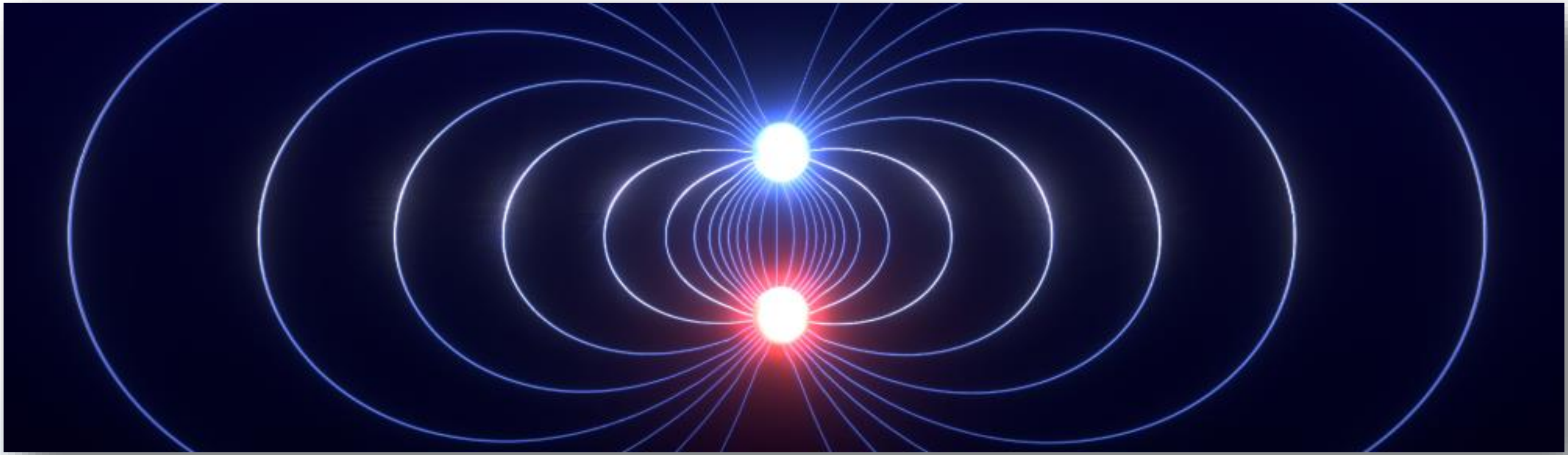


Phys 102 – Lecture 3

The Electric field

Today we will...

- Learn about the *electric field*
- Apply the superposition principle

    Ex: Dipole, line of charges, plane of charges

- Represent the E field using electric field lines
- Apply these concepts!

    Dipoles in electric fields

    Conductors in electric fields

The electric field

The electric field is defined at a *location* in space around a charge or set of charges

Field at position *P* → $$\vec{E} \equiv \frac{\vec{F}}{q}$$

Force a charge *q* at position *P* *would* feel

Charge *q*

Magnitude

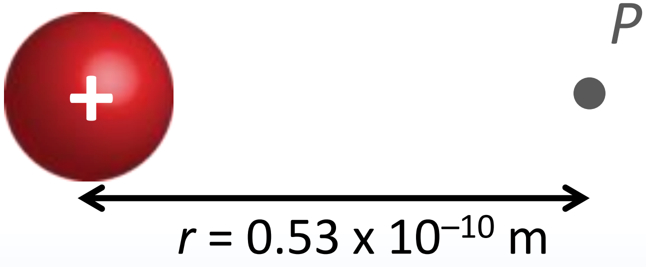
Magnitude given by: $E = \dfrac{F}{|q|}$ Units: N/C

Direction

Direction is the same as for the force that a + charge *would feel* at that location

Calculation: Electric field in H atom

What is the magnitude of the electric field due to the proton at the *position* of the electron?

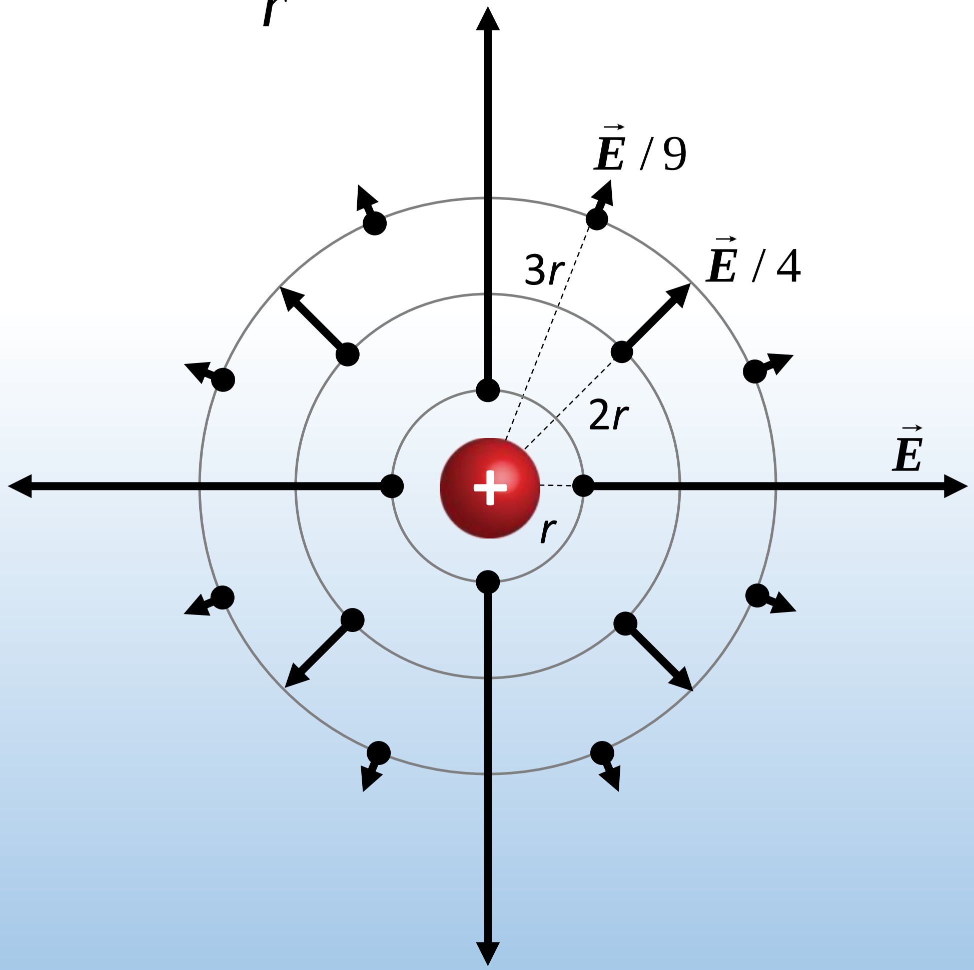


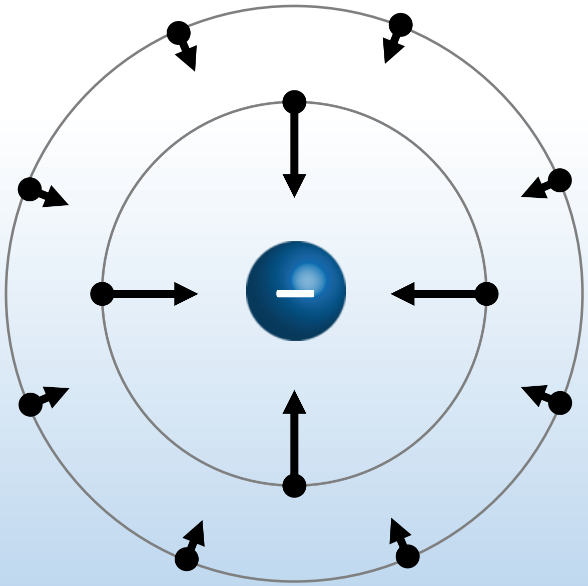
What is the direction?

Electric field from + and – charges

Magnitude $E = \dfrac{k|q|}{r^2}$

Direction Away from + charge, toward – charge



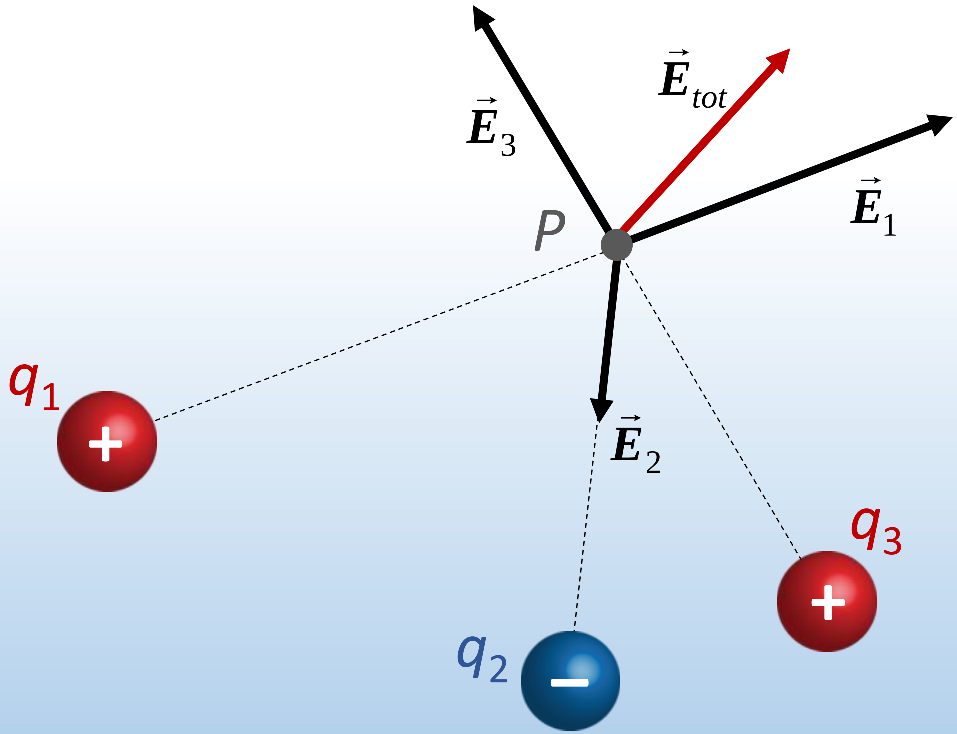


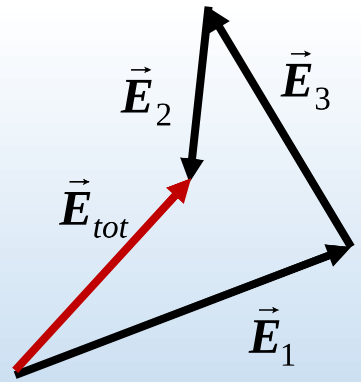
Superposition principle

Total E-field due to several charges = sum of individual E-fields

$$\vec{E}_{tot} = \sum \vec{E}$$

Ex: what is the E-field at point P due to q_1, q_2, and q_3?





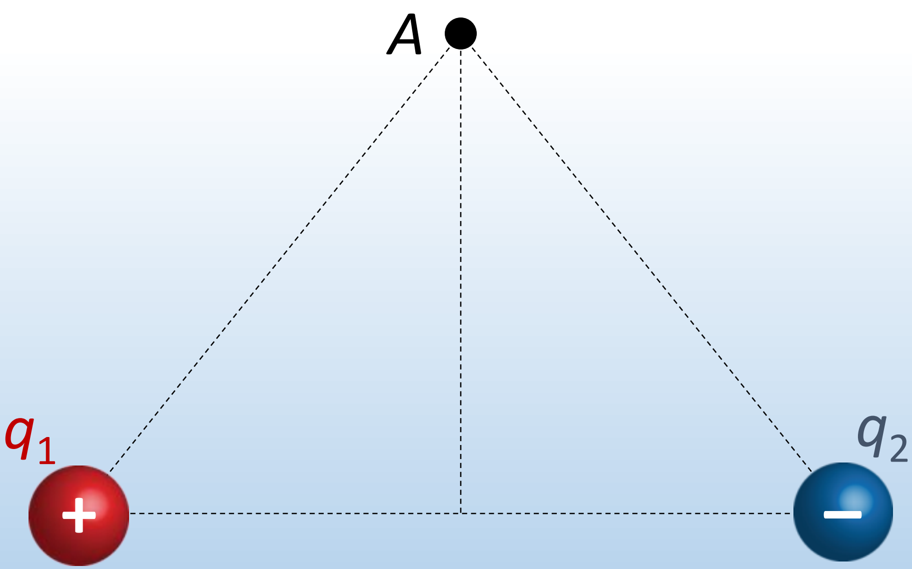
Order does not matter!

Same approach as for force

$$\vec{E}_{tot} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$$

ACT: CheckPoint 1.1

Two equal, but opposite charges are placed on the x-axis at $x = -5$ and $x = +5$. What is the direction of the electric field at point A on the y-axis?



A. Up

B. Down

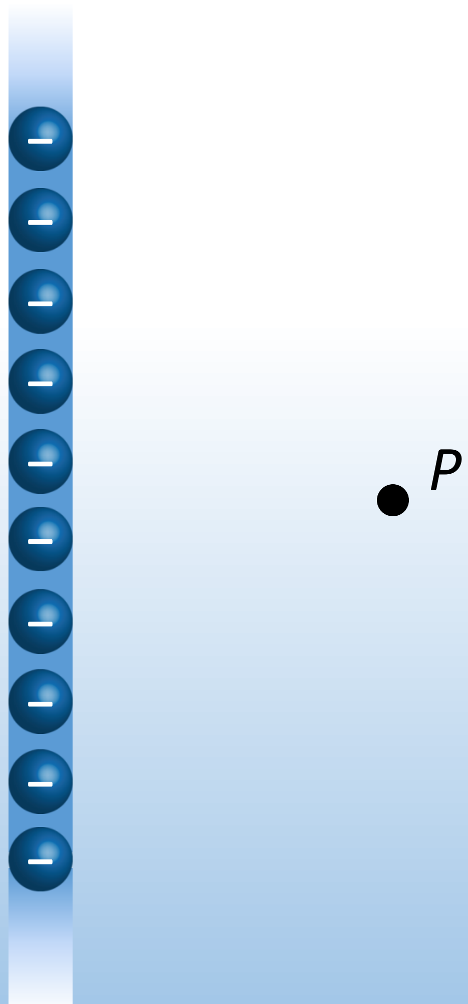
C. Left

D. Right

E. Zero

ACT: Line of charge

Consider a very long line of negative charges (ex: DNA). What is the direction of electric field at point *P*?



A. Up

B. Down

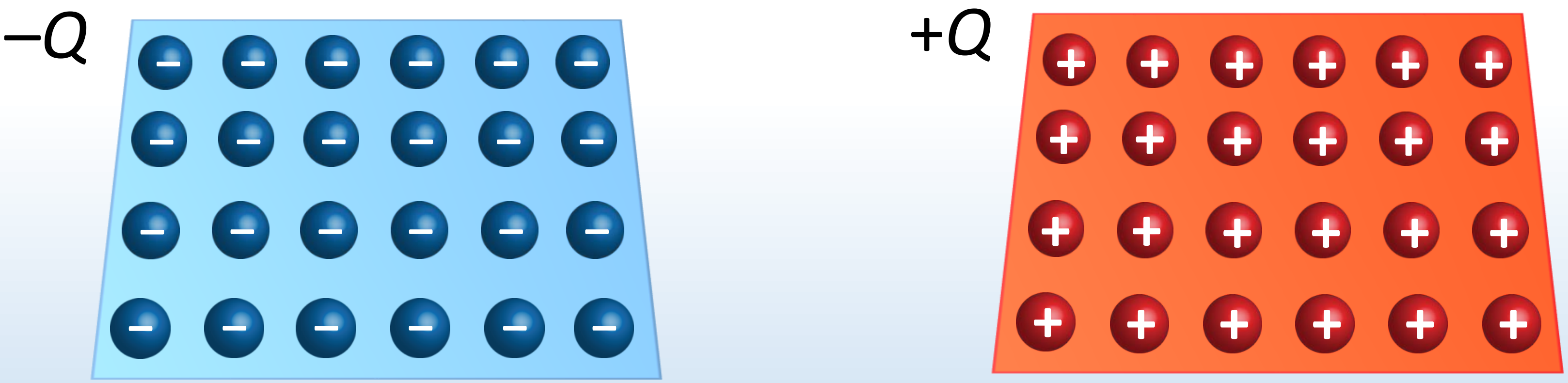
C. Left

D. Right

E. Zero

Plane of charge

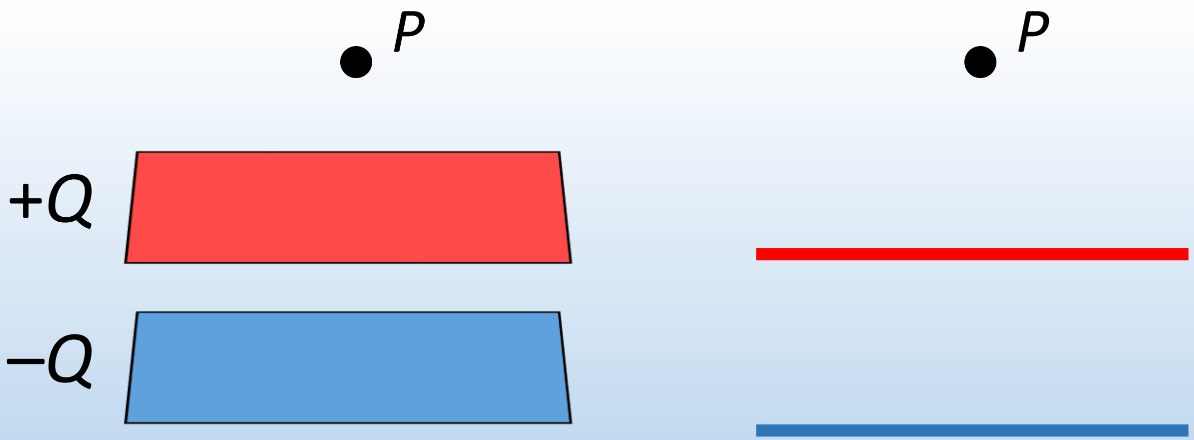
A large plane of charges creates a *uniform* electric field (constant magnitude, direction)



ACT: two charged planes

Consider two large parallel planes with equal and opposite charge $+Q$ and $-Q$ separated by a small distance

If the electric field from one plane is E_{plane}, what is the magnitude of total electric field at position P above the two parallel planes?



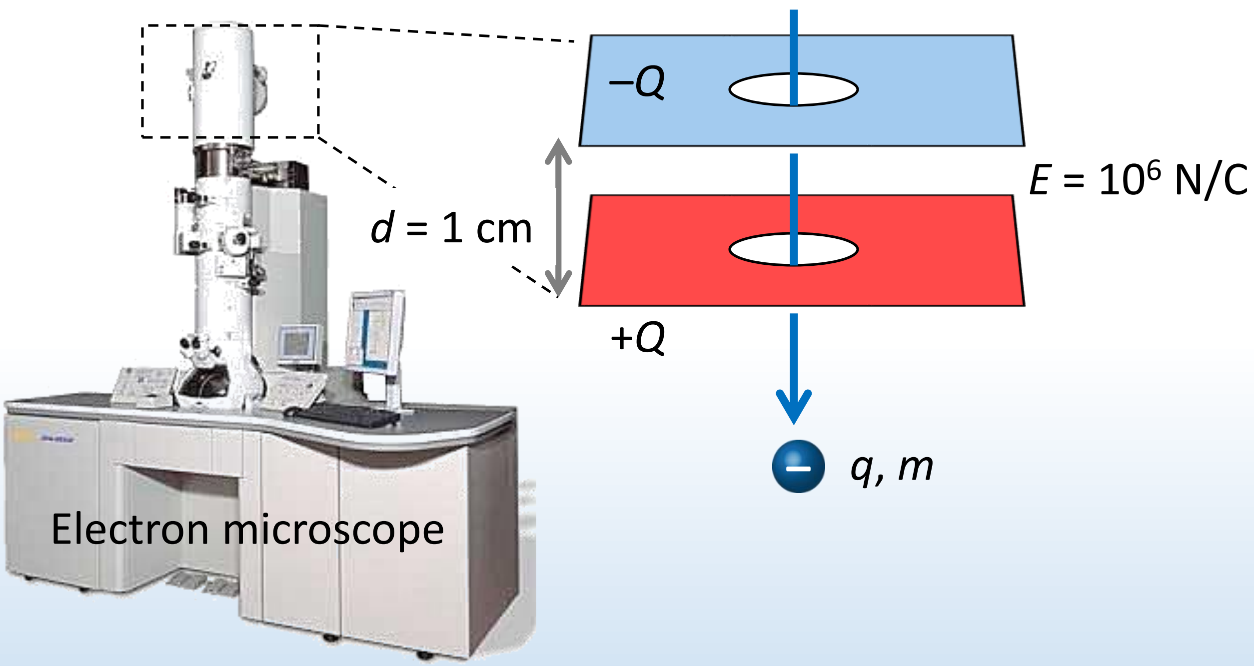
A. 0

B. $E_{plane}/2$

C. $2E_{plane}$

Calculation: Electron microscope

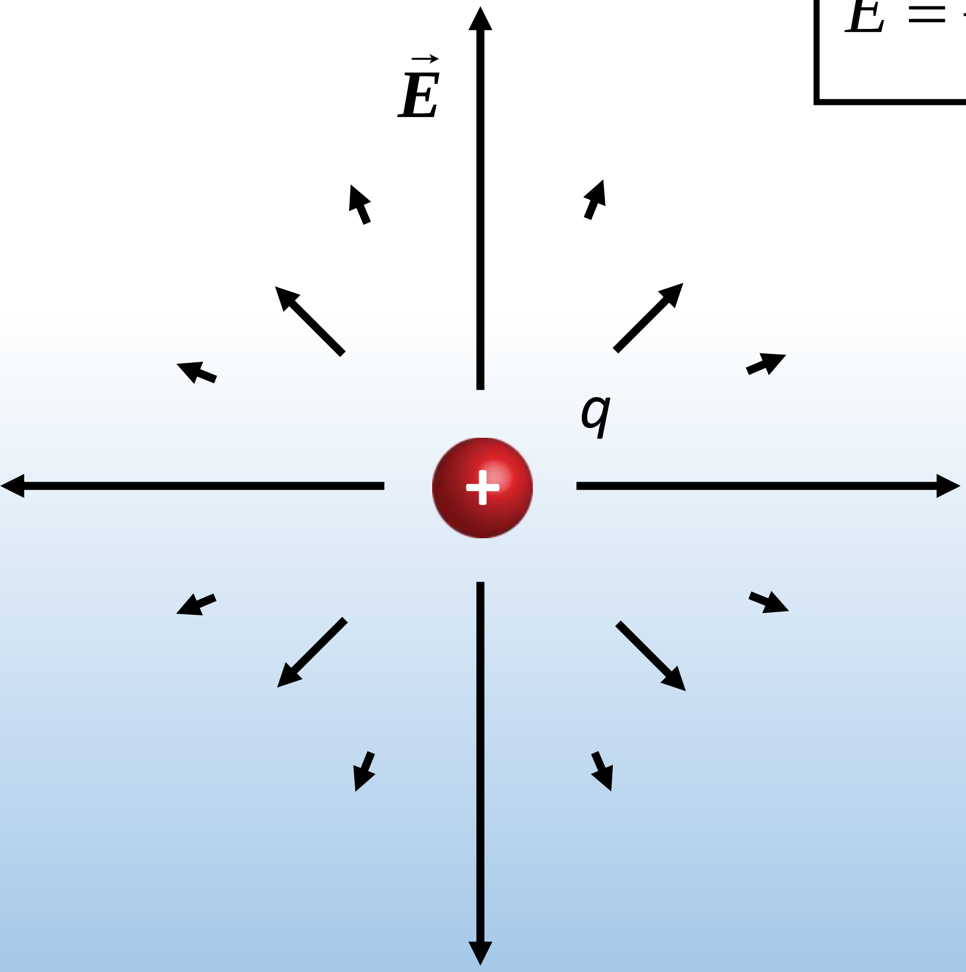
A uniform E field generated by parallel plates accelerates electrons in an electron microscope. If an electron starts from rest at the top plate what is its final velocity?

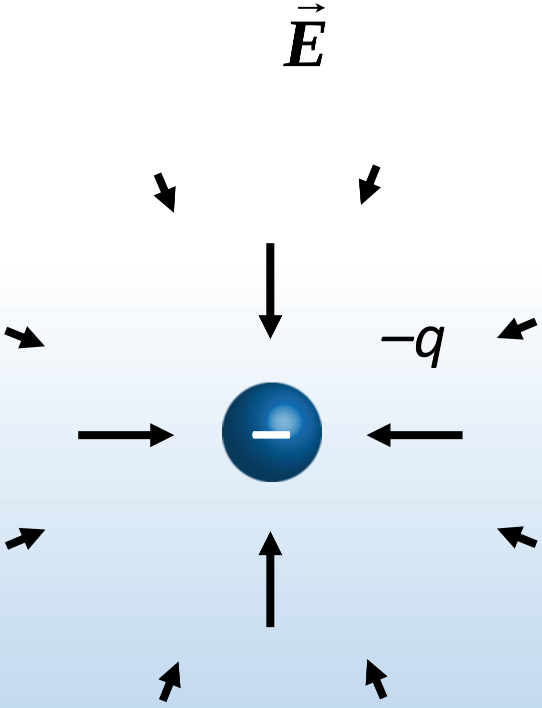


Electric field lines for charges

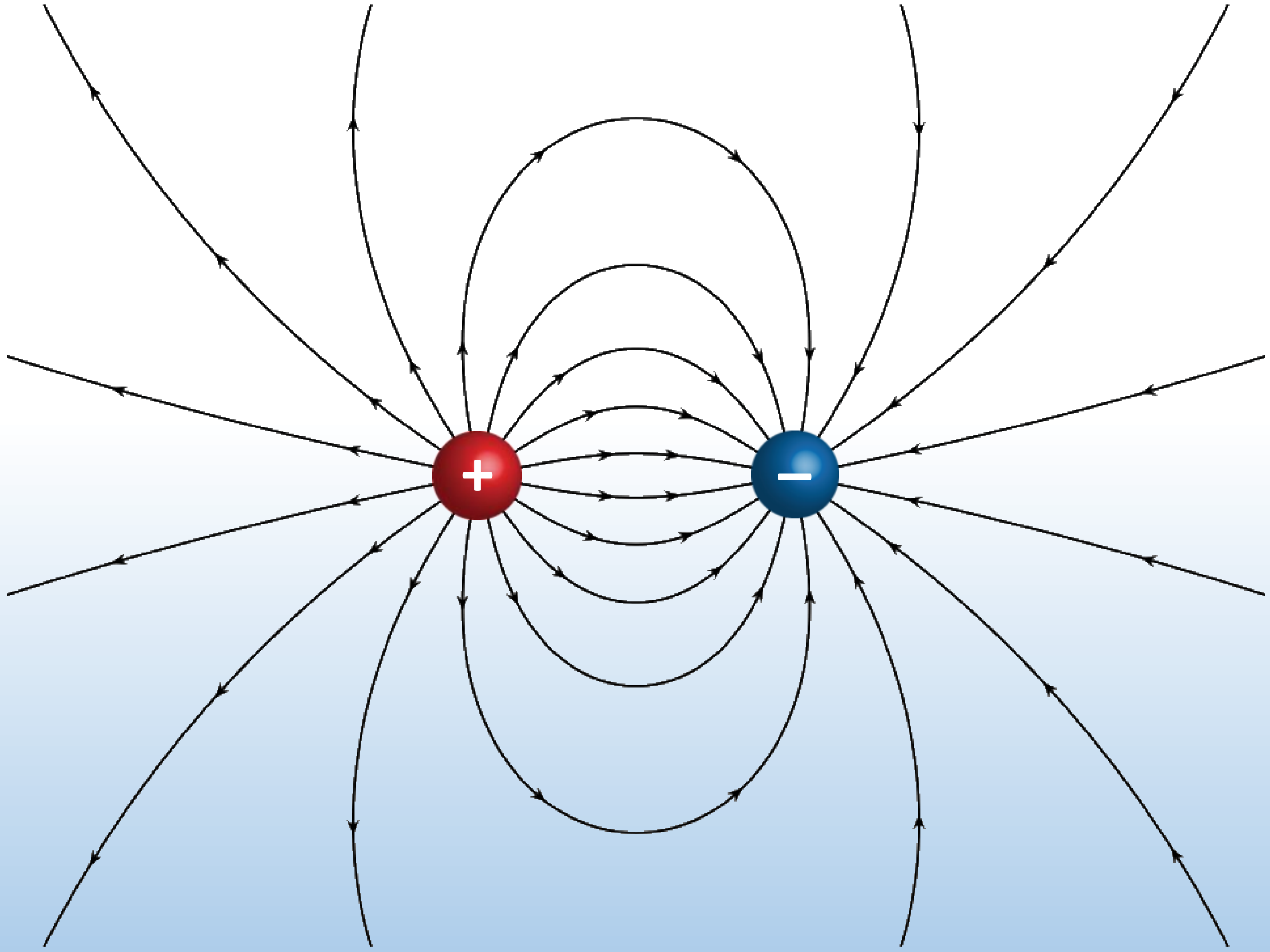
Electric field lines represent E field direction and magnitude graphically

$$E = \frac{k|q|}{r^2}$$

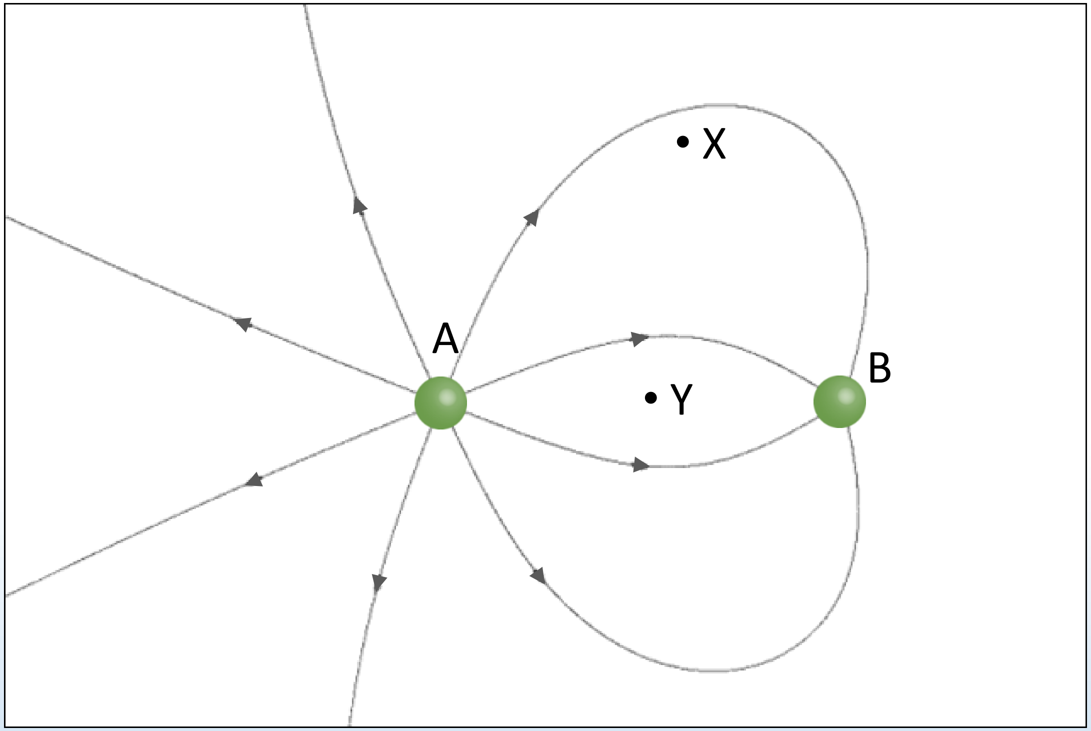




Electric field lines for dipoles



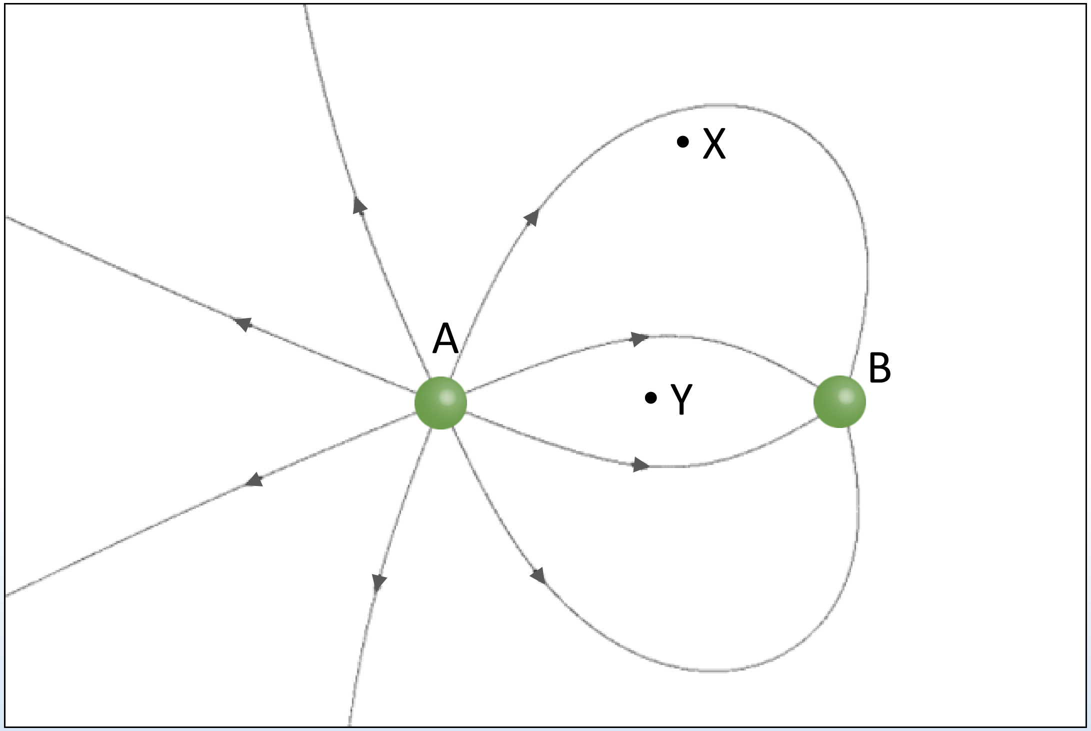
CheckPoint 2.1



Charge A is

A. positive B. negative C. unknown

ACT: CheckPoint 2.2



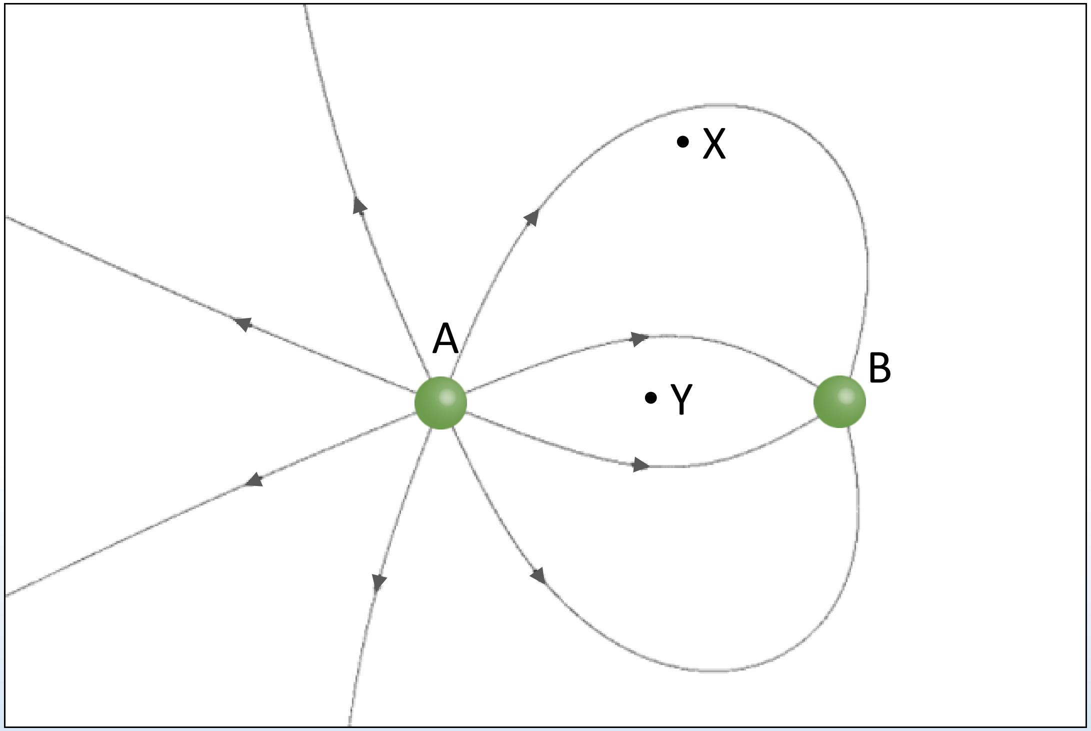
Compare the charges $|Q_A|$ & $|Q_B|$

A. $|Q_A| = |Q_B|/2$

B. $|Q_A| = |Q_B|$

C. $|Q_A| = 2|Q_B|$

ACT: CheckPoint 2.4

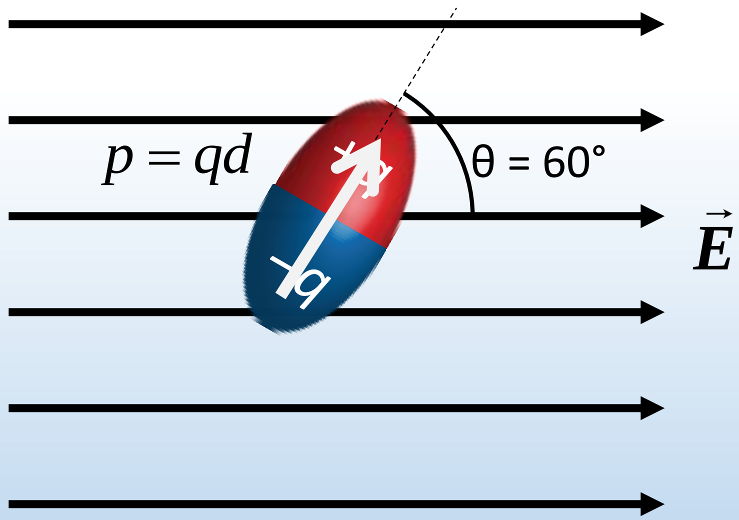


The magnitude of the electric field at point X is greater than at point Y

A. True   B. False

Calculation: dipole in E-field

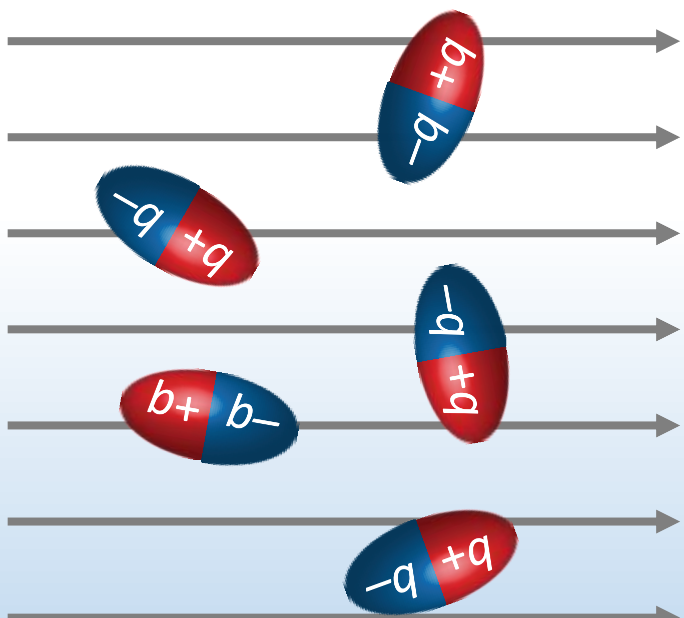
An electric dipole with moment p = 6.2 x 10^{-30} C·m is placed in a uniform external electric field E = 10^6 N/C at an angle θ = 60°. Calculate the total *force* and *torque* on the dipole.



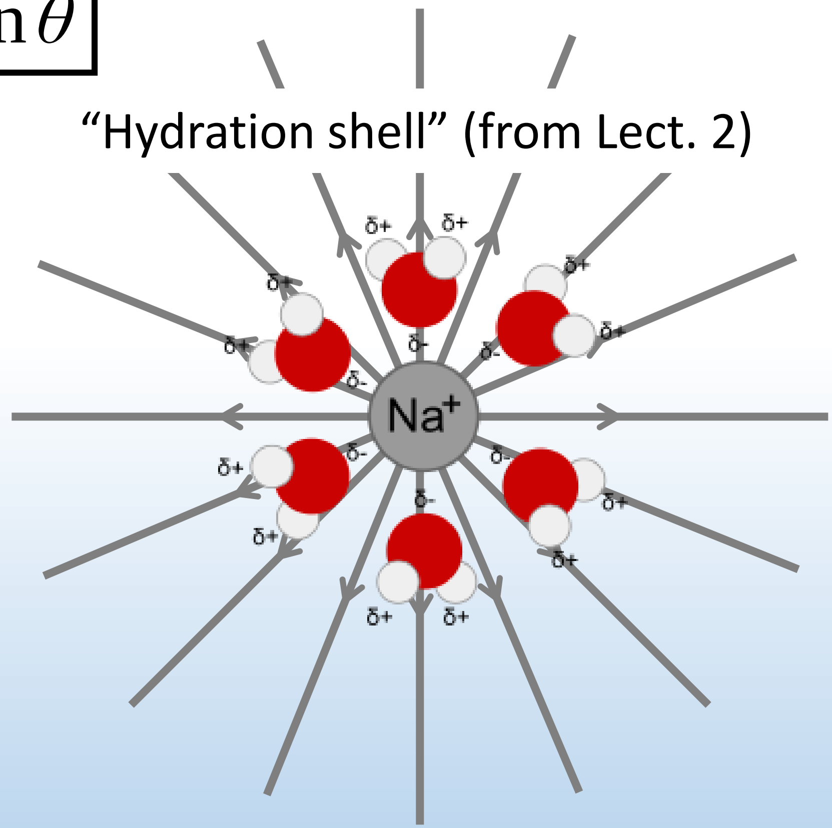
Dipole in E field

Electric dipole moments align parallel to electric field

$$\tau = pE\sin\theta$$



Dipoles in a uniform E field

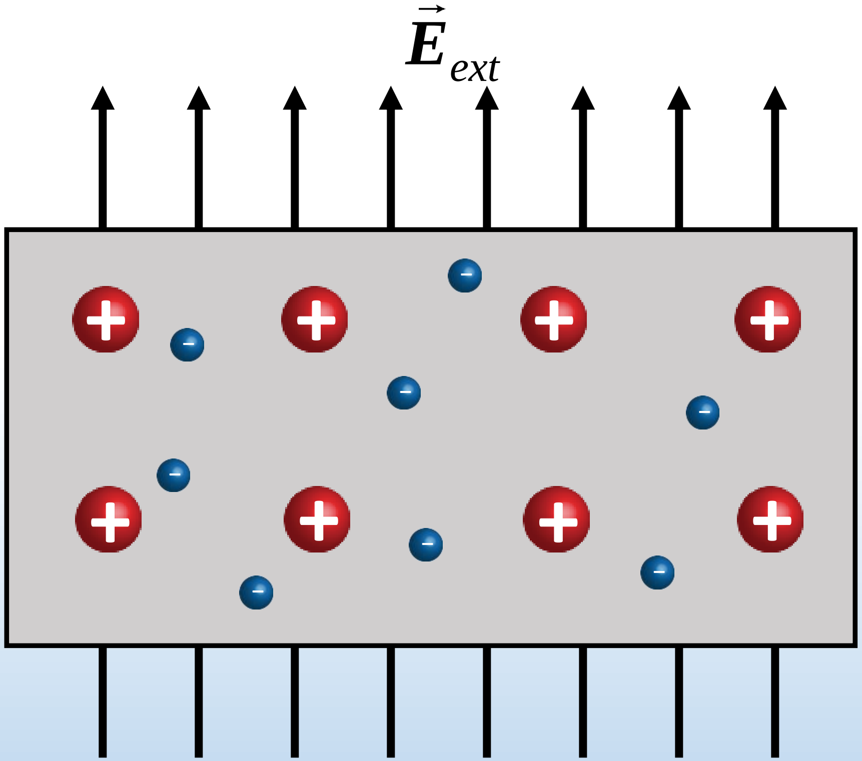


Dipoles near a charge

DEMO

Conductors & electric fields

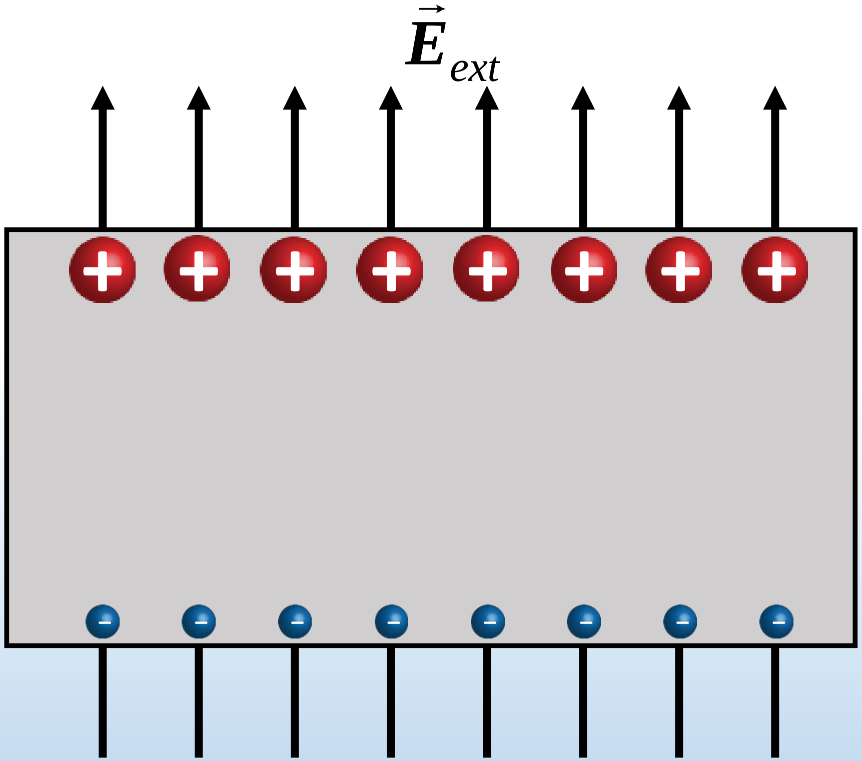
Imagine placing a conductor inside a uniform external E field



Conductors & electric fields

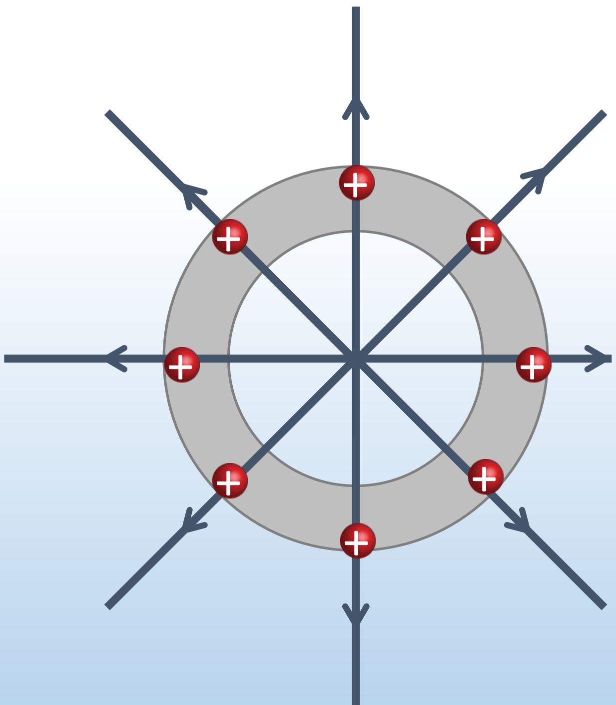
Imagine placing a conductor inside a uniform external E field

Another way to look at it:

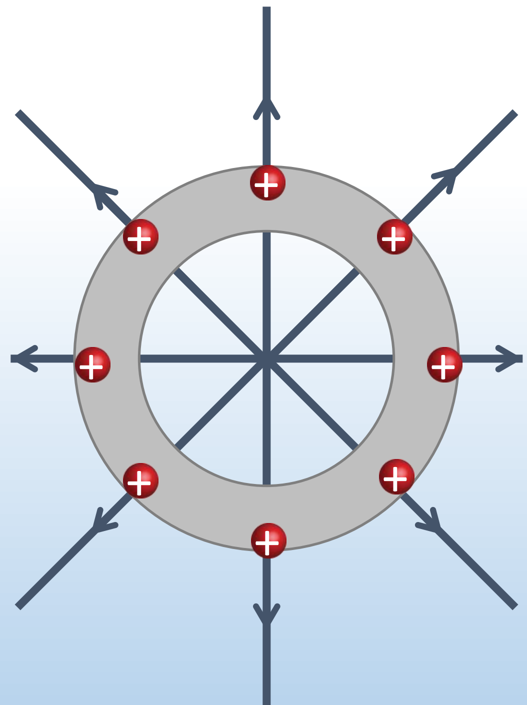


ACT: Conductor & E field

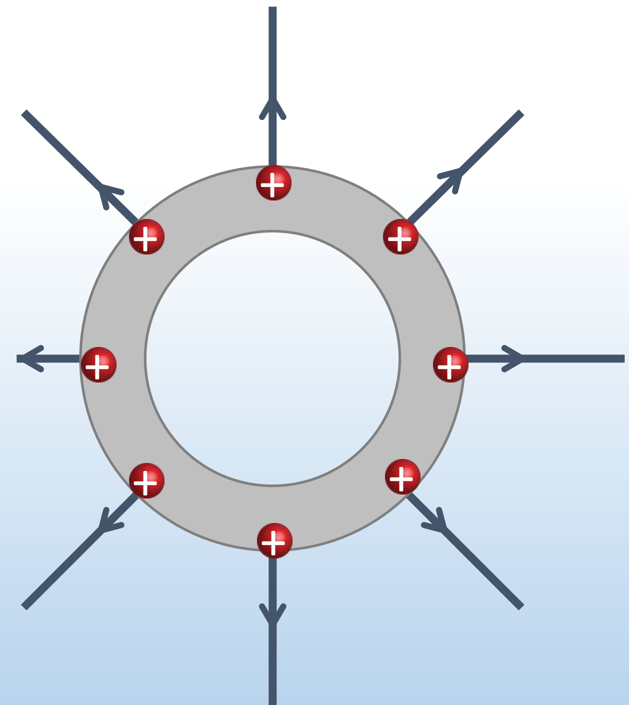
Which diagram best represents the *E* field around a positively charged conducting spherical shell?



A.



B.



C.

Summary of today's lecture

- Electric fields

  Electric field lines

- Superposition principle $\vec{E}_{tot} = \sum \vec{E}$

  Dipole, line, plane

- Dipoles & electric fields
- Conductors & electric fields $\vec{E}_{cond.} = 0$