

EXP.4: Force between Charged Plates

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. Instead of directly measuring the distance between two parallel plates, explain why we use R open: R_o and R closed: R_c values in the experiment. Should they stay the same while taking data? Why?

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Q2. What are the dimensions and unit of the slope when you plot F versus V^2 ? **Show** dimensional **analysis explicitly**. What is the difference between its dimensions and its unit?

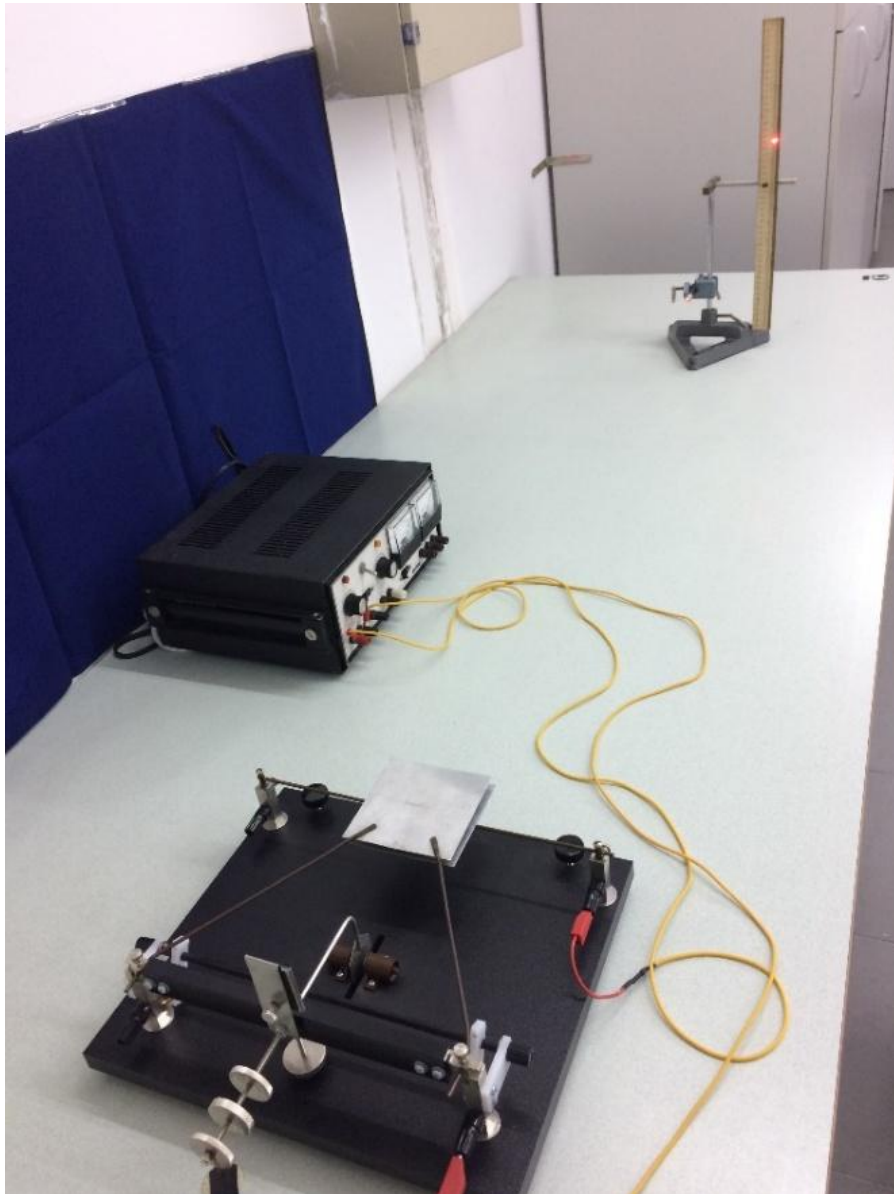
EXP.4: Force between Charged Plates

OBJECTIVE : To measure the force between two parallel plates as the voltage across them is varied, and to analyze the dependence of this force on the constants of the system, and to determine the permittivity constant.

THEORY : The force between two charged plates can be shown as:

$$F = \frac{\epsilon_0 A}{2d^2} V^2$$

where **A** is the area of the plates, **d** is the separation between the plates and **V** is the voltage across them.



APPARATUS : Parallel-wires apparatus, laser pointer with a ruler, meter stick, high voltage power supply.

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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 plate and the connected parts can move freely without touching anywhere.
3. Place some weight (rubber etc.) on the upper plate so that it is depressed until it is in contact with the lower plate. Make sure that upper and the lower plates are parallel to each other and the upper plate covers exactly the lower one through its full area.
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 plates 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) onto the mass hanger (at the backside of the mirror), increase the current until the scale reading indicates the initial reading, R_o .
9. When you hit the original R_o value, read **the red scale** of the voltmeter on the power supply.
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_e versus V^2 (a best fit line), chose two slope points other than data points on the line and determine the slope. Then determine ϵ_0 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.

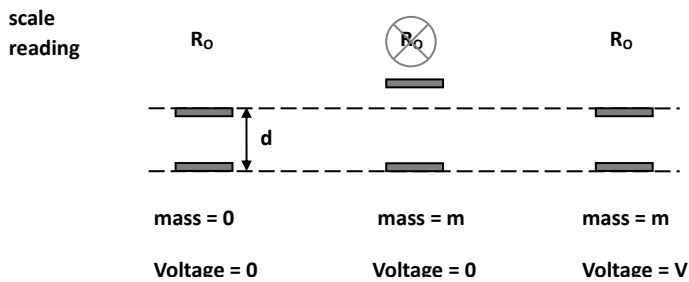
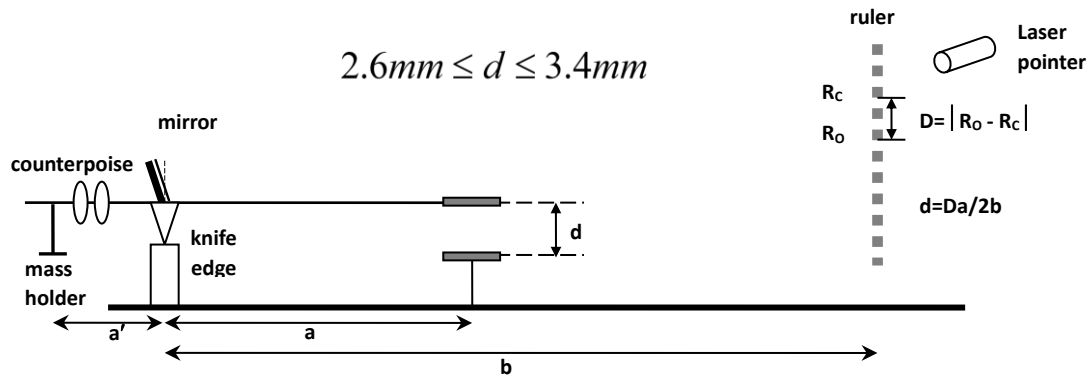
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DATA:

Description	Symbol	Value & Unit
Length of the lever arm	a	=
Length of the lever arm till te mass hanger	a'	=
Distance from the mirror scale to the ruler	b	=

Description	Symbol	Value & Unit
Length of the plate	L	=
Area of the plate	A	=

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$$F_e = kV^2$$

$$k = \frac{\epsilon_0 A}{2d^2}$$

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Description	Symbol	Value & Unit
Reading when the plates are open	$R_0 =$
Reading when the plates are closed	$R_C =$
Difference in readings	$D =$
Separation between the Plates	$d =$

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Limits for d : $2.6 \text{ mm.} \leq d \leq 3.4 \text{ mm.}$

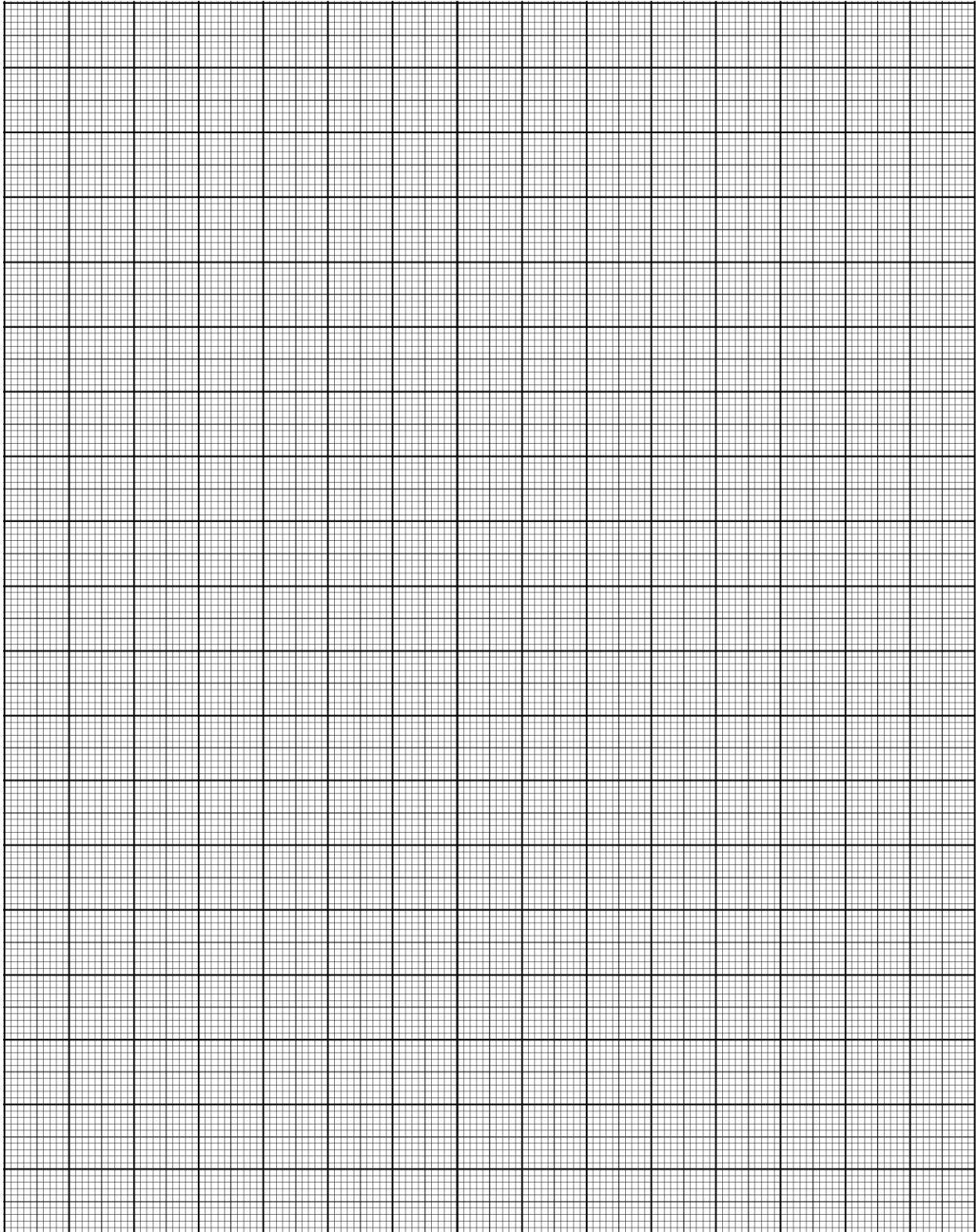
Mass m ()	Force $F_e = mga/a$ ()	Potential V ()	Square of Potential V^2 ()

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_e versus V^2

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RESULTS:

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

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

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

Description	Calculation (show each step)	Result
SLOPE	=	
	

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Using the slope calculate $(\epsilon_0)_{EV}$ and compare it with the theoretical value.

Description	Calculation (show each step)	Result
$(\epsilon_0)_{EV} =$	
	

Theoretical Value of permittivity of air:

$(\epsilon_0)_{TV} =$	$8.85 \times 10^{-12} \text{ N/V}^2$	All figures significant!
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% Error for ϵ_0 :

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Using the value of μ_0 (from the previous experiment) and $(\epsilon_0)_{EV}$ determined from your data, calculate **the speed of light (c) in vacuum**. Compare it with its theoretical value. (Make a quick search on internet)

Description	Calculation (show each step)	Result
$(C)_{EV} =$	
% Error for C :	

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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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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.