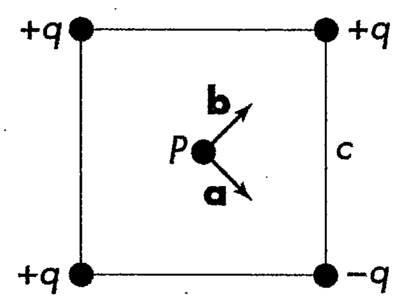
Lecture # 4

Electric Field Lines

PhysiQuiz 23-1



The diagram here shows a square with charges as marked located at the vertices. What is the direction of the electric field at *P*, the center of the square? Assume the magnitudes of all charges are the same.

A	B	C	D
+a	**−a**	**+b**	**−b**

Extra: Show that the magnitude of the electric field at *P* is $E = 4kq/c^2$, where *c* is the side of the square.

(9)

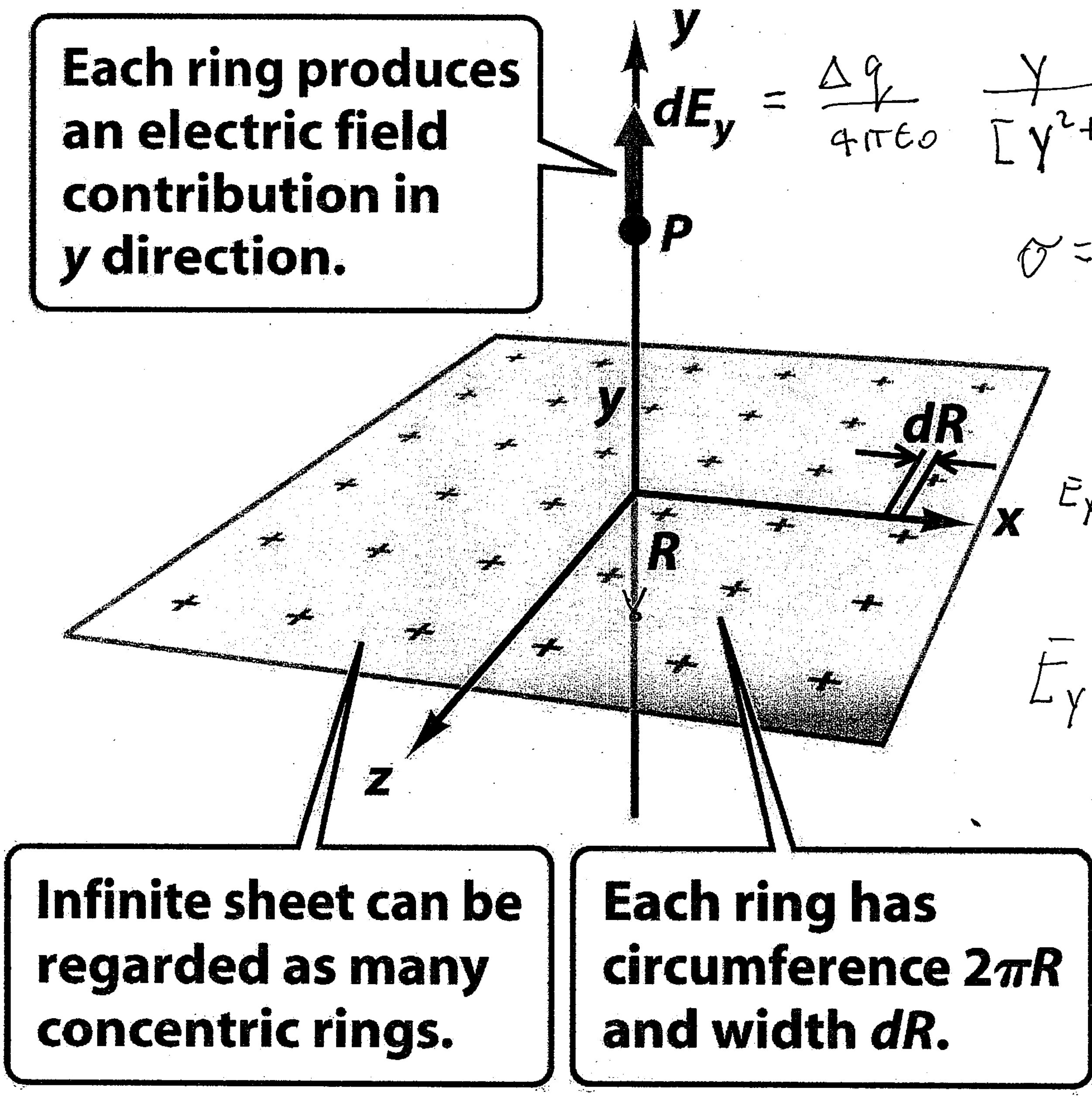


Figure 23-9 Physics for Engineers and Scientists 3/e

$$dE_y = \frac{\Delta q}{4\pi\epsilon_0} \frac{y}{[y^2+R^2]^{3/2}}$$

$$\sigma = \frac{Q}{A} = \frac{\Delta Q}{2\pi R \Delta R}$$

$$\Delta q = \sigma \Delta A = \sigma 2\pi R \Delta R$$

$$E_y = \int dE_y = \int_0^\infty \frac{\sigma 2\pi R dR\, y}{4\pi\epsilon_0 [y^2+R^2]^{3/2}}$$

$\therefore$

$$E_y = \frac{\sigma}{2\epsilon_0}$$

we used

$$I = \int_0^\infty \frac{dR\, R\, y}{[y^2+R^2]^{3/2}}$$

let $z = R/y$, then

$$I = \int_0^\infty \frac{dz\, z}{[z^2+1]^{3/2}} = \left. \frac{-1}{(z^2+1)^{1/2}} \right|_0^\infty = 1$$

(1)

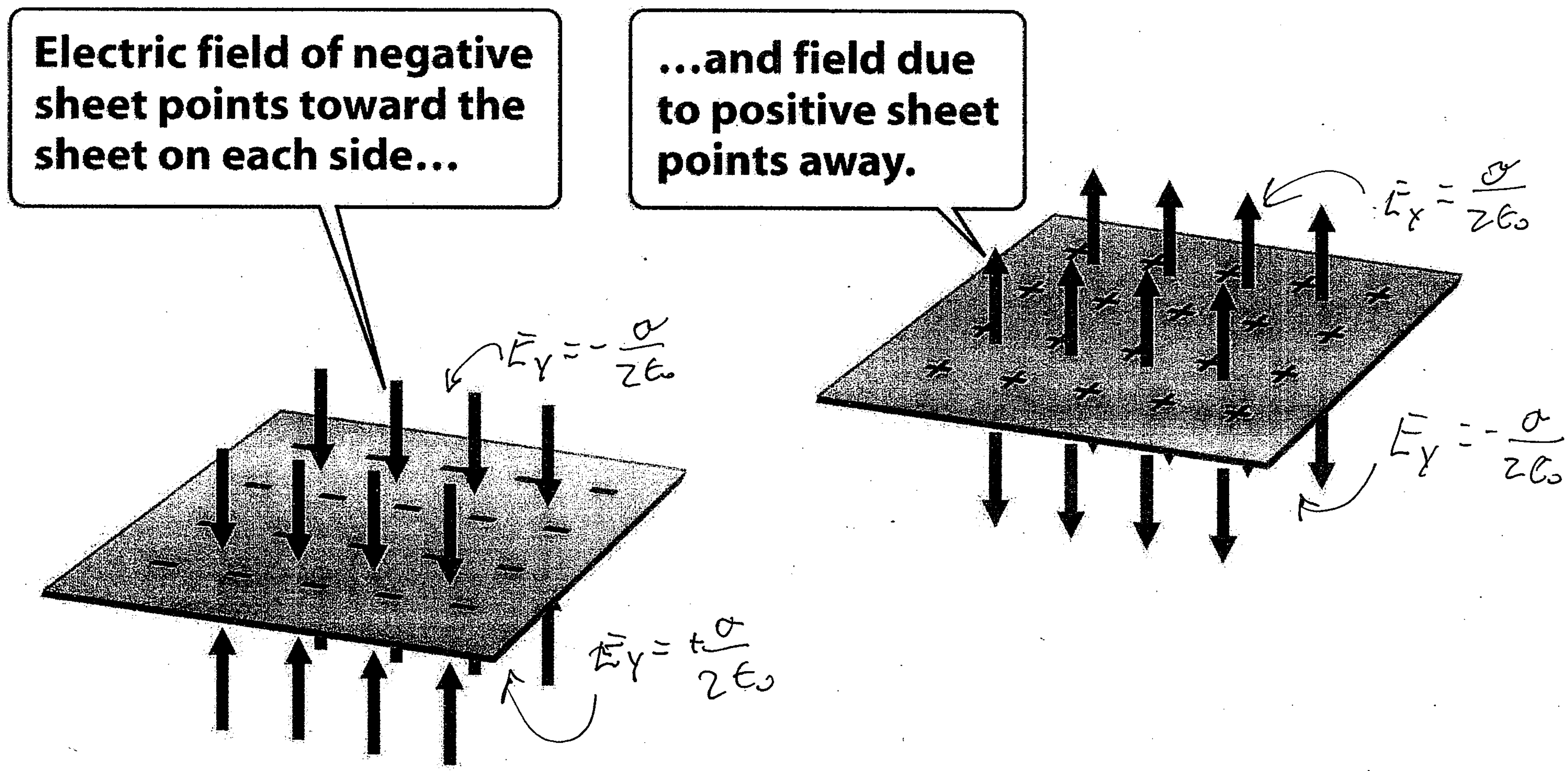


Figure 23-10a Physics for Engineers and Scientists 3/e

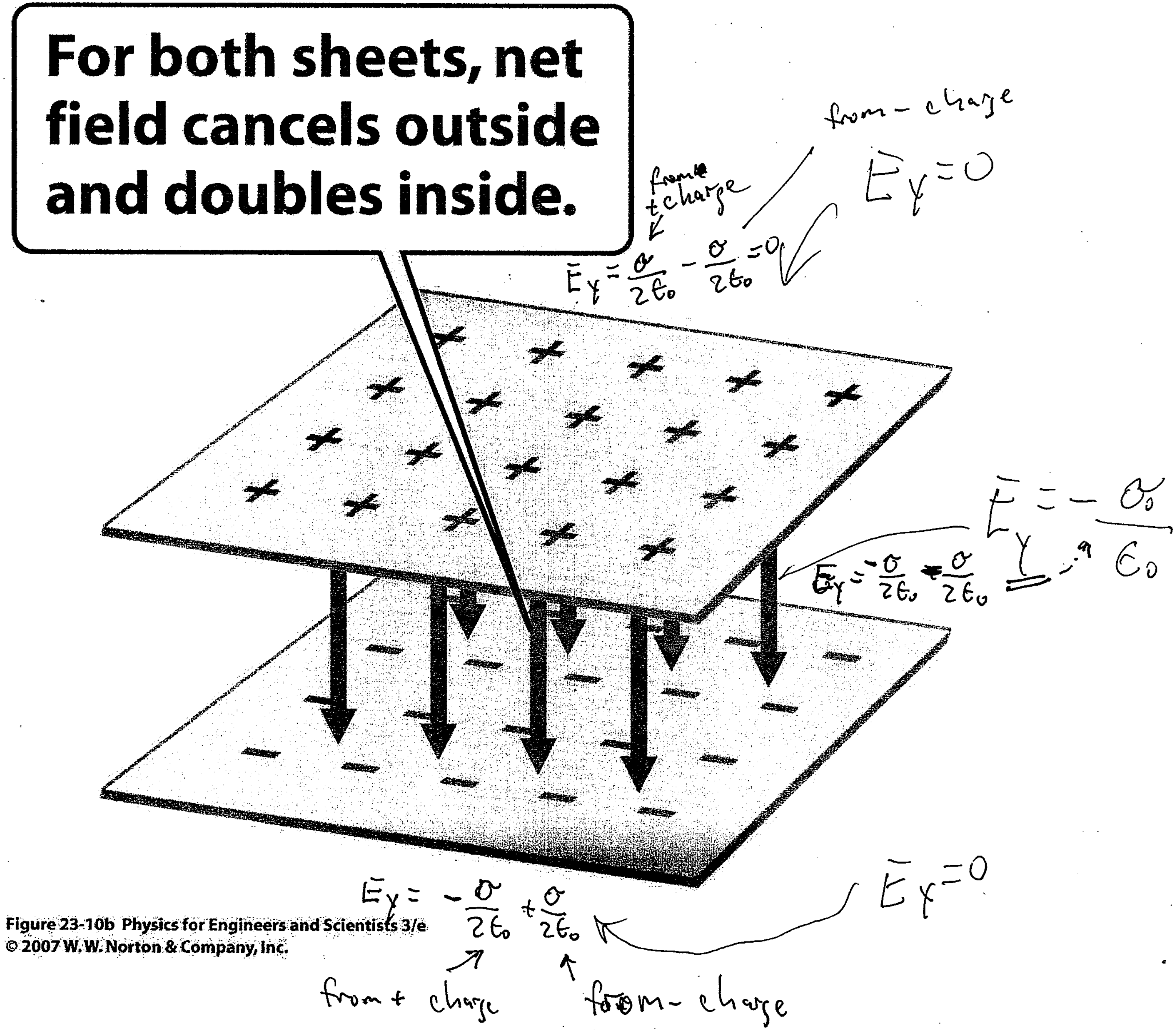


Figure 23-10b Physics for Engineers and Scientists 3/e

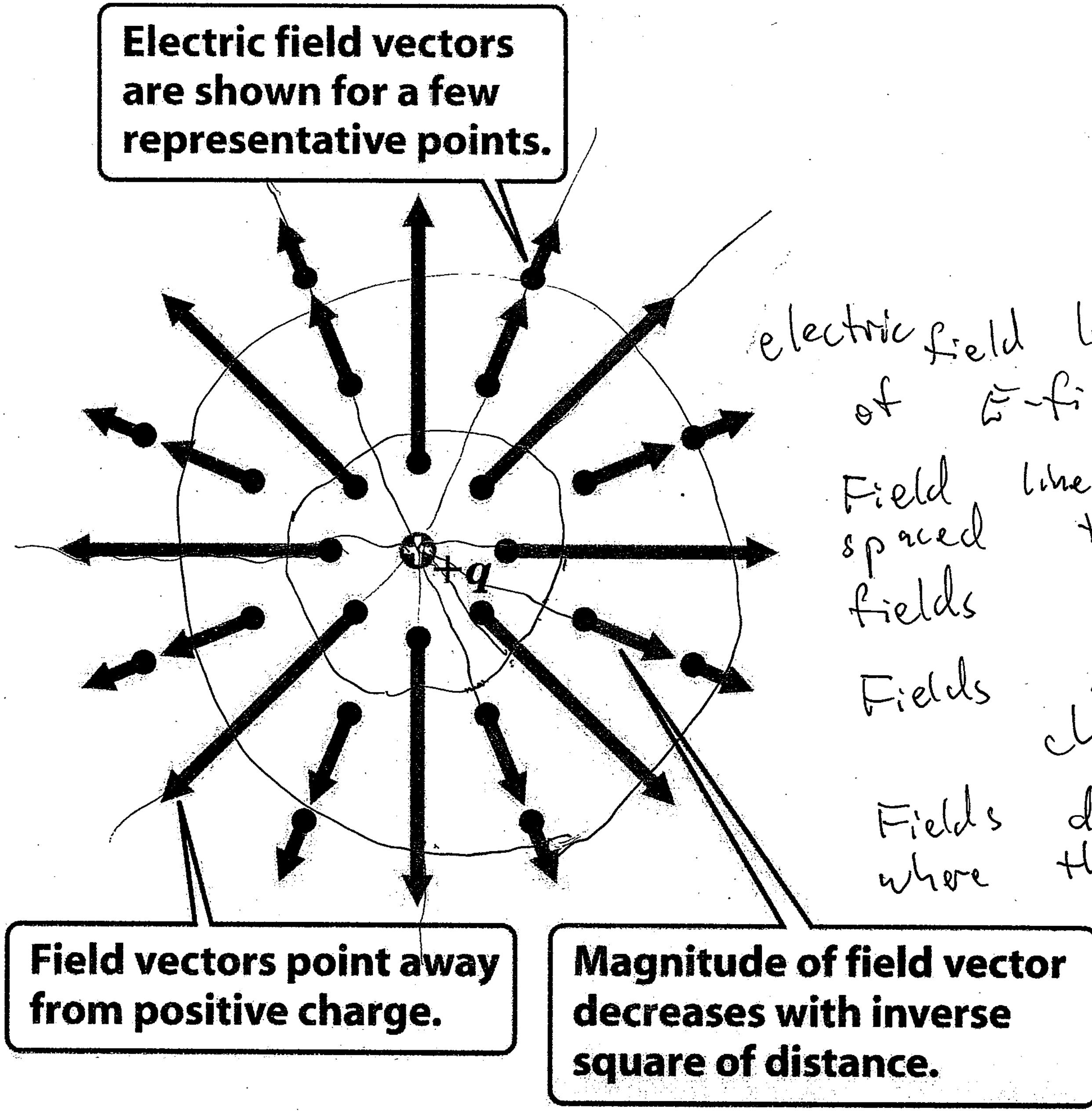


Figure 23-12 Physics for Engineers and Scientists 3/e

electric field lines in direction of $\vec{E}$-fields

Field lines ~~are~~ more spaced the weaker the fields

Fields start from + charge

Fields don't intersect where there is no charge

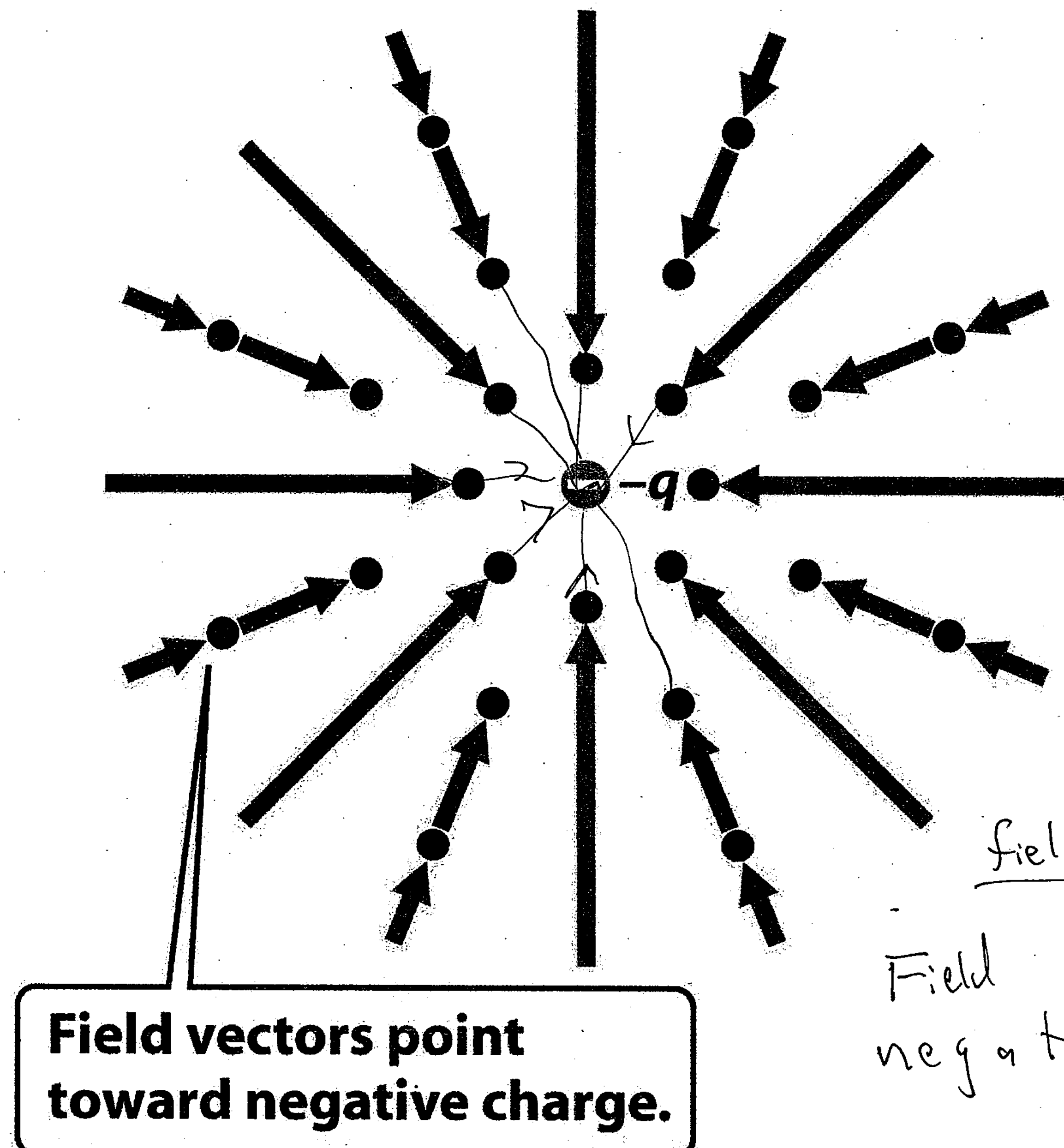


Figure 23-13 Physics for Engineers and Scientists 3/e

field lines:

- Field lines end on negative charges

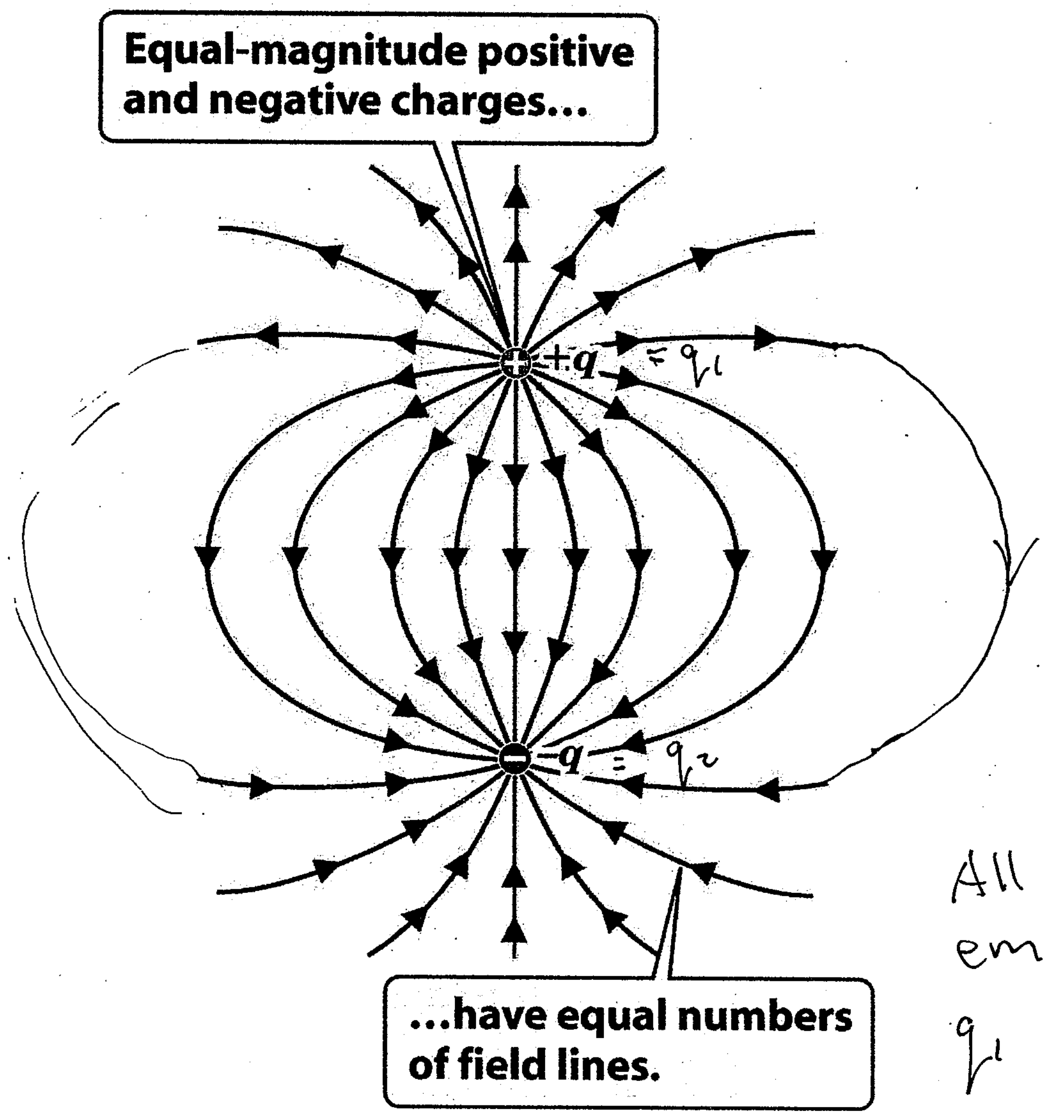


Figure 23-17 Physics for Engineers and Scientists 3/e

dipole

$|+q_1| = |-q_2|$

All field lines emanating from q_1 end on q_2

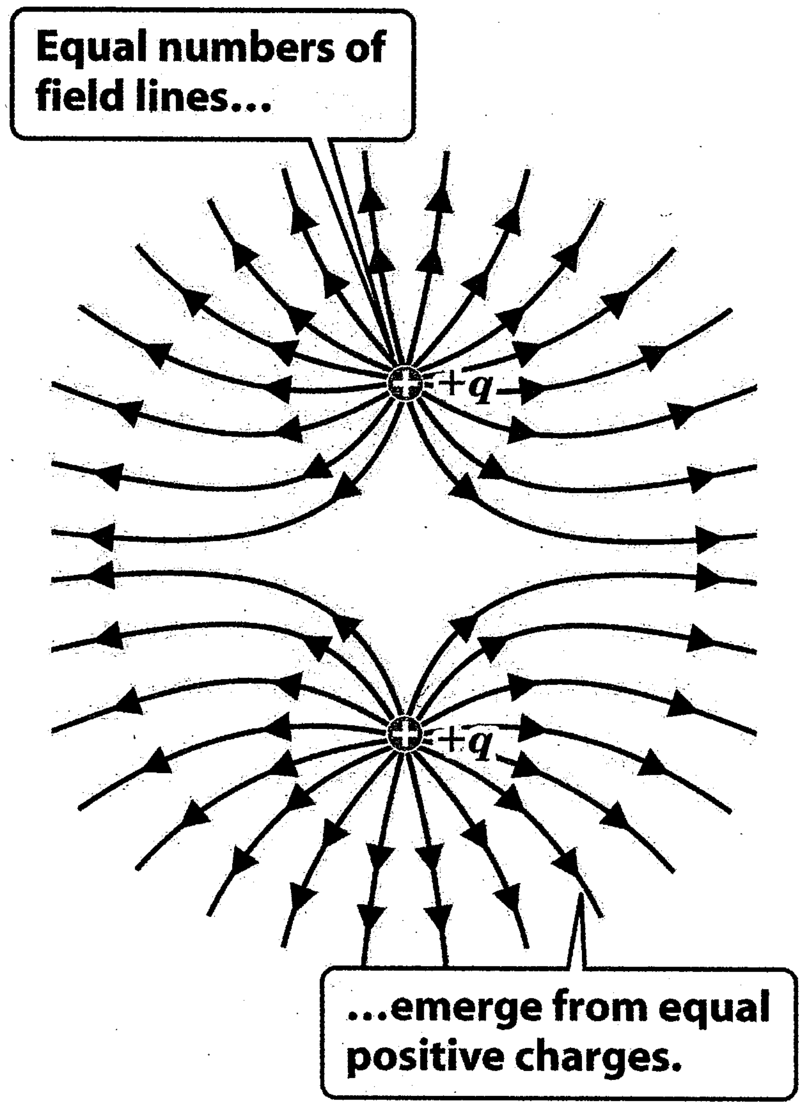
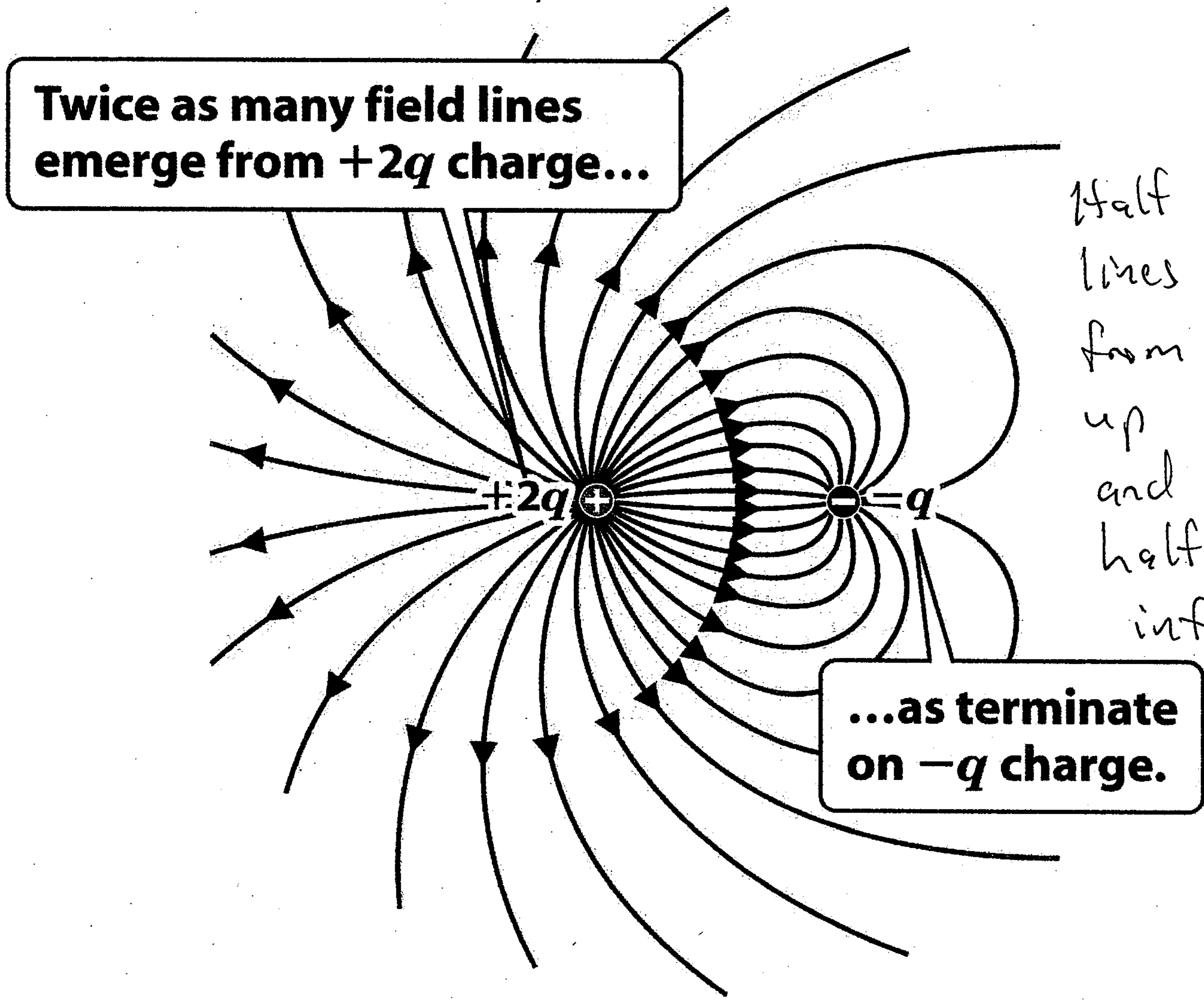


Figure 23-18 Physics for Engineers and Scientists 3/e

Field line don't cross

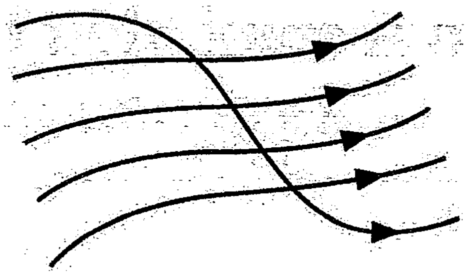
All field lines end at infinity



Half the field lines emanating from 2q end up at −q and the other half go to infinity

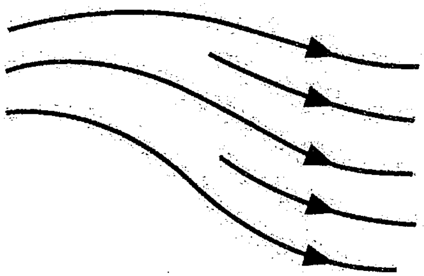
Figure 23-19 Physics for Engineers and Scientists 3/e

(a)



E-Field don't cross

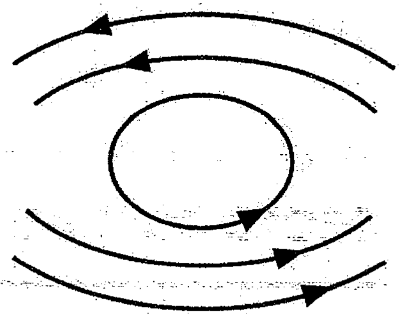
(b)



These field line diagrams are incorrect. Why?

E-field lines cannot begin where there is no + charge

(c)



field lines do not close on themselves

Figure 23-21 Physics for Engineers and Scientists 3/e

Find θ!

$m\frac{dv_y}{dt} = eE_y$ $m\frac{dv_x}{dt} = 0$

$a_y = \frac{eE_y}{m}$, $v_y(t) = v_{y0} + a_y t = \frac{eE_y t}{m}$ ($v_{y0} = 0$)

time to cross capacitor, $T = d/v_0$

$v_y(t) = eE_y d / m v_0$

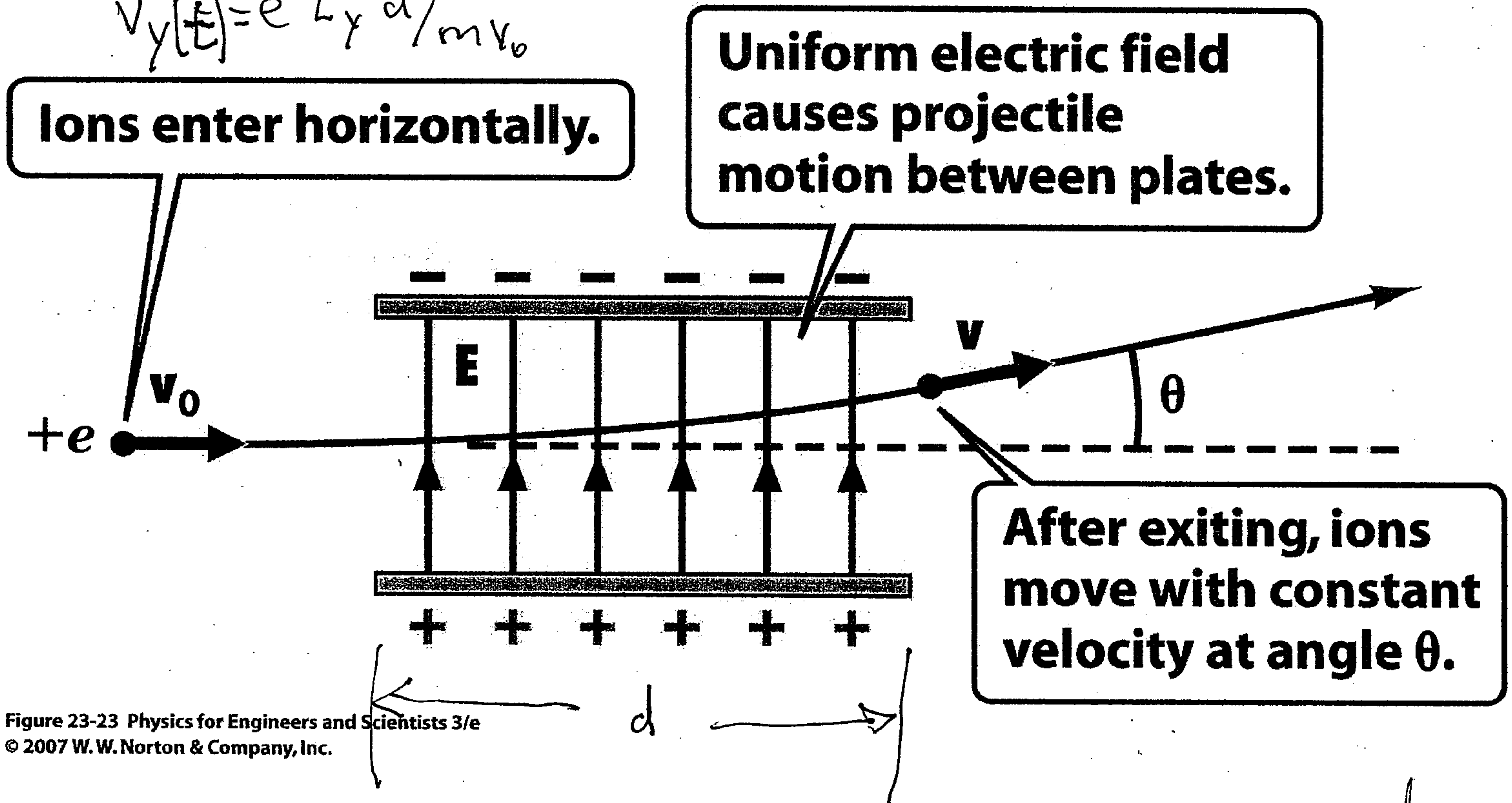


Figure 23-23 Physics for Engineers and Scientists 3/e

$d = v_0 T$, $T = \frac{d}{v_0}$

$$\tan\theta = \frac{v_y(T)}{v_x(T)} = \frac{eE_y d}{m v_0^2}$$

$\theta + \phi = 90^\circ$

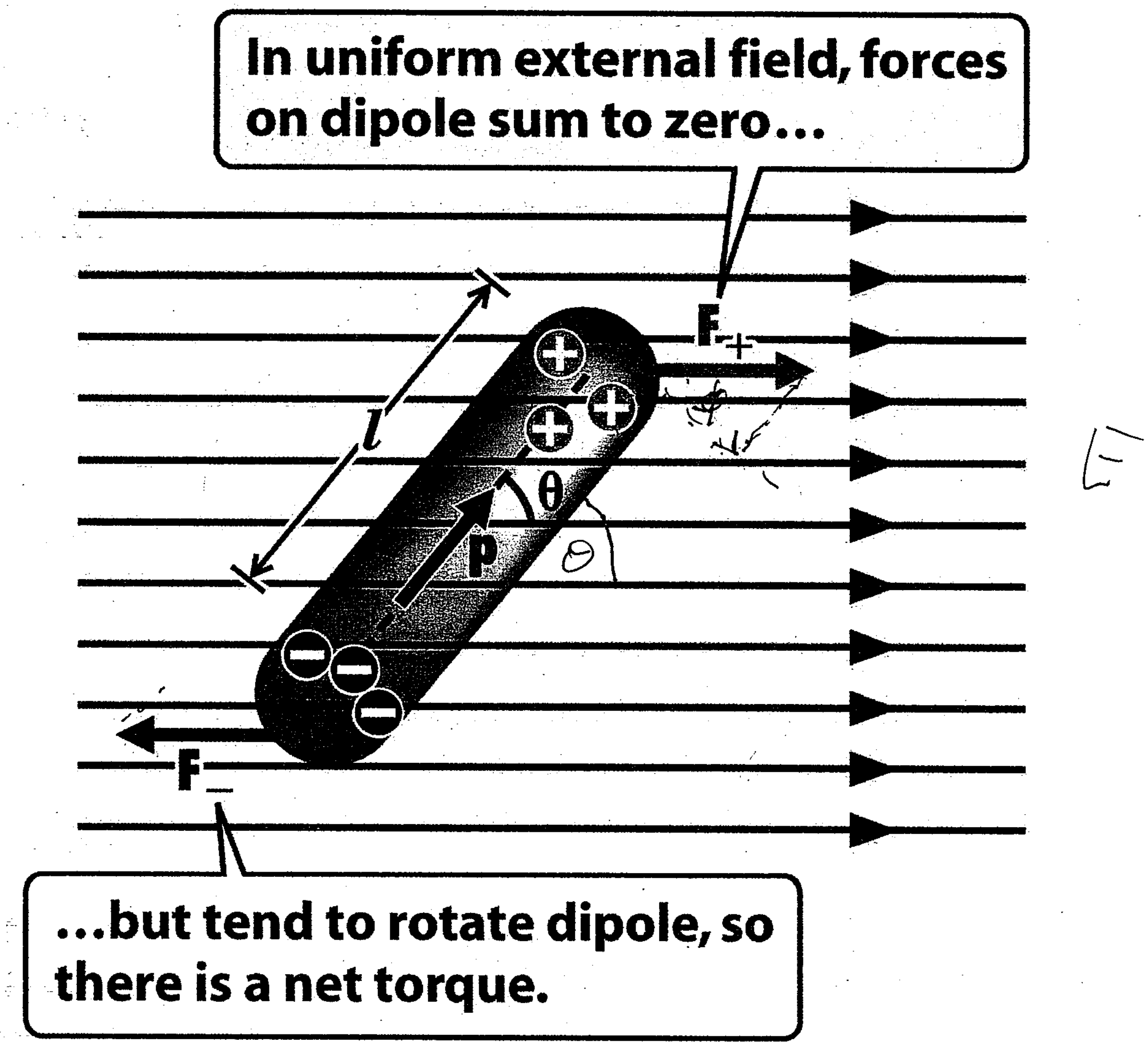


Figure 23-25 Physics for Engineers and Scientists 3/e

torque $\equiv \tau = qE\cos\phi = qE\sin\theta\, l$

Dipole moment $p \equiv ql$, $\therefore$ $\tau = pE$

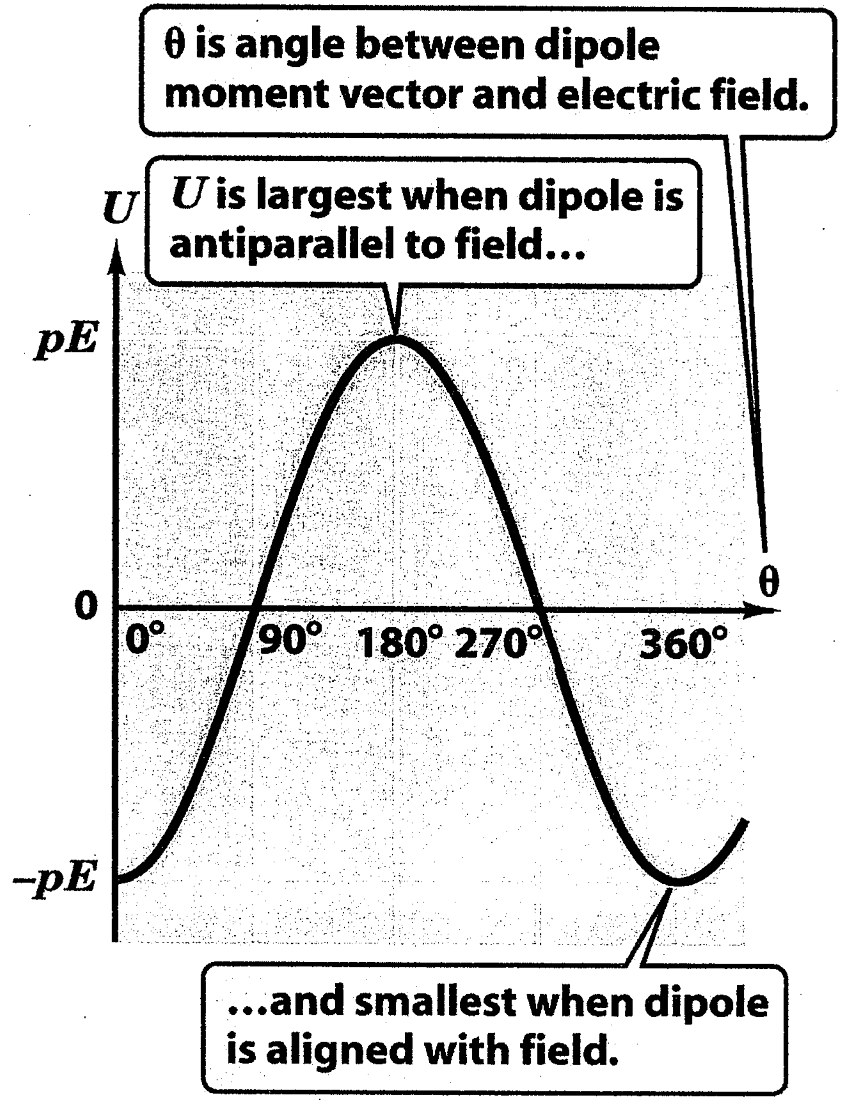


Figure 23-26 Physics for Engineers and Scientists 3/e

− sin θ