TP N°2 : Rheography Tank

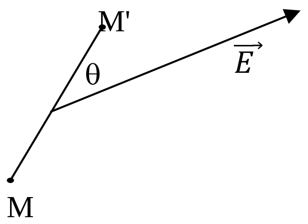
I. Purpose

Space electrical state characterization between two charged conductors by experimentally determining equipotential surfaces and field lines.

II. Theory

It is necessary, before starting this manipulation, to know the potential V and the electric field ($\vec{E}$) at a point M. These two quantities are related by the relationship:

$$dV = -\vec{E}.\vec{dl} = -\vec{E}.\overrightarrow{MM'} \qquad (3.1)$$



This relation gives us the potential difference $dV=V_{M'}-V_M$ between the neighbouring points M and M', as the field function $\vec{E}$ in the vicinity of M and M'.

As a results, we can define electric potential, V, thus can calculate the field:

$$\Delta V = -\int_A^B \vec{E}.\vec{dl} \;\Rightarrow\; E = -\frac{dV}{dx} \; (in\ 1D) \qquad (3.2)$$

Note that in equation (3.2) we only defined ΔV, the potential difference PD between two points, and not the potential V. This is because potential is like height – the location we choose to call "zero" is completely arbitrary. In this lab we will choose one location to call zero (the "ground"), and measure potentials relative to the potential at that location.

III. Manipulation

The conductors (attached to 12 V-1 A DC wall power supply) are placed in an insulating tank filled with a weakly conductive liquid. Current flows through the tank from one electrode to the other. With the voltmeter, it is can be measured the potential at different points in the space between the electrodes. From these potentials, electric field lines can be deduced (eq. (3.2)). If the conductors are made up of electrodes perpendicular to the tank bottom, it is sufficient to study, instead of equipotential surfaces, their projection on the tank bottom (***28×28 cm²***). These are equipotential curves. To measure the potential at the different points of the tank, small probes will be used, perpendicular to the tank bottom and with a trace that is practically punctual.

IV. Materials

a)- Conductors

We have two pairs of electrodes:

- The first pair consists of parallel plates connected to a power supply.
- The second pair consists of two cylindrical and concentric which will be connected to the positive and ground terminals of a power supply.

b)- Probe : The "1-wire" probe allows to determine the PD between any point M of the tank in which it is immersed and one of the two electrodes taken as a reference (zero potential), by inserting a voltmeter between the point M and the reference electrode.

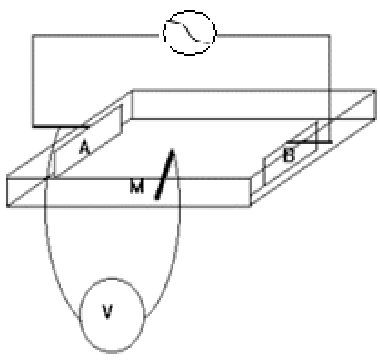


Figure 3.1: Rheography tank

Note: Before connecting the voltage source, the voltmeter should always be on the maximum gauge. If the needle does not deflect enough, switch to the lower gauge after checking that the needle will not exceed the scale end.

c)-Tank: A graph paper sheet is placed under the bottom of this transparent tank and allows you to locate the different positions of the probe electrode. These positions are transferred to scale 1 on another sheet graph paper. Measurements must be made with care, avoiding parallax errors as much as possible.

V. Experiment

A) - 1 st part : Potential and field produced by parallel plates capacitors:

- Setup 1 carried out during the lab session is shown in the figure opposite.

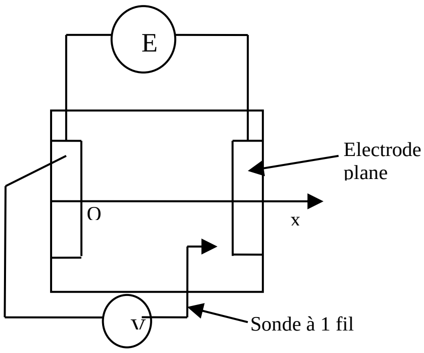


Figure 3.2: Diagram of apparatus Setup 1

- The plot of the 2, 3, 4 and 5 volt equipotential lines with field lines is shown on graph paper (with a scale to be deduced) as follows :

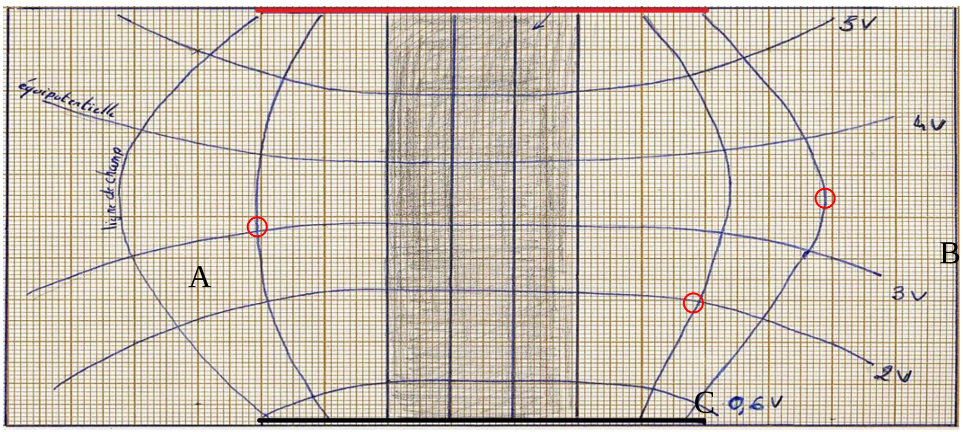


Figure 3.3: Draw the equipotential lines and the field lines.

- Derive the shape and direction of the field lines (comment on the path).
- Draw the field vector at points A, B, and C.
- - The potential values V(x) by moving the probe 2 by 2 cm along the x-axis are given in the following table:

x (cm)	2	4	6	8	10	12	14	16	18	20	24	28
V (volt)	3,0	4,0	5,0	6,0	6,5	7,5	8,2	9,0	9,8	10,5	12,5	14,0

- - Draw the corresponding V(x) graph.
- - Deduce from this graph the potential variation law V versus x.
- - Also deduce the electric field law E throughout the tank.

B)- 2nd part: Potential and field produced by two concentric circular electrodes:

Setup 2 was carried out, using a small circular electrode A with a radius of 1 cm, and a large circular electrode B. V=0 V is placed on electrode A.

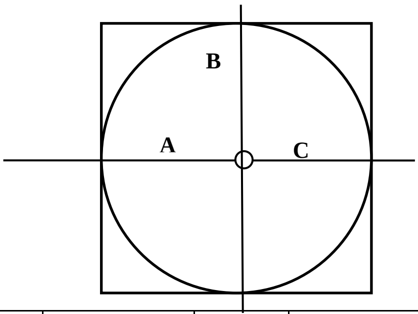


Figure 3.4: Setup 2

- What is the equipotential lines shape in this case?
- - Results are reported in a table:

x (cm)	1	3	5	7	9	11	13	15
V(volt)	0,0	6,0	8,5	10,0	11,5	12,5	13,2	13,7

- Plot the graph showing the change in potential **V** versus the radius r (or x).
- Using this curve, plot the 2 to 2V equipotential on graph paper. In which region is the electric field strongest?
- Deduct from the graph **V(r)** the local electric field values ***E(r)*** from cm to cm (take inspiration from the average and instantaneous velocities seen in mechanics and the relationship).
- Draw the graph of E(r).
- What mathematical function does the look of this graph suggest to you?
- From this we can derive the potential variation law V as a function of r.

Note: Please leave your bench in a tidy fashion. Thank you.