Lance Nelson

disk

$$E = \frac{2k|\lambda|}{r}$$

ring

$$E = \frac{kq}{r^2}$$

$$E_z = \frac{kz|Q|}{(z^2 + R^2)^{3/2}}$$

finite line

infinite line

$$E_z = \frac{k|Q|}{r\sqrt{r^2 + (L/2)^2}}$$

dipole

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{p}}{r^3}$$

sphere

Infinite plane

$$E_z = \frac{\eta}{2\epsilon}\left[1 - \frac{z}{\sqrt{z^2 + R^2}}\right]$$

$$\vec{E} = -\frac{1}{4\pi\epsilon_0}\frac{\vec{p}}{r^3}$$

$$p = qs$$

$$E_x = \frac{\eta}{2\epsilon_0}$$

$$F = qE$$

disk

ring

$$E = \frac{2k|\lambda|}{r}$$ 8

$$E = \frac{kq}{r^2}$$ 7

$$E_z = \frac{kz|Q|}{(z^2+R^2)^{3/2}}$$ 6

finite line

infinite line

$$E_z = \frac{k|Q|}{r\sqrt{r^2+(L/2)^2}}$$ 9

dipole

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{p}}{r^3}$$ 3

sphere

$$\vec{E} = -\frac{1}{4\pi\epsilon_0}\frac{\vec{p}}{r^3}$$ 2

Infinite plane

$$E_z = \frac{\eta}{2\epsilon}\left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]$$ 4

$$E_x = \frac{\eta}{2\epsilon_0}$$ 10

$$p = qs$$ 1

$$F = qE$$ 5

disk

ring

$$E = \frac{2k|\lambda|}{r}$$ **8**

$$E = \frac{kq}{r^2}$$ **7**

$$E_z = \frac{kz|Q|}{(z^2+R^2)^{3/2}}$$ **6**

finite line

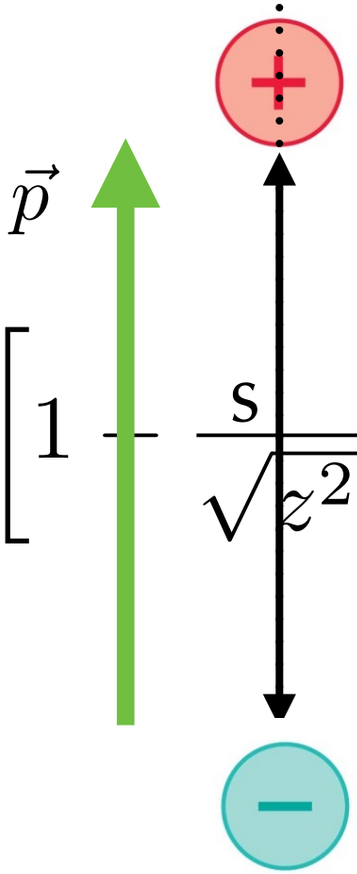
infinite line

$$E_z = \frac{k|Q|}{r\sqrt{r^2+(L/2)^2}}$$ **9**

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{p}}{r^3}$$ **3**

dipole

sphere



4

Infinite plane

$$\vec{E} = -\frac{1}{4\pi\epsilon_0}\frac{\vec{p}}{r^3}$$ **2**

$$E_z = \frac{\eta}{2\epsilon}\left[1 - \frac{s \quad z}{\sqrt{z^2+R^2}}\right]$$

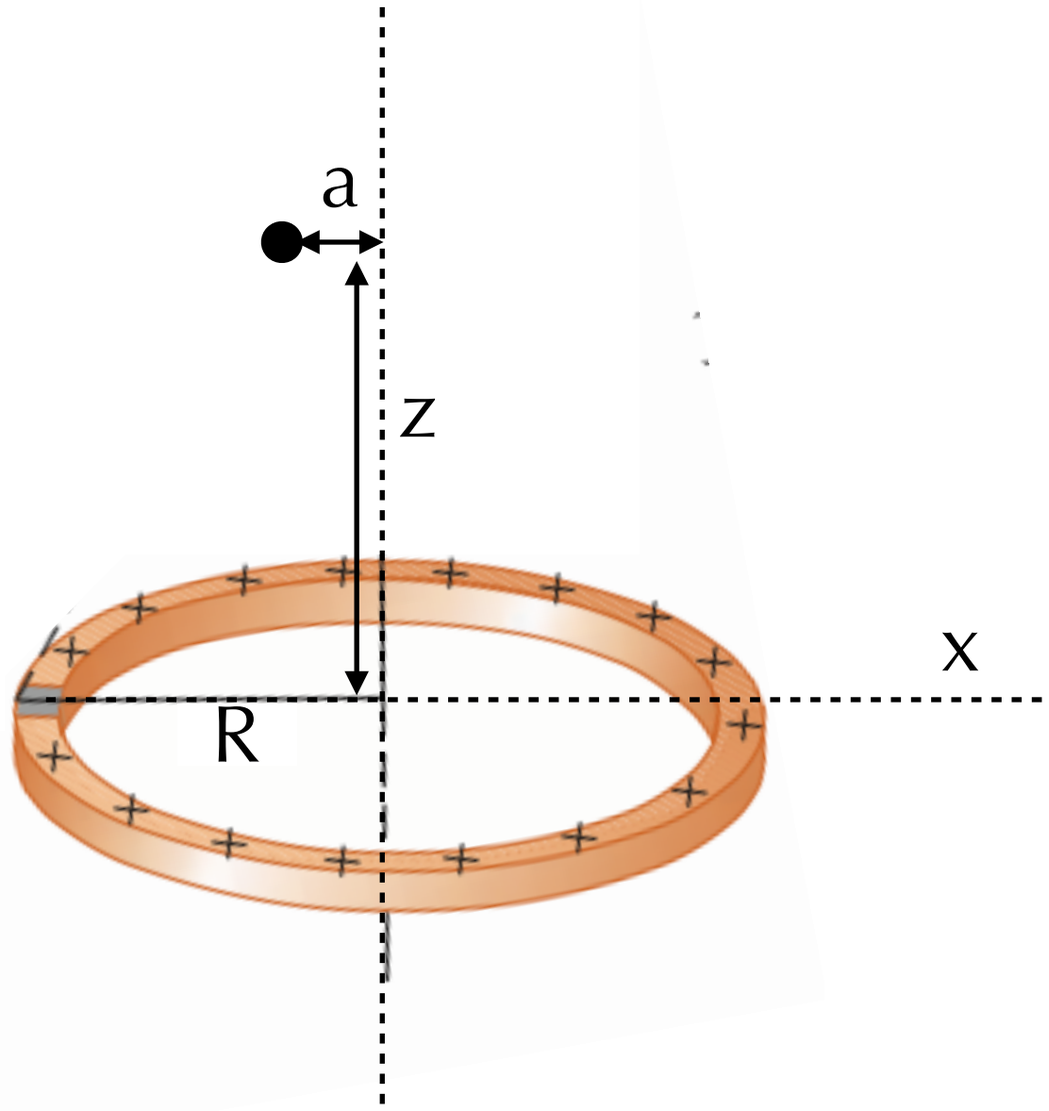
$$E_x = \frac{\eta}{2\epsilon_0}$$ **10**

$$F = qE$$ **5**

$$p = qs$$ **1**

Back to the ring of charge

Let's step off the symmetry axis in one dimension. Which components of the electric field will be nonzero.



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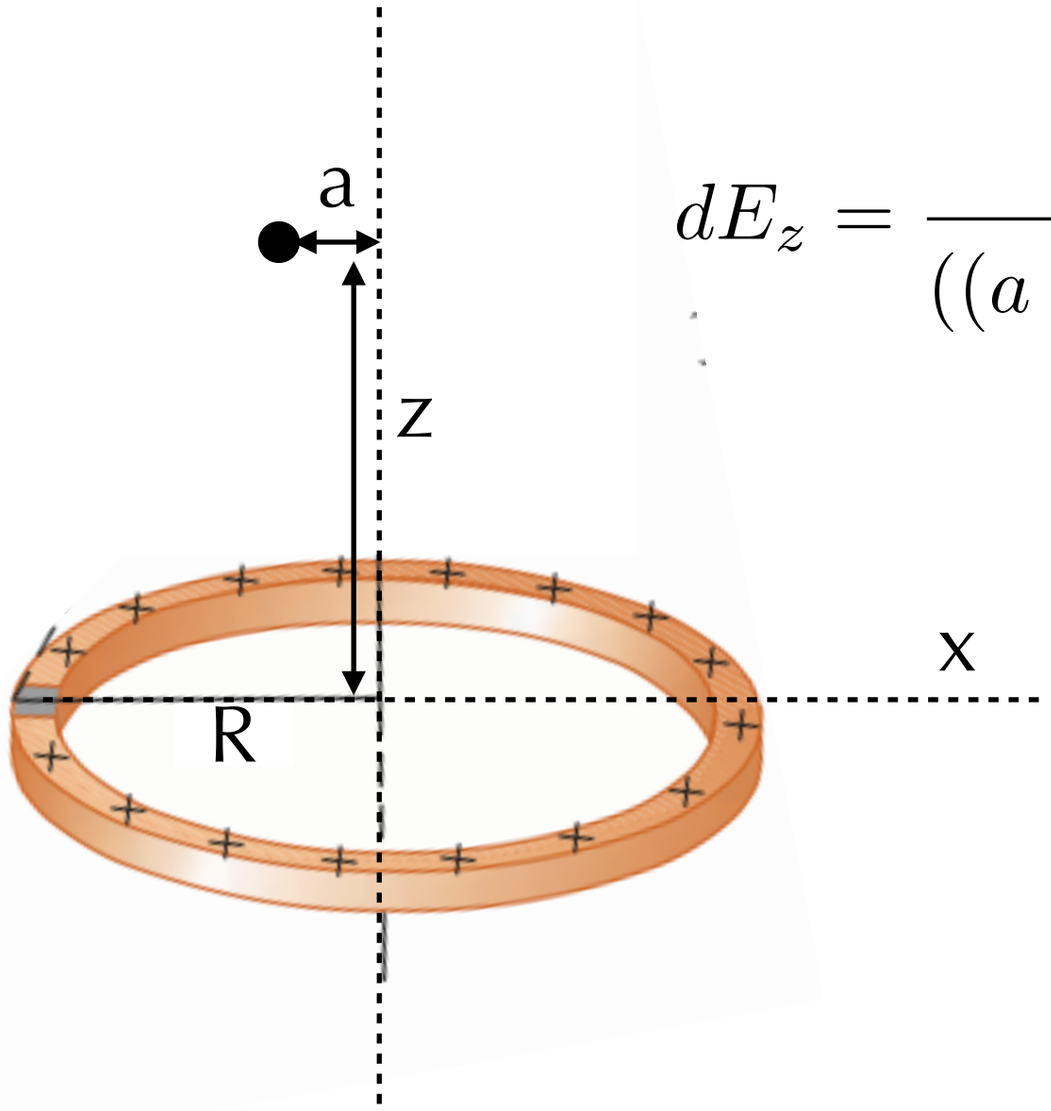

$$dE_z = \frac{k\lambda R z d\theta}{\left((a + R\cos\theta)^2 + (R\sin\theta)^2 + z^2\right)^{3/2}}$$

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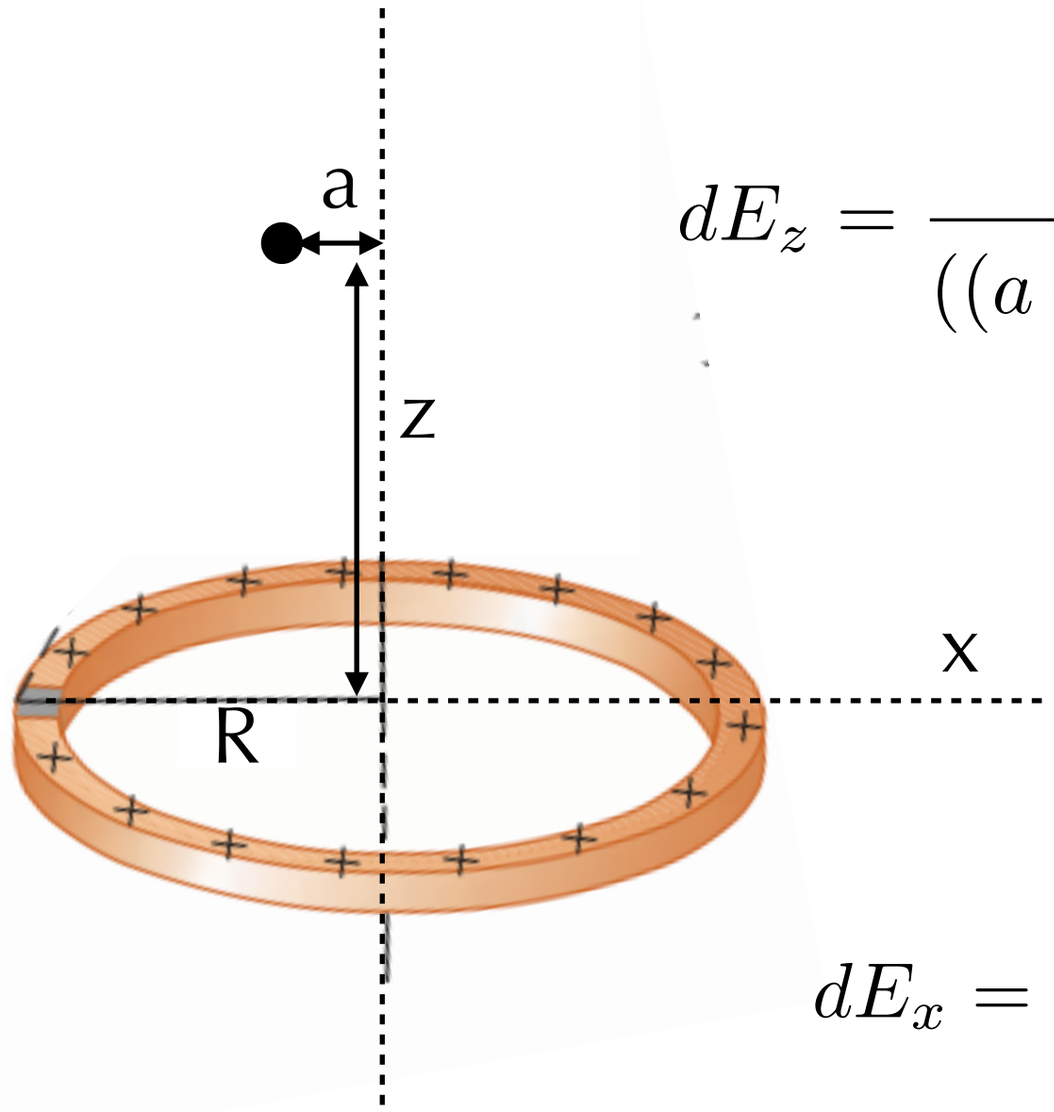
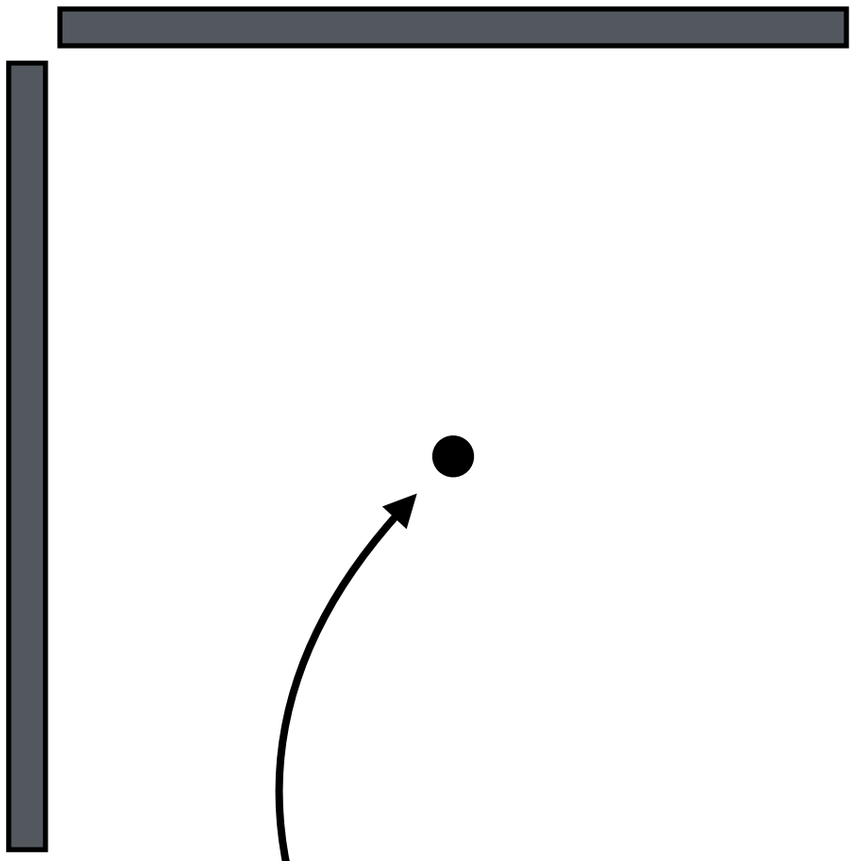


$$dE_z = \frac{k\lambda R z d\theta}{\left((a + R\cos\theta)^2 + (R\sin\theta)^2 + z^2\right)^{3/2}}$$

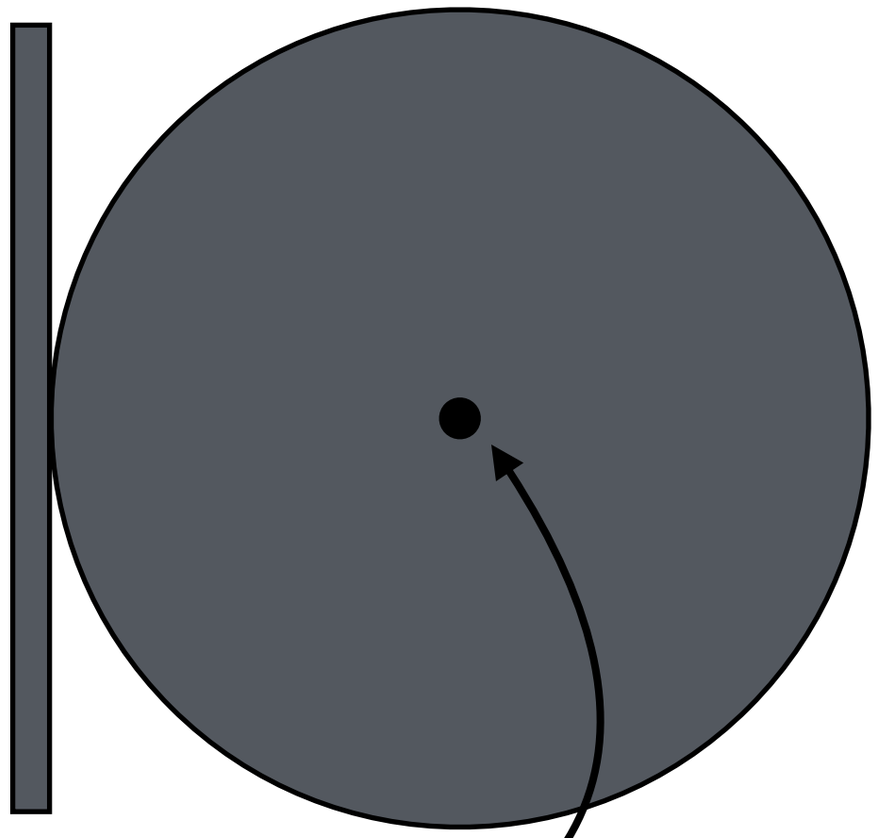
$$dE_x = \frac{k\lambda R(a + R\cos\theta)d\theta}{\left((a + R\cos\theta)^2 + (R\sin\theta)^2 + z^2\right)^{3/2}}$$

How would you approach this problem?

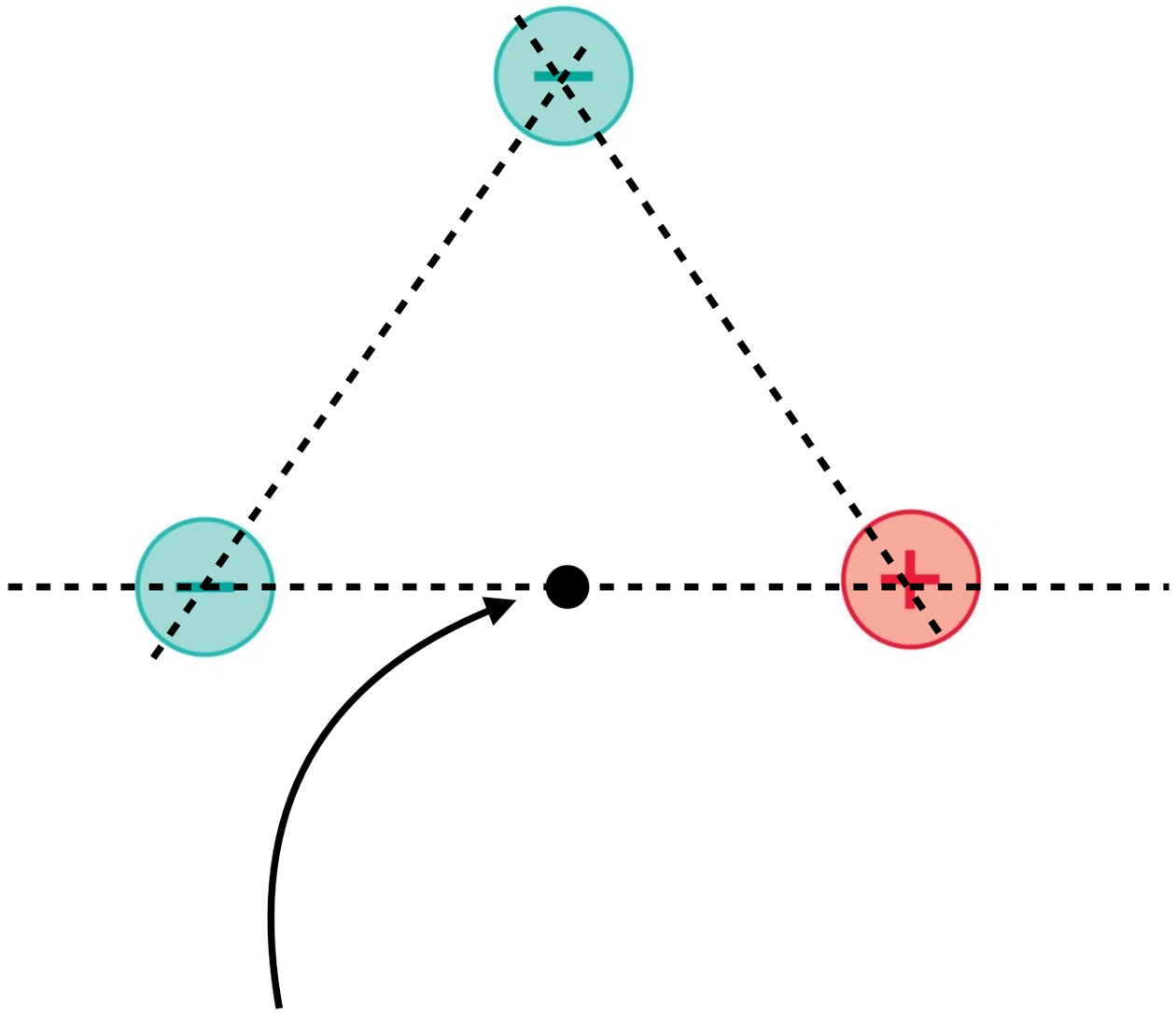
Top View



Side View



What's the electric field here



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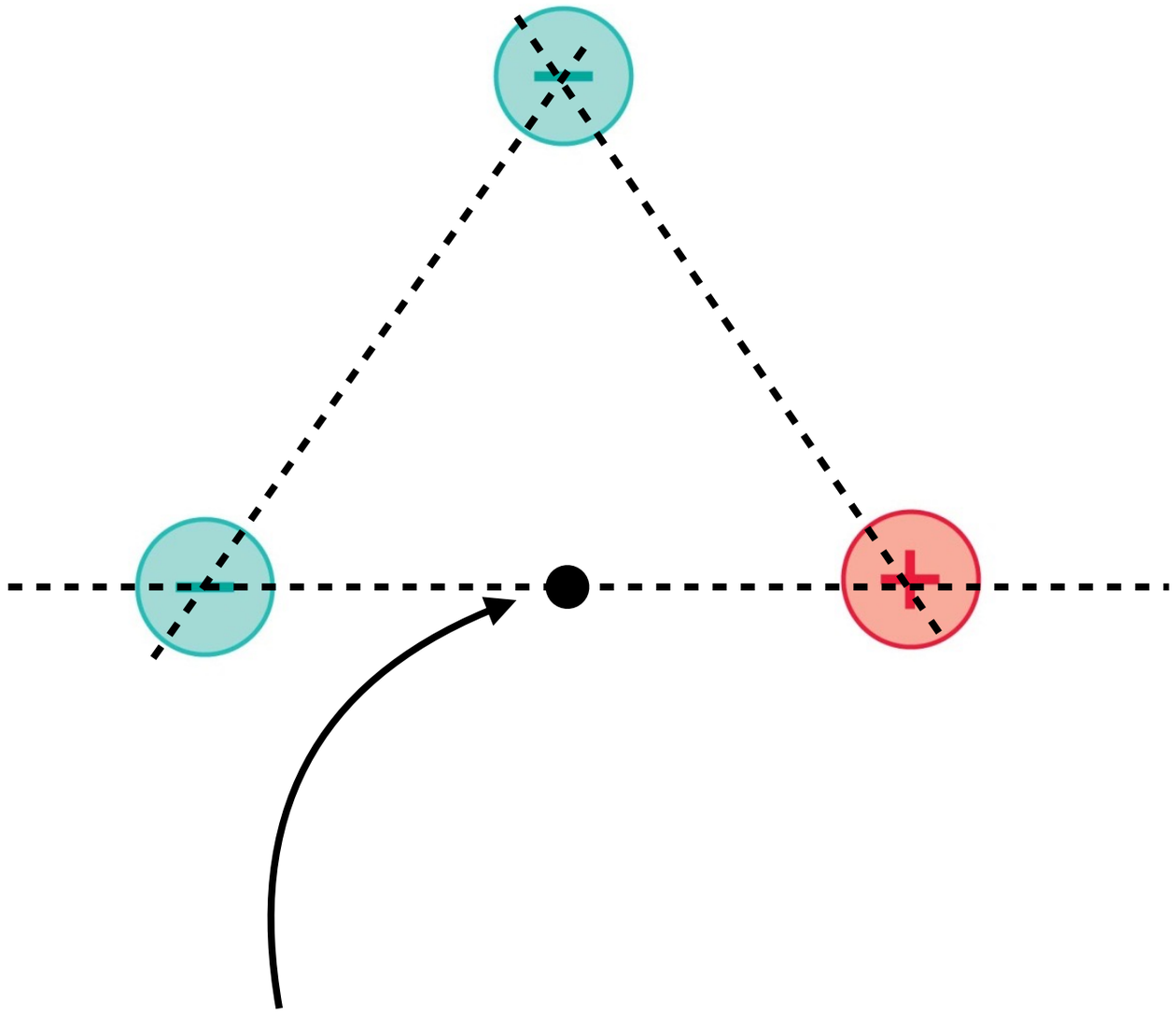
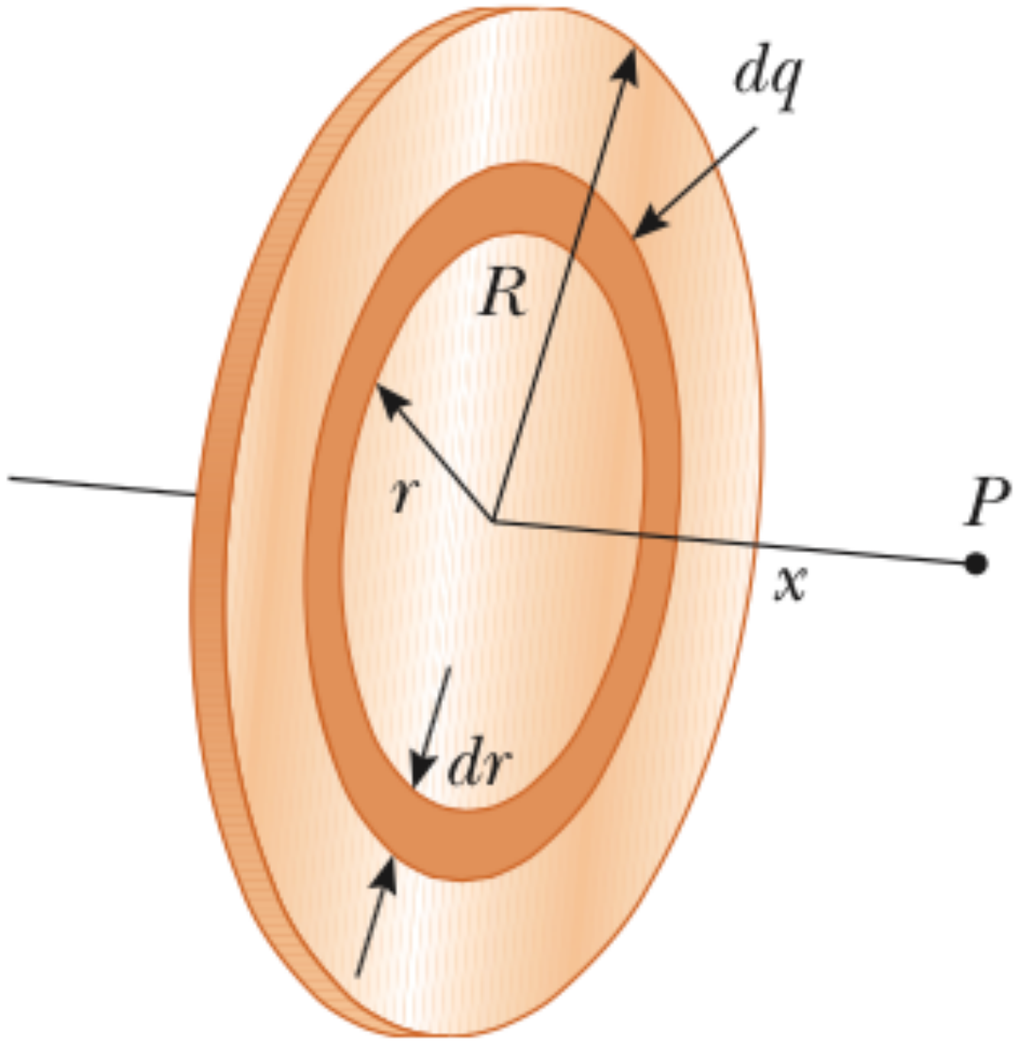


What's the electric field here?

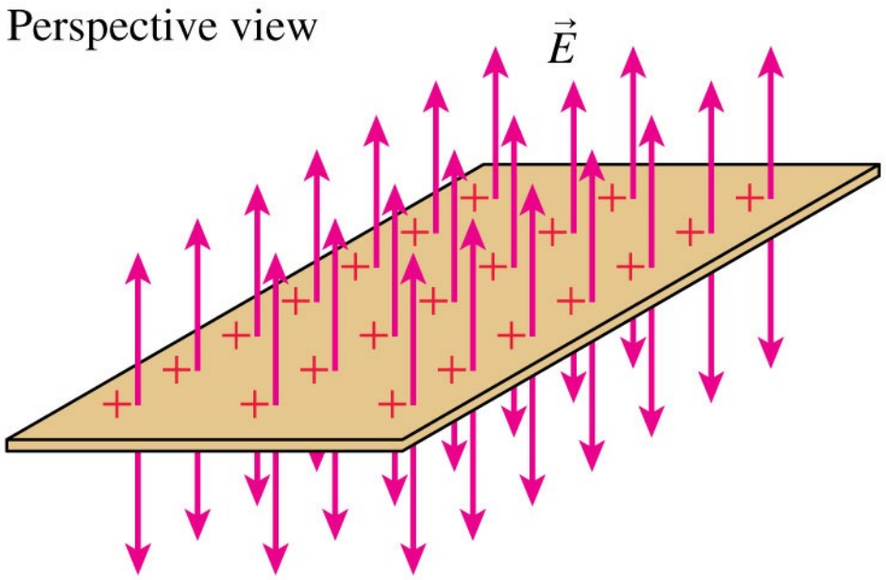
A plane of charge

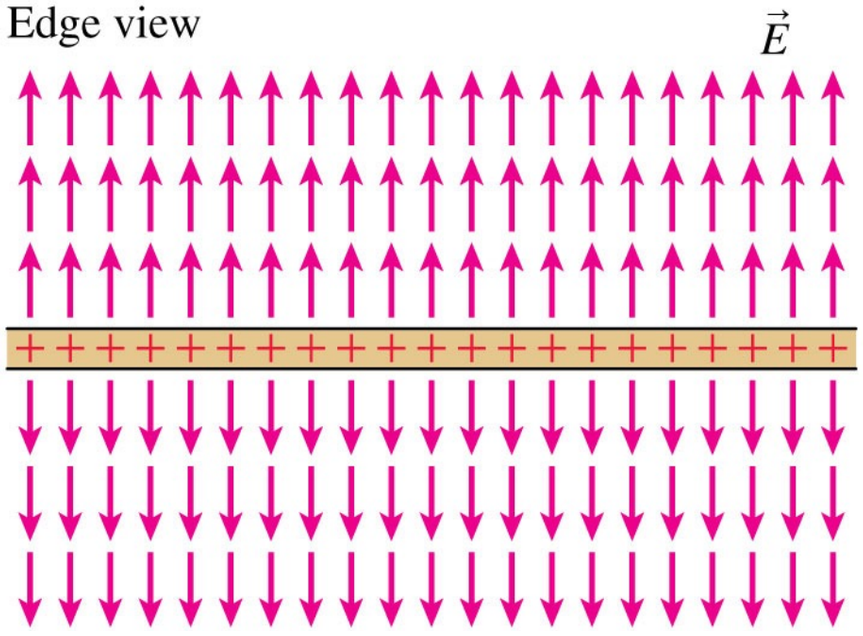
What does the disk become if we let:

$$R \to \infty$$



A plane of charge





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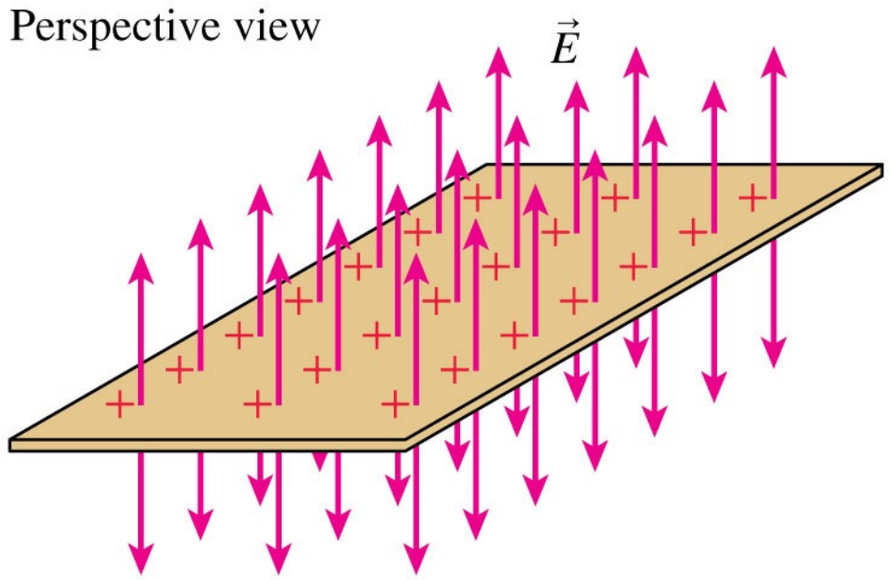

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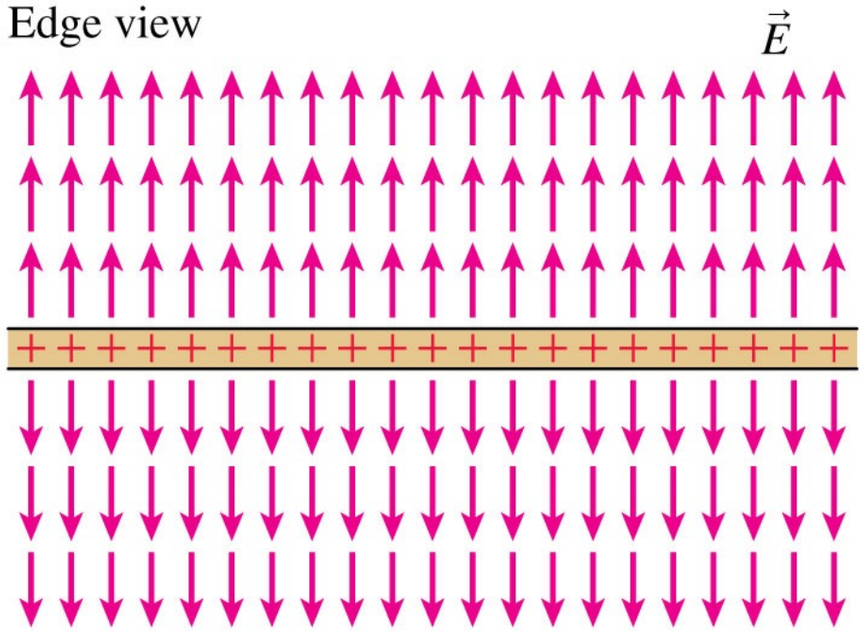
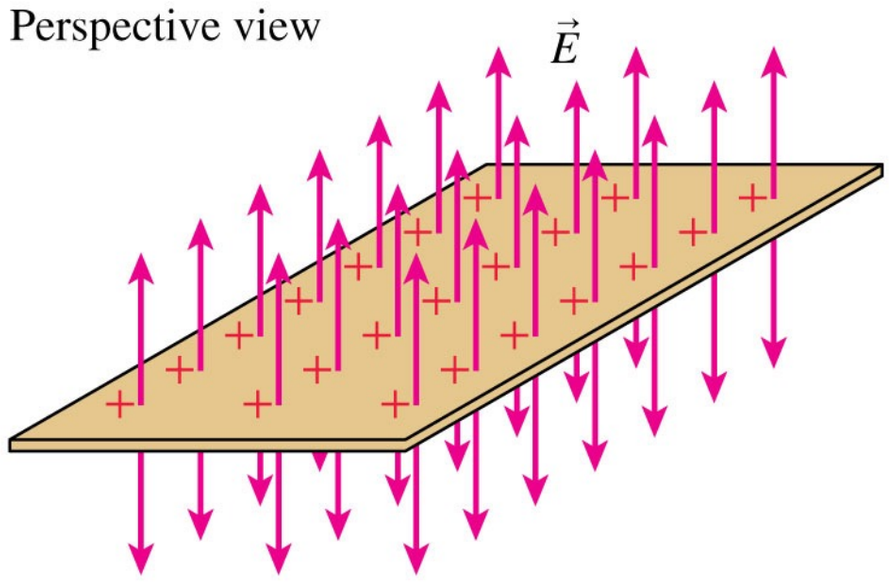


What does this function become?

A plane of charge



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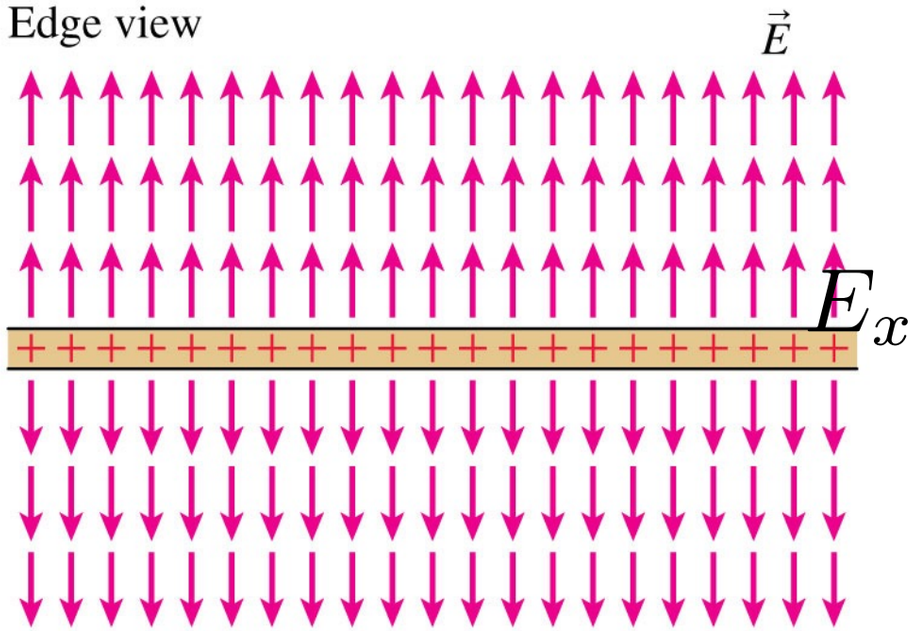

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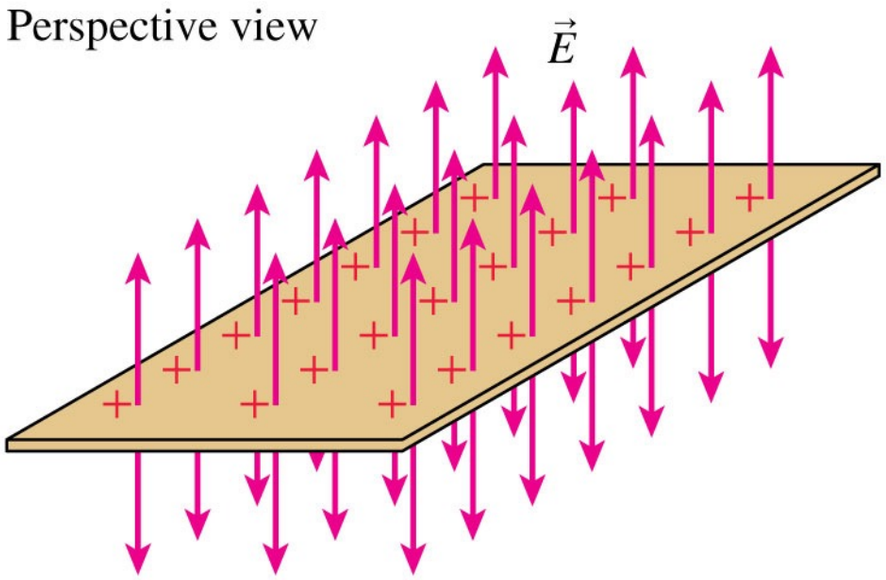
$$E_x = \frac{\eta}{2\epsilon_0}\left[1 - \frac{x}{\sqrt{R^2\left(\frac{x^2}{R^2} + 1\right)}}\right]$$

A plane of charge



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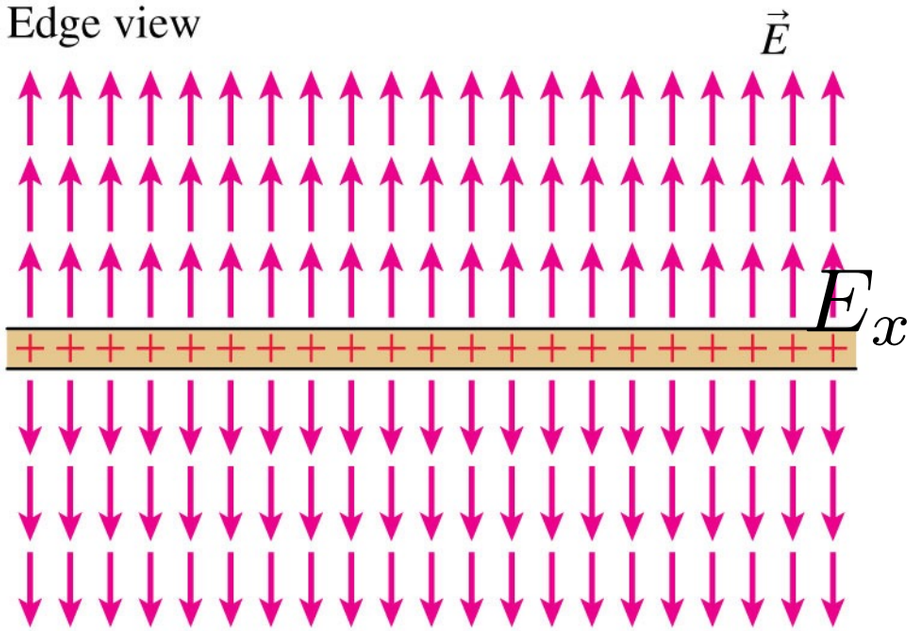

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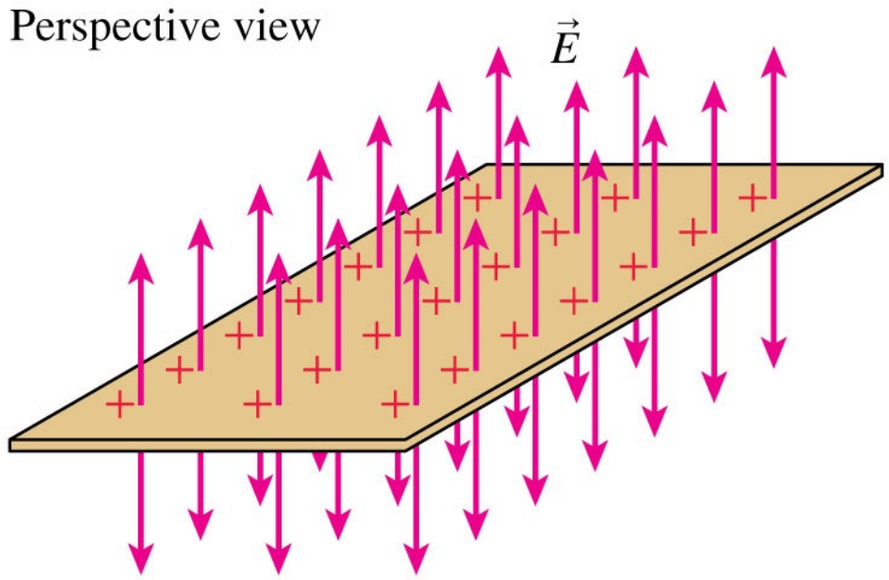

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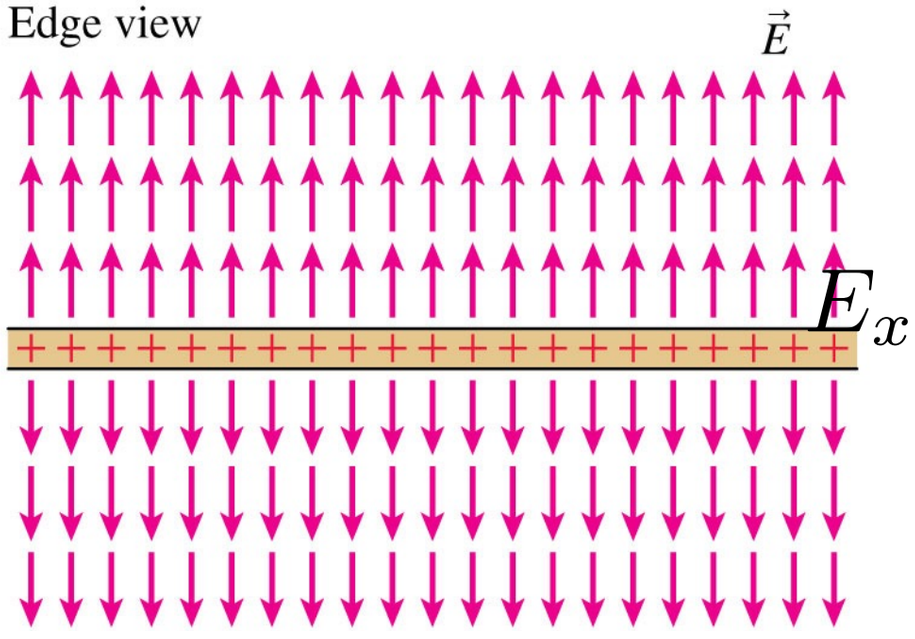

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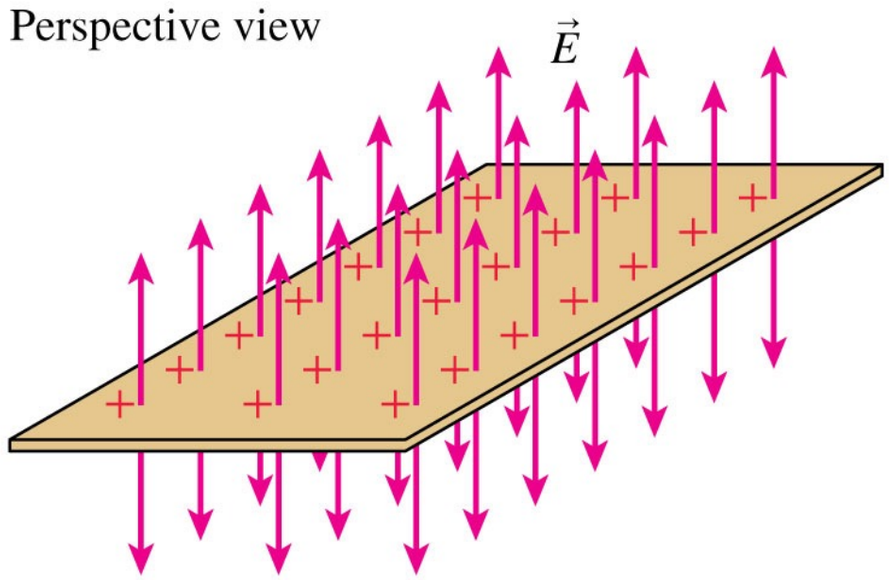
A plane of charge



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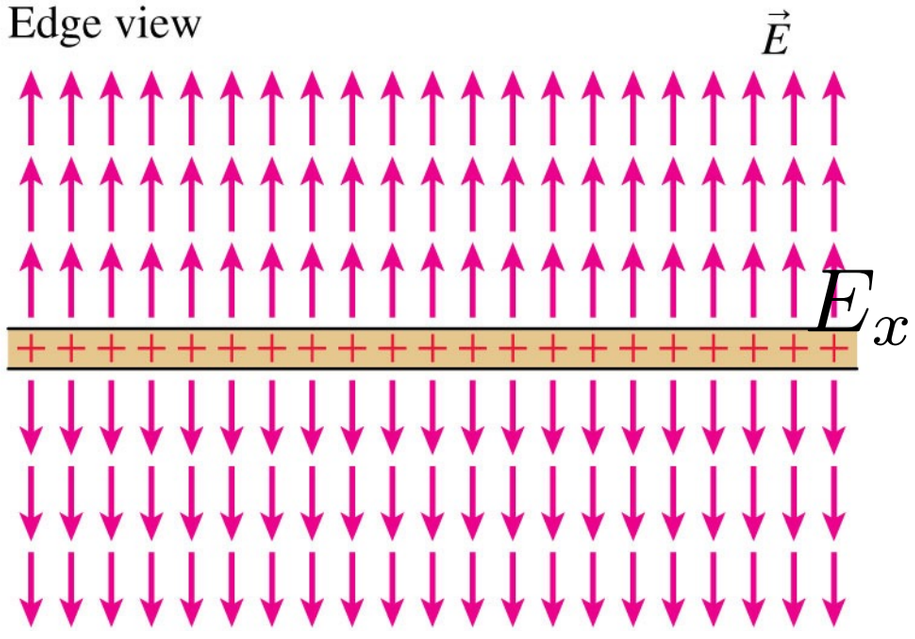

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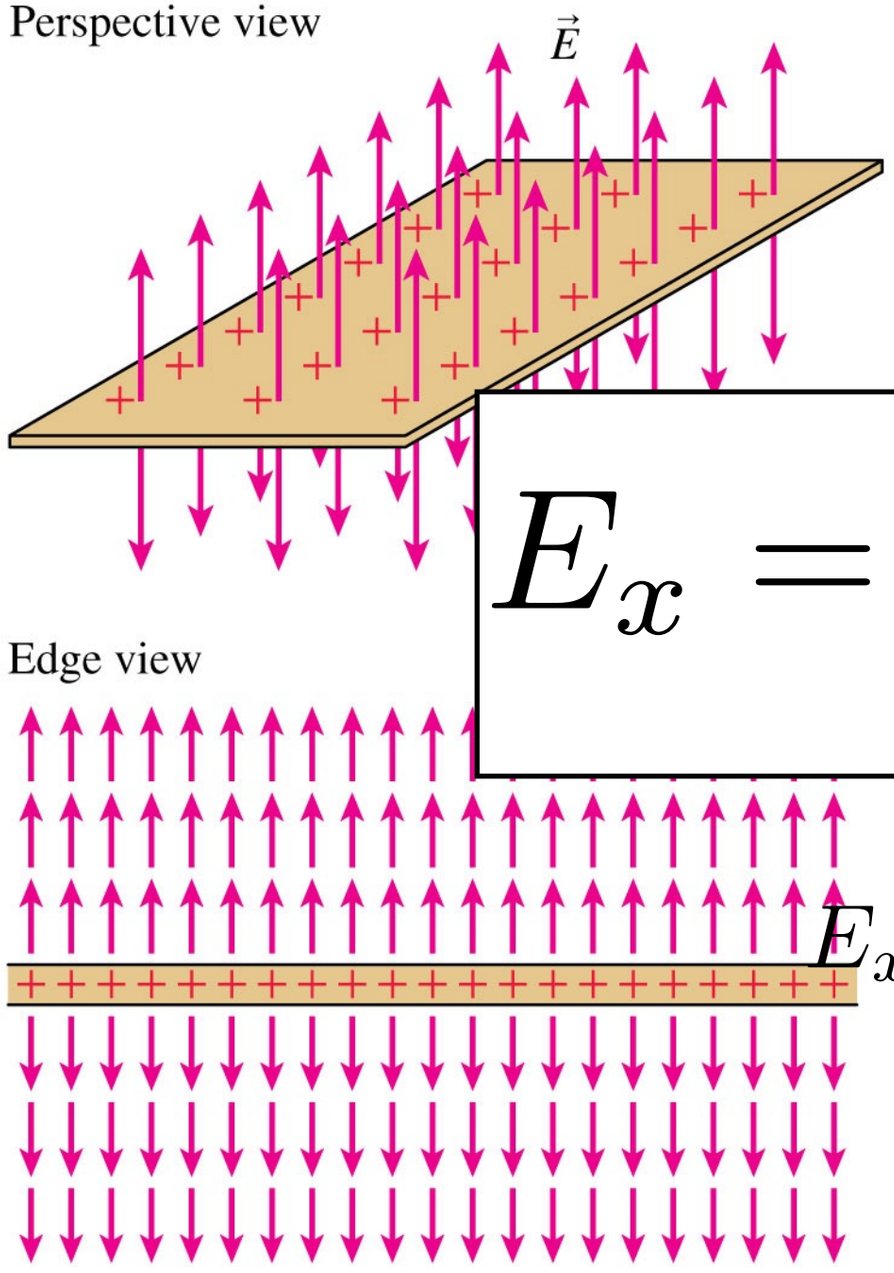

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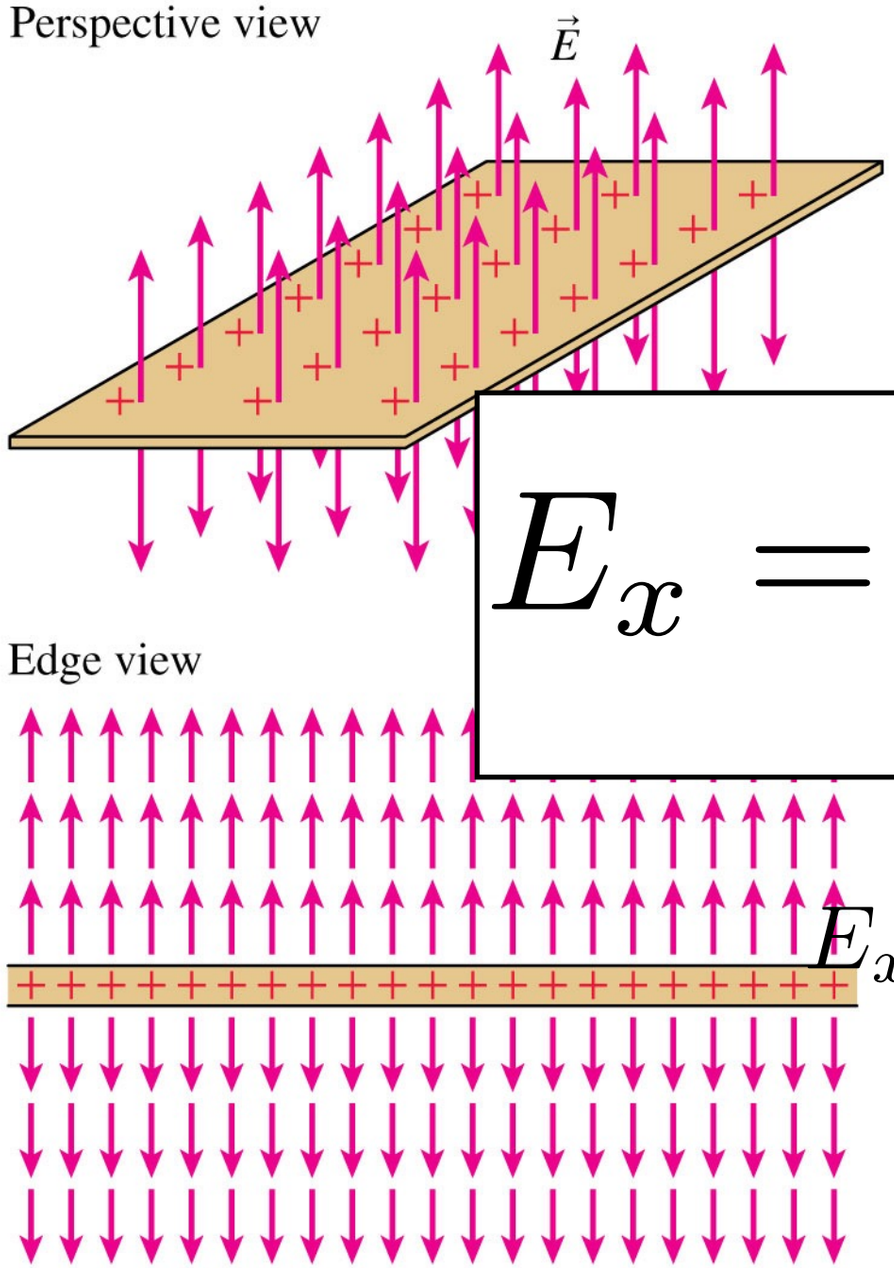

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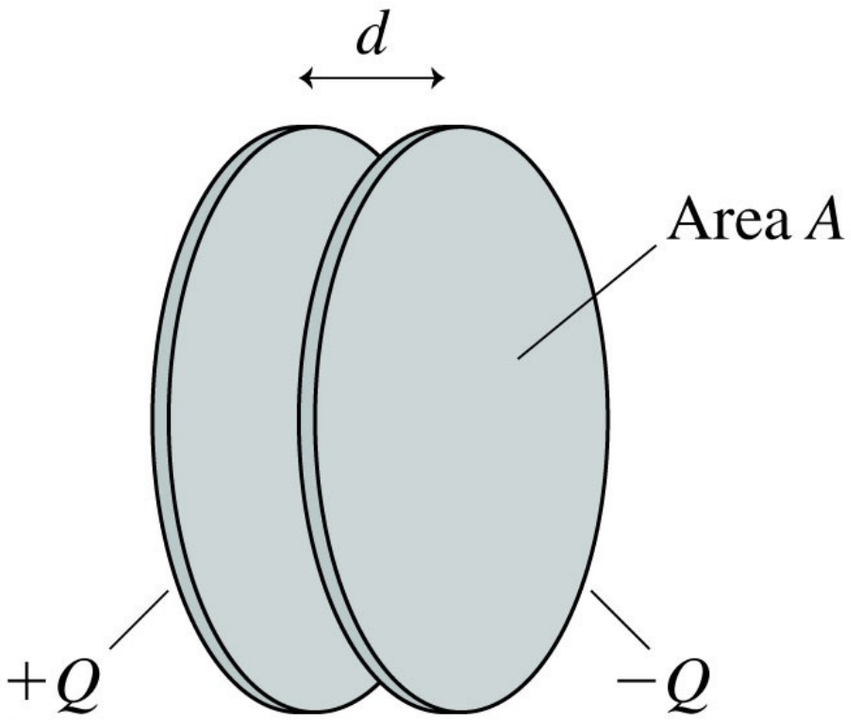
binomial expansion

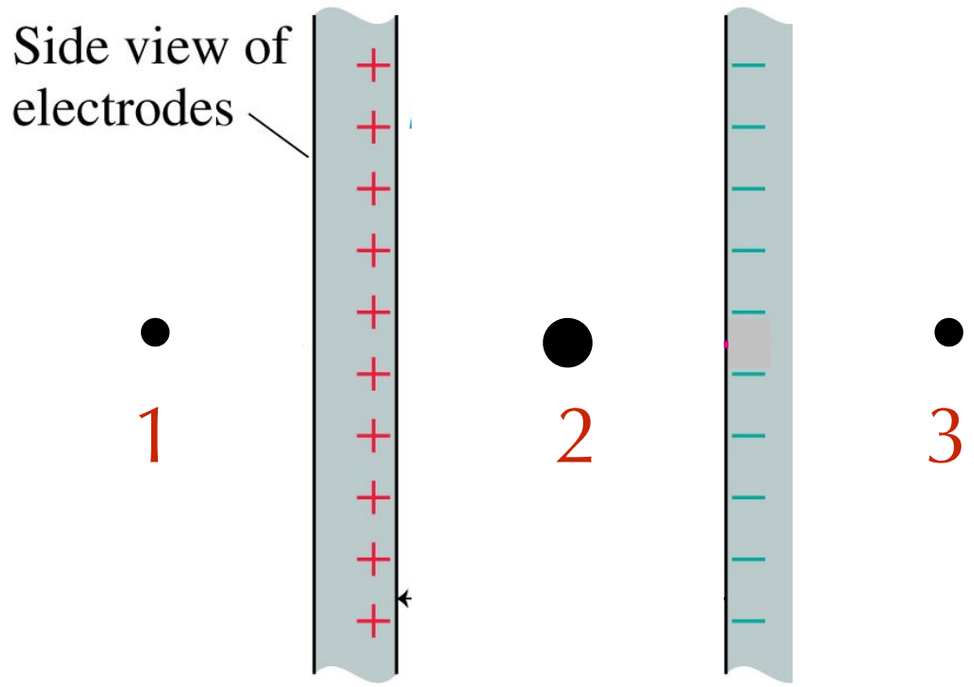
$$(1+x)^n \approx 1 + nx \quad (\text{if} \quad x \ll 1)$$

$$E_x = \frac{\eta}{2\epsilon_0}\left[1 - \frac{x}{R}\right]$$

Parallel Plate Capacitor

What is the direction and magnitude of the electric field at these points?





Point 1:

A $E = \frac{\eta}{\epsilon_0}$ to the right.

B $E = \frac{\eta}{\epsilon_0}$ to the left.

C $E = \frac{\eta}{2\epsilon_0}$ to the right.

D $E = \frac{\eta}{2\epsilon_0}$ to the left.

E $E = 0$

Point 2:

A $E = \frac{\eta}{\epsilon_0}$ to the right.

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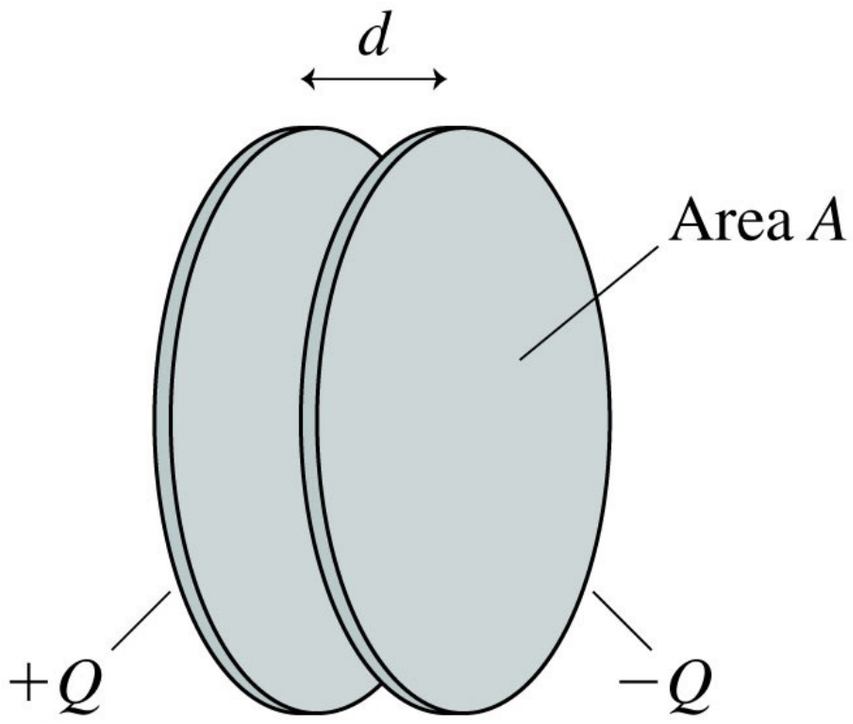

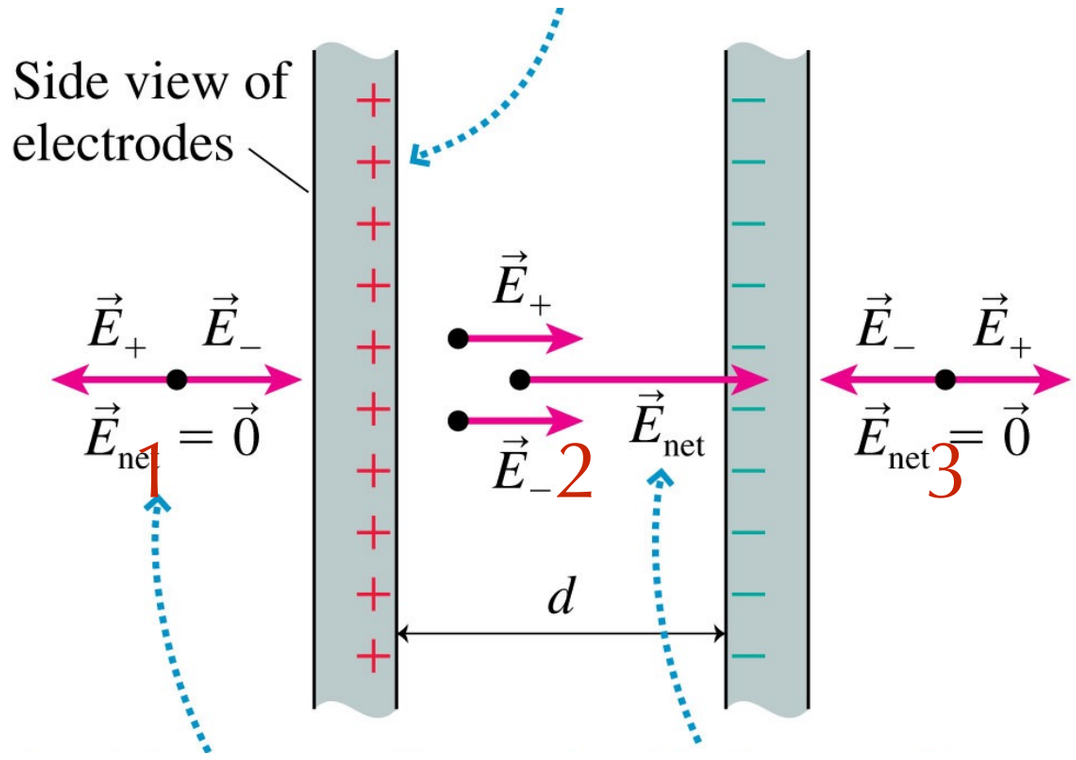

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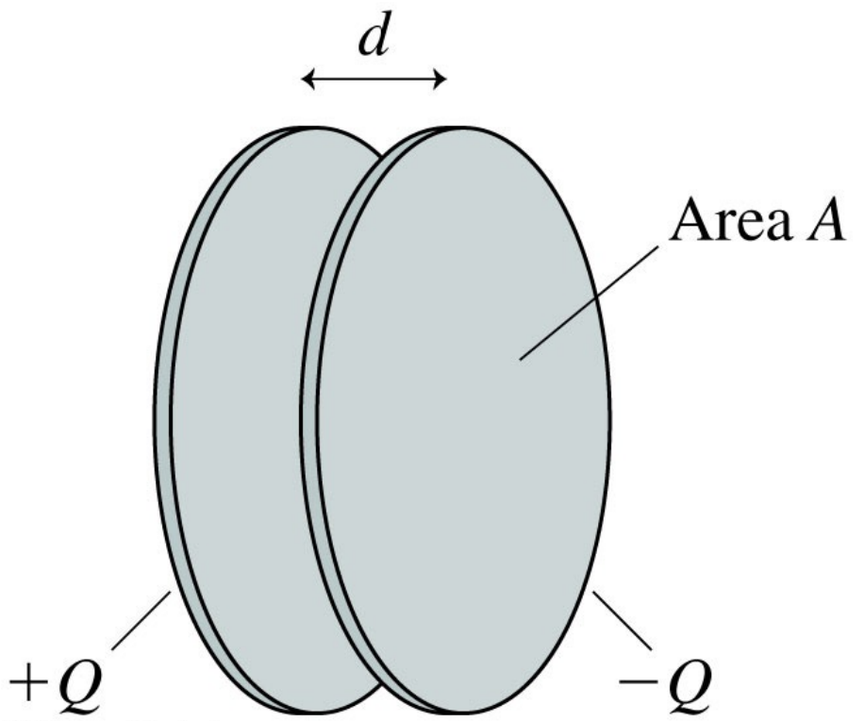

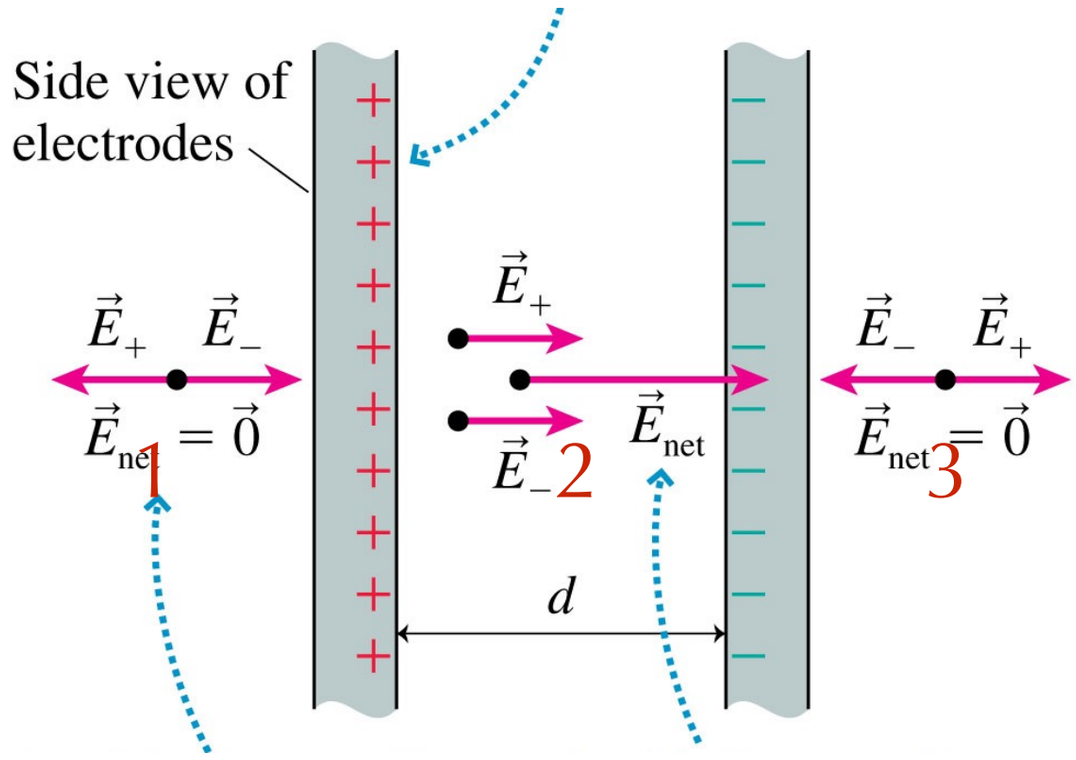

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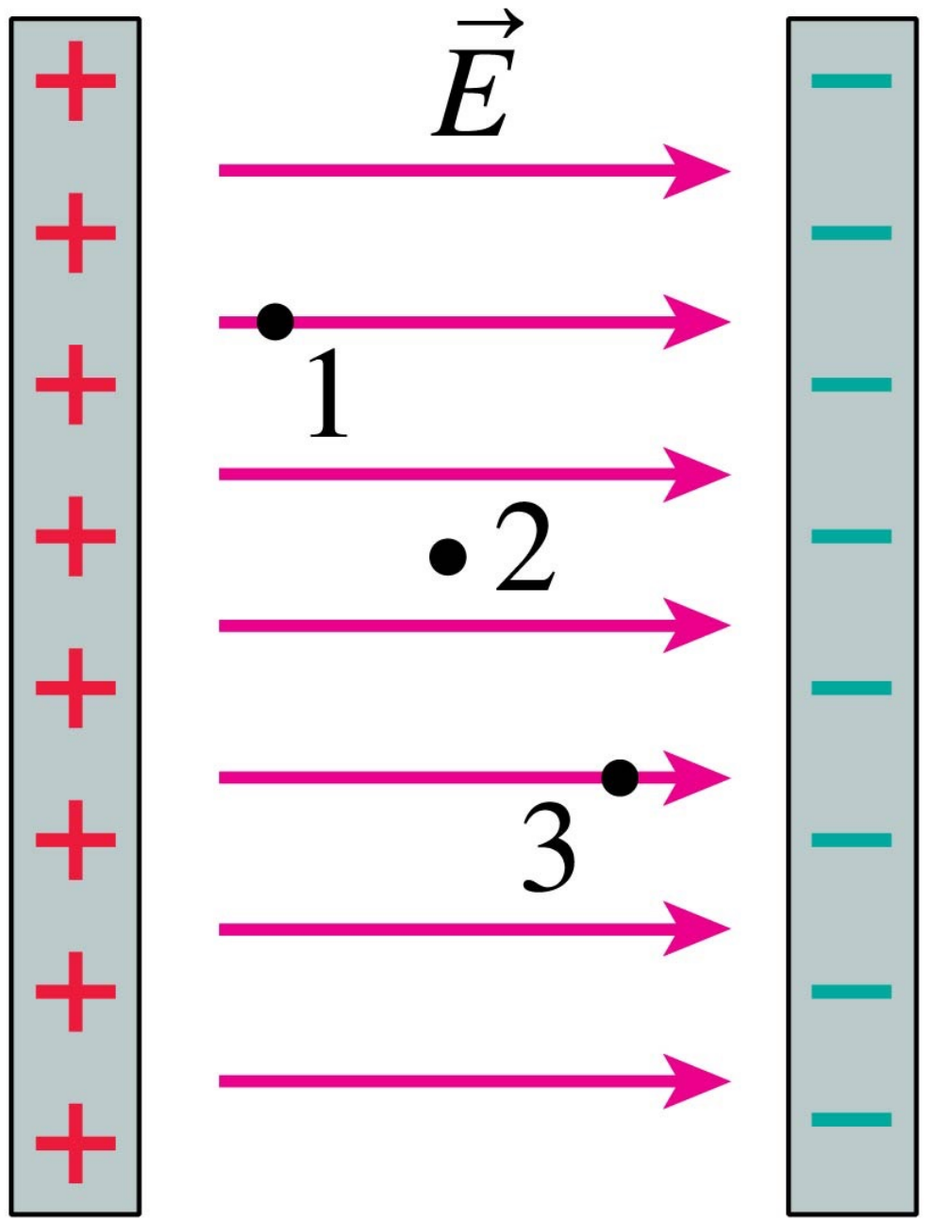
Quiz

Three points inside a parallel-plate capacitor are marked. Which is true?



A. $E_1 > E_2 > E_3$

B. $E_1 < E_2 < E_3$

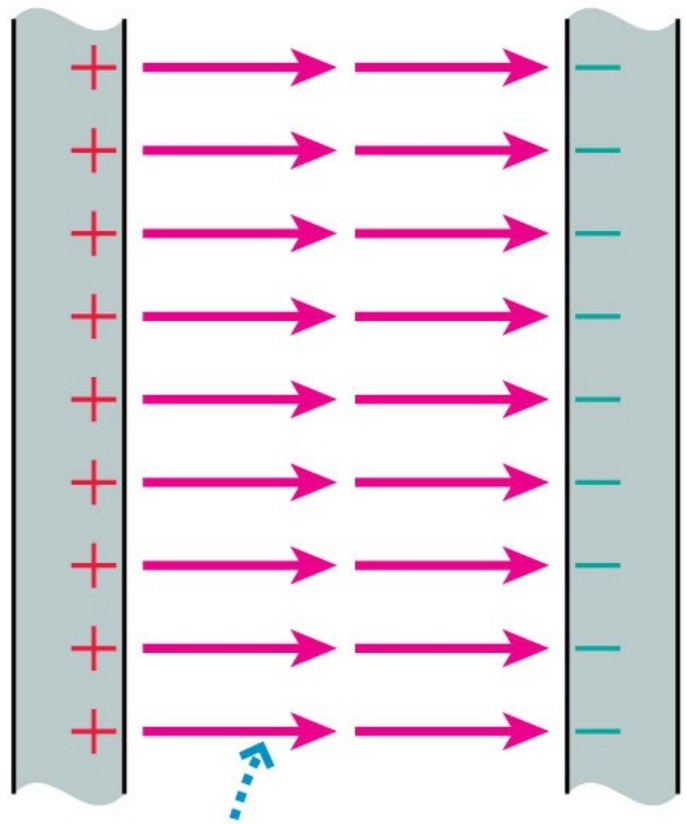
C. $E_1 = E_3 > E_2$

D. $E_1 = E_2 = E_3$

uniform field

Ideal capacitor

If d is much smaller than electrode size.



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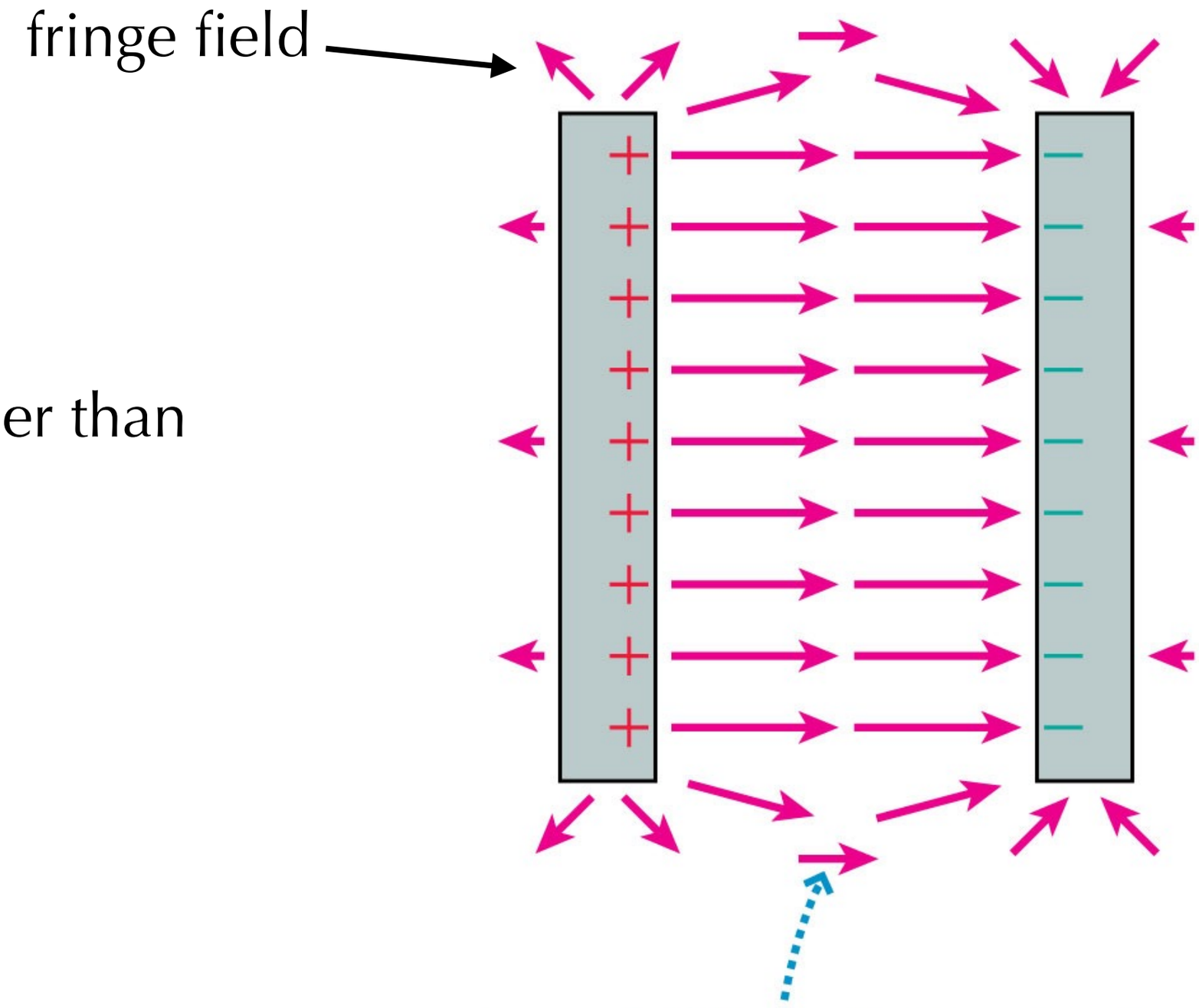
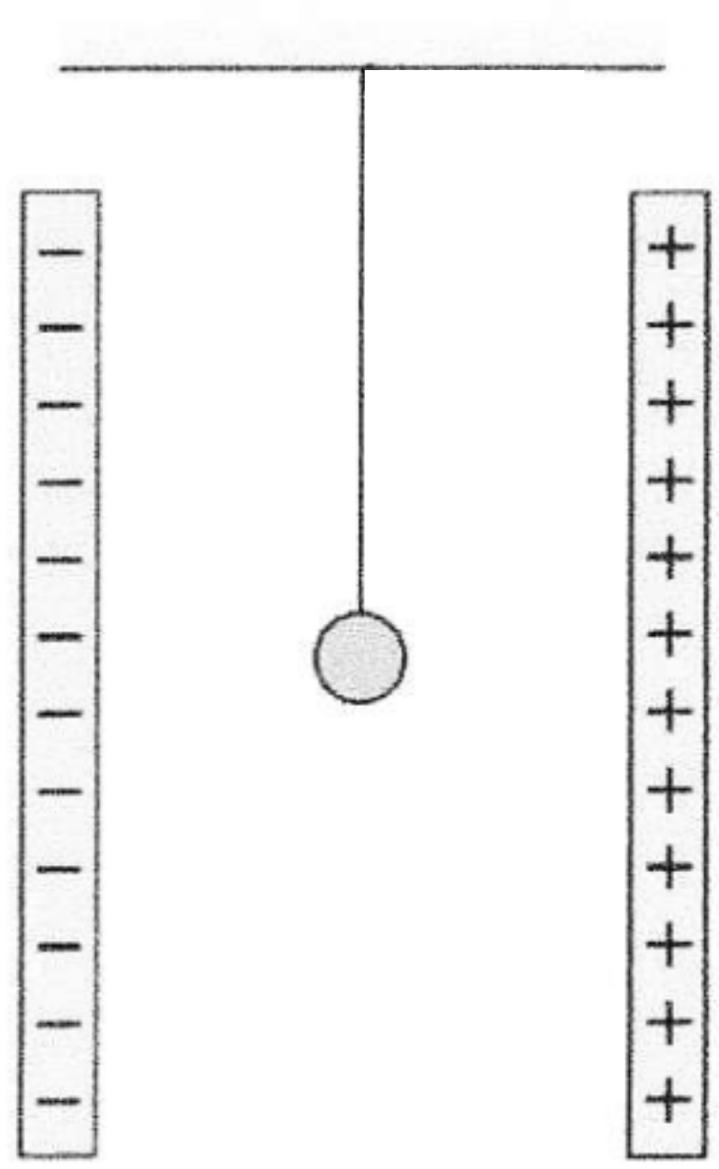


Quiz

If I place a negative charge on this ball, what will happen?

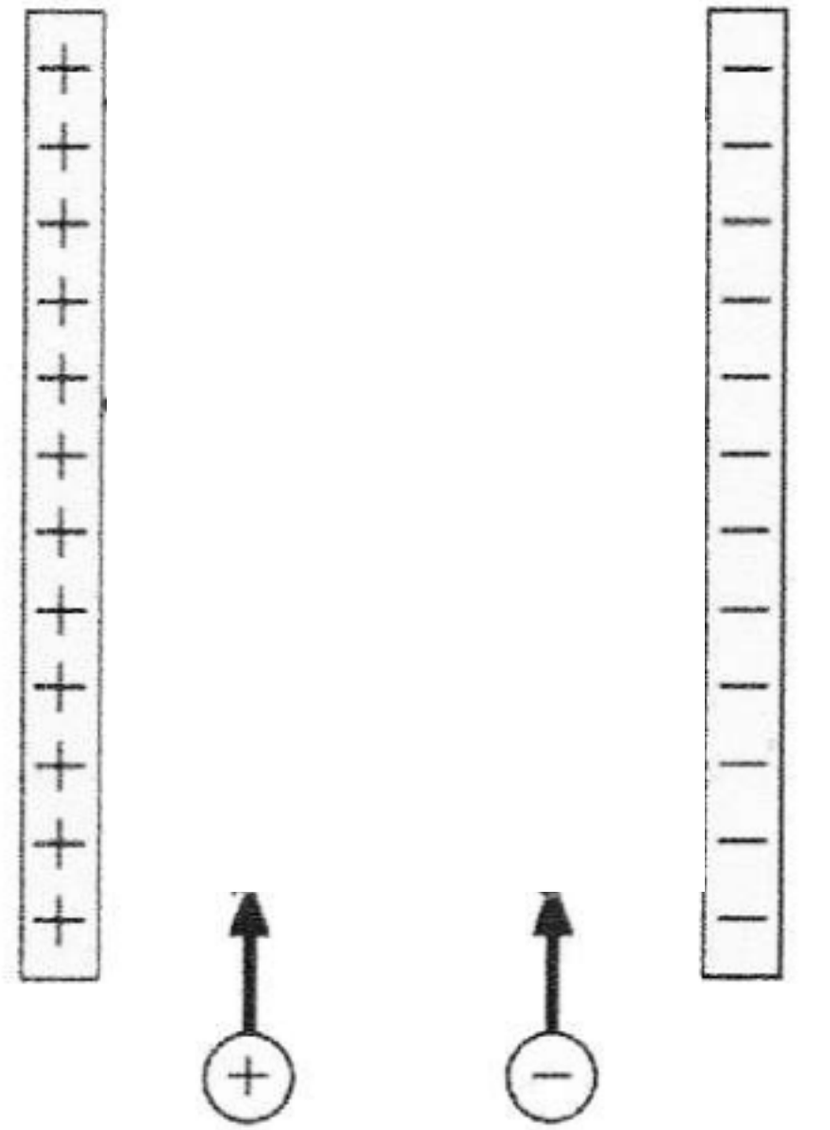
a) stays where its at.
b) swings to the left
c) swings to the right.



Quiz

What will the trajectories of the particles look like?

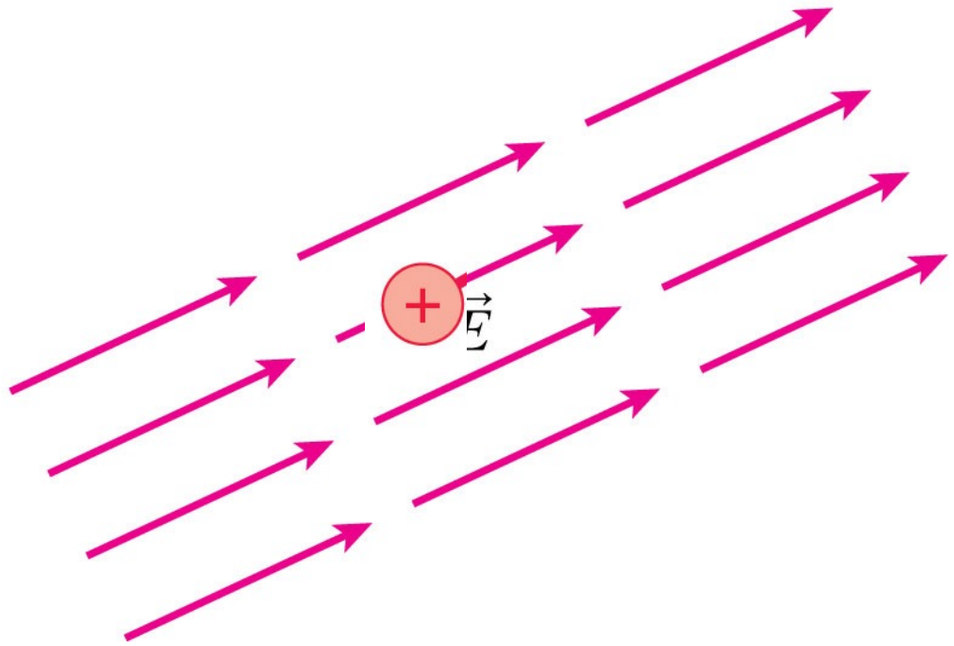
a) proton curves left, electron curves right.
b) proton moves straight, electron curves left
c) proton curves right, electron curves left.
d) electron moves straight, proton curves right.



Motion of a charged particle in uniform field

Draw the force vector on the proton.

Write an expression for the acceleration of this proton



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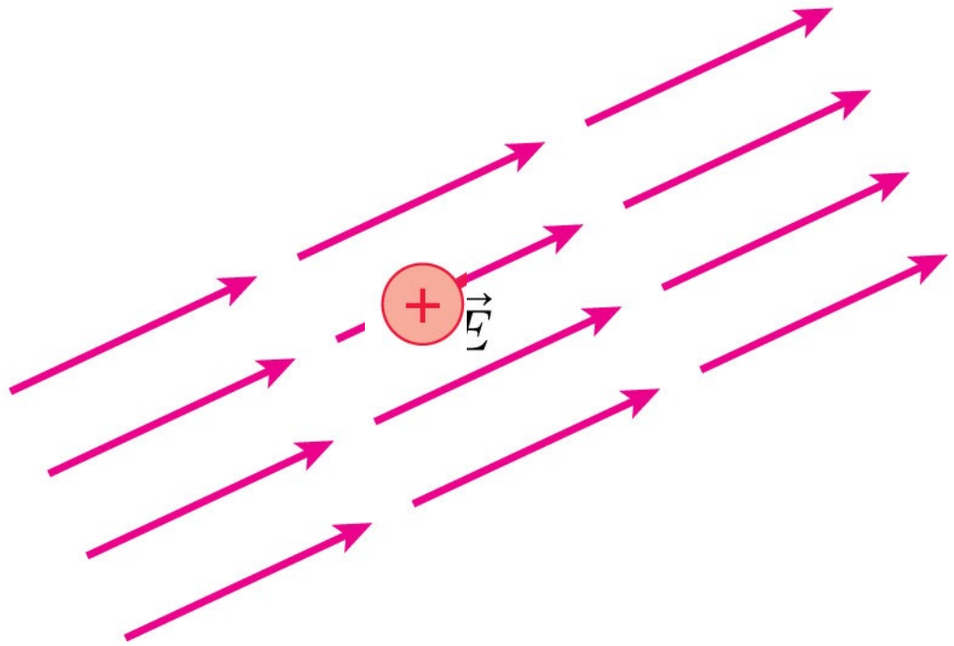

$$a = \frac{F}{m} = \frac{eE}{m}$$

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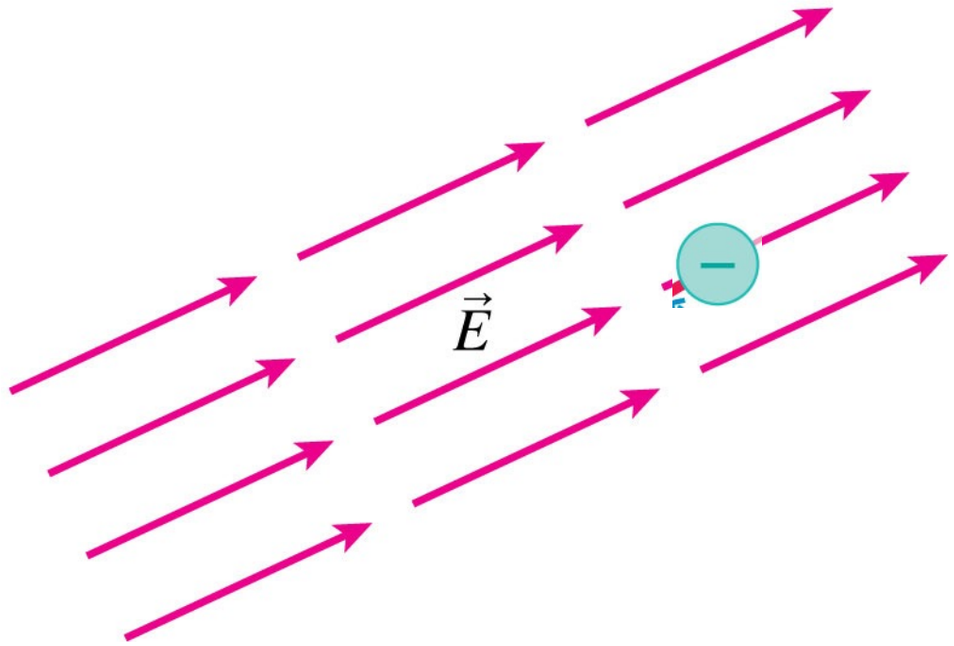
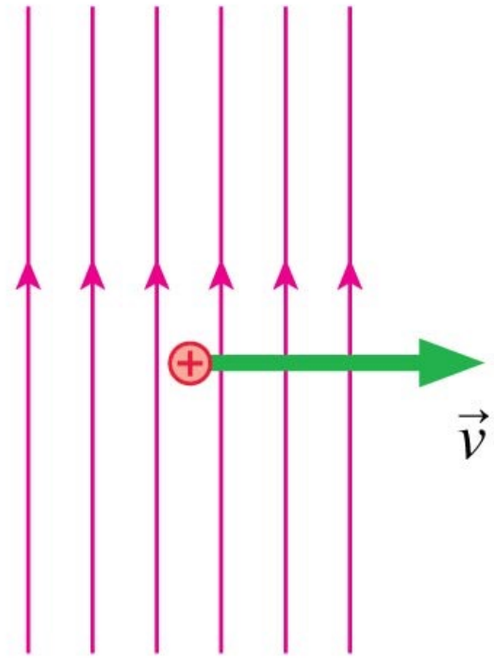


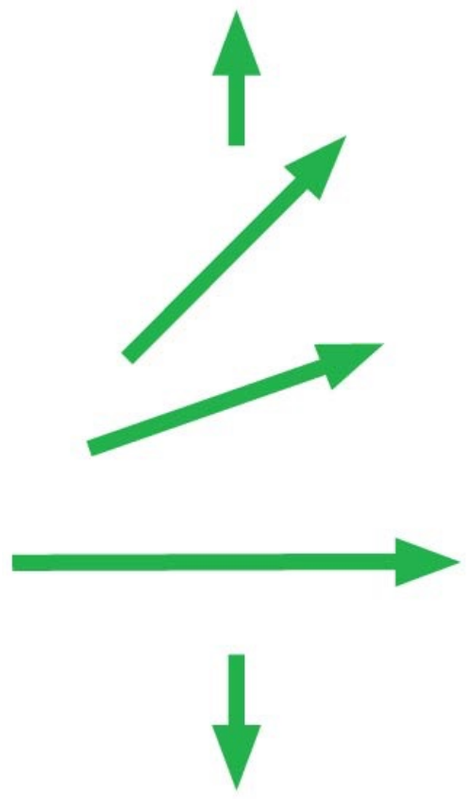
$$a = \frac{F}{m} = \frac{eE}{m}$$

Quiz

A proton is moving to the right in a vertical electric field. A very short time later, the proton's velocity is



A



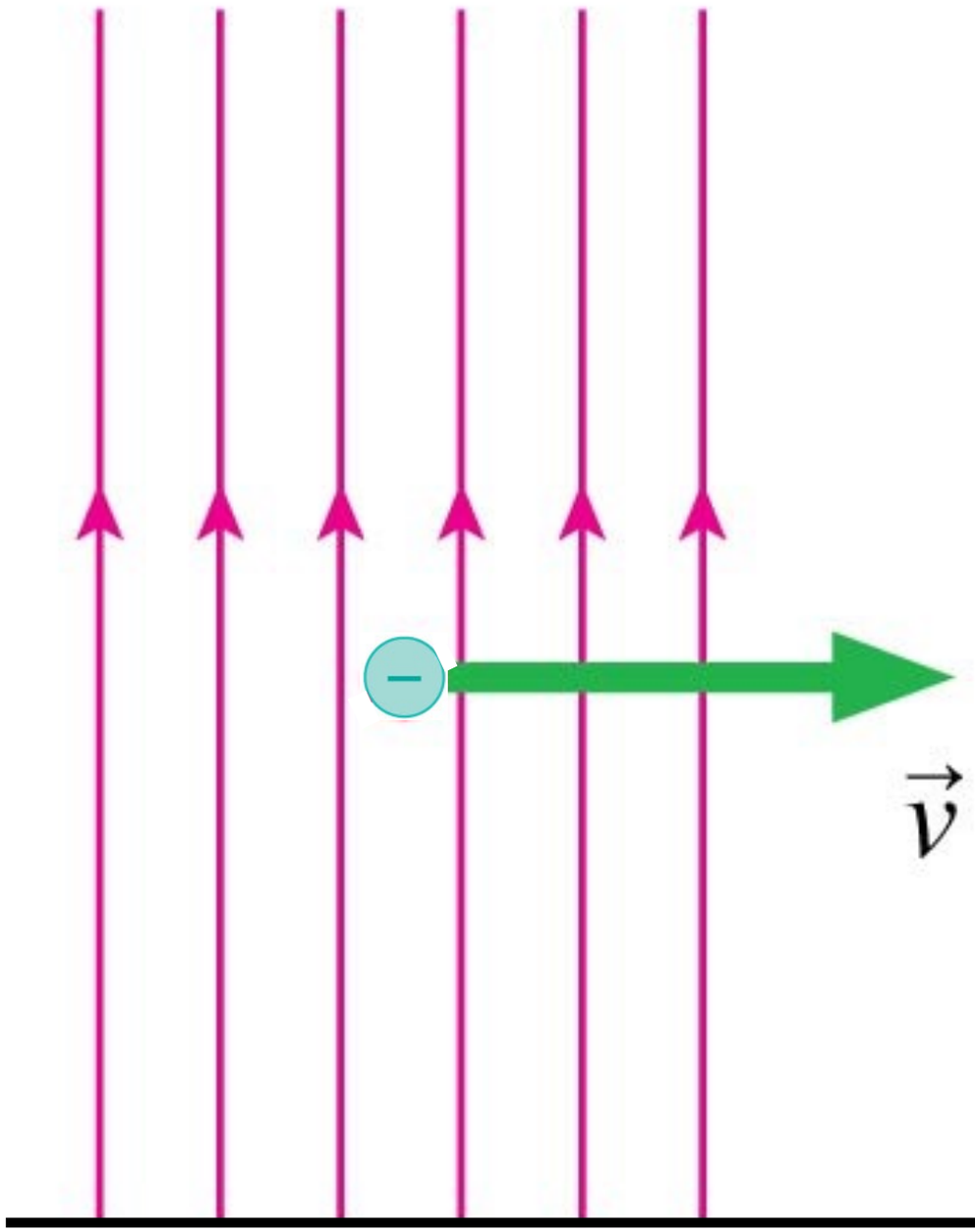
B

C

D

E

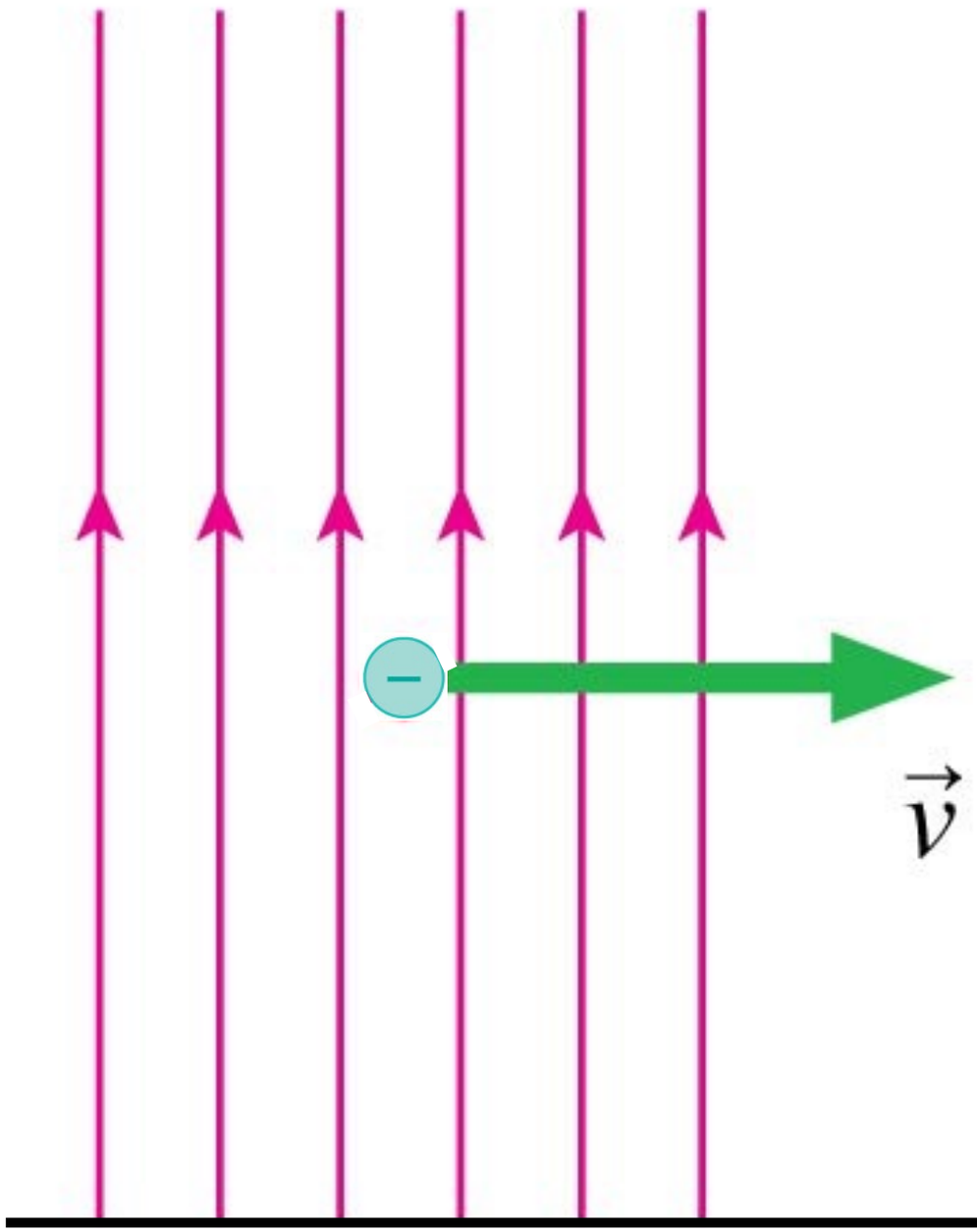
Homework-Style Problem



If the electron is fired horizontally, how far will it travel before hitting the bottom plate.

How long before it hits the bottom plate?

Homework-Style Problem



If the electron is fired horizontally, how far will it travel before hitting the bottom plate.

How long before it hits the bottom plate?

$$|\vec{E}| = 200,000 \text{ N/C}$$

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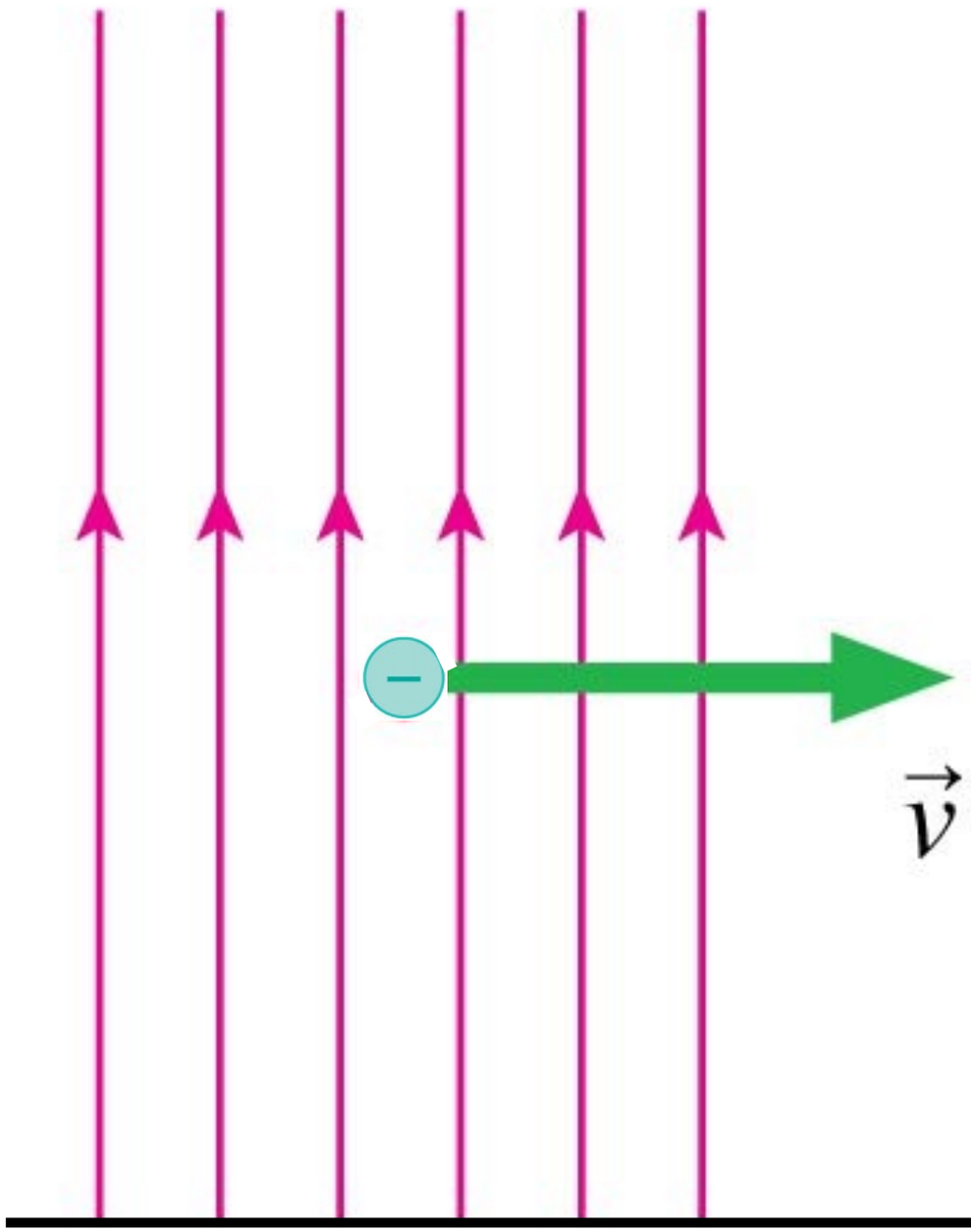

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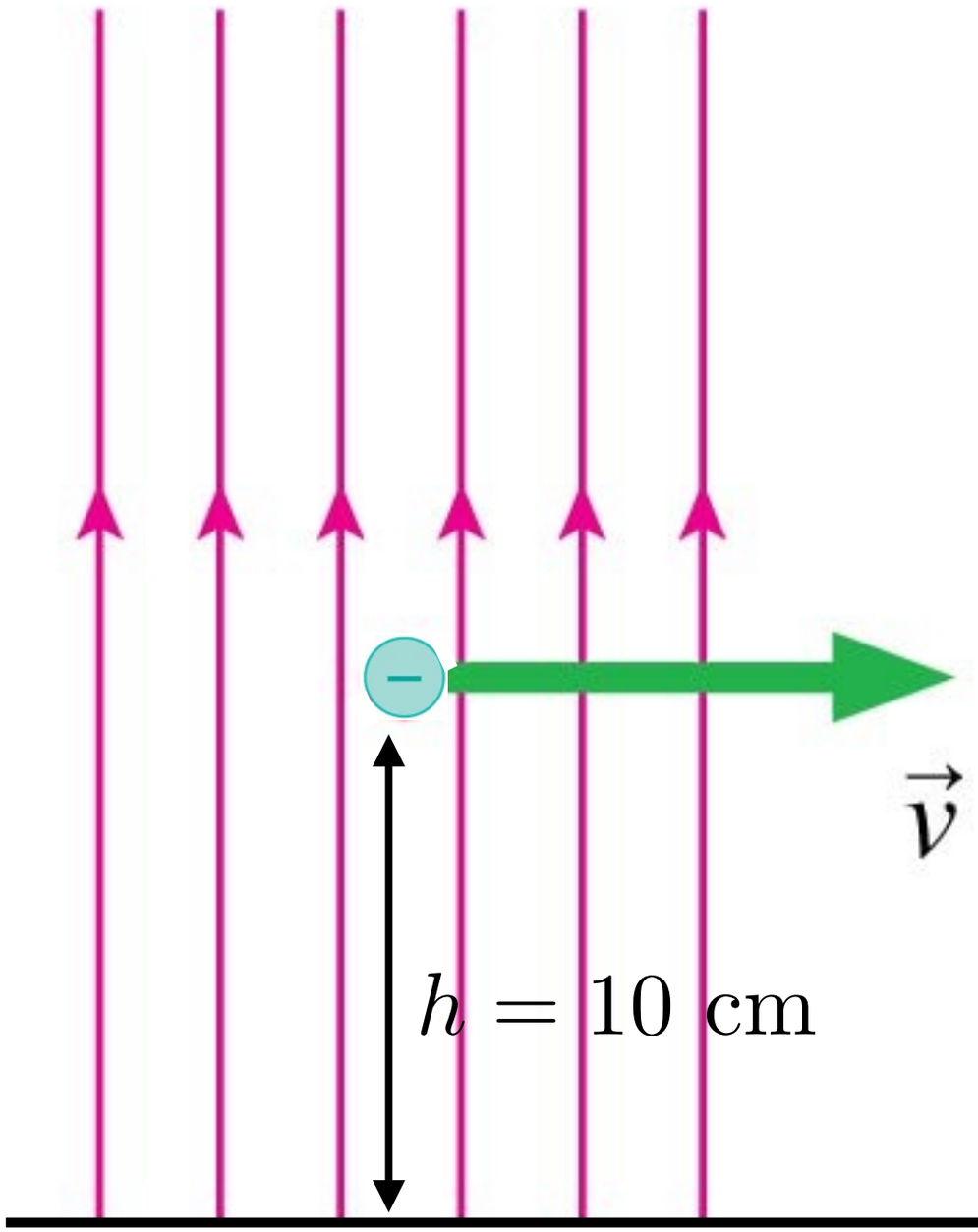
$$|\vec{E}| = 200,000 \text{ N/C}$$

$$v_i = 5000 \text{ m/s}$$

Homework-Style Problem



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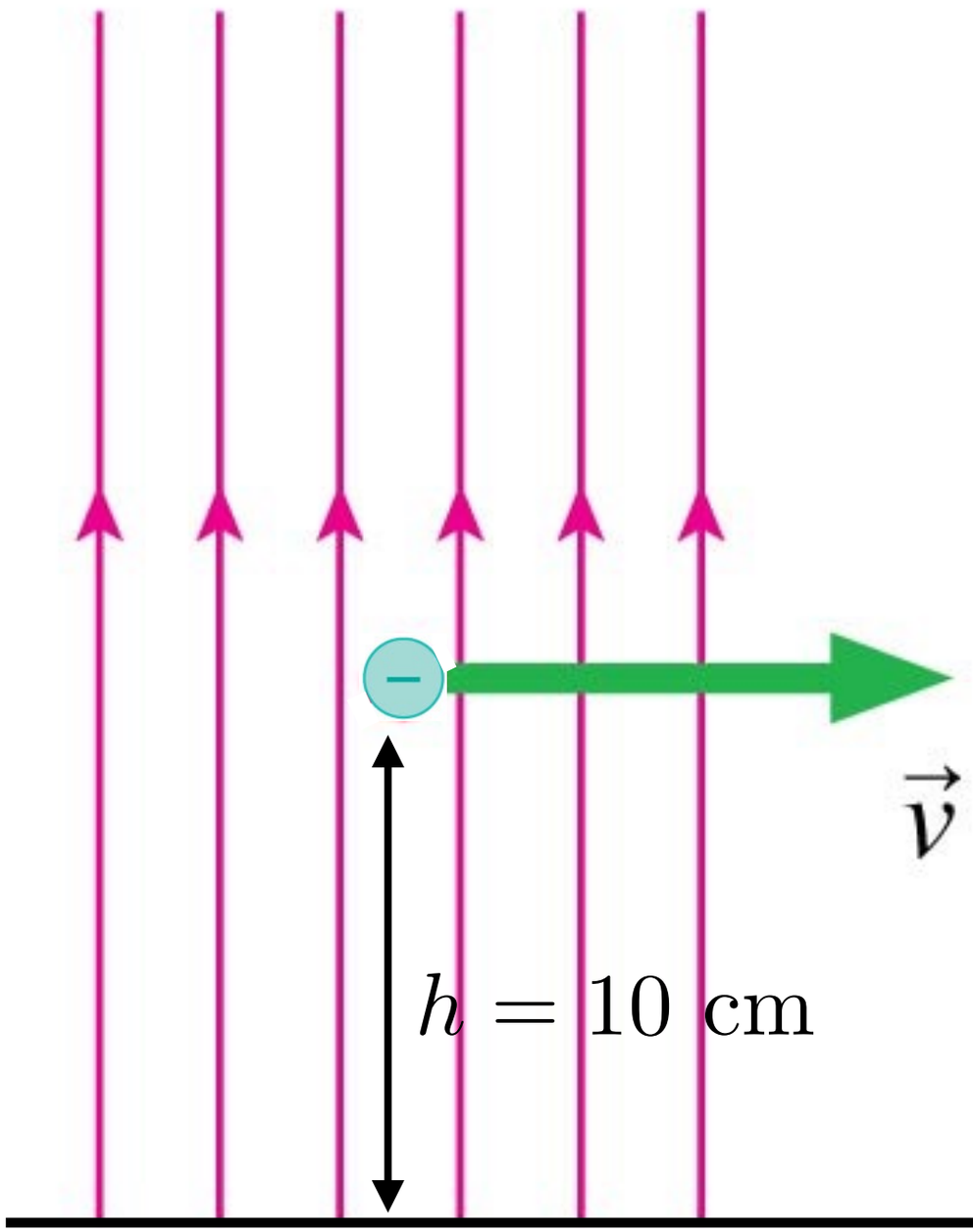

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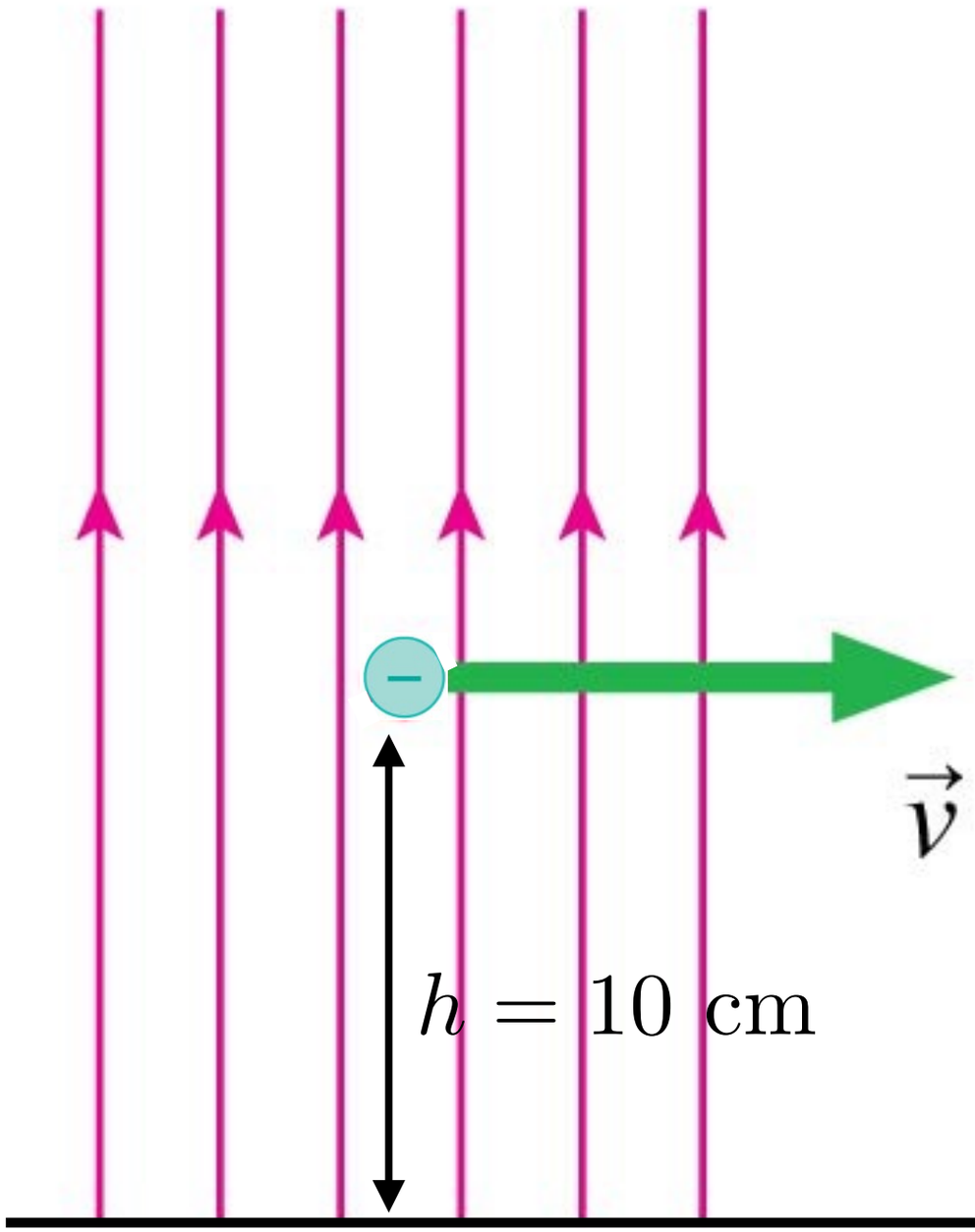
$v_i = 5000$ m/s

$\Delta t = 7.5 \times 10^{-8}$ s

Homework-Style Problem



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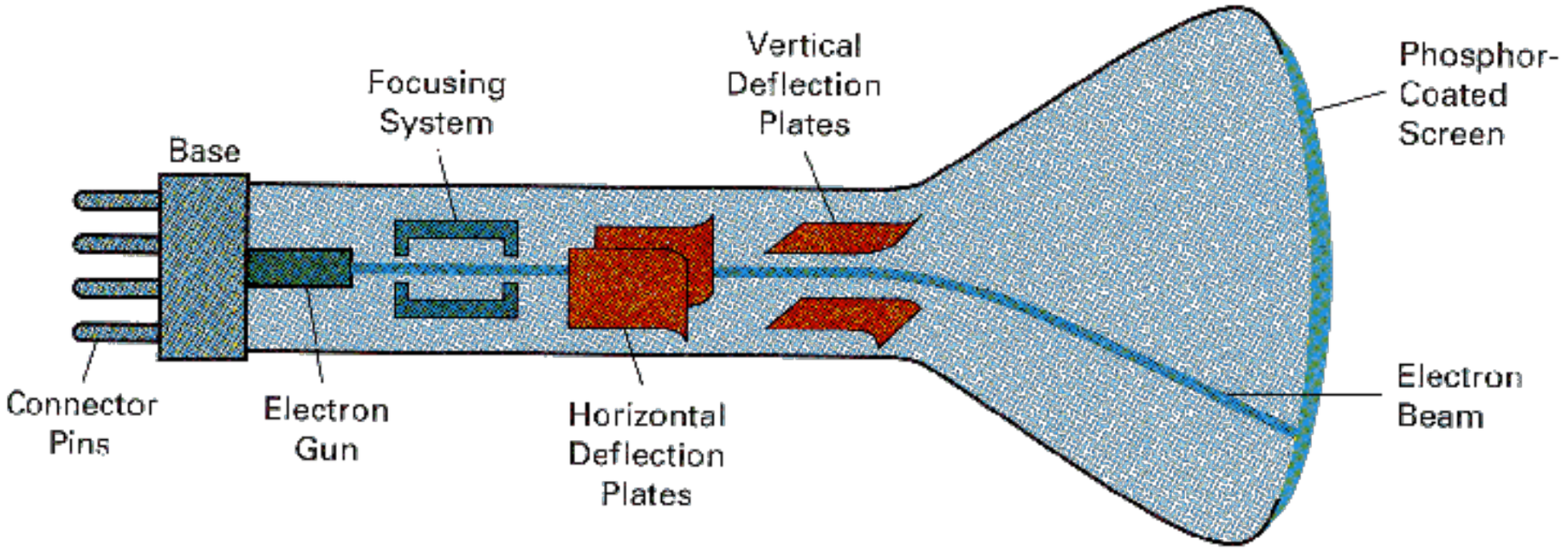
$|\vec{E}| = 200,000$ N/C

$v_i = 5000$ m/s

$\Delta t = 7.5 \times 10^{-8}$ s

$\Delta x = 3.8$ mm

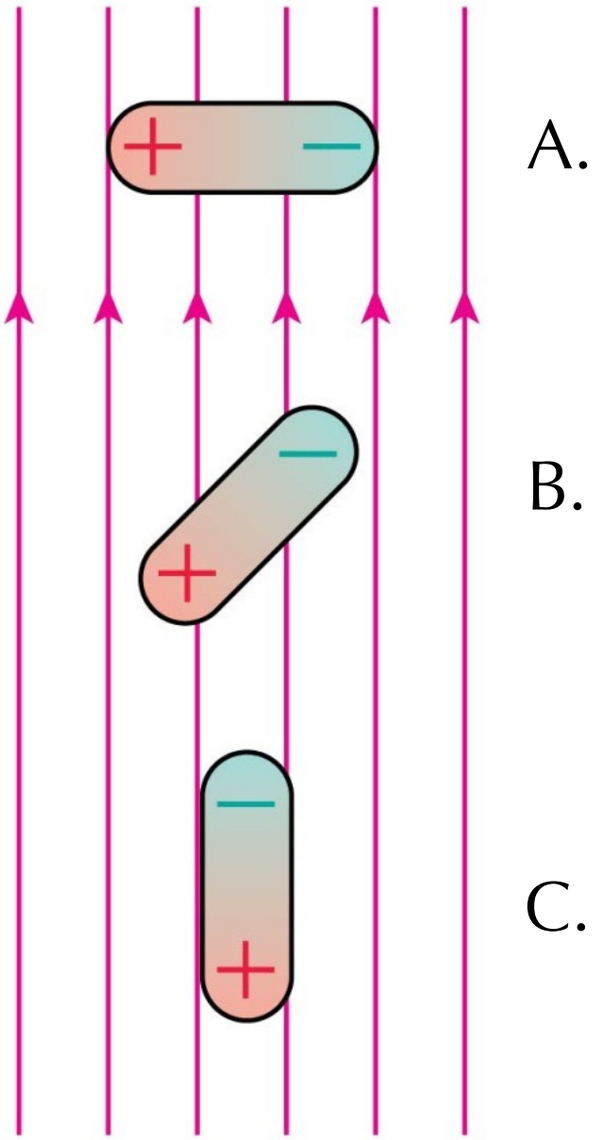
Cathode Ray Tube



Quiz

Which dipole experiences no net force in the electric field?

A. Dipole A.
B. Dipole B.
C. Dipole C.
D. Both dipoles A and C.
E. All three dipoles.



Quiz

Which dipole experiences no net torque in the electric field?

A. Dipole A.
B. Dipole B.
C. Dipole C.
D. Both dipoles A and C.
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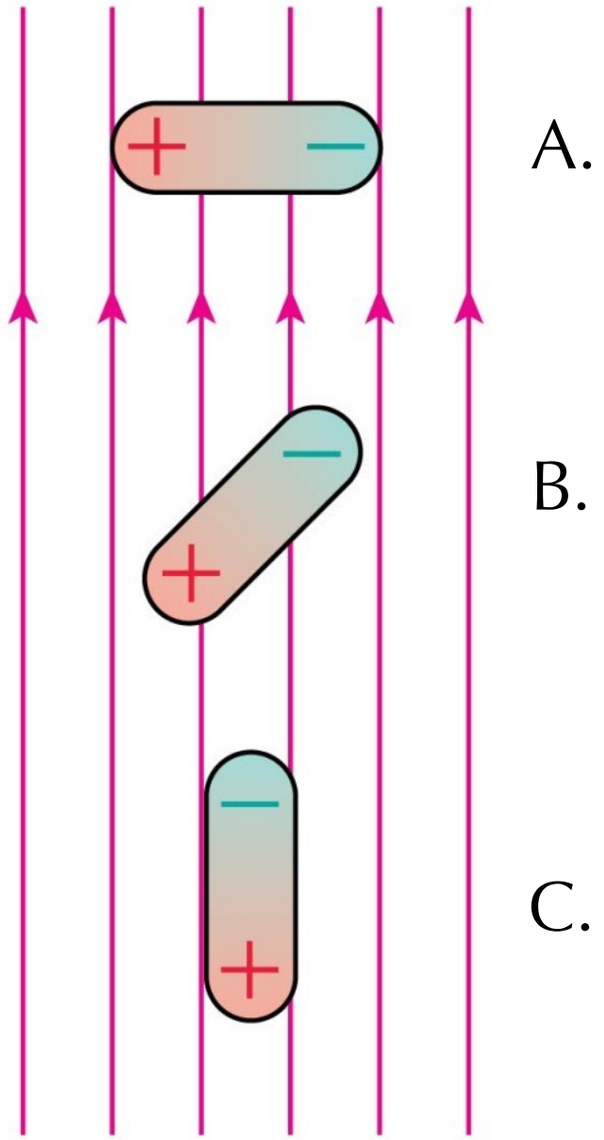
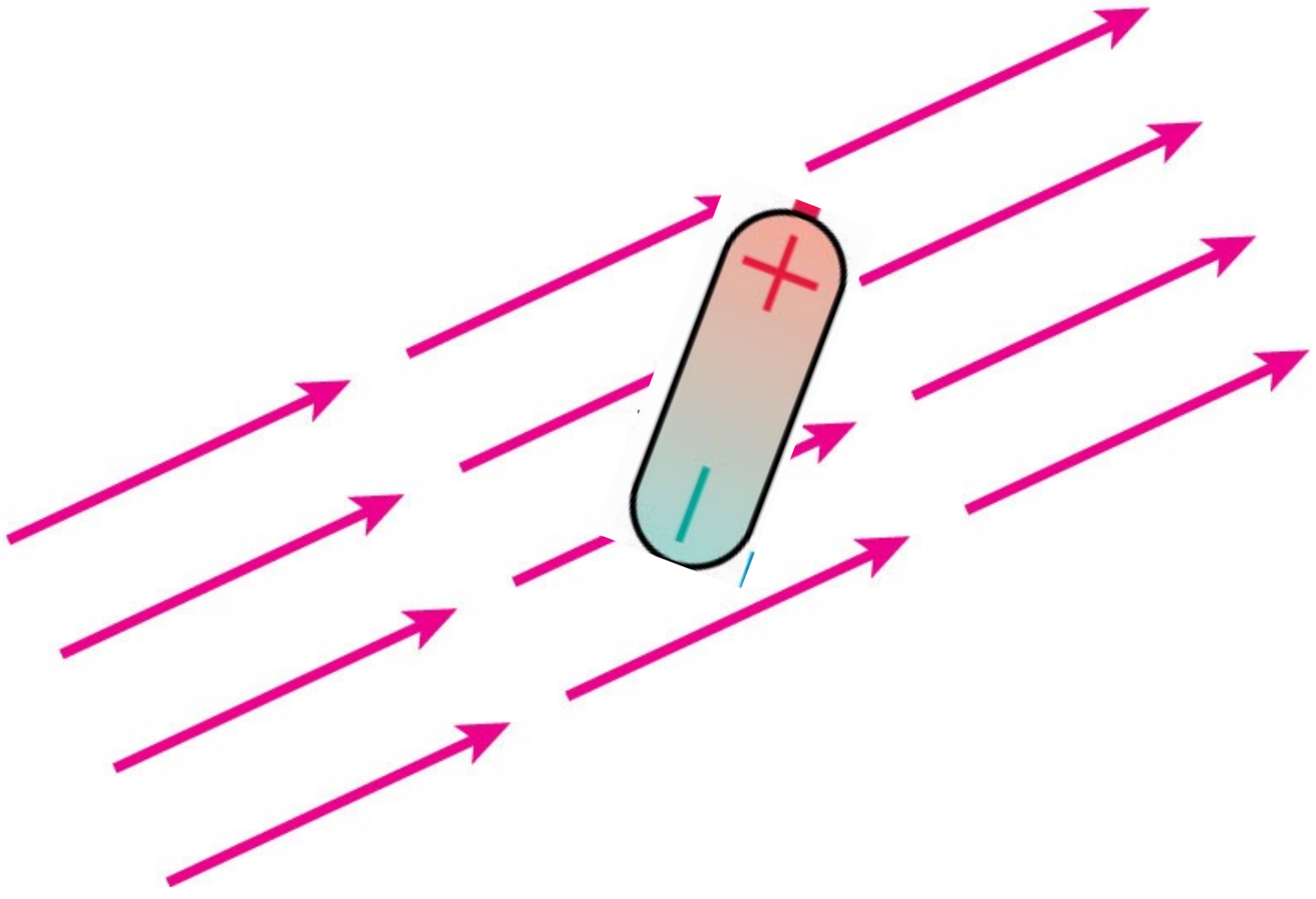


Dipoles in Uniform fields

What will happen to the dipole?



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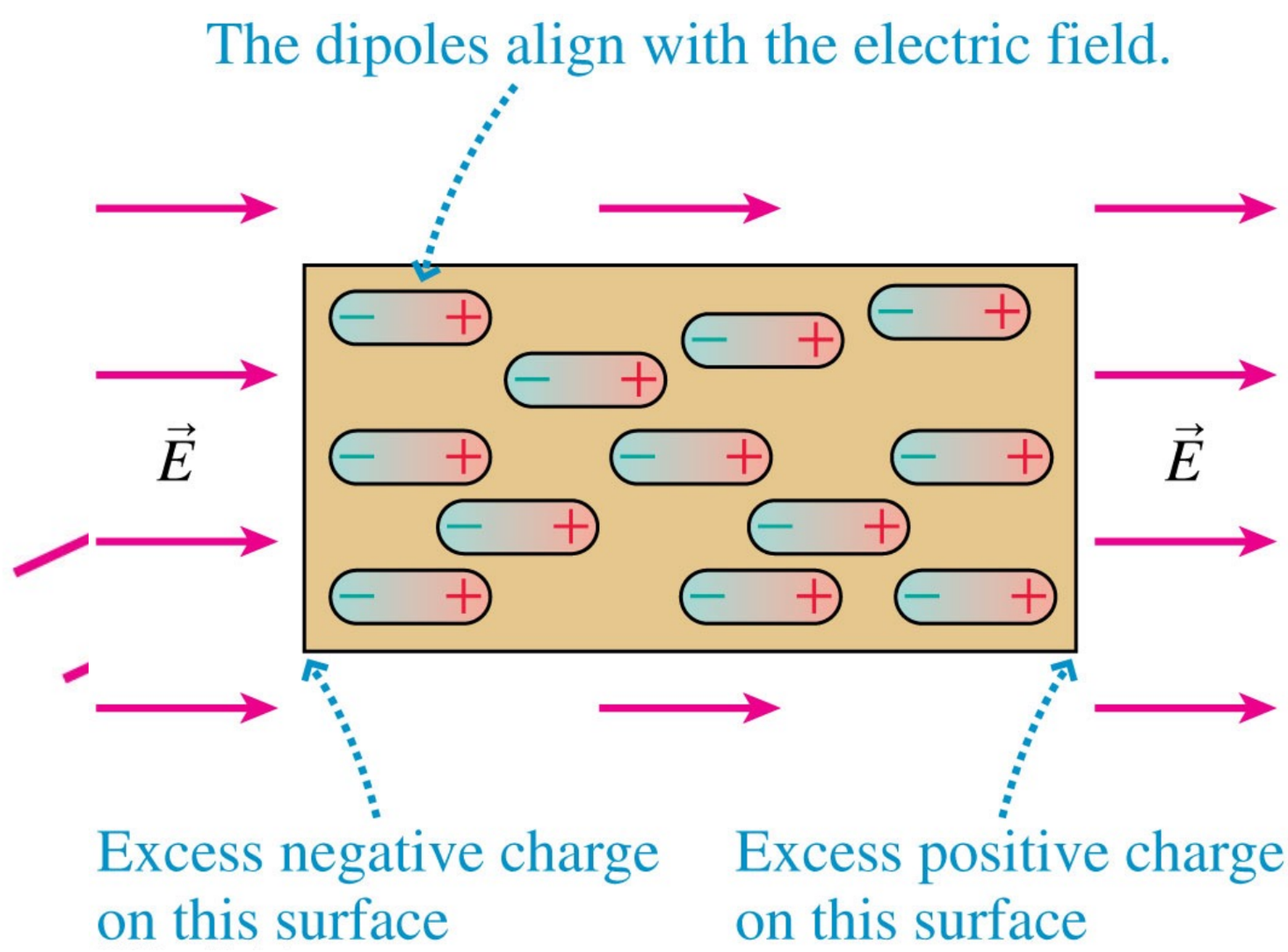
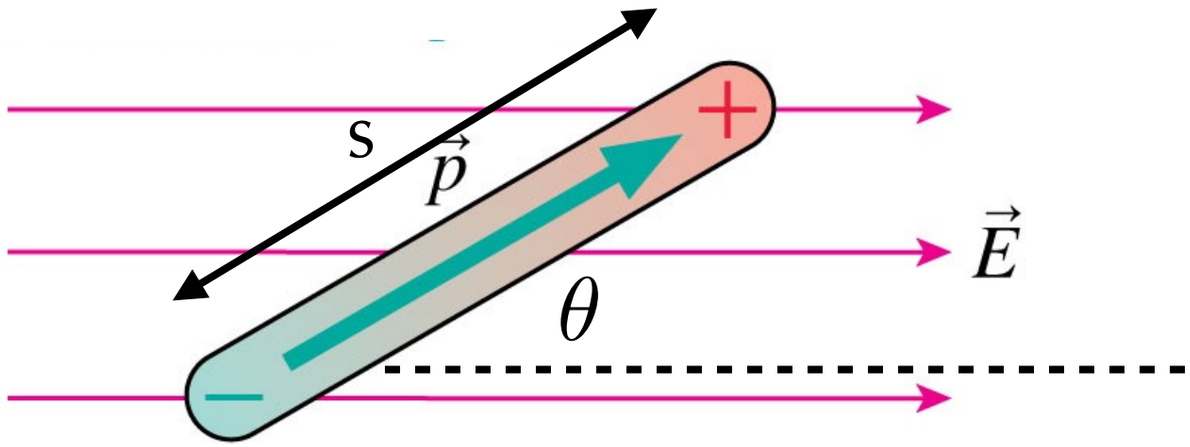
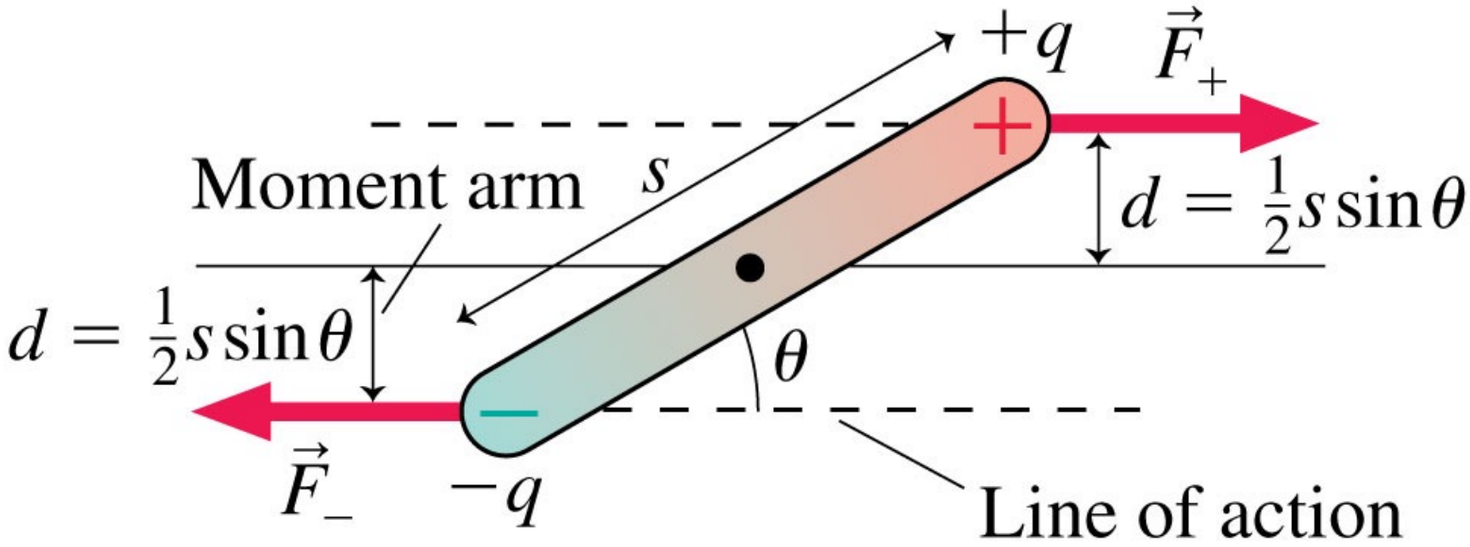


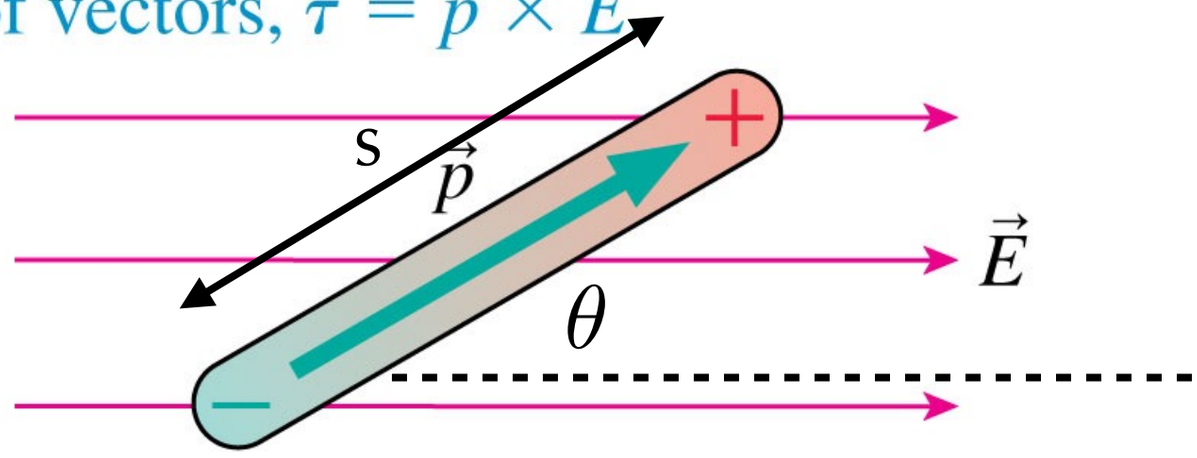
Write down an expression for the torque that this dipole experiences



Write down an expression for the torque that this dipole experiences



In terms of vectors, $\vec{\tau} = \vec{p} \times \vec{E}$



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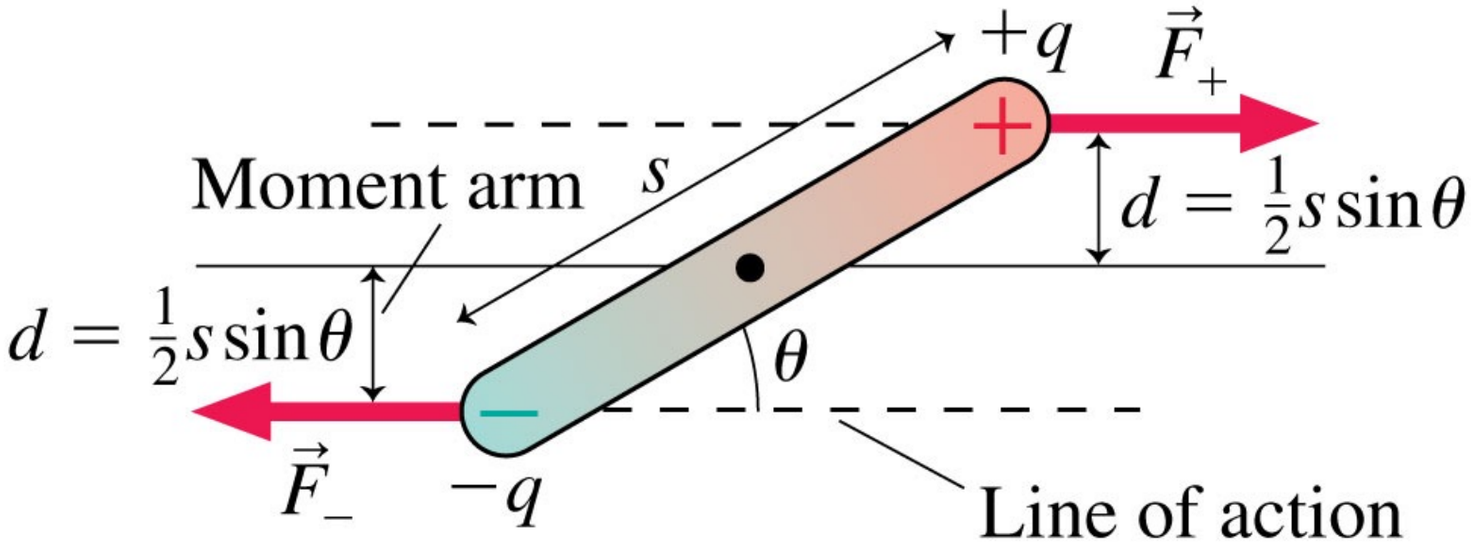

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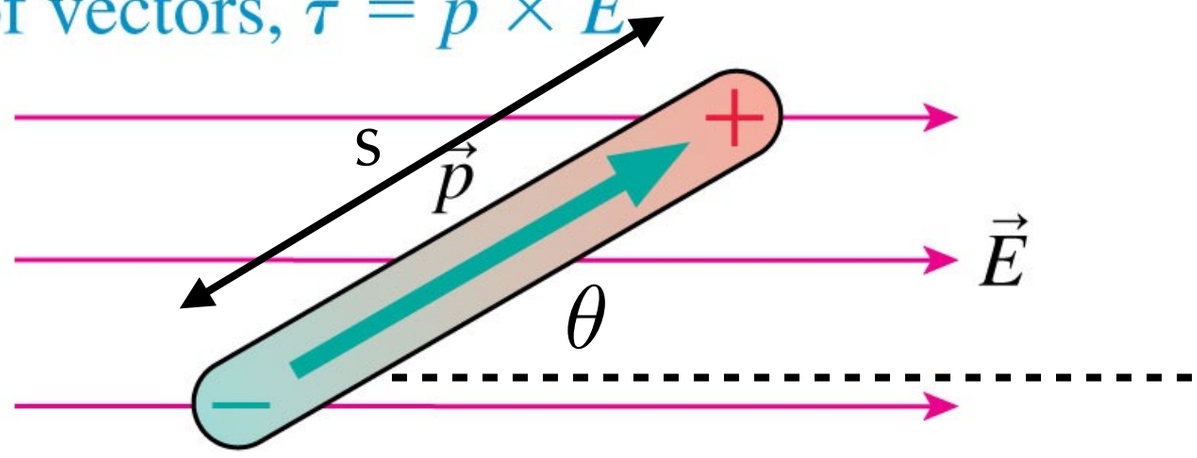
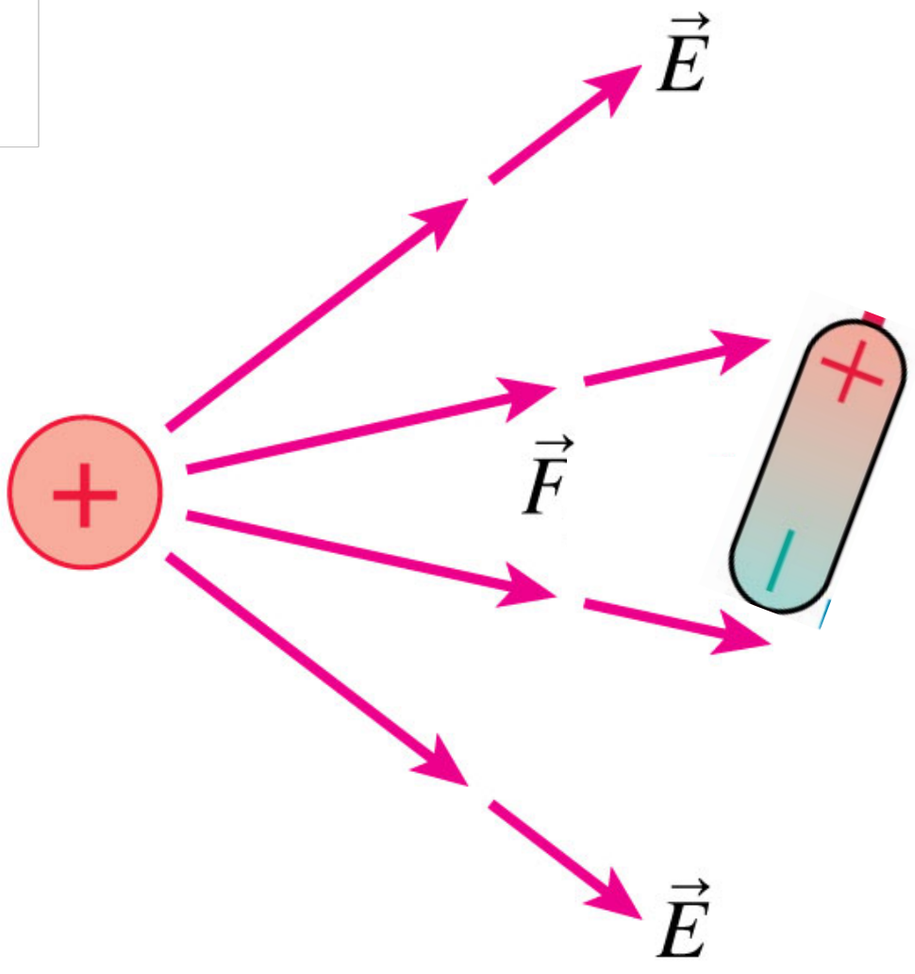


$$\tau = 2 \times dF_+ = 2(\tfrac{1}{2}s\sin\theta)(qE) = pE\sin\theta$$

Dipole in nonuniform field

A dipole is placed near a positive point charge.
Describe the motion of the dipole.



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