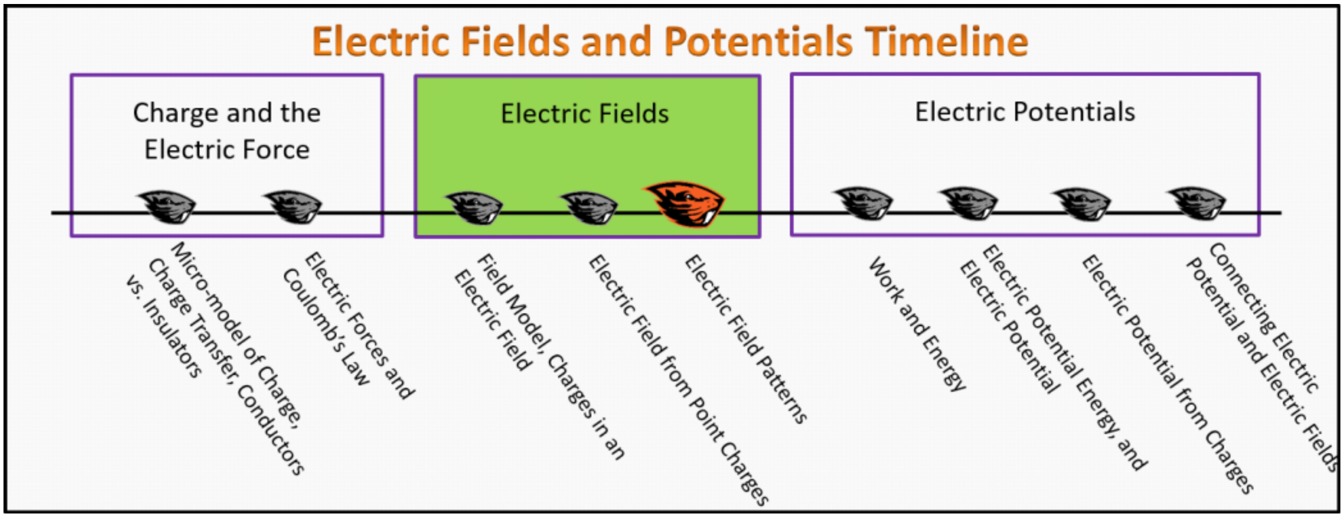
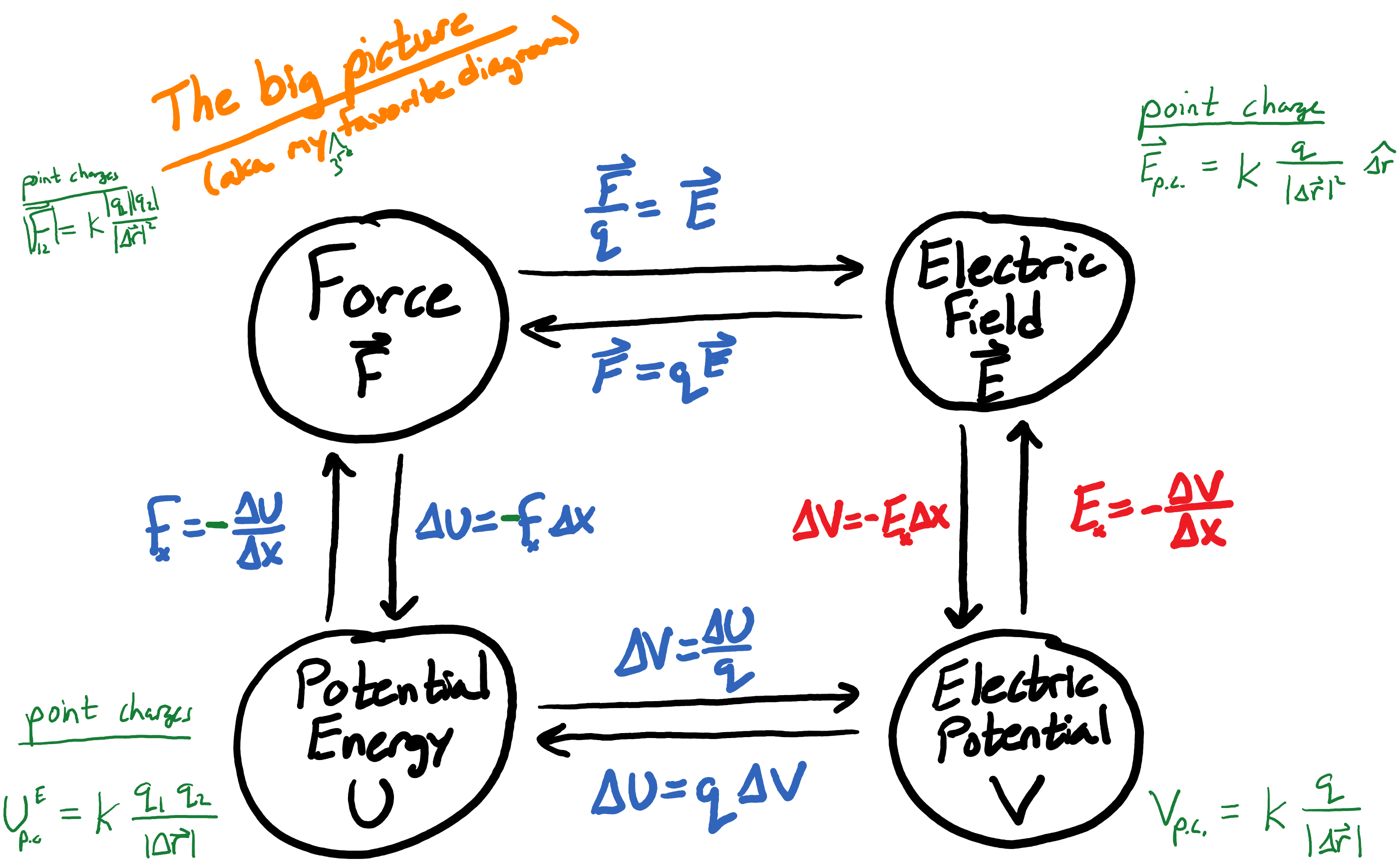
Electric Potentials
Foundation Stage (EP.L3.2)

Lecture 3
Connecting Electric Potentials and Electric Fields





Warm up

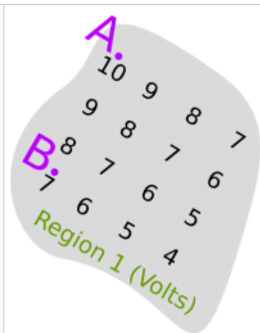
Problem Statement: Three students are discussing the following electric potential maps of two separate regions of space.

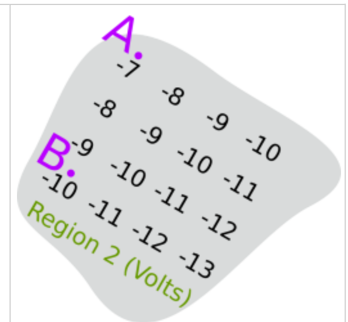
(a) Which student do you agree with most?

(1) I think the proton that moves from point **A** to point **B** in region **1** will gain more kinetic energy than a proton in region **2**, eh.

(2) Cool story bro, but they are opposite potential energy gains, so one will gain kinetic energy while the other loses it.

(3) What huh? I don't think there is any difference between **A** and **B** in either region, or **A** and **C** for that matter foo.



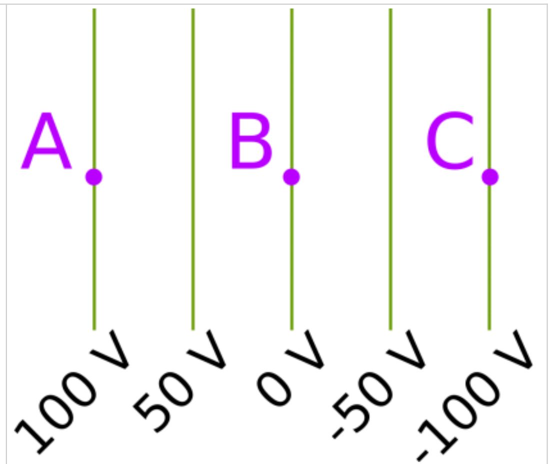


(b) A proton starts at rest at point **B** in region **2**. What is the protons speed when it reaches point **A**? Ignore gravitational and drag effects. $\textbf{mass}_{\textbf{proton}} = 1.67 \times 10^{-27}$ kg ; $\textbf{e} = 1.60 \times 10^{-19}$ C

Warm up 2

Problem Statement: A proton is released from rest at point **B**, where the electric potential is 0 V. Afterward, the proton

(1) moves toward **A** with a steady speed.
(2) moves toward **A** with an increasing speed.
(3) moves toward **B** with a steady speed.
(4) moves toward **B** with an increasing speed.
(5) remains at rest at **B**.



Act I: Rules and Regulations

EP.L3.2-02:

Problem Statement: Below is a physical representation of the electric field and the equipotential lines for a certain charge distribution. From this image, what can you conclude about the relationship between electric field lines and equipotential lines?

(1) Electric field lines are always perpendicular to equipotential lines. (2) The electric field lines are sometimes perpendicular to equipotential lines. (3) The electric field is stronger in regions where the equipotential lines are closer. (4) The electric field strength is weaker in regions where the equipotential lines are closer. (5) Electric field lines point towards increasing electric potential. (6) Electric field lines point towards decreasing electric potential.	IMG

EP.L3.2-03:

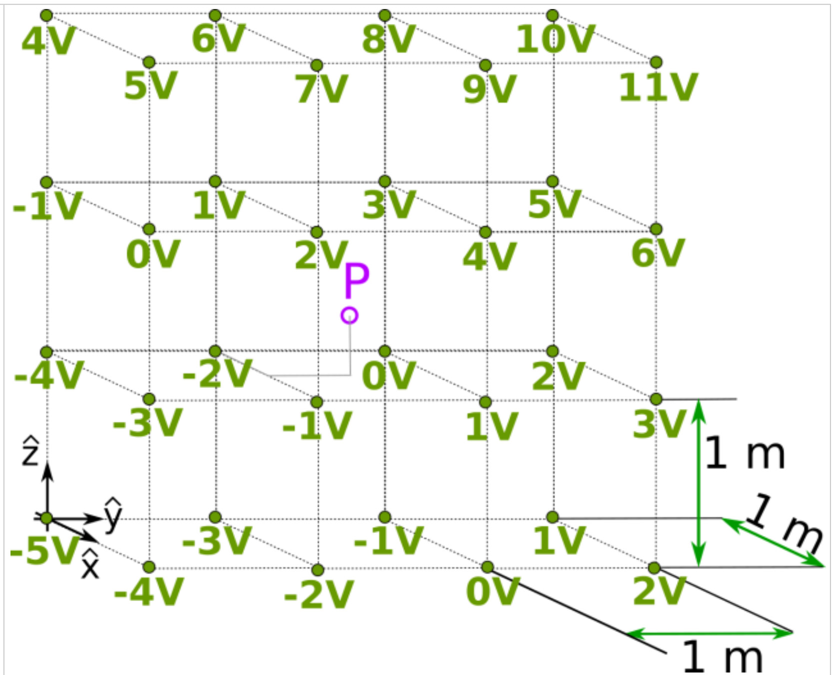
Problem Statement: The electric potential was recorded at 1.00 meter spacing in 3-D space as shown in the figure below. We wish to estimate the electric field at the center of one of the 1.0 m x 1.0 m x 1.0 m cube. Estimate the electric field at this location.

(1) < 0 , 0 , 0 > N/C

(2) < 1 , 2 , 3 > N/C

(3) < 0.5 , 1 , 1.5 > N/C

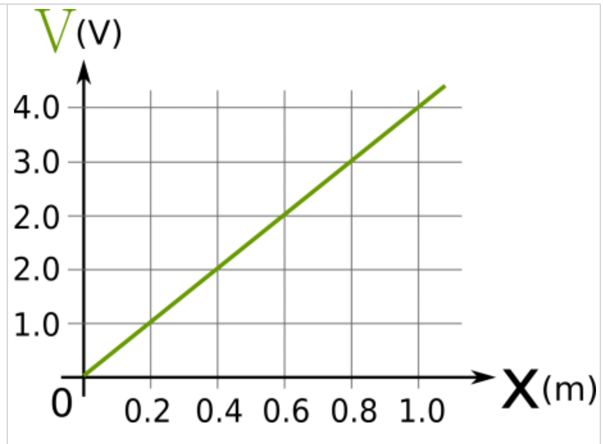
(4) < 1 , 1 , 1 > N/C



EP.L3.2-04:

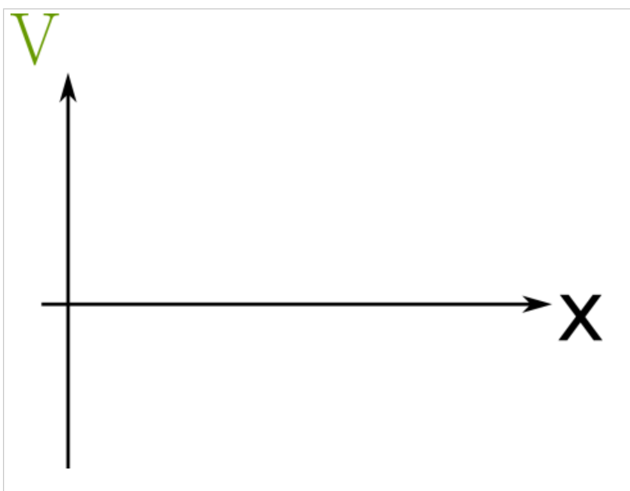
Problem Statement: The plot shows the electric potential as a function of x for some distribution of charge. Which one of the following statements concerning the electric field associated with this potential is correct? The electric field…

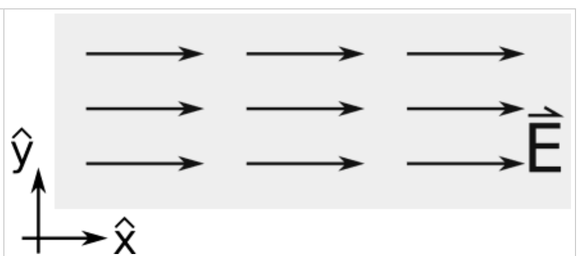
(1) increases linearly and points in the positive x-direction.
(2) increases linearly and points in the negative x-direction.
(3) is uniform in the x-direction and points in the positive x-direction.
(4) is uniform in the x-direction and points in the negative x-direction.
(5) has a zero x component.



EP.L3.2-04:

Problem Statement: Sketch the voltage as a function of x for the electric field shown below.



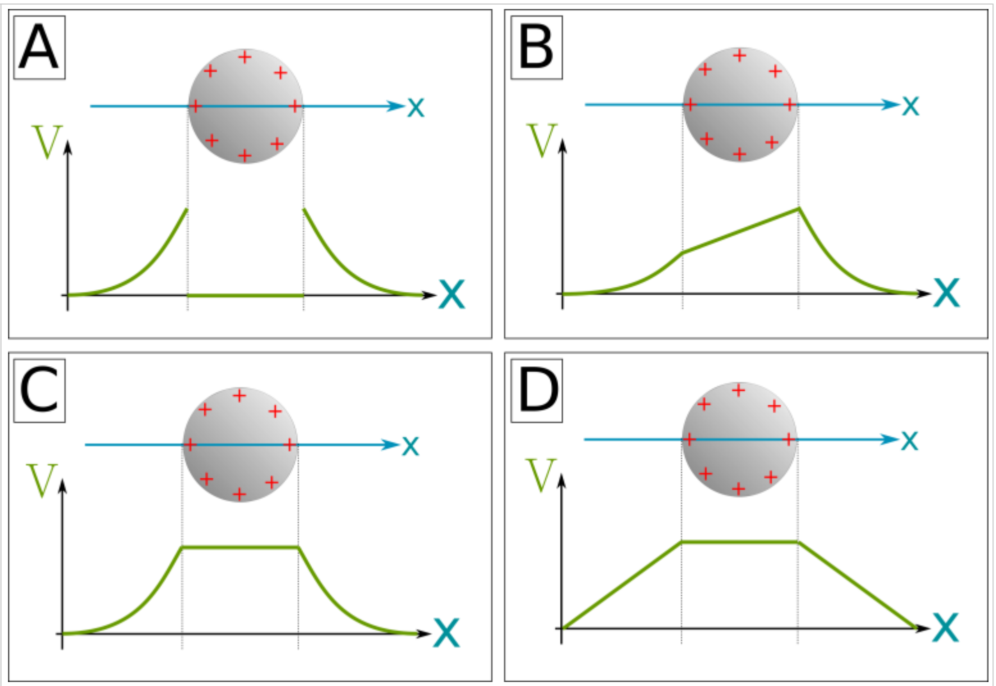


Act II: Conductors and Fields

EP.L3.2-5:

Problem Statement: A solid metal sphere is positively charged. Which of the following graphs could represent the electric potential along the axis shown in the figures?

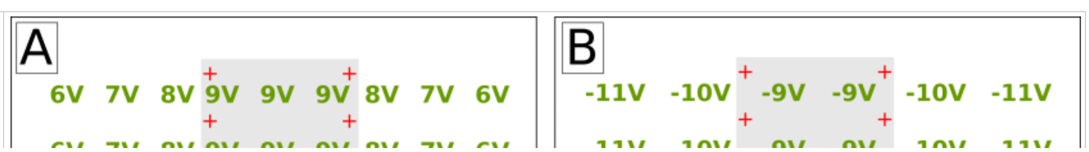
(1) A
(2) B
(3) C
(4) D

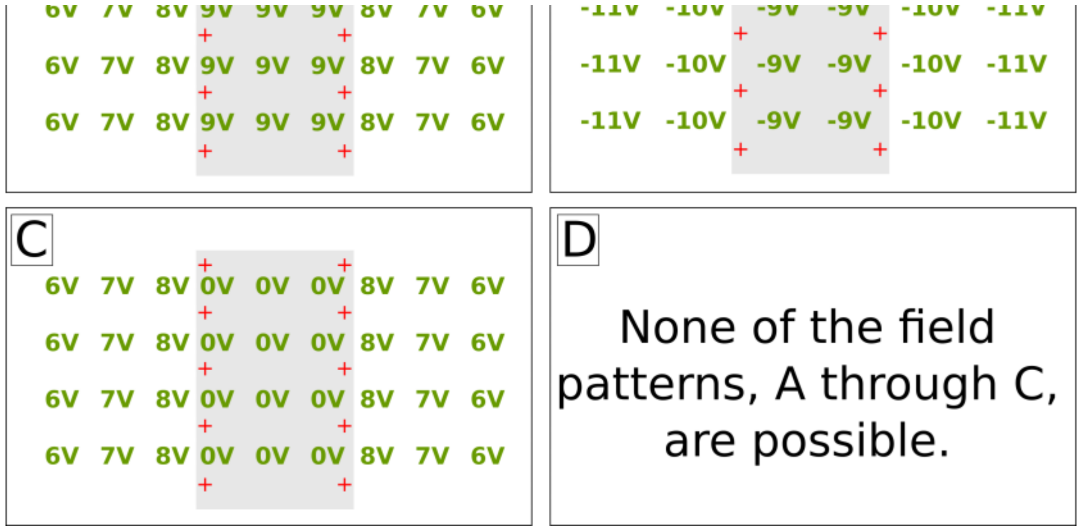


EP.L3.2-6:

Problem Statement: Shown below is a large rectangular slab of metal. Which voltage map could represent the electric potential?

(1) A
(2) B
(3) C



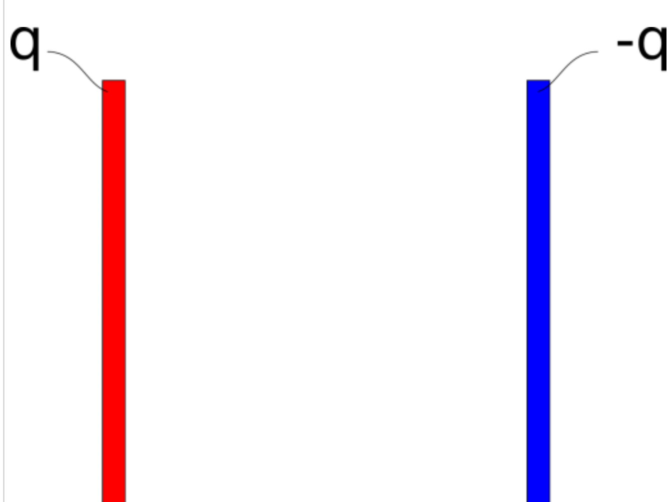
(4) D	

Act III: Uniform Electric Fields

EP.L3.2-09:

Problem Statement: A parallel plate capacitor (two charged rectangular sheets separated by some distance) is shown in the image below. The distance between the two charged plates is 10 cm.

(a) Sketch the electric field in the region of space between the two plates.

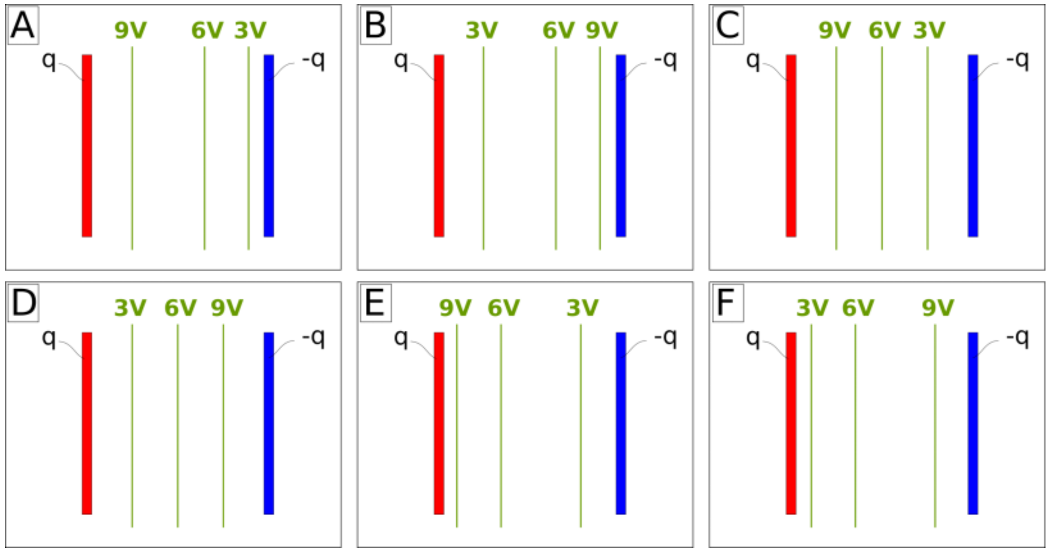


(b) Which plate is at a higher electric potential?

(1) + plate
(2) - plate
(3) They are at the same voltage.

(c) Which of the following figures below could represent the 3 V, 6 V, and 9 V equipotential lines?

(1) A
(2) B
(3) C
(4) D

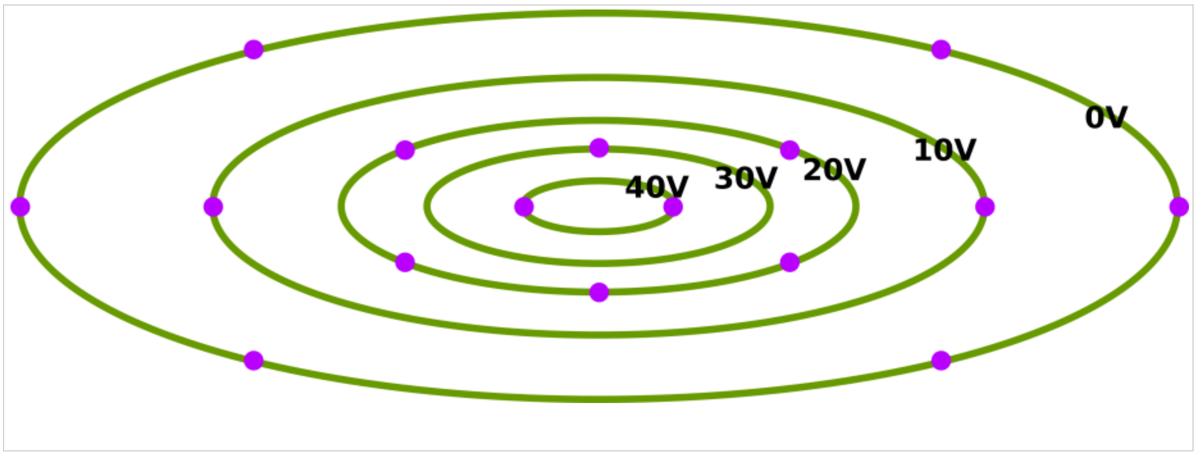


(d) An electron is placed just at the surface of the negative plate, what speed does it have when it lands on the positive plate?

Act IV: Non-Uniform Fields

EP.L3.2-09:

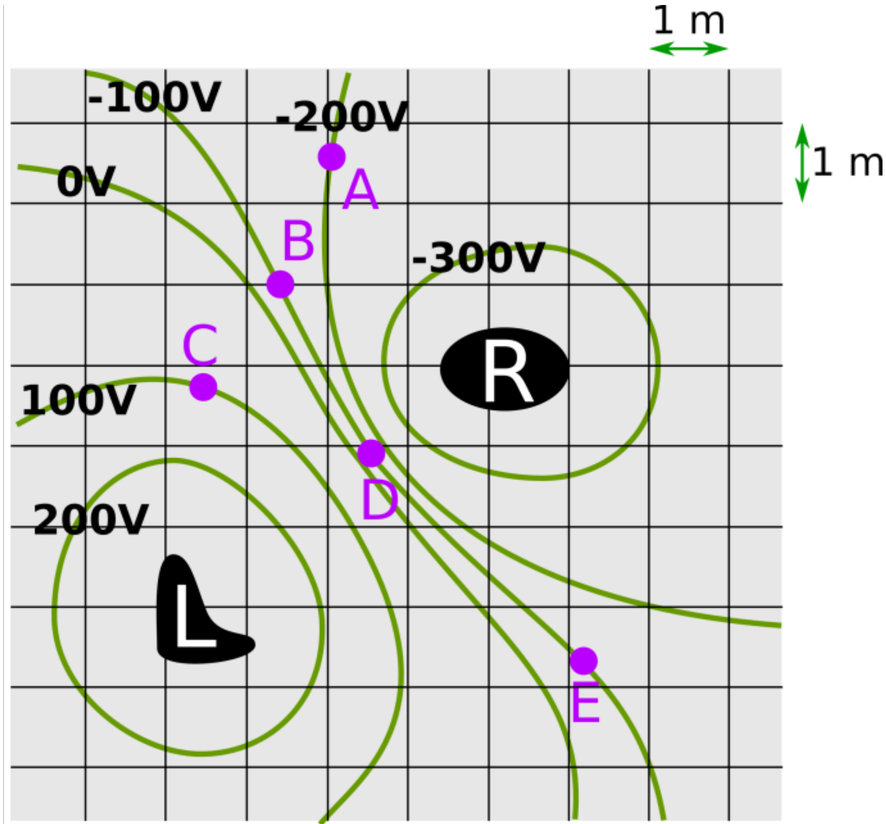
Problem Statement: The equipotential lines are mapped out around a charge distribution shown below. Sketch the electric field vectors at the locations labeled with dot.



EP.L3.2-10:

Problem Statement: The electric potential is mapped out with equipotential lines around a charge distribution with two charged objects, **L** and **R**.

(a) Sketch the electric field lines in the region of space provided.



(b) Which conductor is positively charged?

(1) L
(2) R

(c) Estimate the electric field strength at point E.

(d) At which labeled point would an electron have the greatest electric potential energy?

(1) A
(2) B
(3) C
(4) D
(5) E

(e) At which labeled point would a charged particle feel the strongest magnitude force?

(1) A
(2) B
(3) C
(4) D
(5) E

(f) Choose which contour plot would represent the electric field potential field in the region.

Act V: Synthesis

EP.L3.2-12:

Problem Statement: A parallel plate capacitor is constructed by taking two very large conducting plates and separating them by 10 cm. The electric potential is plotted as a function of x, where x is perpendicular distance away from center of the capacitor as shown in the image below. A proton is released from rest at the surface of the positively charged plate. Find the speed of the proton when it reaches the negatively charged plate.

(a) Solve this by a conservation of energy analysis.

(b) Solve this by first finding an electric field strength and direction, then using a force analysis and a kinematics analysis.

(c) Solve this by first finding an electric field strength and direction, then using a momentum-impulse analysis and a kinematics analysis.

Conceptual questions for discussion

1. Coming soon to a lecture template near you.

Hints

EF.2.L2-1: No hints.

EF.2.L2-2: No hints.

EF.2.L2-3: No hints.

EF.2.L2-4: No hints.

EF.2.L2-5: No hints.

EF.2.L2-6: No hints.