

FIELD LINES AND EQUIPOTENTIAL LINES

Instruction Manual



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UNPACKING FIELD LINES & EQUIPOTENTIAL LINES



EXPERIMENTS:

Exp-1 To investigate the equipotential lines of electric fields.

Exp-2 To draw the equipotential lines for bar electrode.

Exp-3 To draw the equipotential lines for disc Electrode.

Exp-4 To draw the equipotential lines for ring Electrode.

CONTENTS :

S.No.	Items	Qty.
1	Trough	1
2	Needle Probe	1
3	Rod with Socket	1
4	Multimeter	1
5	Cyndrical Base	1
6	Bar Electrode	2
7	Disc Electrode	2
8	Ring Electrode	1
9	Stand Rod	1
10	Boss head (Plastic)	1
11	Power Supply 2-12V	1
12	Flexible plug lead set	1
13	Bar Graph Book	1



THEORY :

ELECTRIC FIELD :

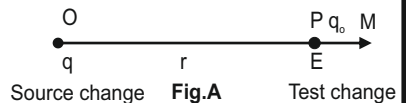
Is the space around the charge within which its influence can be felt by the very small test charge. It is a vector quantity.

ELECTRIC FIELD INTENSITY E :

At a point in the electric field is the force experienced by the unit +ve charge at that point. The direction is in which unit +ve charge move if free to do so.

If F is the force experienced at a point in electric field by test charge q_0 at a distance r from source charge q then electric field at p

$$E = \frac{F}{q_0} \text{ (NA}^{-1} \text{ S}^{-1}\text{) along PM}$$



ELECTRIC FIELD LINE :

Is the path followed by unit +ve charge in the electric field. The tangent to the electric field line at the point give the direction of field at that point. Two electric lines never intersect each other. Because if they intersect, then there will be two electric fields at the same point, which is not possible.

ELECTRIC POTENTIAL V:

At a point in electric field is defined as the amount of work done in taking a unit +ve charge from infinity to that point without acceleration.

$$V = -\frac{W}{q_0} \text{ (Volt = JC}^{-1}\text{)}$$

EQUIPOTENTIAL SURFACE :

The locus of all points which are at same potential is called as equipotential surface.

RELATION BETWEEN ELECTRIC FIELD AND POTENTIAL DIFFERENCE BETWEEN TWO EQUIPOTENTIAL SURFACES. is

$$E = -\frac{dv}{dr}$$

Where dr= distance between two equipotential, surfaces having a potential difference dV.

CHARACTERISTICS OF EQUIPOTENTIAL SURFACES :

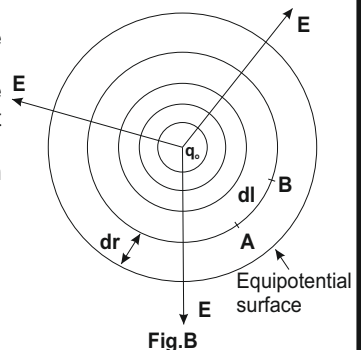
- (1) The equipotential surface never intersect each other.
- (2) The equipotential surfaces of point charge are concentric sphere (fig-B)
- (3) Since $dr \propto \frac{1}{E}$, so where E is more dr is small. As E is more near the charge So equipotential surfaces of point charge are crowded near the charge as shown.
- (4) Work done in taking a unit +ve charge from A to B on equipotential surface is zero

$$W_{AB} = V_B - V_A = \vec{E} \cdot d\vec{r}$$

$$V_B = V_A \text{ on equipotential surface so}$$

$$W_{AB} = 0$$

As



(5) Electric field is always perpendicular to the equipotential surface.

Using

Edlco

As

$$\begin{aligned} W_{AB} &= \vec{E} \cdot d\vec{l} \\ W_{AB} &= 0 \\ \text{So } \vec{E} \cdot d\vec{l} &= 0 \\ \text{or } Edl \cos\theta &= 0 \\ \text{or } \cos\theta &= 0 = \cos 90^\circ \\ \text{or } \theta &= 90^\circ \end{aligned}$$

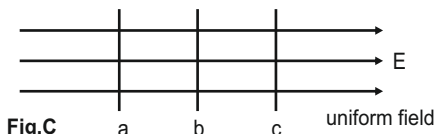


Fig.C

(6) The equipotential surfaces of uniform electric field E are parallel plane a,b,c perpendicular to the field lines

IMPORTANCE:

The equipotential surfaces gives the visual picture of electric field in terms of its magnitude and direction of the field

This experiment is suitable for training at undergraduate level and provide a novel technique for plotting the equipotential curves for the following geometries of electrodes.

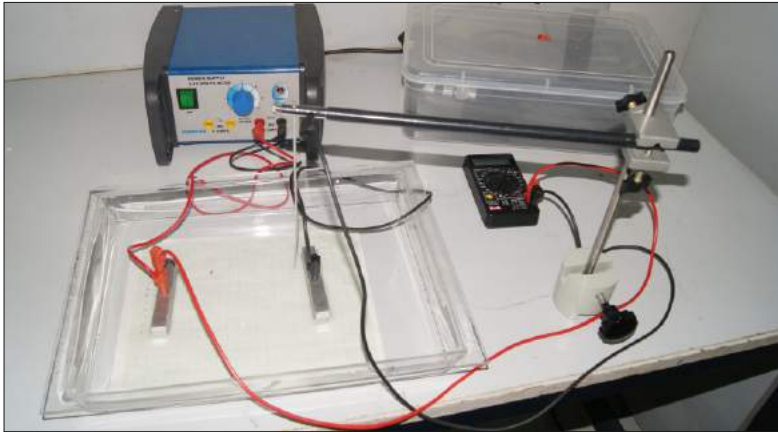
In a shallow tray of water the equipotential surfaces are vertical surfaces in the water which can be represented as lines when viewed from above. Equipotential lines can be mapped for different arrangements of electrodes:

1. Two parallel plate sources with a circular conductor between them
2. Two point sources
3. Two parallel plates/point sources with conducting ring.

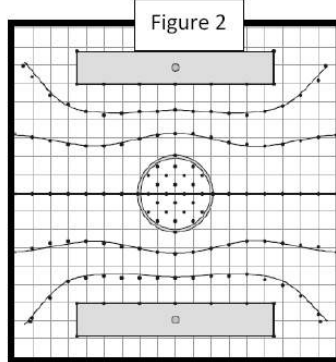
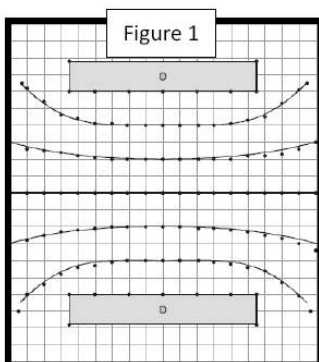
PROCEDURE:

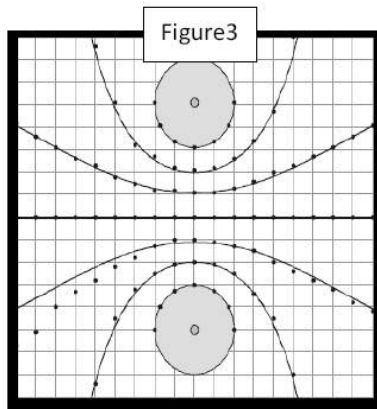
1. Take two graph papers and place the electrodes at a distance of 15 cm on the graph paper and mark their position. Label the two sheets of graph paper identically. On the long side and short side of the paper assign a letter for each row. The two sheets of graph paper should be labeled identically with references to each other.
2. Place the clear dish on top of one of the sheets of graph paper and also place the electrodes on the marked position.
3. Make the connections as shown in figure with the needle as the test probe connected to the multimeter to measure the voltage.
4. Fill the transparent acrylic trough with water such that the electrodes are half dipped in the water.
5. Starting with the points close to the on of the electrode, place the test probe into the water directly over the position above the box of the graph paper and search for the points of equal potential.





6. Read the voltage off of the multimeter and write the value in the corresponding box on another graph paper.
7. Continue this process until the entire graph paper is filled out.
8. Join the points of equal potential on the graph paper to find out that near a source, the equipotential lines are parallel to the surface of the charge distribution, and the electric field lines are perpendicular to the surface of the charge distribution.
9. Similarly, draw the equipotential lines with disc electrode.
10. Place a conducting ring, which will not be connected to any voltage source. Map the equipotential lines and electric field lines in the region containing the two plates and the conducting ring.
11. Draw the equipotential lines for different arrangements of electrodes of your choice.





12. Figure 1, figure 2, figure3 shows the electrode arrangement with parallel electrodes, parallel electrodes with a conductor ring and disc electrodes respectively.
13. Electric field is everywhere at right angles to the equipotential surfaces and the fact that electric fields start on positive charges and end on negative charges can now be used to draw the field lines in the region where equipotential are traced.
14. On your drawing, place your pencil at a point representing the bar conductor surface and draw a line perpendicular to the bar going toward the nearest equipotential line. As your line approaches the equipotential, be sure that it curves to meet the line at a right angle. Proceed similarly to the next equipotential, and so on until your line ends on the drawing of the round conductor.

TECHNICAL NOTES:

1. Two equipotential surface can never intersect each other. If they intersect there will be two values of electric field intensity at a point which is not possible.
2. An AC potential difference is maintained between the electrodes which causes the distribution of potential in electrolyte.
3. The equipotential surfaces for infinite long plates electrodes will be straight lines parallel to the electrodes. The equipotential curve for plate electrodes of finite length as plotted in fig-1. get curved near the end of the plate electrodes to be perpendicular to electric field lines near ends, because charge distribution is more at ends.
4. An AC potential difference is maintained between the electrodes which causes the distribution of potential in electrolyte. In this method AC is preferred to D.C. because D.C. Will dissociate the electrolyte which will result in polarization of charged ions in the electrolyte. This polarization will change the potential distribution in the electrolyte which should essentially be maintained the same throughout the measurement at a point.
5. The electrolyte water allow us to measure the potential at any point in the region between the electrodes using multimeter.
6. The distance between the electrodes preferably should be less than their length.
7. Insert the probe, exactly vertical in the electrolyte

**TEACHING NOTES AS EYE CATCHERS (MEMORY TIPS)
TO MAKE CONCEPTS ONLY (NOT FOR DEMONSTRATION)**

- 1) The concept of Lines of forces was first given by Faraday.
- 2) Electric Lines of force may form either open or closed curve. However magnetic Lines of force are always close Lines.
- 3) Electric field between plates of the parallel plate capacitor is uniform electric field. In uniform field electric Lines of force are parallel and equidistant.
- 4) In a non-uniform electric field the electric Lines are not parallel and not equidistant from each other.
- 5) Electric flux is a scalar quantity.
- 6) No point charge produces electric field at its location.
- 7) Electric field Lines are perpendicular to the surface of charged conductor.
- 8) Electric field Lines are perpendicular to the equipotential surface.
- 9) If a charge is a positive then the direction of E is same as that of force F, that is perpendicular to the surface directing outward.
- 10) If the charge is negative then the direction of E is opposite to that of force, that is perpendicular to surface directing inward.
- 11) The torque on dipole in an electric field is zero both in stable as well as in unstable state.
- 12) The potential energy of the dipole in an electric field is minimum in stable equilibrium.
- 13) The electric charge always reside on the surface of the charged conductor.
- 14) A charged conductor behave as a shell of charge, because the charge reside on the surface of conductor.
- 15) The surface of a charge conductor is equipotential although the electric field may be different at different points.
- 16) $300 \text{ V} = 1 \text{ stat volt} = 3 \times 10^{10} \text{ ab volt}$
- 17) $10 \text{ A} = 1 \text{ abA} = 3 \times 10^{10} \text{ Stat A}$
- 18) $10 \text{ C} = 1 \text{ ab C} = 3 \times 10^{10} \text{ Stat C}$
ab (absolute) and stat are the CGS units in emu and e.s.u systems, respectively.
- 19) Electric potential, electric potential difference, and electro motive force are scalar quantities.
- 20) The +ve electric potential (due to +ve charge) means work is done in transferring a +ve test charge from infinity to that point by the external agent.
- 21) The -ve electric potential difference means work is done by the electric field in transferring the positive charge from infinity to that point.
- 22) **Electric potential at a point P in electric E is given by $v = - \int_{\infty}^P \vec{E} \cdot d\vec{r}$**
- 23) **Electric potential due to a point source q at a distance r from it is given**

by $V = \frac{q}{4\pi\epsilon_0 r}$

- 24) The relation between electric field at a point and negative potential gradient is $E = \frac{-dV}{dr}$

- 25) The electric field is conservative, that is the work done in moving a test charge does not depend upon path followed however it depends upon the INITIAL and FINAL position of the test charge.

- 26) Electric potential of earth is arbitrarily assumed to be zero.

- 27) The surface of a conductor is an equipotential surface because electric field inside, the conductor is zero which implies that potential remain constant.

- 28) The electric potential inside a charge conductor is same as that on its surface and it is independent of the shape of conductor.

- 29) Electric potential at any point on the charged conductor is independent of the surface density of charge.

- 30) Along an equipotential surface the intensity of electric field is always zero.

- 31) Potential energy of a system decreases when like charges are carried away as repulsive forces help in doing so.

- 32) Potential energy of a system decreases when unlike charges are brought closer to each other as work is done by attractive forces.

- 33) The potential energy increases when the unlike charges are taken apart.

- 34) The potential energy of a conductor at potential V having charge q

is $U_v = \frac{1}{2} qV$

- 35) If a charge q placed at a point where electric potential due to another source charge be V, then electric potential energy

is $U_p = qv$

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