between parallel, current carrying conductors and to analyze the dependence of this force on the constants of the system.

THEORY : Force between the current carrying wires is given as:

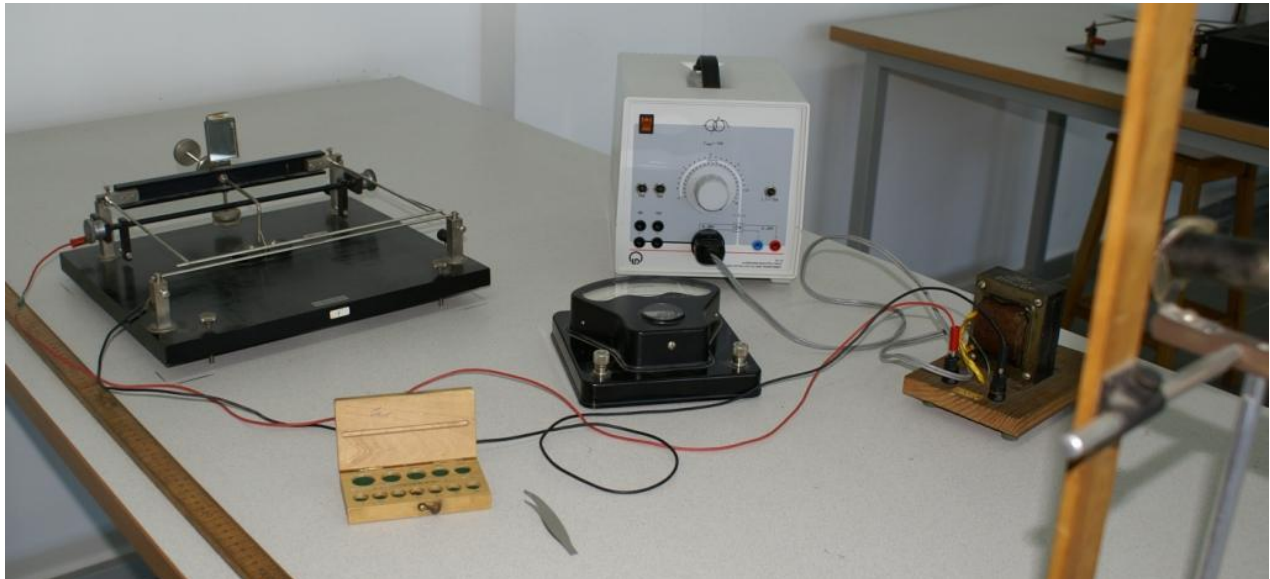
$$F = \frac{\mu_o}{2\pi} \frac{L}{d} I_1 I_2$$

and if the same current is passing through the wires as:

$$F = \frac{\mu_o}{2\pi} \frac{L}{d} I^2$$

where L is the length of the wires and d is the separation between the parallel wires. By measuring the force between current carrying parallel wires as a function of the current passing through them, we can determine the permeability of air. When the force values are plotted as a function of the squares of the corresponding current values, the straight line that fits the data best will have a slope that includes the permeability constant. From the slope of the straight line we can calculate the permeability constant as:

$$\mu_o = \frac{2\pi(\text{slope})d}{L}$$



APPARATUS : Parallel-wires apparatus, laser pointer with a ruler, meter stick, 9-A AC-ammeter, AC power supply with a transformer.

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PROCEDURE :

1. Turn on the laser pointer and make sure that it reflects from the mirror and falls onto the ruler so that you can measure some value on it. If not, rotate or translate the ruler holder accordingly until this condition is satisfied.
2. Make sure that the upper bar and the connected parts can move freely without touching anywhere.
3. Place some weight (rubber etc.) on the upper bar so that it is depressed until it is in contact with the lower bar. Make sure that upper and the lower bars are parallel to each other and the upper bar touches the lower one along its full length.
4. Record the laser pointer reading on the ruler (R_c). Chose upper or lower edge of the laser beam and read the corresponding value. You shall always read from the same edge of the laser beam.
5. Measure the necessary parameters asked for in the report.
6. Adjust the counterpoise so that the separation between bars, d_o , seems to be around 3 mm. Record the scale reading at equilibrium (R_o).
7. Calculate the separation d_o between the wires using the triangle similarity formula and verify that it falls in the desired interval around 3 mm. If not go back to Step 6.
8. To make measurements, add a certain mass (small wires) to the weight pan, increase the current until the scale reading indicates the initial reading, R_o .
9. When you hit the original R_o value, read the ammeter.
10. Calculate the force exerted due to small masses from their mass values* which are given according to their shapes**.
11. Repeat steps 8-10 for 5 different mass values.
12. Plot F_m versus I^2 (a best fit line), chose two slope points other than data points on the line and determine the slope. Then determine μ_o using this slope.

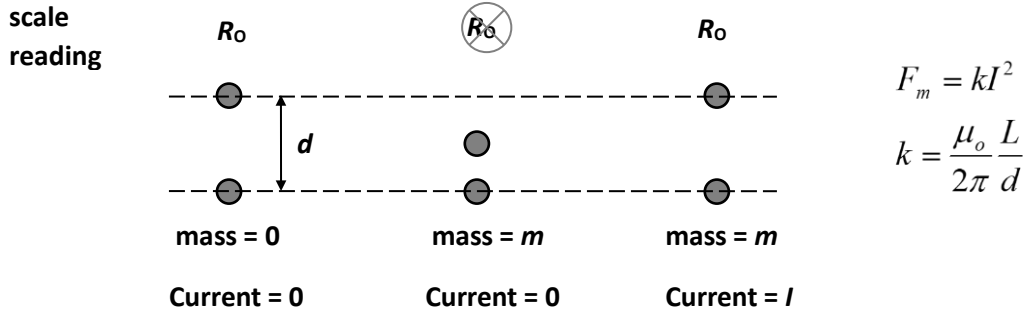
Note: If you cannot come back to your original R_o value, your balance might have been changed. Please make the current zero and take the masses on the pan away and check step 7.

In order not to disturb this sensitive setup, try not to touch the setup and the desk by force.

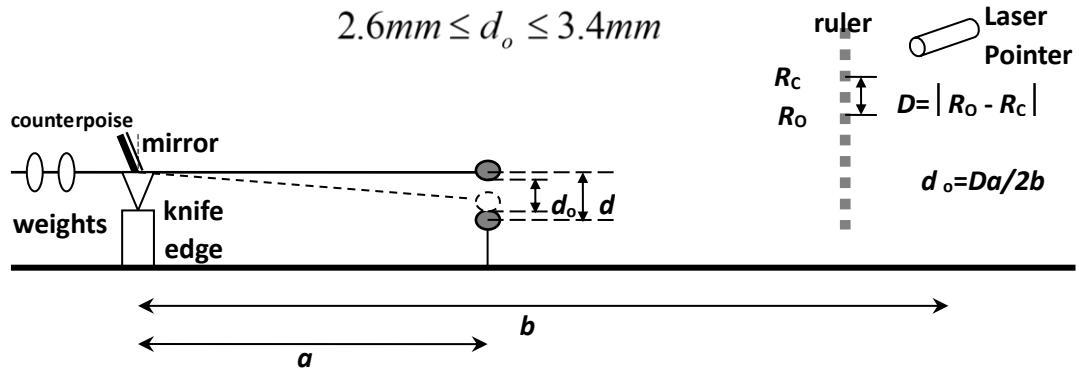
*Gravitational acceleration is given by $g= 9.81 \text{ N/kg}$.

** v-shaped: 5 mg ; u-shaped: 10. mg ; O-shaped: 20. mg.

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$$2.6\text{mm} \leq d_o \leq 3.4\text{mm}$$



DATA:

Description	Symbol	Value & Unit
Length of the lever arm	a	=
Distance from the scale with the mirror to the ruler	b	=
Diameter of the wire	$2r$	=
Length of the wire	L	=

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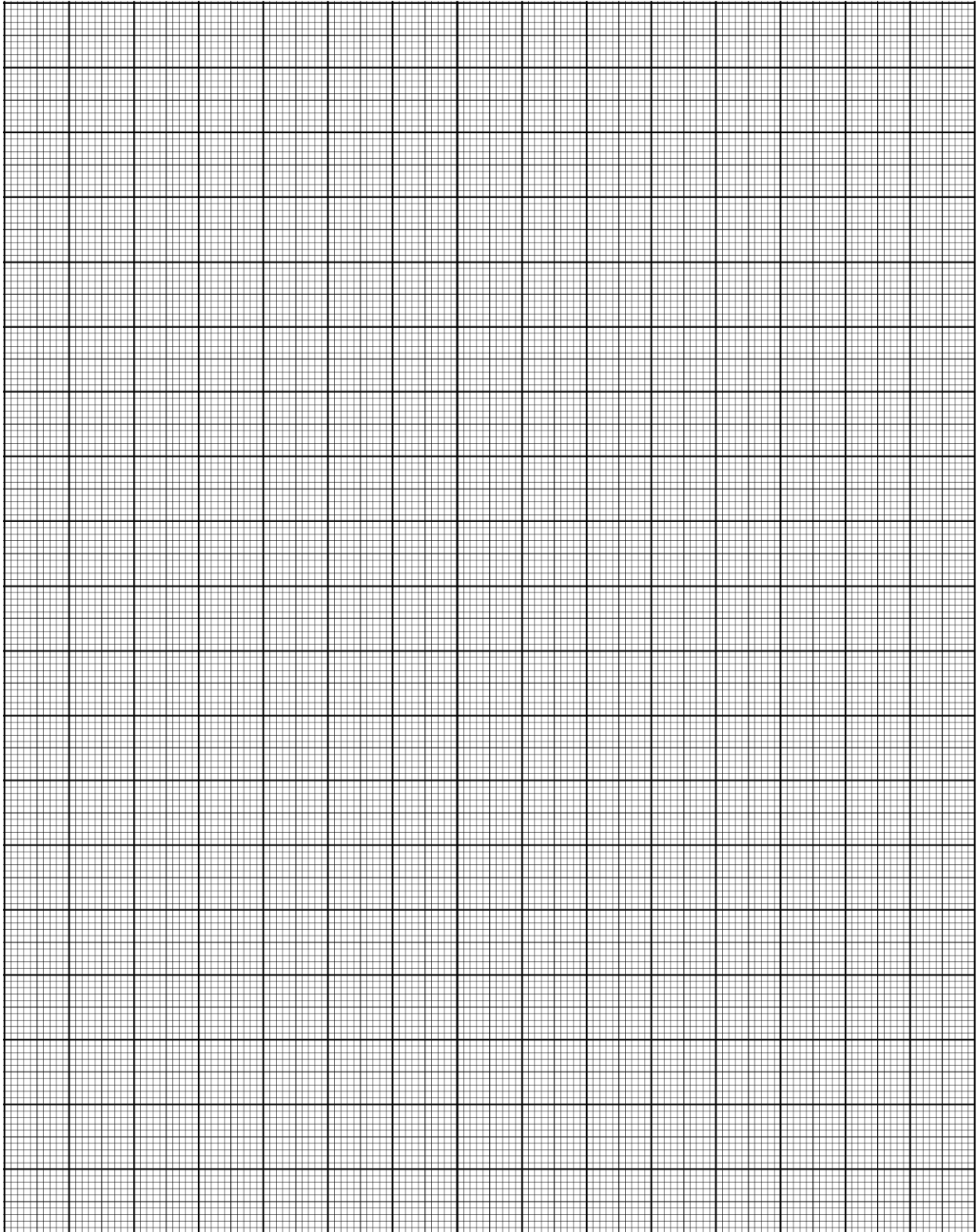
Description	Symbol	Value & Unit
Reading when the wires are open	$R_0 =$
Reading when the wires are closed	$R_C =$
Difference in readings	$D =$
Separation between the wires	$d_o =$
5 Separation between the wire centers	$d =$

Mass m ()	Current I ()	Force $F_m = m.g$ ()	Square of the Current I^2 ()

NOTE on SF: The number of significant figures (SF) is reduced by ONE when squaring data, though you may choose to leave it as it is if you wish to do so, as both conventions are widely accepted. However, only one of these methods should be implemented consistently for all data.

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Plot F_m versus I^2 :



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A) From the graph, choose two SLOPE POINTS other than data points,

$SP_1 : (\quad ; \quad)$
 $SP_2 : (\quad ; \quad)$

RESULTS:

Description	Calculation (show each step)	Result
SLOPE	=
$(\mu_0)_{EV}$	=
<p><i>Theoretical Value of permeability of air: $\mu_{oTV} = 4\pi \times 10^{-7} \text{ N / A}^2$ All figures significant! Compare your μ_0 with μ_{oTV}</i></p>		

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% Error for μ_0 =

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Note the value of μ_0 determined from your data. Bring it with you to the next experiment in order to determine the speed of light.

Note: This experiment will not be included in the applied exam. However the lab exam will contain questions covering the experimental setup, underlying concepts, procedures, and the required theoretical background.

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Suggested Post-Lab Questions

Q1. What are the **relative** current directions in the wires in this experiment and how can you conclude this?

Q2. How would you change the experiment procedure or modify the setup if the relative directions were **otherway around**, i.e. the opposite case of the present situation? (*Hint: Have a look at the paralel plate experiment! Do not offer to invert the current directions! This would be trivial!*)

Q3. Why do we use a transformer in the experiment setup? What can be its function?

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Post-Lab Report

Aim of the experiment:

Suggestions for possible solutions to the problems experienced during the experiment:

Conclusion:

9 I have completed this experiment myself as specified in the lab sheet and as explained by the lab instructor.

Name & Surname:

Student ID:

Lab Section:

Table #:

Date:

Signature of the
student

As the instructor of this Lab Section I confirm that the student has participated in and completed this experiment on time.

Stamp of the PHYS
Labs and signature of
the instructor

This page serves as proof of the fact that the student participated in and completed the experiment, only if it is submitted in time and accepted by the Lab instructor. The student and the instructor shall sign it along with the stamp of the Physics Laboratories.