3-2022

Experiment 2.02: Electric and Potential Fields

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I. EXPERIMENT 2.02: ELECTRIC AND POTENTIAL FIELDS

A. Abstract

The qualitative features of the electric field lines and equipotential lines for several 2-D charge configurations are determined.

B. Formulas

$$\bar{E}_s = -\frac{\Delta V}{\Delta s} \tag{1}$$

$$E = \frac{\sigma}{\varepsilon_0} \tag{2}$$

where the second equation is the electric field magnitude between two parallel, oppositely and uniformly charged infinite planes.

C. Description and Background

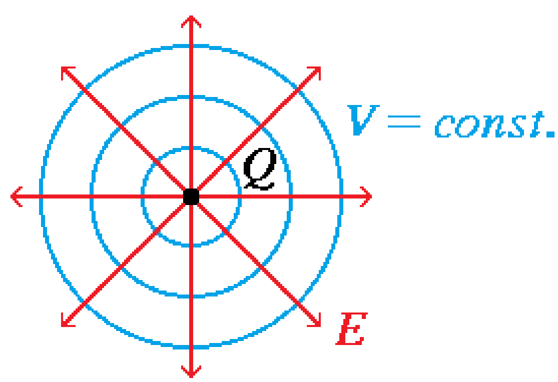


FIG. 1. Electric field lines and equipotential surfaces of a point electric charge.

Michael Faraday visualized the presence of electric currents and electric charges as lines (curves) in space. These visualizations of Faraday's turned out to be not only useful devices in understanding electric amd magnetic phenomena but were later theoretically vindicated by the work of James Clerk Maxwell. The figure shows the electric field lines of an isolated point charge. The circles represent projections of the associated spherical equipotential surfaces. Note that the electric field lines do not cross, nor do the equipotential circles. Furthermore the electric field lines and the equipotential surfaces (lines in two dimensions) are perpendicular.

In the experiment, one will determine the structure of the electric field lines of three charge arrangements (two charged spheres, two charged plates, and a sphere and plate).To do so, a voltmeter will be used to probe the regions around the charge arrangements. By finding adjacent points with the same potential (relative to one of the charges), one can infer the equipotential lines that are expected. From the equipotential lines, the electric field lines can subsequently be inferred.

D. Procedure

1. For each of the three charge configurations, locate five equipotential lines ($V = 1, 2, 3, 4, 5\ Volts$) using the voltmeter and probe.

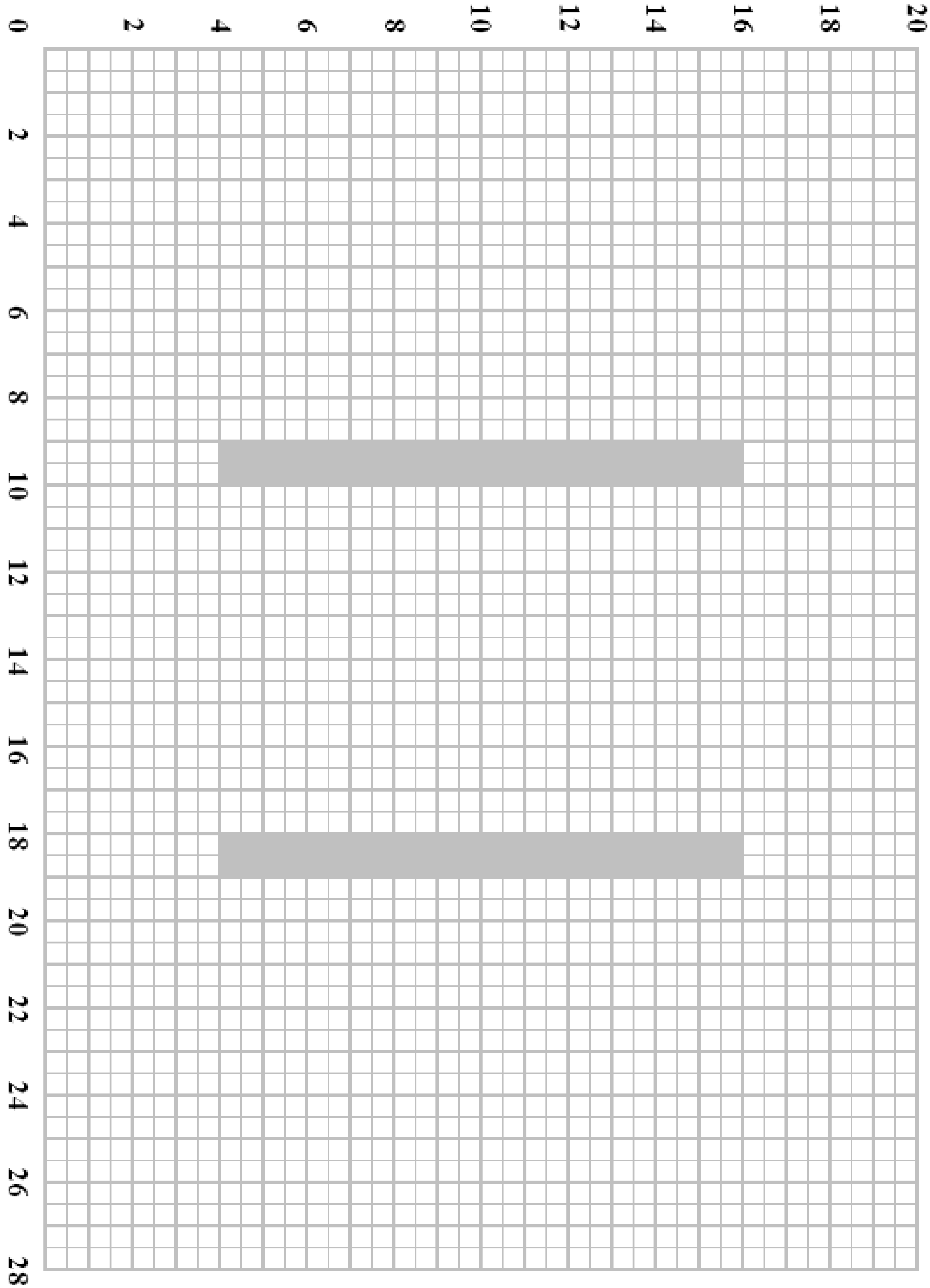
2. From the map of the equipotential lines, determine five curves that intersect the equipotentials at right angles. These are the electric field lines.

3. Generate three maps displaying each charge configuration with the qualitative features of the equipotential lines (in black) and the electric field lines (in red).

4. For the parallel plate configuration, set up a symmetry axis perpendicular to the plates with origin at the plate with $V = 0\ Volt$.

5. Record the location (s) of the intersection points of the equipotential lines with the axis. Also record the location of the opposite plate and its potential. *Note*: The units on the graphs are not true centimenters, so use a ruler in measuring locations.

1. Templates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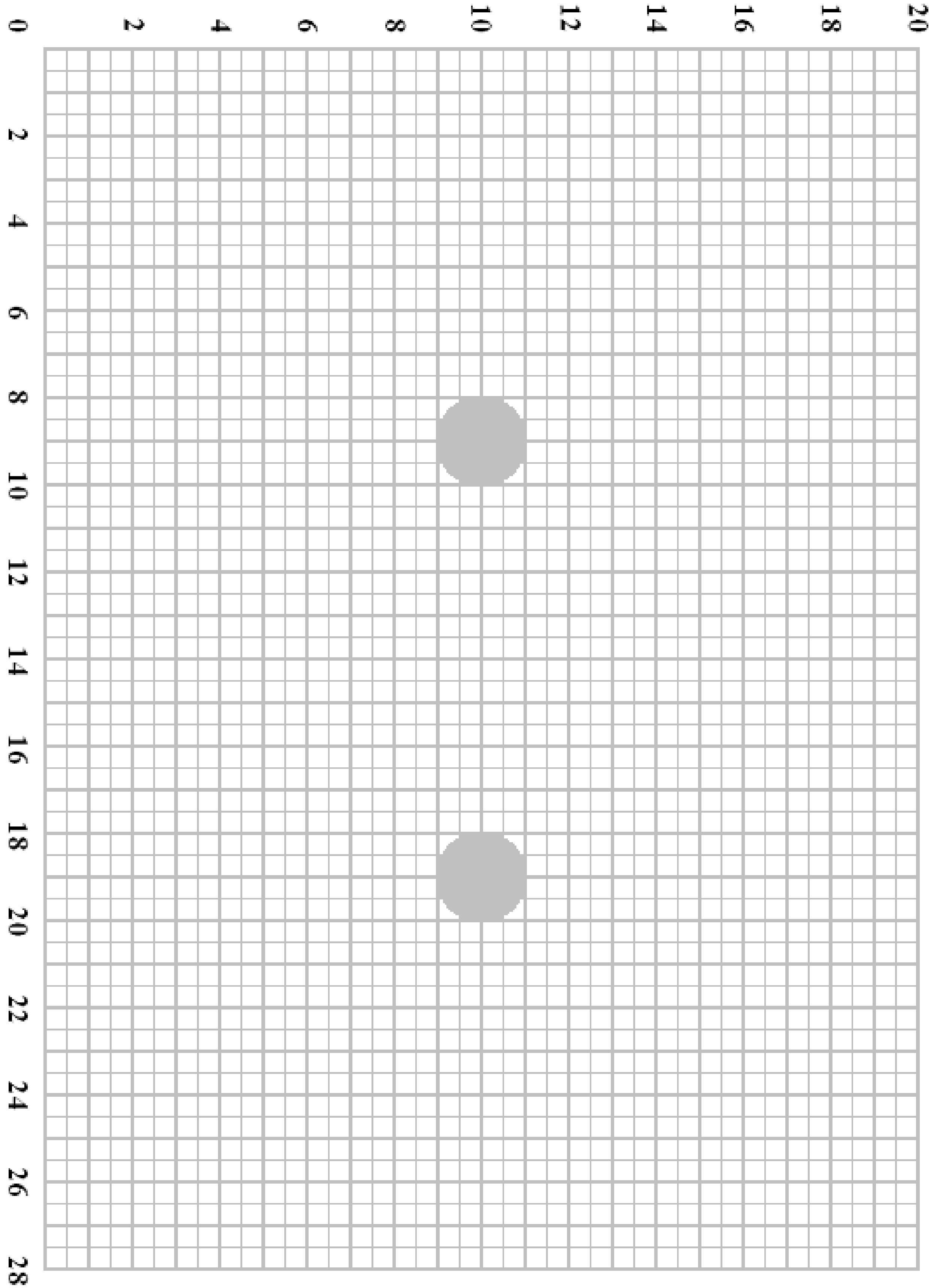
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28


0 2 4 6 8 10 12 14 16 18 20
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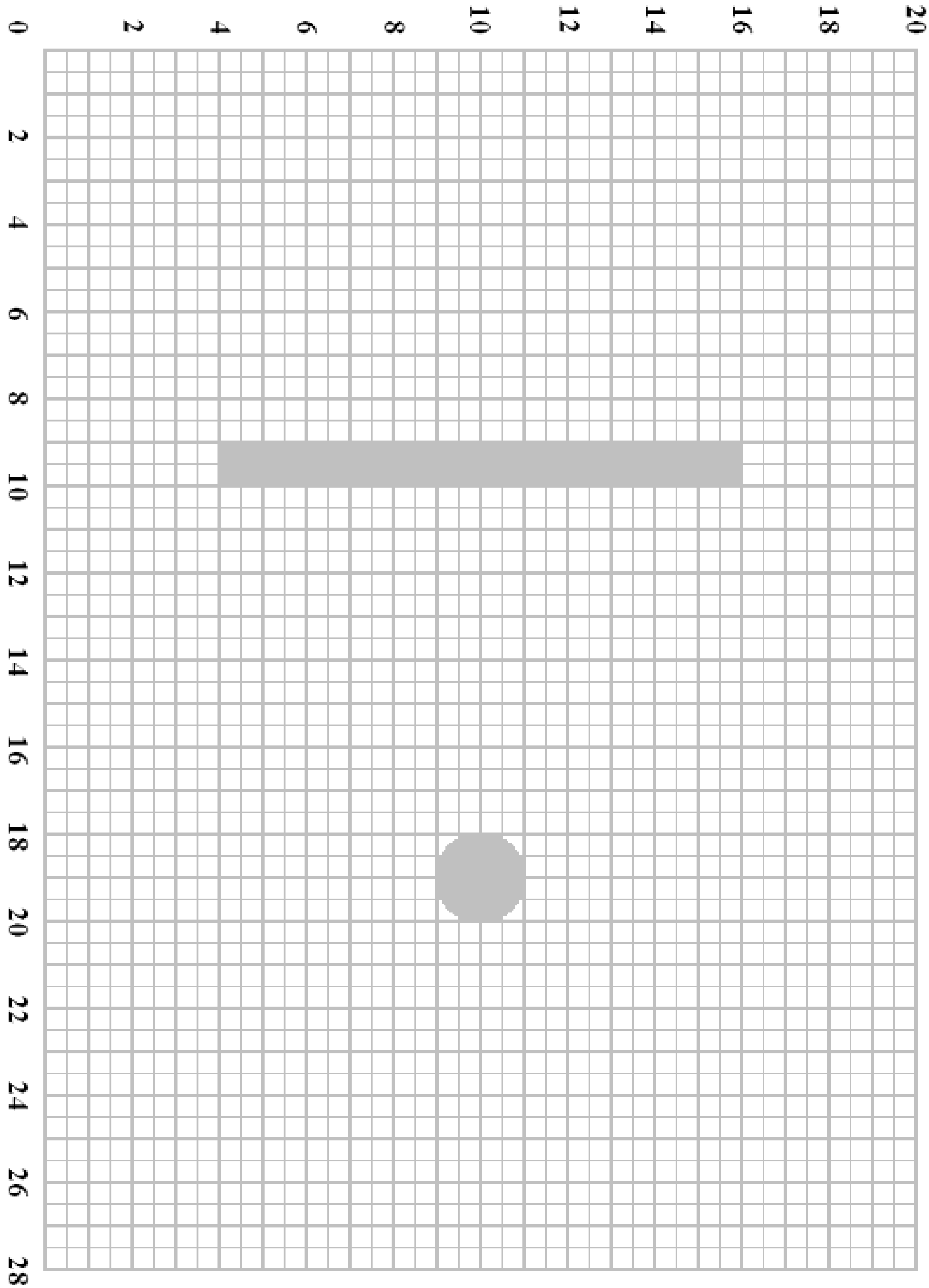
0 2 4 6 8 10 12 14 16 18 20
2 4 6 8 10 12 14 16 18 20 22 24 26 28

E. Measurements

parallel plates	
location along axis, s [cm]	V [$Volt$]
0	0

F. Instructions

1. Submit the three templates displaying the equipotential lines and electric field lines.

2. Use the excel file, **EquiPotentialsPlot.xlsx**, to plot V *vs.* s, and submit the graph.

3. Determine the linear least squares (LS) fit and therewith the approximate electric field between the plates.

4. What effective charge density (σ) would you associate with 3-D plates if your answer to the question above were the electric field between them? Express your answer in *pico-Coulombs*$/m^2$.

G. Calculations

E [V/m]	
σ [pC/m^2]	