PHYSICS 1B – Fall 2007

Electricity
&
Magnetism

Professor Brian Keating

SERF Building. Room 333

UCSD

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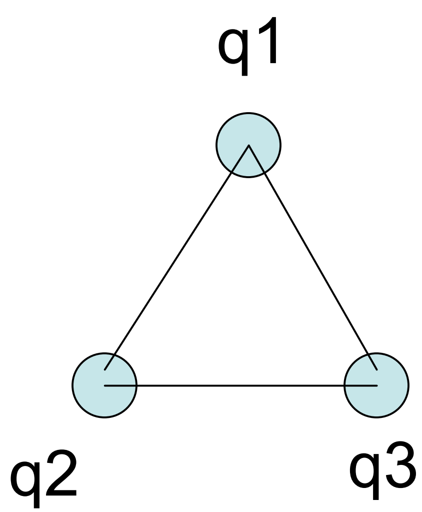
16.1 PART 2 & 16.2 ELECTRIC POTENTIAL (CONTINUED)

Quiz grades: on the web by 3 digit number
Email jkaufman@physics.ucsd.edu
If you DON'T know your 3 digit number.

Average was an 8 with a standard deviation of 2.

3 charges of $1x10^{-9}$ C are placed at the corners of a equilateral triangle Each side of the triangle has a length of 1.0 cm. Find the work needed to bring the charges together from a long distance away.



PE due to Coulomb interaction

How many interactions? 3

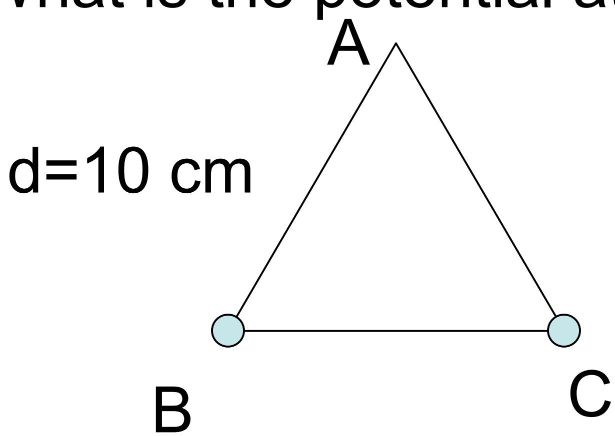
$$PE = PE_{12}+PE_{13}+PE_{23}$$

$$PE = 3\frac{k_e q^2}{r}$$

$$PE = 3\frac{9x10^9(1x10^{-9})^2}{(0.01)^2} = 2.7x10^{-4}J$$

Two charges of +q each are placed at corners of an equilateral triangle, with sides of 10 cm. The Electric field due to each charge is 100 V/m at A.

What is the potential at A?



A. 10V
B. 100V
C. 1000V

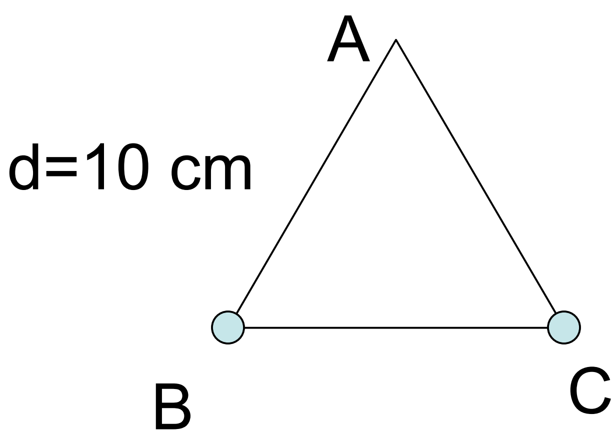
$$\frac{E}{V} = \frac{1}{r}$$

$$V = Er = 100(0.1) = 10V$$

$V_{total}=V_{BA} + V_{CA}=2V = 20\ V$

Potential is a scalar

Two charges of +q each are placed at corners of an equilateral triangle, with sides of 10 cm. If the Electric field due to each charge is 100 V/m at the A find the potential at A



V at A due to each charge

$$E = \frac{k_e q}{r^2}$$

$$V = \frac{k_e q}{r}$$

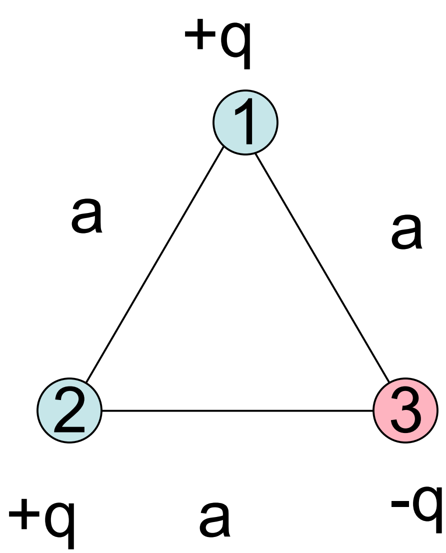
$$\frac{E}{V} = \frac{1}{r}$$

$$V = Er = 100(0.1) = 10V$$

$V_{total}=V_{BA}+V_{CA}=2V=20$ V

Potential is a scalar

The following charges are brought together from a large distance away.



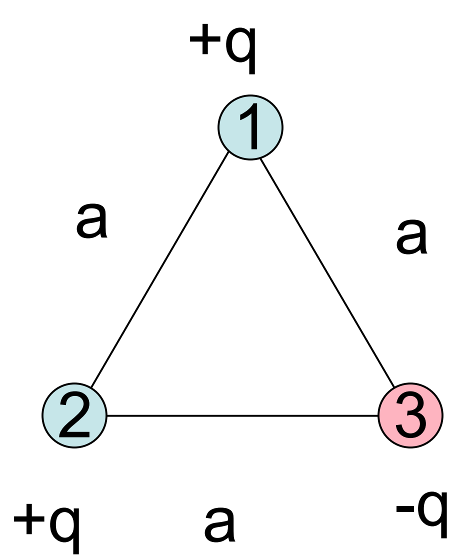
How many interactions?

How many positive?

How many negative?

Write your answer as “123” for example

The following charges are brought together from a large distance away. What is the change in PE? Is the charge distribution stable? (i.e. does it have a negative PE)



How many interactions? 3

How many positive? 1

How many negative? 2

What is the total change in PE?

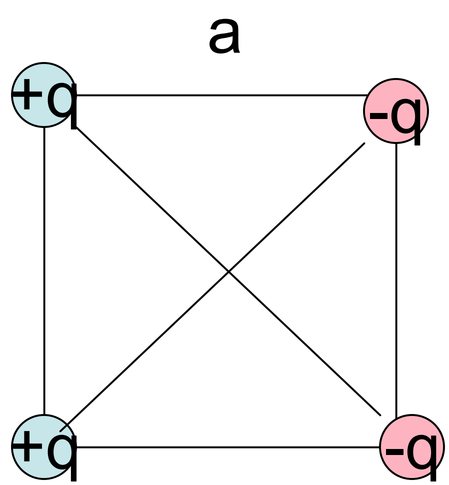
$$PE = PE_{12} + PE_{13} + PE_{23}$$

$$PE = PE_0 - 2PE_0 = -PE_0 = -\frac{k_e q^2}{a}$$

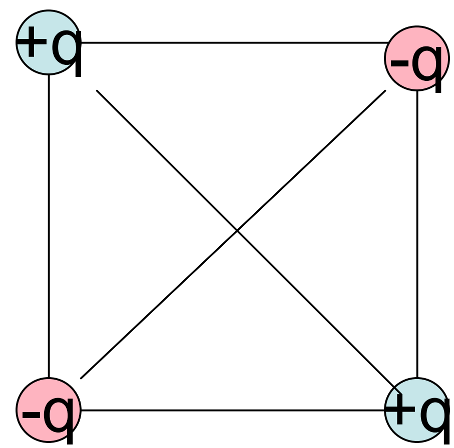
STABLE

Which of the charge distributions is the most stable?
(has the lowest PE)

$$PE_0 = \frac{k_e q^2}{a}$$



A. This one



B. This one

STABLE

	A		B
PE_0	+2	-2	-4
$PE_0/\sqrt{2}$		-2	+2
Total PE	$-\frac{2}{\sqrt{2}}PE_0 = -1.4PE_0$		$(-4+\frac{2}{\sqrt{2}})PE_o = -2.6PE_0$

Potential energy due to 2 point charges

$$PE = q_1 V_2 = q_2 V_1$$

$$PE = \frac{k_e q_1 q_2}{r}$$

$$PE = 0 \quad \text{at } r = \infty$$

Potential energy and Potential are Scalar (not Vector) quantities

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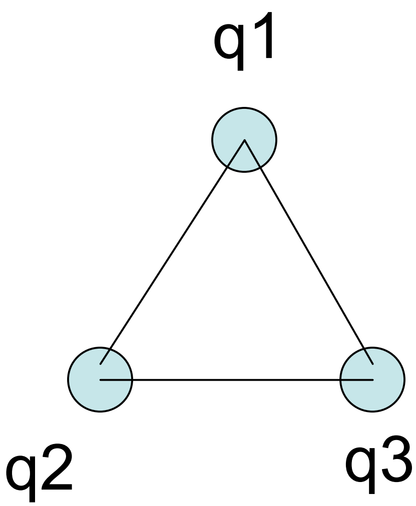


PE due to Coulomb interaction

How many interactions? 3

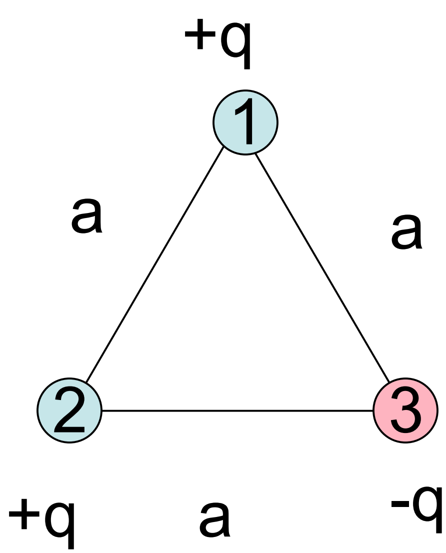
$$PE = PE_{12} + PE_{13} + PE_{23}$$

$$PE = 3\frac{k_e q^2}{r}$$

$$PE = 3\frac{9x10^9(1x10^{-9})^2}{(0.01)^2} = 2.7x10^{-4}J$$

Unstable compared to infinite distance

The following charges are brought together from a large distance away. What is the change in PE? Is the charge distribution stable? (i.e. does it have a negative PE)



How many interactions? 3

How many positive? 1

How many negative? 2

What is the total change in PE?

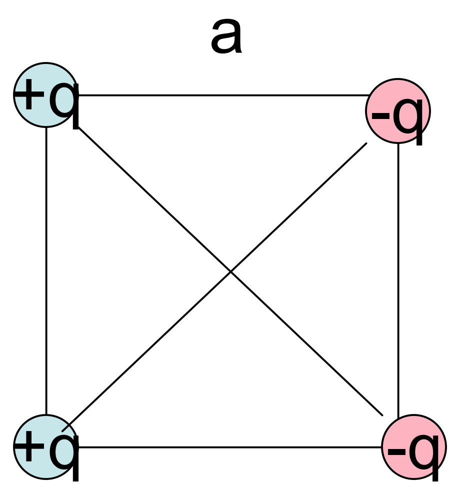
$$PE = PE_{12} + PE_{13} + PE_{23}$$

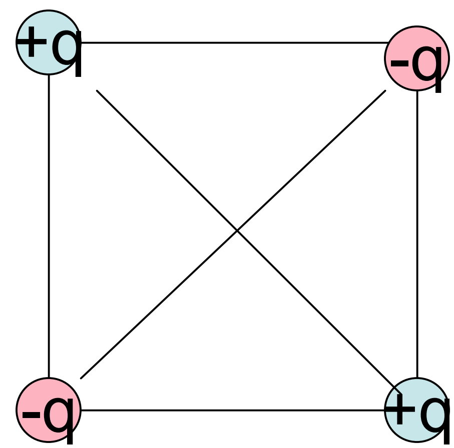
$$PE = PE_0 - 2PE_0 = -PE_0 = -\frac{k_e q^2}{a}$$

STABLE compared to infinite distance

Which of the charge distributions is the most stable?
(has the lowest PE)

$$PE_0 = \frac{k_e q^2}{a}$$





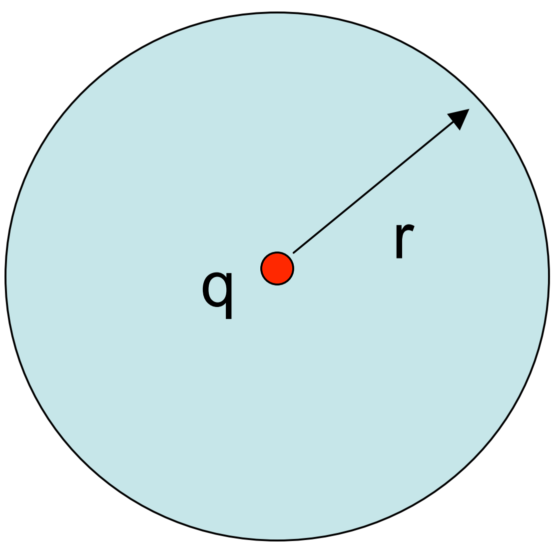
	#+V?	#-V?	#+V?	#-V?
PE_0	+2	-2		-4
$PE_0/\sqrt{2}$		-2	+2	
Total PE	$-\frac{2}{\sqrt{2}}PE_0 = -1.4PE_0$		$(-4+\frac{2}{\sqrt{2}})PE_o = -2.6PE_0$ more stable	

16.2 Equipotentials

Equipotential surfaces

Equipotential Surface - positions in space at which the electrical potentials are equal

Example 1- A sphere centered around a point charge



Every point on the surface of the sphere of radius r has the same potential

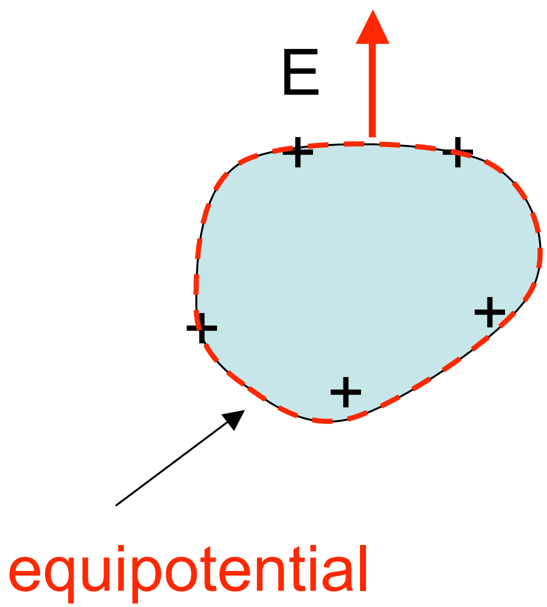
$$V = \frac{k_e q}{r}$$

The surface of the sphere is an equipotential surface

Equipotential surface-

Example 2: a charged conductor

The surface of a conductor is an equipotential surface.



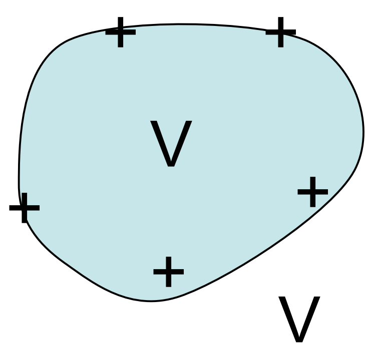
E field is perpendicular to the surface.

Component of E =0 parallel to the surface

$$\Delta V = Ed = 0$$

Thus, No change in potential along the surface

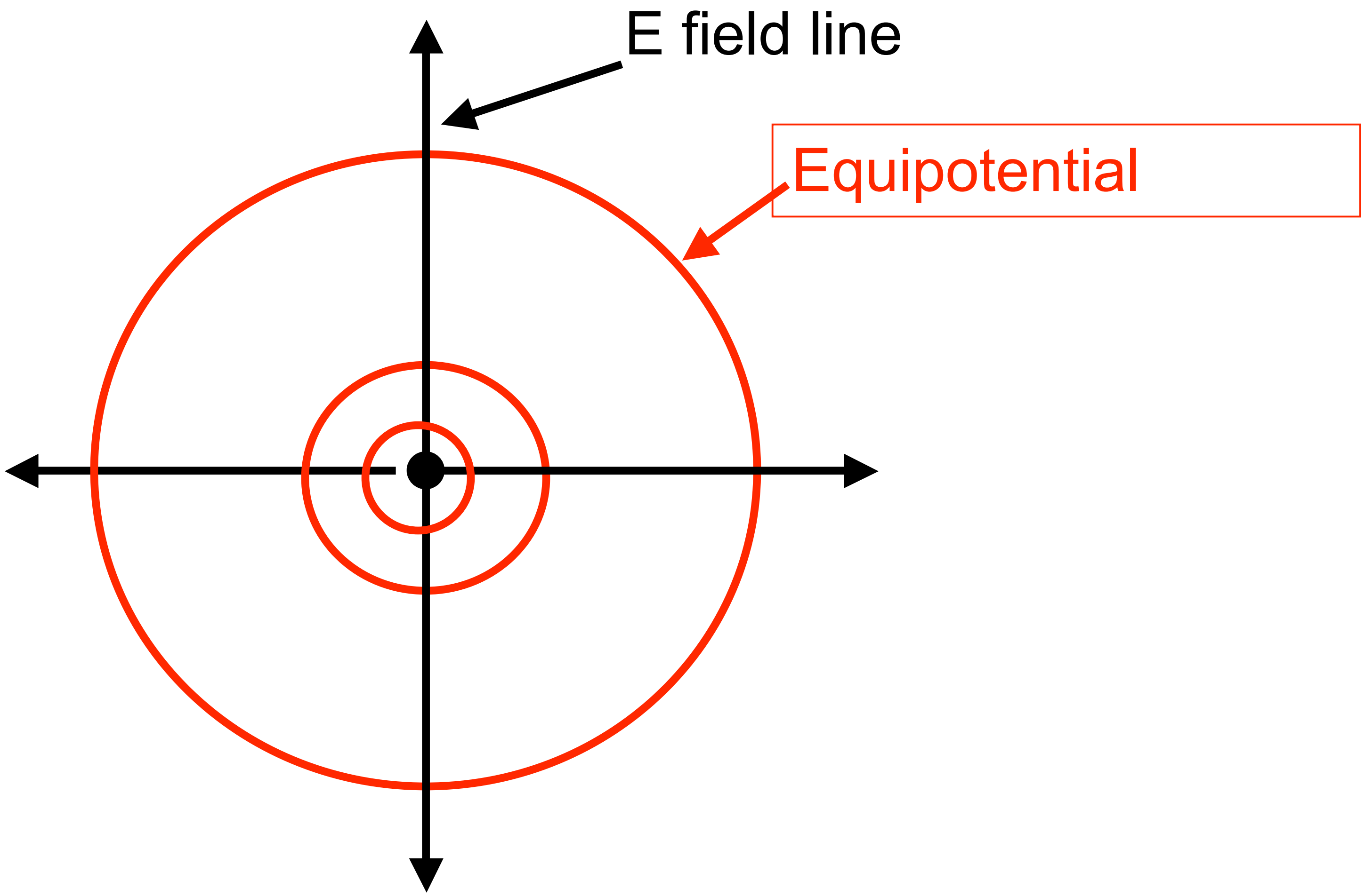
The interior of the conductor is an equipotential and at the same potential as the surface.



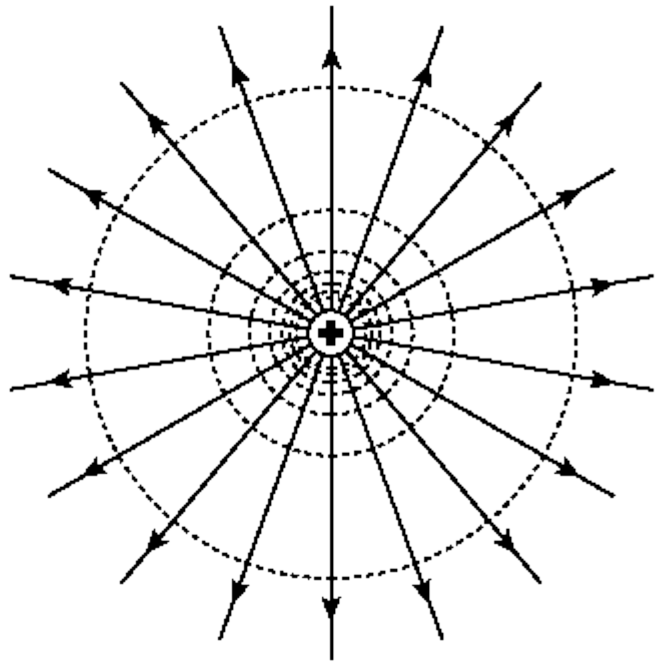
E=0 in the conductor

Thus, the potential doesn't change from the surface potential

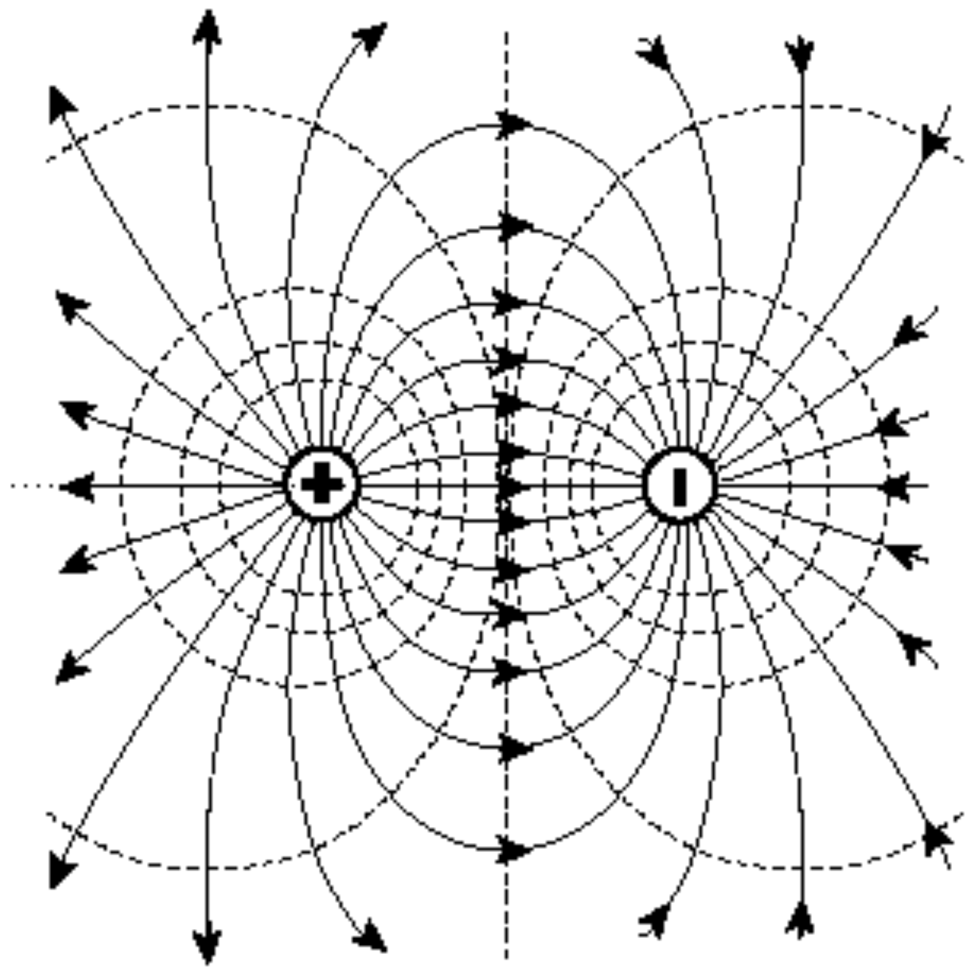
The equipotential surfaces are perpendicular to E field lines.



Equipotential lines: point charge



Equipotential lines: dipole

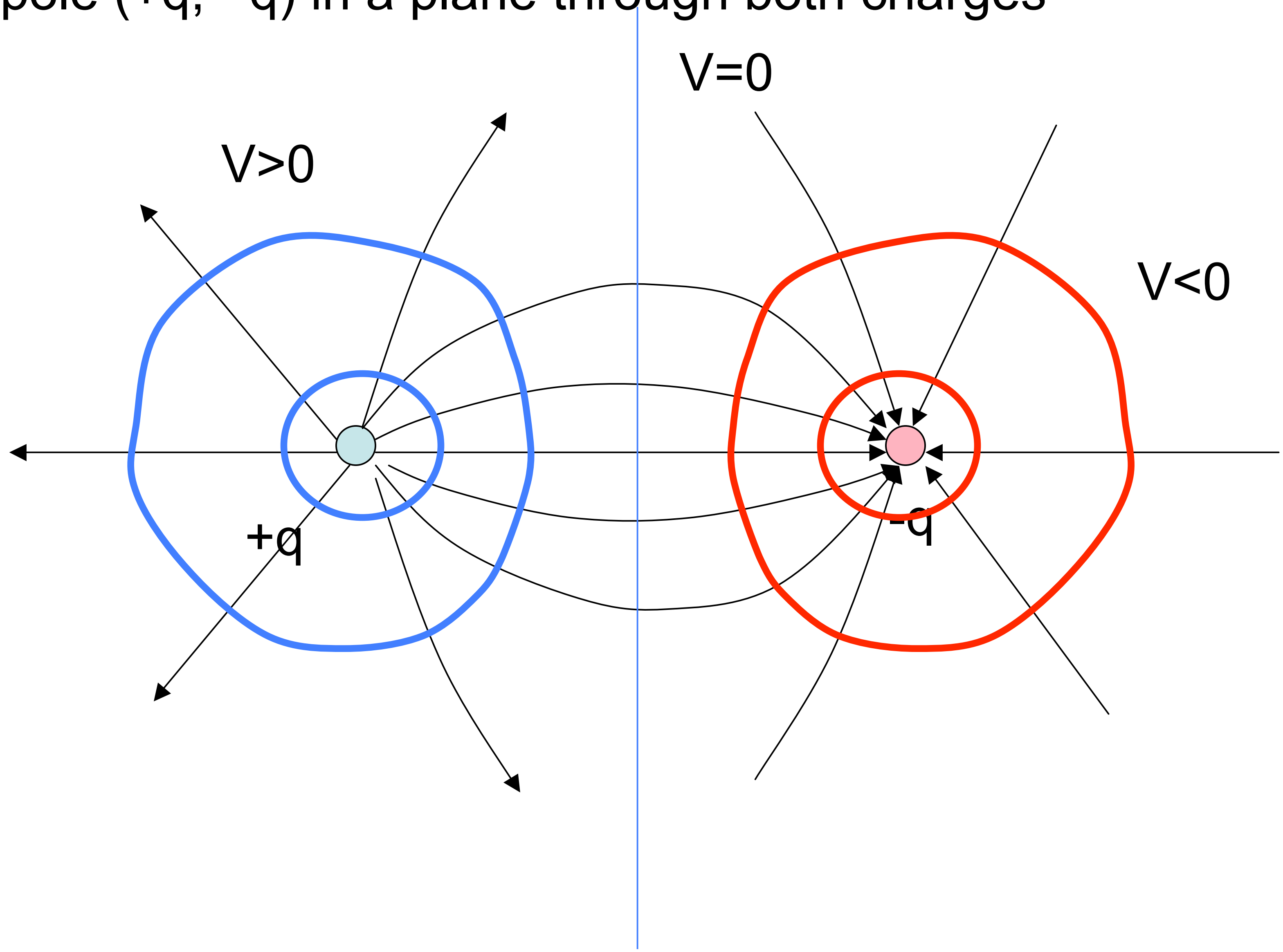


Which line type/style represents the electric field?

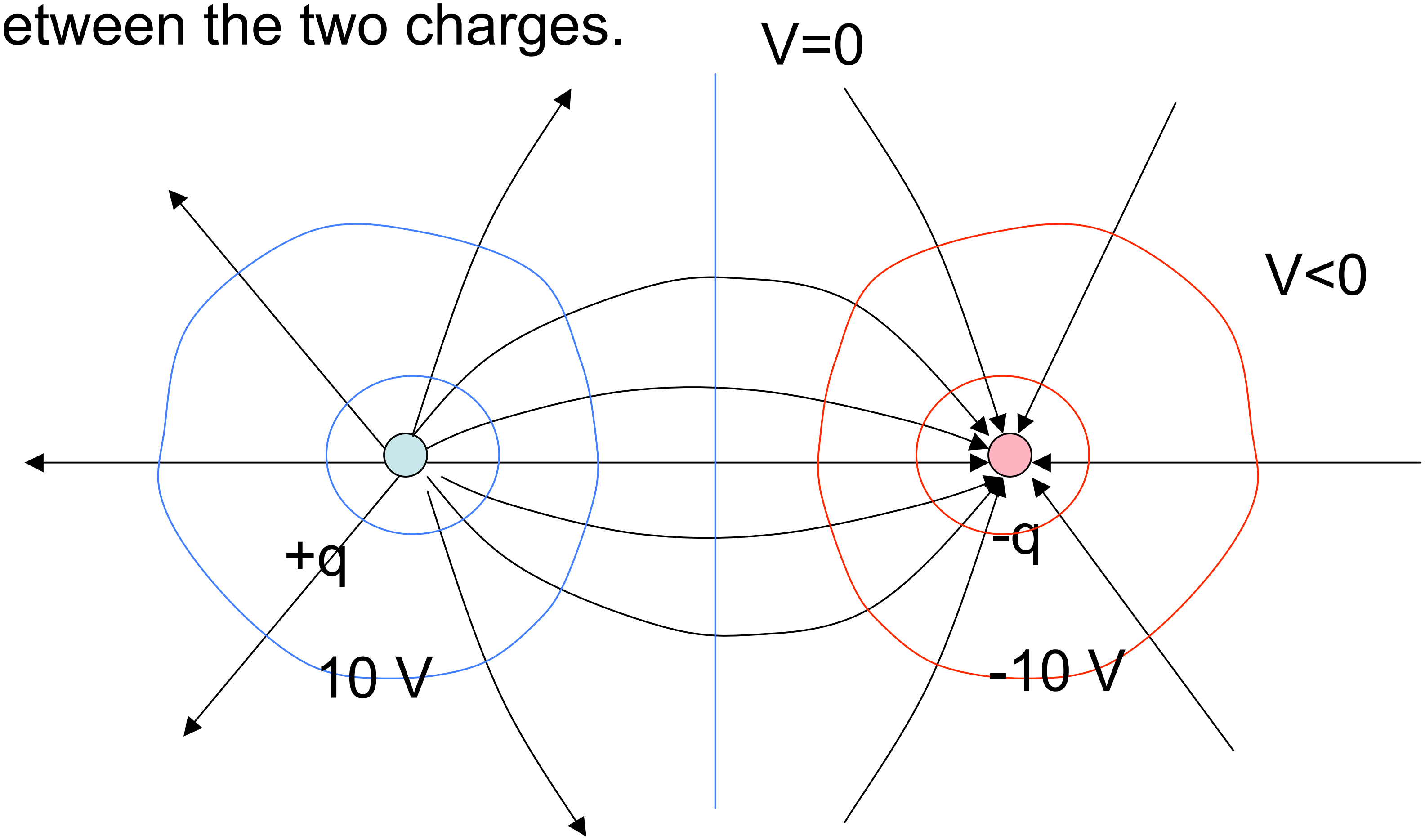
A. solid

B. dashed

Draw a sketch of the equipotential surfaces for a electric dipole (+q, –q) in a plane through both charges



Suppose the two charges are 10 cm apart and the equipotential surfaces are as labeled estimate the E field between the two charges.



$$E = \frac{\Delta V}{d} \approx \frac{20}{0.05} \approx 400V/m$$

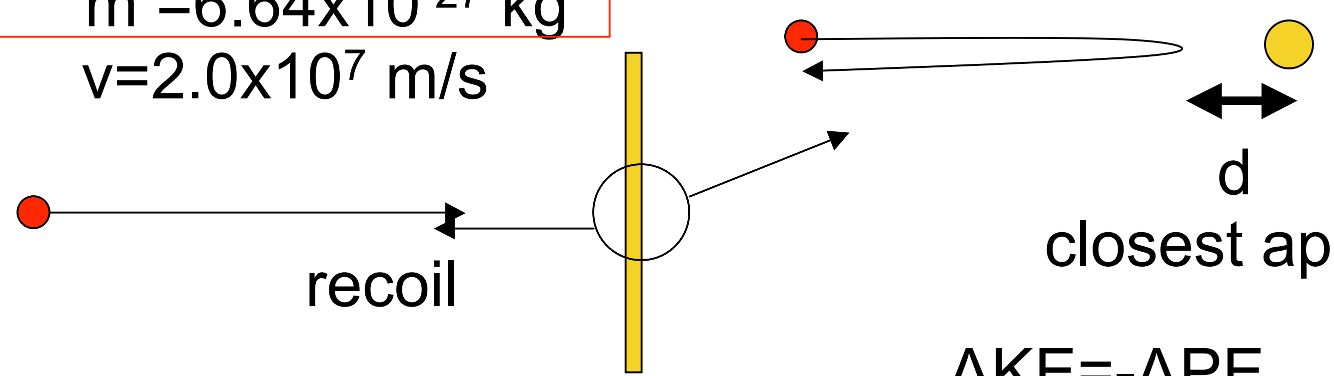
Rutherford Scattering experiment
Determination of the size of the nucleus

α particle He nucleus

$q=+2e$

$m = 6.64\times10^{-27}$ kg

$v=2.0\times10^{7}$ m/s



$\Delta KE = -\Delta PE$

$$\frac{1}{2}mv^2 = \frac{kqQ}{d}$$

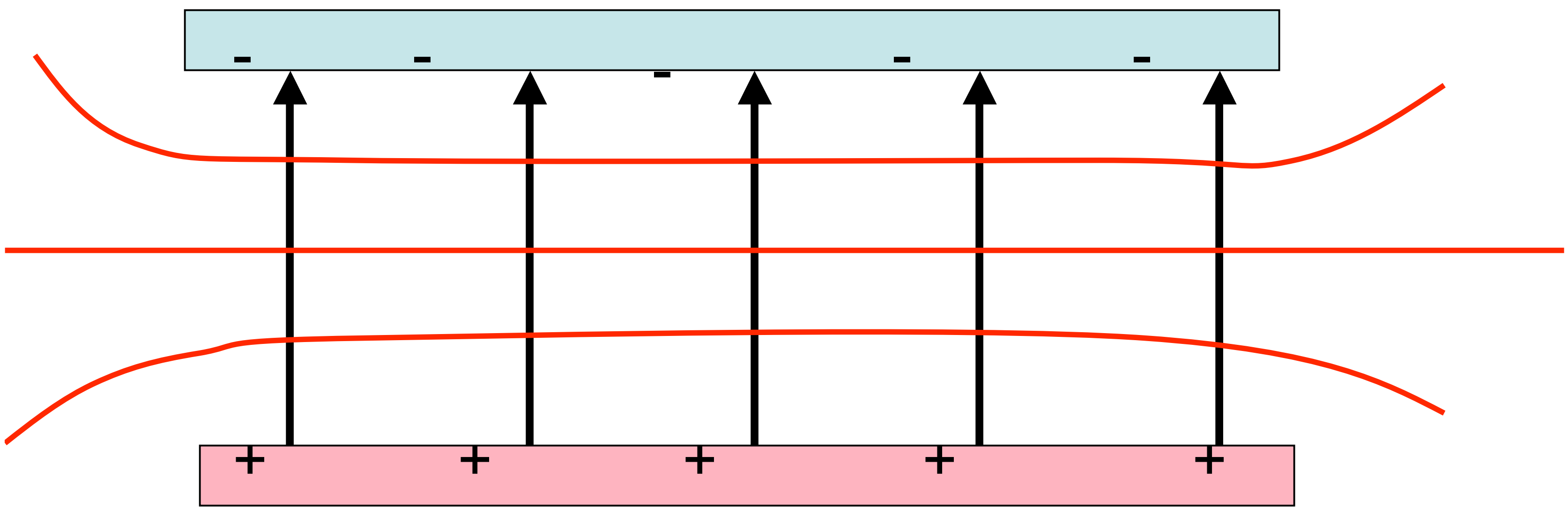
gold nuclei
$Q=+79e$

$$d = \frac{2k_e qQ}{mv^2} = \frac{2(9\times10^{9})(2)(79)(1.6\times10^{-19})^2}{6.64\times10^{-27}(2\times10^{7})^2}$$

$$d = 2.7\times10^{-14}\,\mathrm{m}$$

nuclear size < d, much smaller than size of an atom~ 0.3×10^{-9} m

Parallel plate capacitor

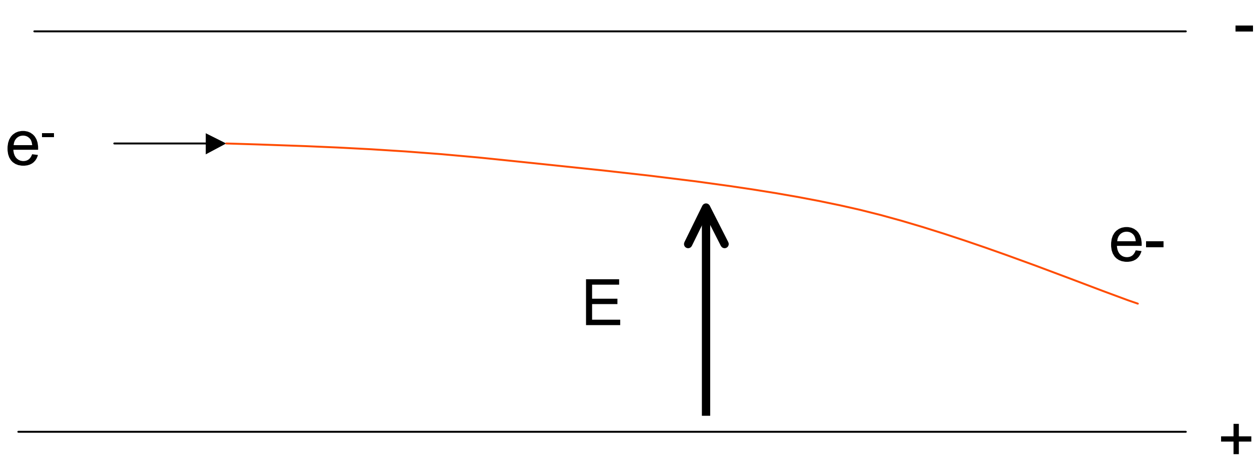


FIELD LINES IN BLACK (VECTORS)

POTENTIAL CONTOURS IN RED

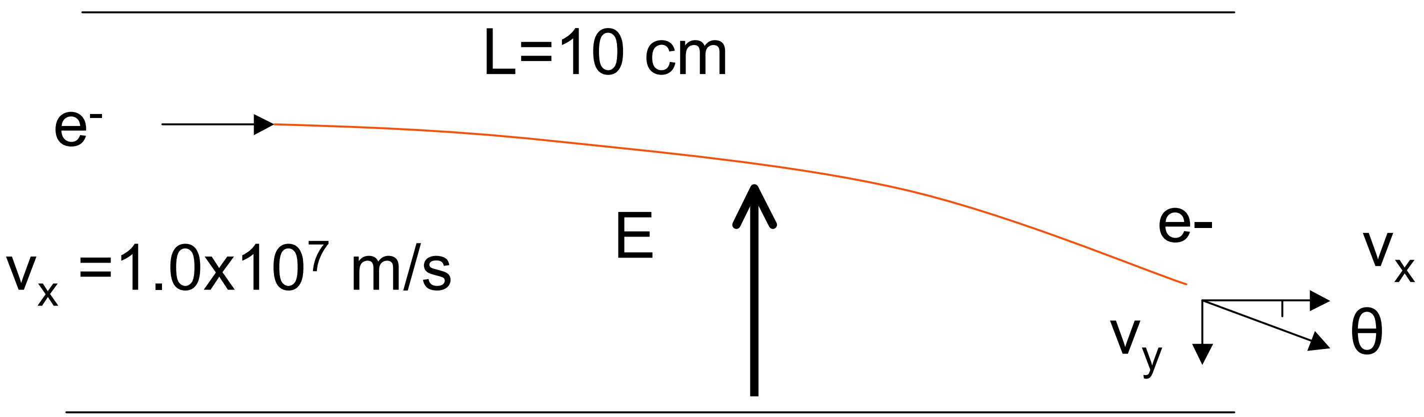
(NO ARROWS, BECAUSE NOT A VECTOR)

Deflection of an electron beam in an electric field



Calculation – velocity, acceleration – Next Slide: calculate the angle the electron exits at…

An electron beam passes through two parallel plates of a length 10 cm having an electric field of E. The initial velocity of the electron is $1.0\text{x}10^7$ m/s. Find the angle through which the beam is deflected.



$$F = qE = ma$$

$$v_y = at = \frac{F}{m}t = \frac{qE}{m}t$$

$$t = \frac{L}{v_x}$$

$$v_y = \frac{qE}{m}\left(\frac{L}{v_x}\right)$$

$$\tan\theta = \frac{v_y}{v_x} = \frac{qEL}{v_x^2 m}$$

$$\theta = \tan^{-1}\left(\frac{qEL}{v_x^2 m}\right) = \tan^{-1}\left(\frac{1.6\text{x}10^{-19}(1000)(0.1)}{(10^7)^2(9\text{x}10^{-31})}\right) = 10^{o}$$