Module 07: Electric Potential; Equipotential Lines and Electric Fields

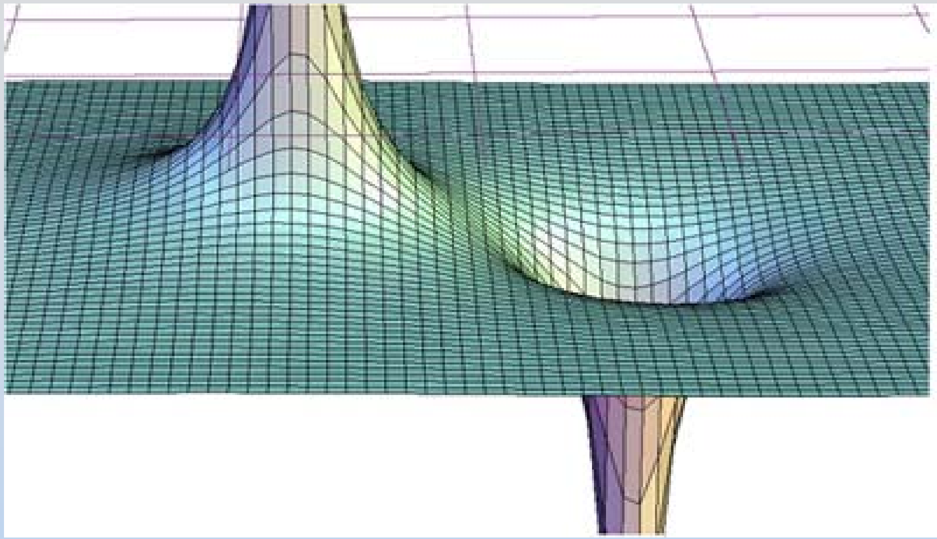
Module 07: Outline

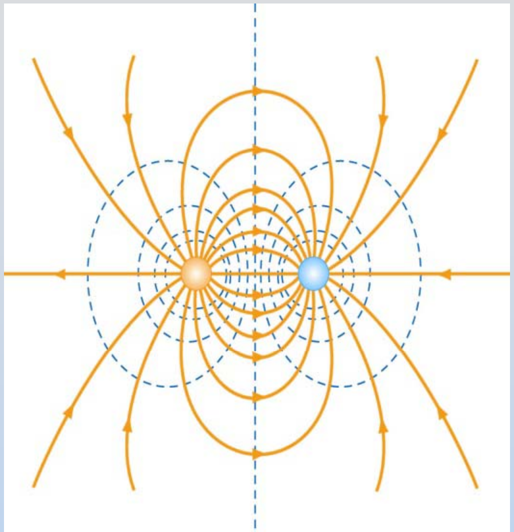
Electric Potential

Lab 1: Equipotentials

Last Time:
Potential and E Field

E Field and Potential: Creating





A point charge *q* creates a field and potential around it:

$$\vec{\mathbf{E}} = k_e \frac{q}{r^2}\hat{\mathbf{r}};\ V = k_e \frac{q}{r}$$

Use superposition for systems of charges

They are related:

$$\vec{\mathbf{E}} = -\nabla V;\ \Delta V \equiv V_B - V_A = -\int_A^B \vec{\mathbf{E}} \cdot d\,\vec{\mathbf{s}}$$

E Field and Potential: Effects

If you put a charged particle, (charge *q*), in a field:

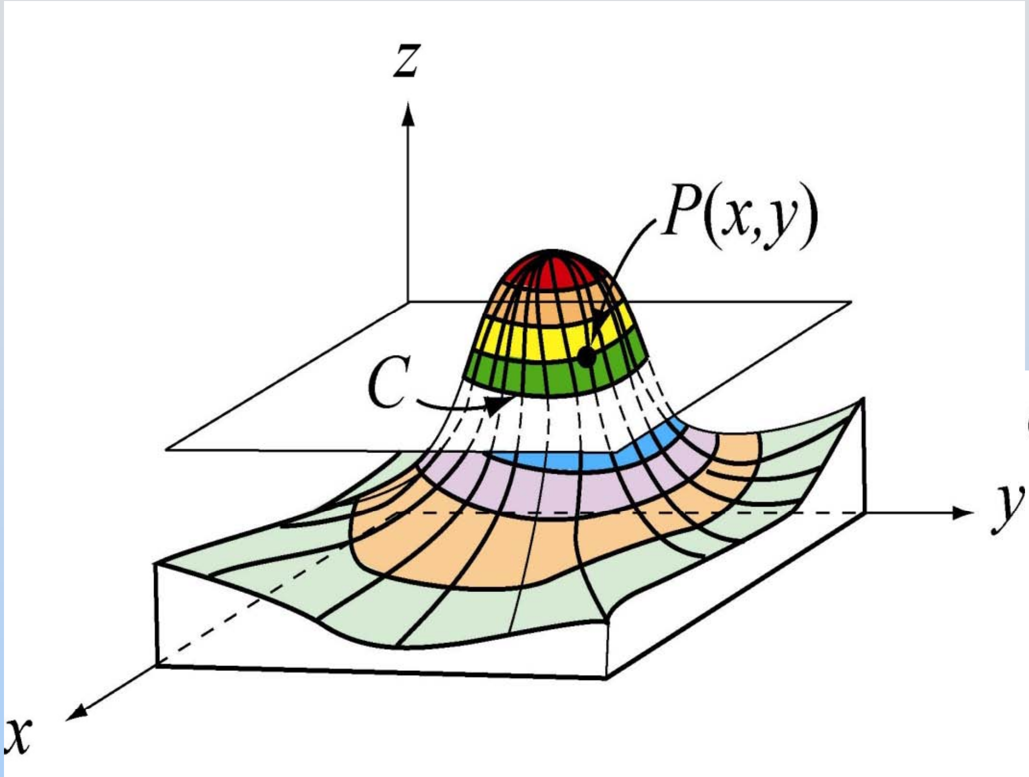
$$\vec{\mathbf{F}} = q\vec{\mathbf{E}}$$

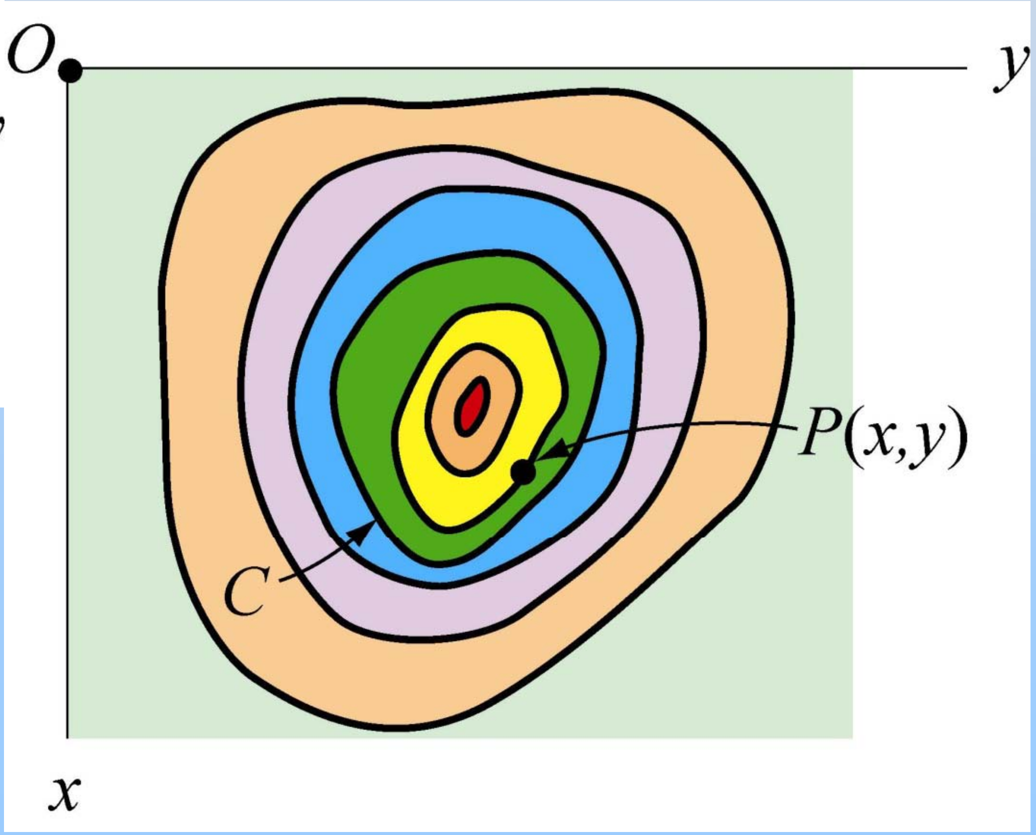
To move a charged particle, (charge *q*), in a field and the particle does not change its kinetic energy then:

$$W_{ext} - \Delta U - q\Delta V$$

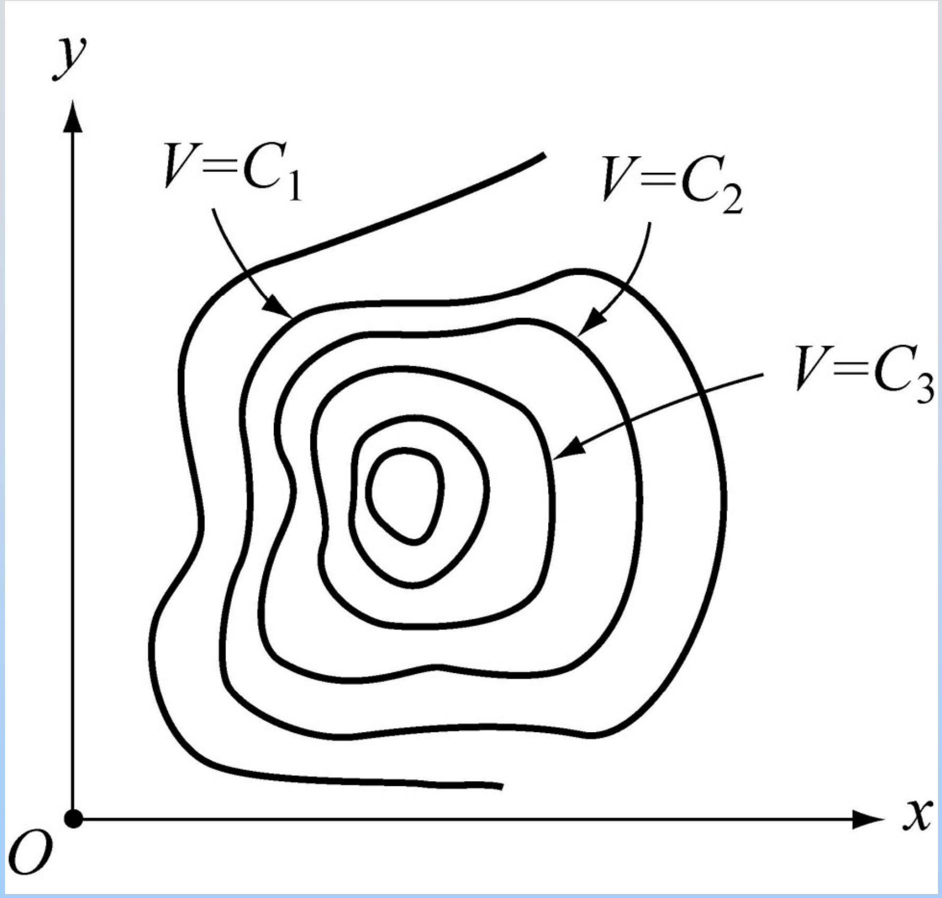
Equipotentials

Topographic Maps





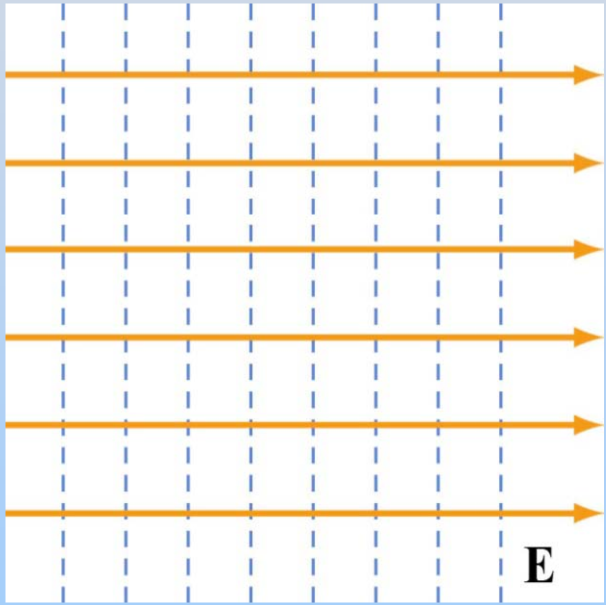
Equipotential Curves



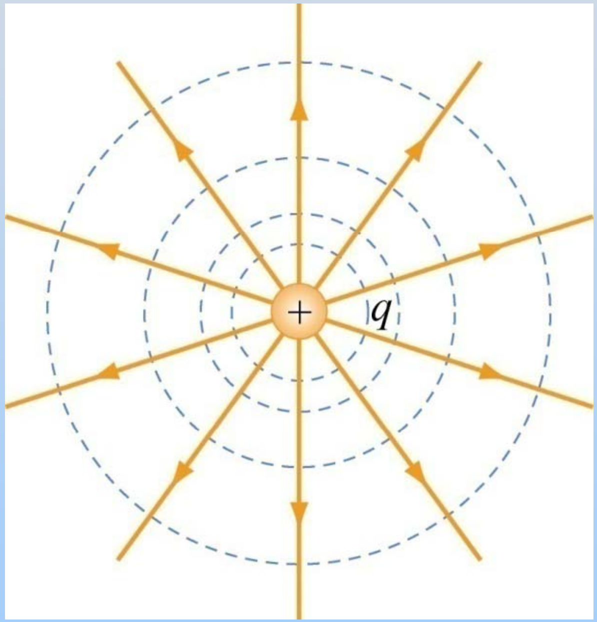
All points on equipotential curve are at same potential.
Each curve represented by V(x,y) = constant

Direction of Electric Field E

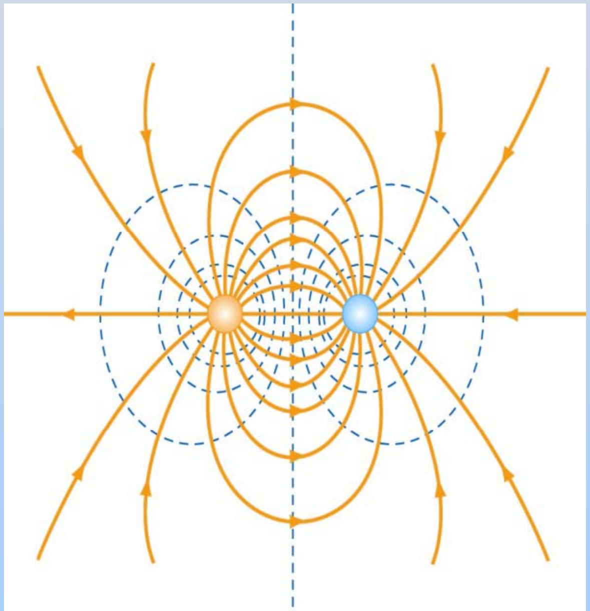
E is perpendicular to all equipotentials



Constant E field



Point Charge



Electric dipole

Properties of Equipotentials

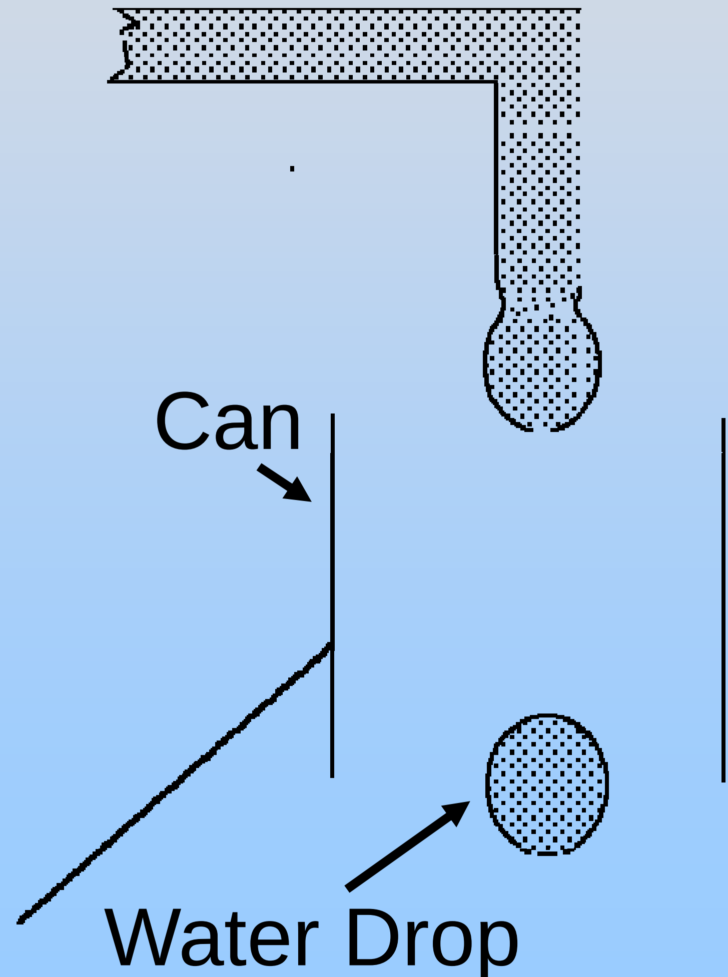
- E field lines point from high to low potential
- E field lines perpendicular to equipotentials
  - Have no component along equipotential
  - No work to move along equipotential

Demonstration: Kelvin Water Drop

Concept Question: Kelvin Water Dropper

A drop of water falls through the right can. If the can has positive charge on it, the separated water drop will have

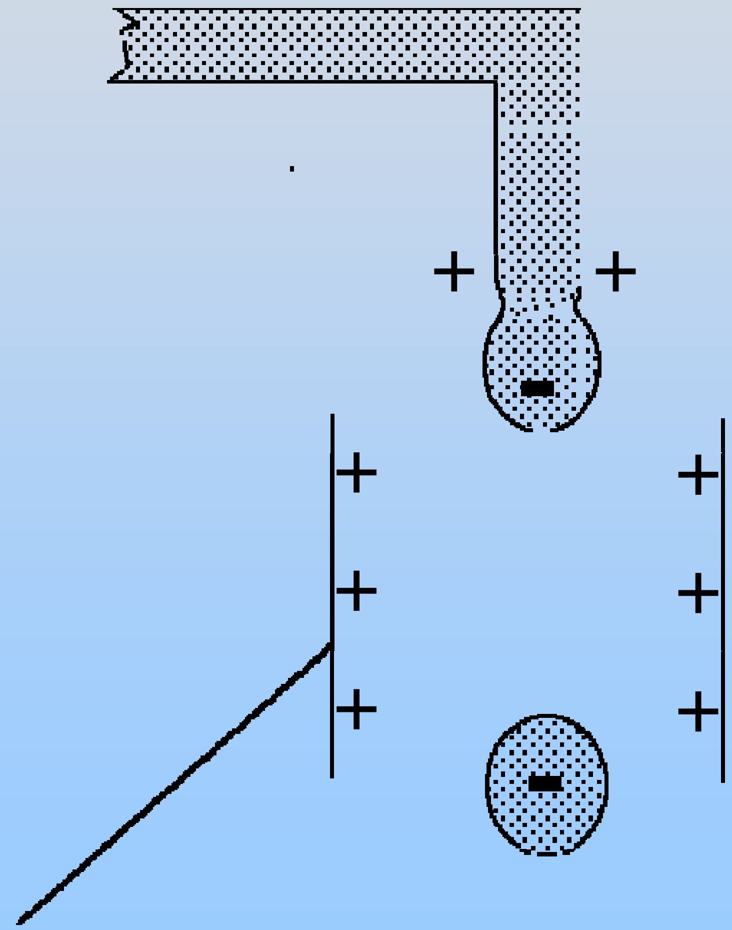
1. no net charge
2. a positive charge
3. a negative charge
4. I don't know



Concept Question Answer: Kelvin Water Dropper

Answer: 3. The drop has a negative charge

The positive charge on the can repels positive charge to the top of the drop and attracts negative charge to the bottom of the drop just before it separates. After the drop separates its charge is therefore negative.



Equipotential Visualization

Experiment 1: Equipotentials

Download LabView file (save to desktop) and run it

Log in to server and add each student to your group (enter your MIT ID)

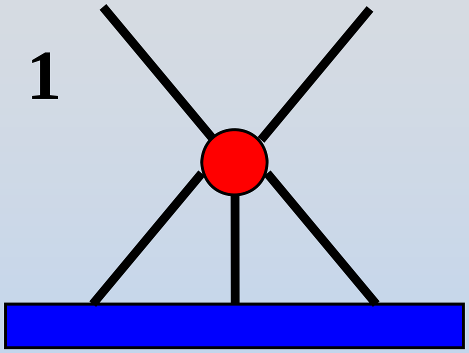
Each group will do two of the four figures (your choice). We will break about half way through for some Concept Question

Concept Question Questions: Midpoint Check

Concept Question: Equipotential

The circle is at +5 V relative to the plate. Which of the below is the most accurate **equipotential map**?

1



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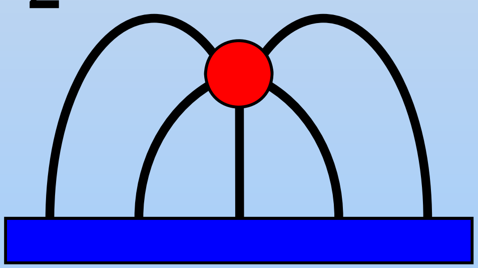

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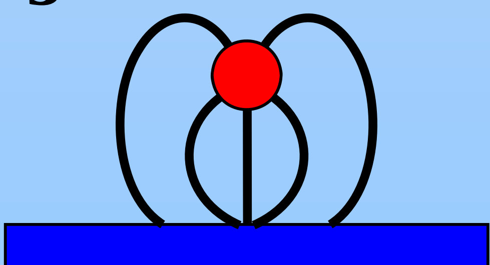

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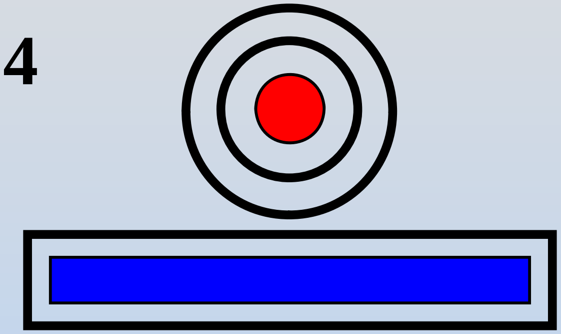

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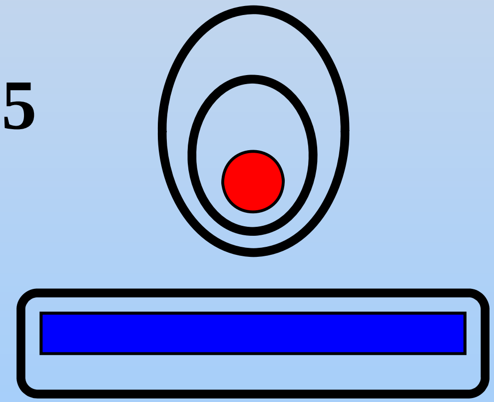

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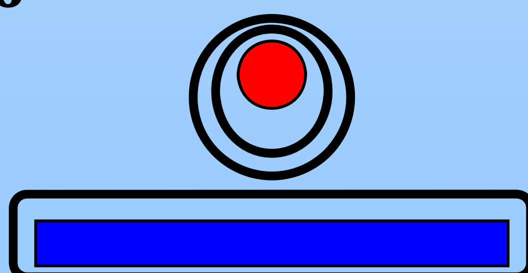
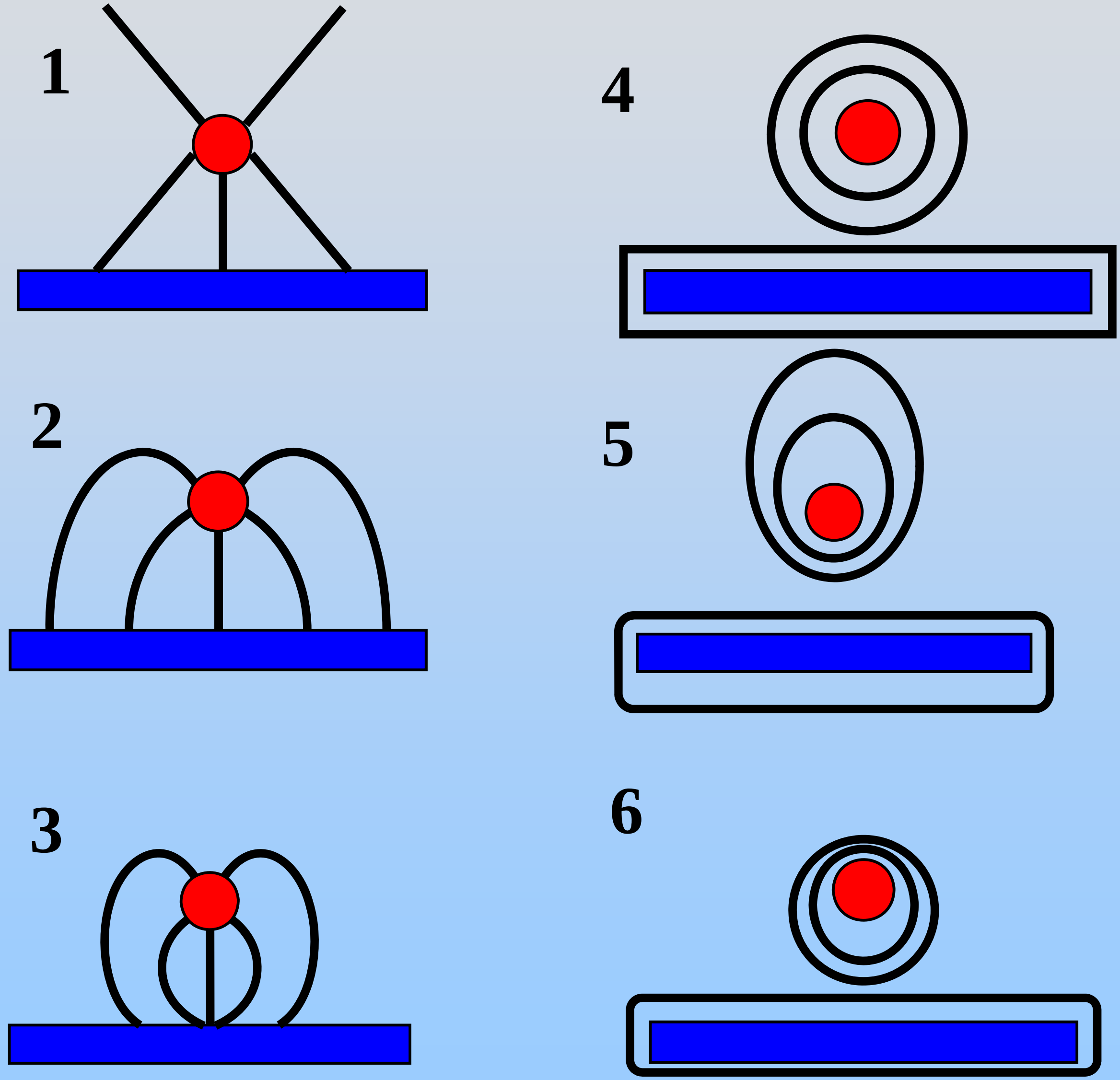


Concept Question: Field Lines

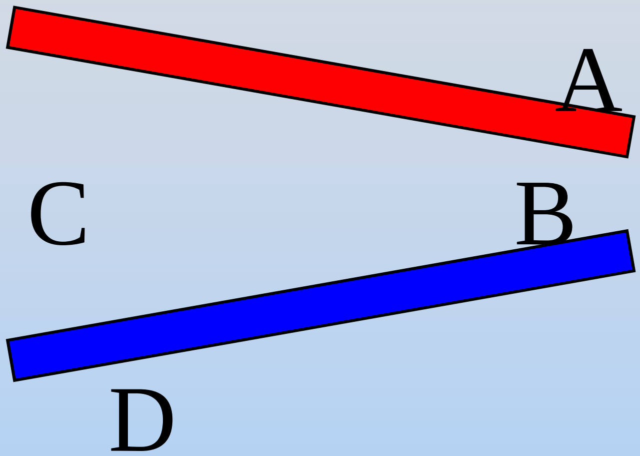
The circle is at +5 V relative to the plate. Which of the below is the most accurate **electric field line map?**



Concept Question Questions: Lab Summary

Concept Question: Lab Summary: Potentials

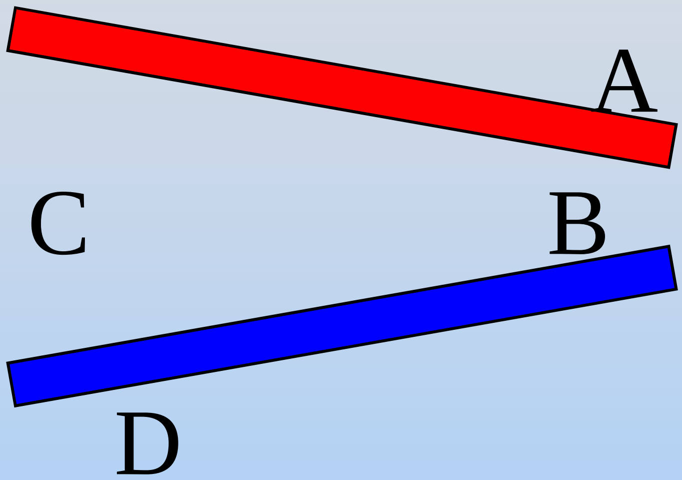
Holding the red plate at +5 V relative to the ground of the blue plate, what is true about the electric potential at the following locations:



1. V(A) > V(B) > V(C) > V(D)
2. V(A) > V(B) ~ V(C) > V(D)
3. V(A) ~ V(B) > V(C) ~ V(D)
4. V(D) > V(C) ~ V(B) > V(A)
5. V(B) > V(C) > V(D) ~ V(A)
6. V(A) > V(D) ~ V(C) > V(B)

Concept Question: Lab Summary: E Field

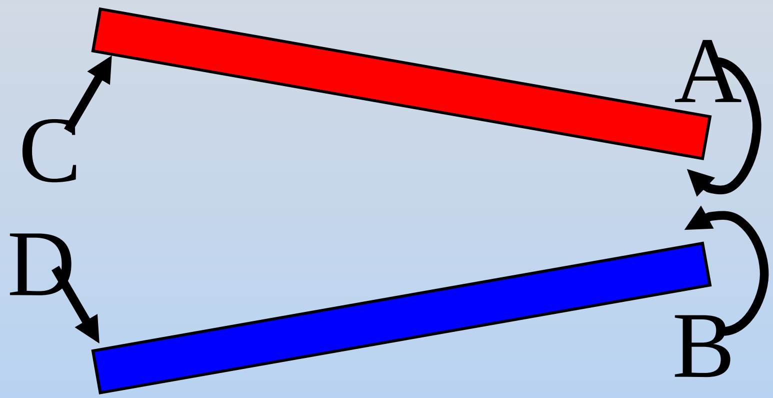
Holding the red plate at +5 V relative to the ground of the blue plate, what is true about the electric field at the following locations:



1. E(A) > E(B) > E(C) > E(D)
2. E(A) > E(B) ~ E(C) > E(D)
3. E(A) ~ E(B) > E(C) ~ E(D)
4. E(D) > E(C) ~ E(B) > E(A)
5. E(B) > E(C) > E(D) ~ E(A)
6. E(A) > E(D) ~ E(C) > E(B)

Concept Question: Lab Summary: Charge

Holding the red plate at +5 V relative to the ground of the blue plate, what is true about the amount of charge near the following points:



1. $|Q(A)| \sim |Q(C)| > |Q(B)| \sim |Q(D)|$
2. $|Q(A)| > |Q(B)| \sim |Q(C)| > |Q(D)|$
3. $|Q(A)| \sim |Q(B)| > |Q(C)| \sim |Q(D)|$
4. $|Q(D)| \sim |Q(C)| > |Q(B)| \sim |Q(A)|$
5. $|Q(B)| \sim |Q(D)| > |Q(A)| \sim |Q(C)|$
6. $|Q(A)| > |Q(D)| \sim |Q(C)| > |Q(B)|$