Lecture #2

Electric Forces

Checkup 22.4

Is it possible for a body to have an electric charge of 2.0×10^{-19} C? 3.2×10^{-19} C?

a. Yes; yes

b. Yes; no

c. No; yes

d. No; no

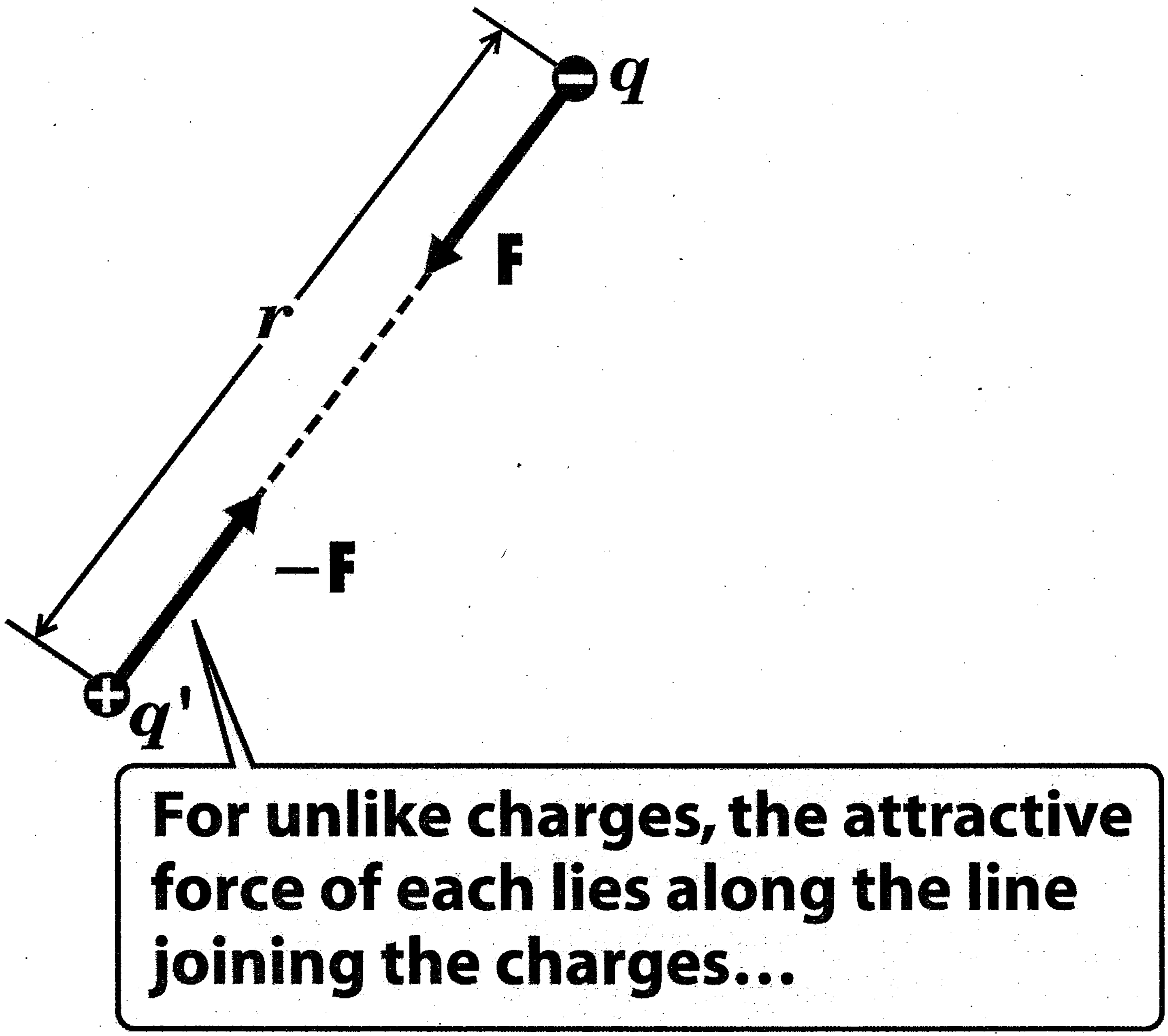


Figure 22-4a Physics for Engineers and Scientists 3/e

Total Forces is Vector Sum of Individual Forces

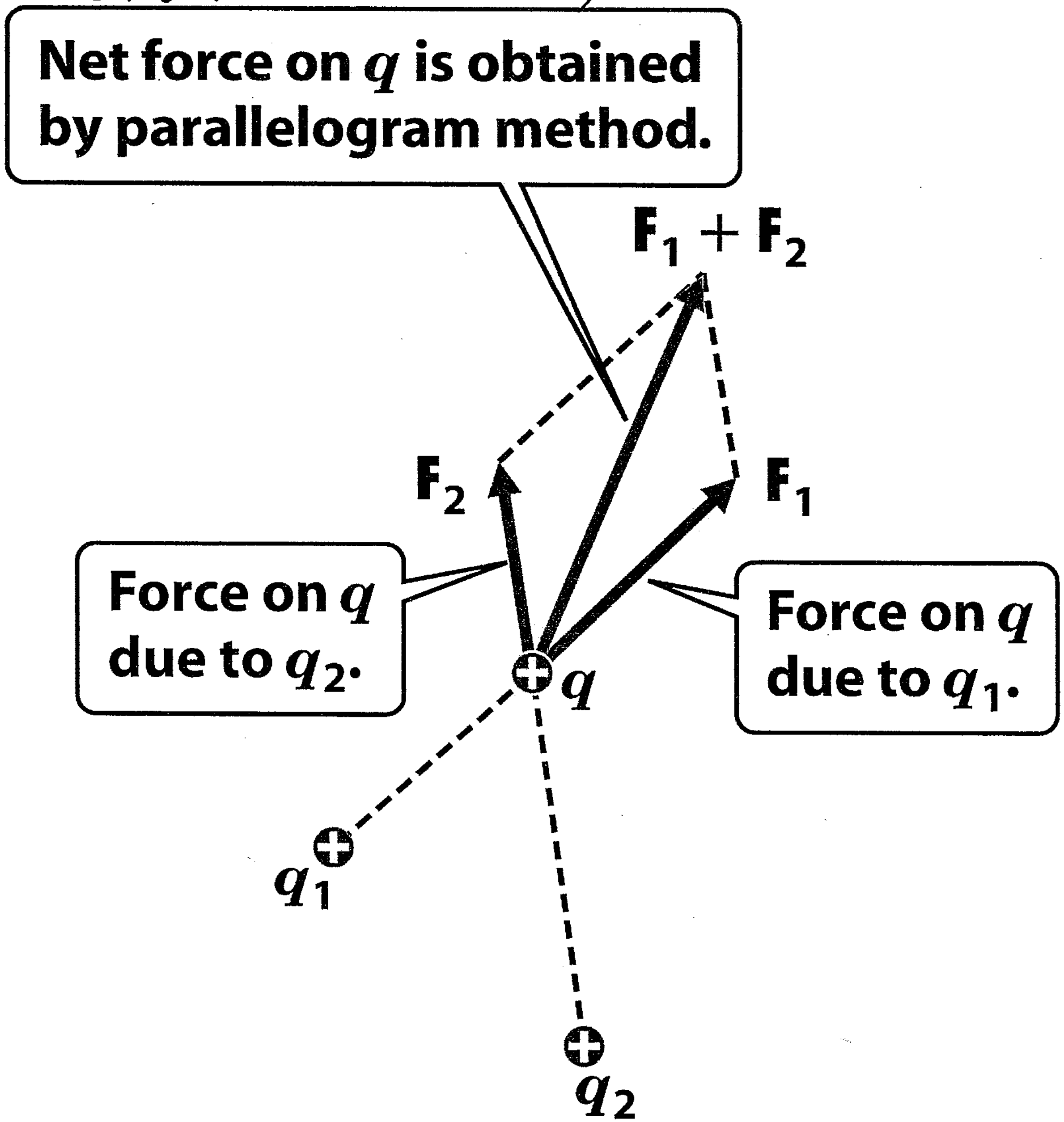


Figure 22-7 Physics for Engineers and Scientists 3/e

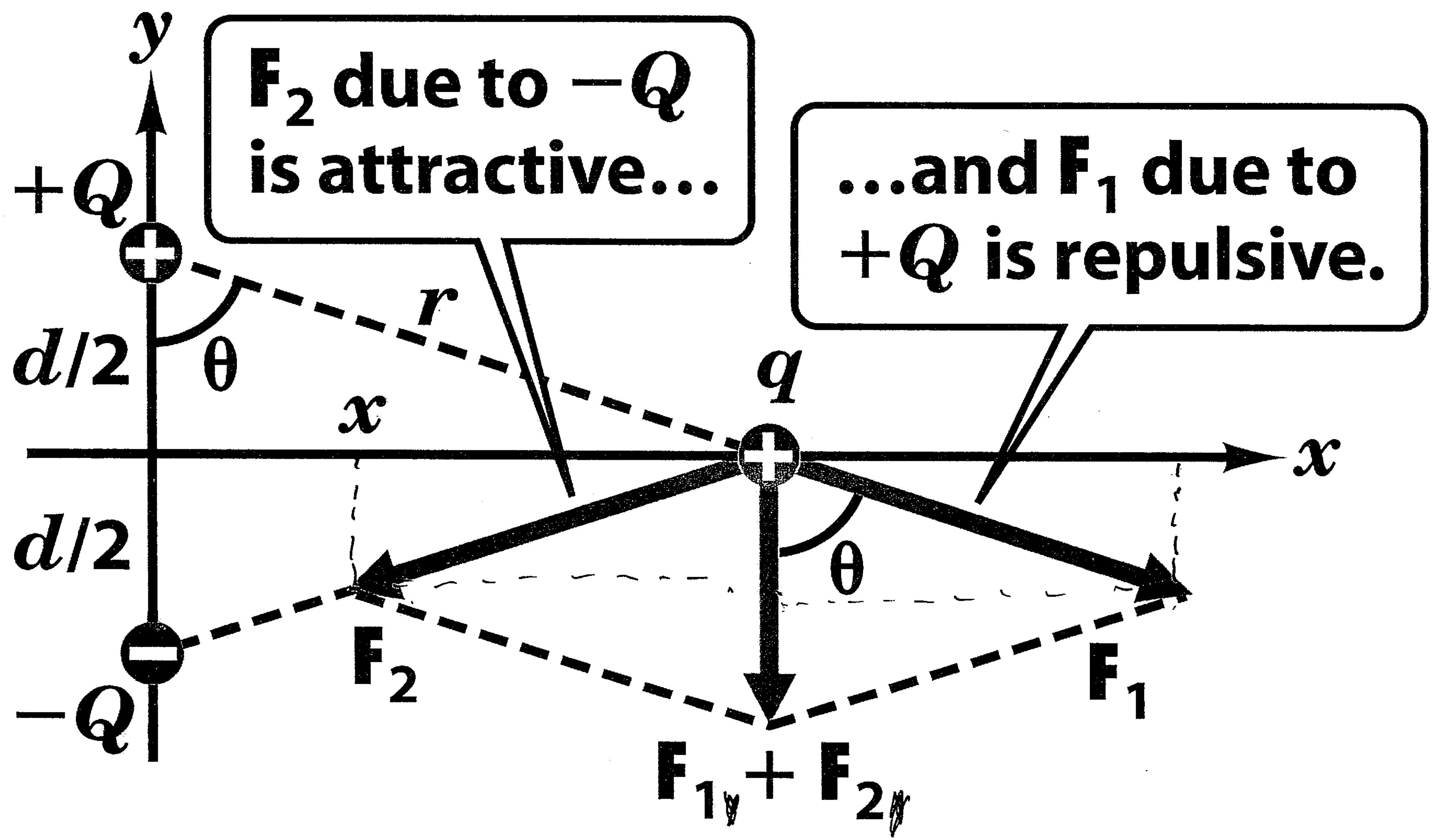
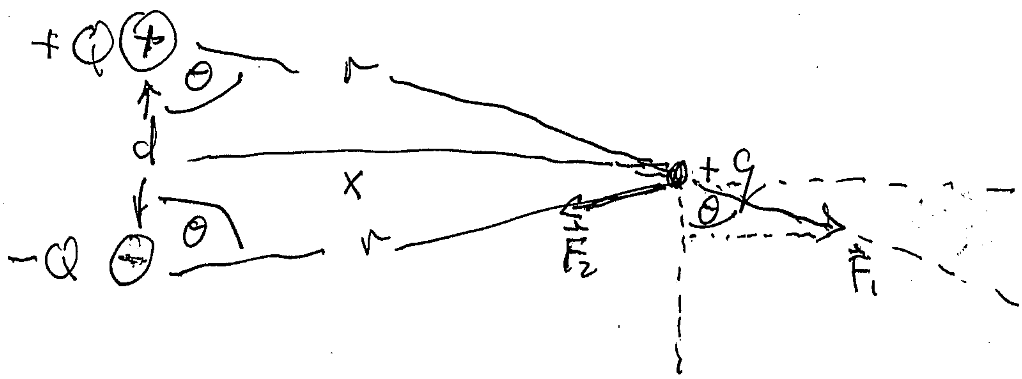


Figure 22-8a Physics for Engineers and Scientists 3/e

What is magnitude of force.

What is direction of force on q if charges at left are both positive?



$$|\vec{F}_1| = \frac{kQq}{r^2} = |\vec{F}_2|$$

Component in -y - direction is

$$|F_1| \sin\theta = \frac{kQq}{r^2} \sin\theta$$

Total Force, add component from $|\vec{F}_2|$ that is of equal magnitude

$$\left(\sin\theta = \frac{d/2}{r} \right)$$

$$|\vec{F}_{total}| = \frac{2kQq \sin\theta}{r^2} = 2kQq \frac{d}{2r^3}$$

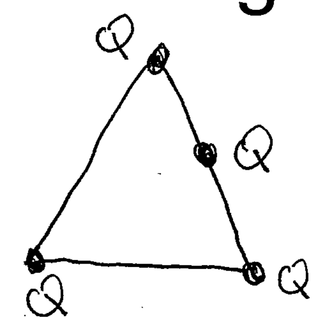
$$r^2 = x^2 + (d/2)^2$$

$$|\vec{F}_{total}| = \frac{2kQq\, d}{2(x^2 + d^2/4)^{3/2}}$$

Checkup 22.3

Three identical point charges are at the vertices of an equilateral triangle. A fourth, identical point charge is placed at the midpoint of one side of the triangle. As a result of the three electric force contributions from the vertex charges, the fourth charge

a. Is in equilibrium and remains at rest
b. Is pushed toward the center of the triangle
c. Is pushed outside the triangle



Rod has a total charge Q uniformly Distributed

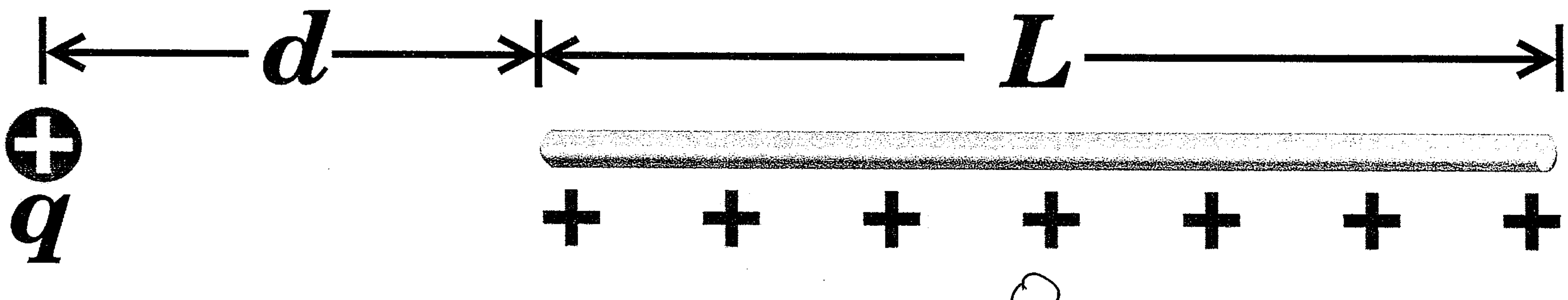
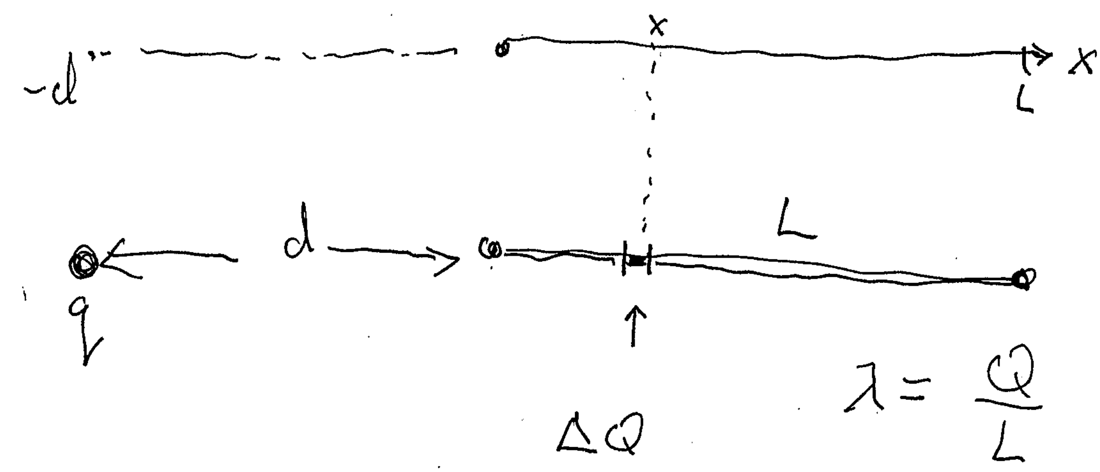


Figure 22-28 Physics for Engineers and Scientists 3/e

Find force on q



$$\Delta Q = \frac{Q}{L}\,\Delta x \qquad \left(\frac{Q}{L} \equiv \lambda \equiv \text{linear charge density}\right)$$

Force on q from ΔQ

$$\Delta \vec{F}_q = -\frac{k q\,\Delta Q}{(x+d)^2}\,\hat{x} = -\frac{k q Q}{L}\,\frac{\Delta x}{(x+d)^2}\,\hat{x}$$

Go to infinitesimal limit

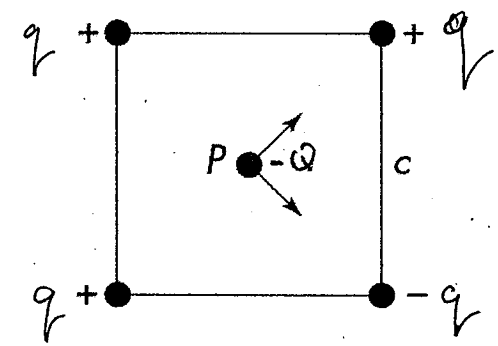
$$d\vec{F}_q = -\hat{x}\,\frac{k q Q}{L}\,\frac{dx}{(x+d)^2}$$

Integrate

$$\vec{F}_q = -\hat{x}\,\frac{k q Q}{L}\int_0^L \frac{dx}{(x+d)^2} = \hat{x}\,\frac{k q Q}{L\,(x+d)}\Bigg|_0^L$$

$$\vec{F}_q = -\hat{x}\,\frac{k q Q}{L}\left(\frac{1}{d} - \frac{1}{d+L}\right)$$

PhysiQuiz 22-4



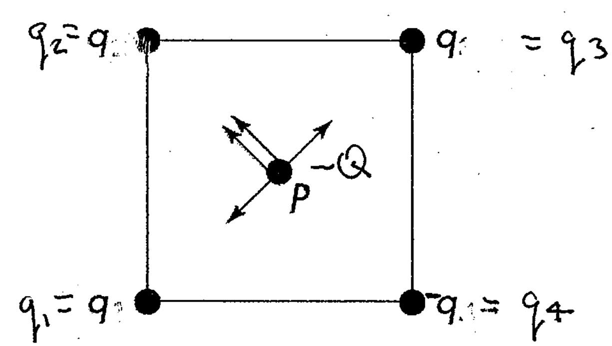
What is the direction of the electric force at P on a negative charge $-Q$? Assume the magnitudes of the charges at the corners have the same value q.

A	B	C	D
↘	↖	↗	↙

Extra: Show that the magnitude of the electric force at P is $F = 4kqQ/c^2$, where c is the side of the square.

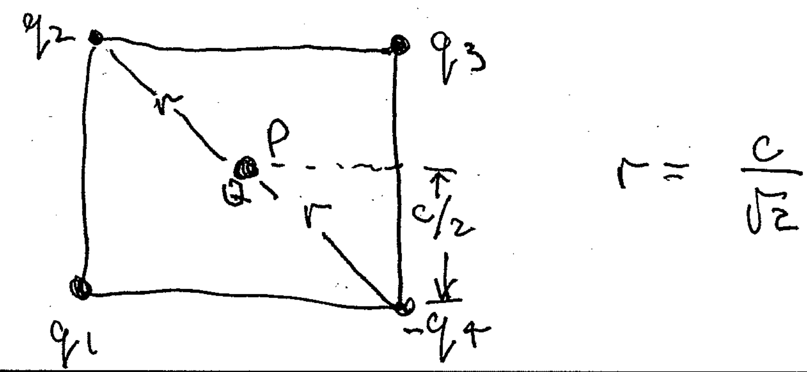
PhysiQuiz 22-4 answer

Explanation:



Explanation—extra: From the sketch in the explanation, the force contributions at P from q_3 and q_1 cancel each other. Thus the magnitude of the resultant force at P is $F = 2(kqQ/r^2)$. Because the distance from corner to the center is $r = \frac{\sqrt{2}}{2}c$, the magnitude of the force can be written as

$F = 4kqQ/c^2$.



Difference of Conductor and Insulator

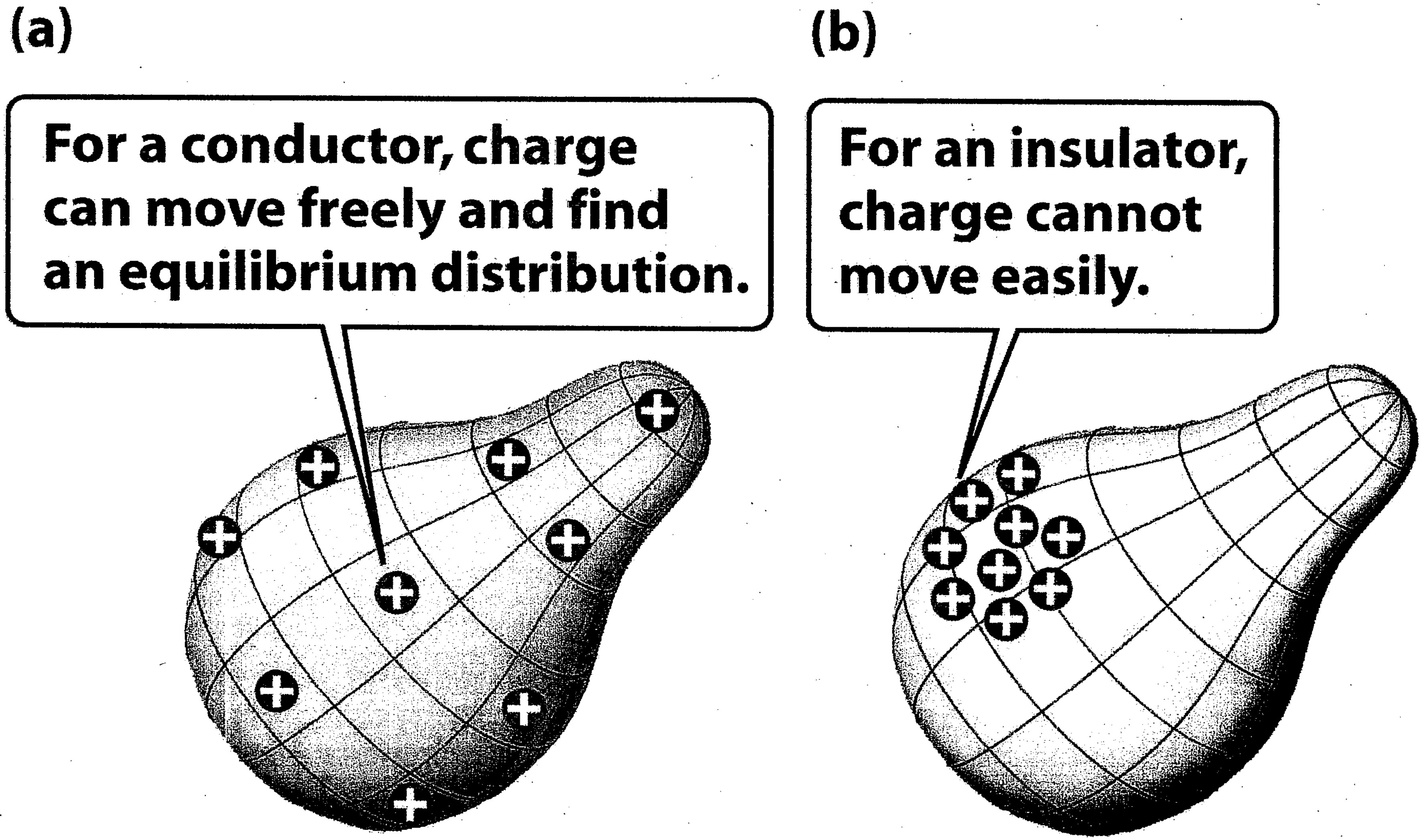
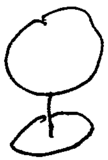


Figure 22-12 Physics for Engineers and Scientists 3/e

Charging Metallic Sphere

zeroth
We have an isolated sphere with no charge



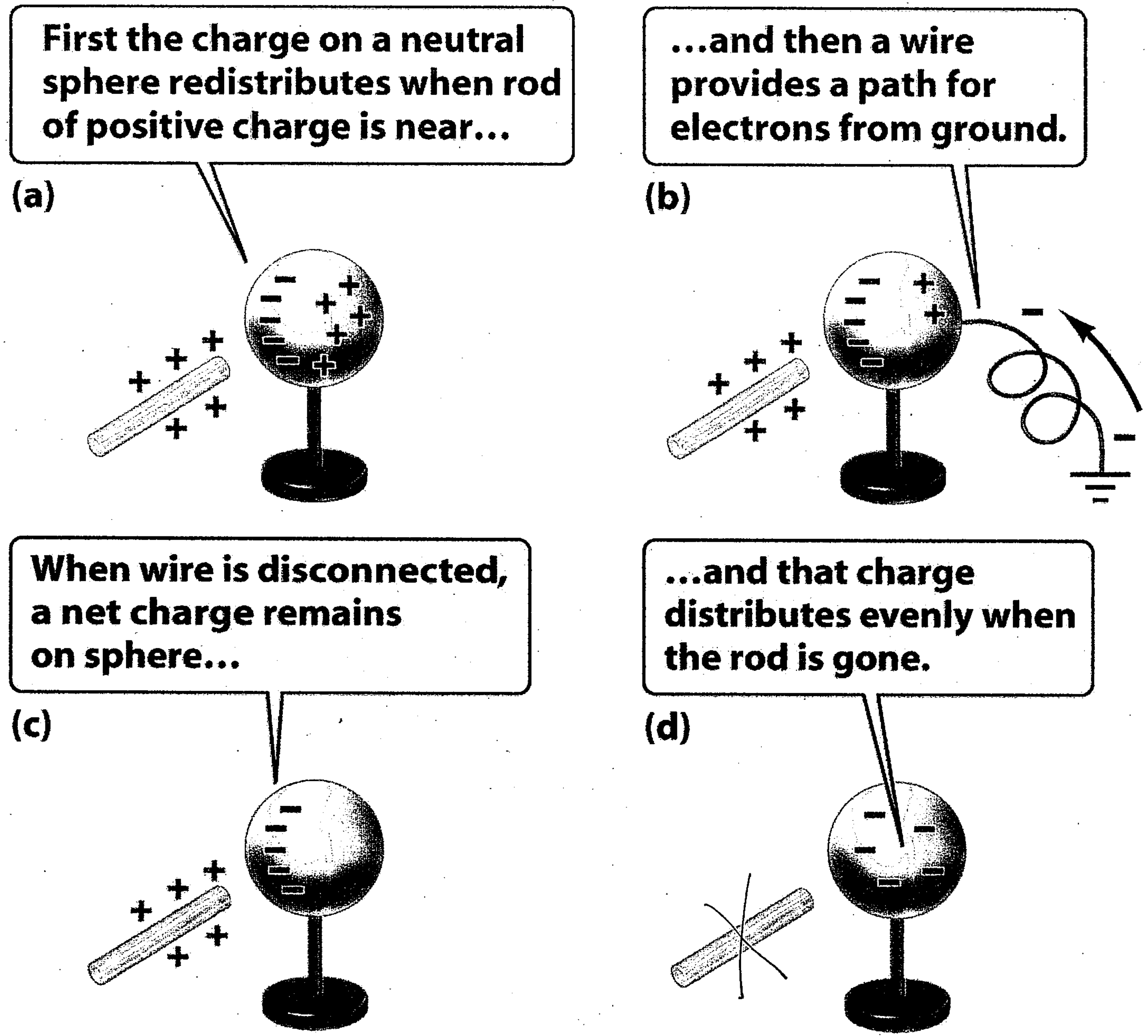


Figure 22-16 Physics for Engineers and Scientists 3/e

then sphere has excess of electrons

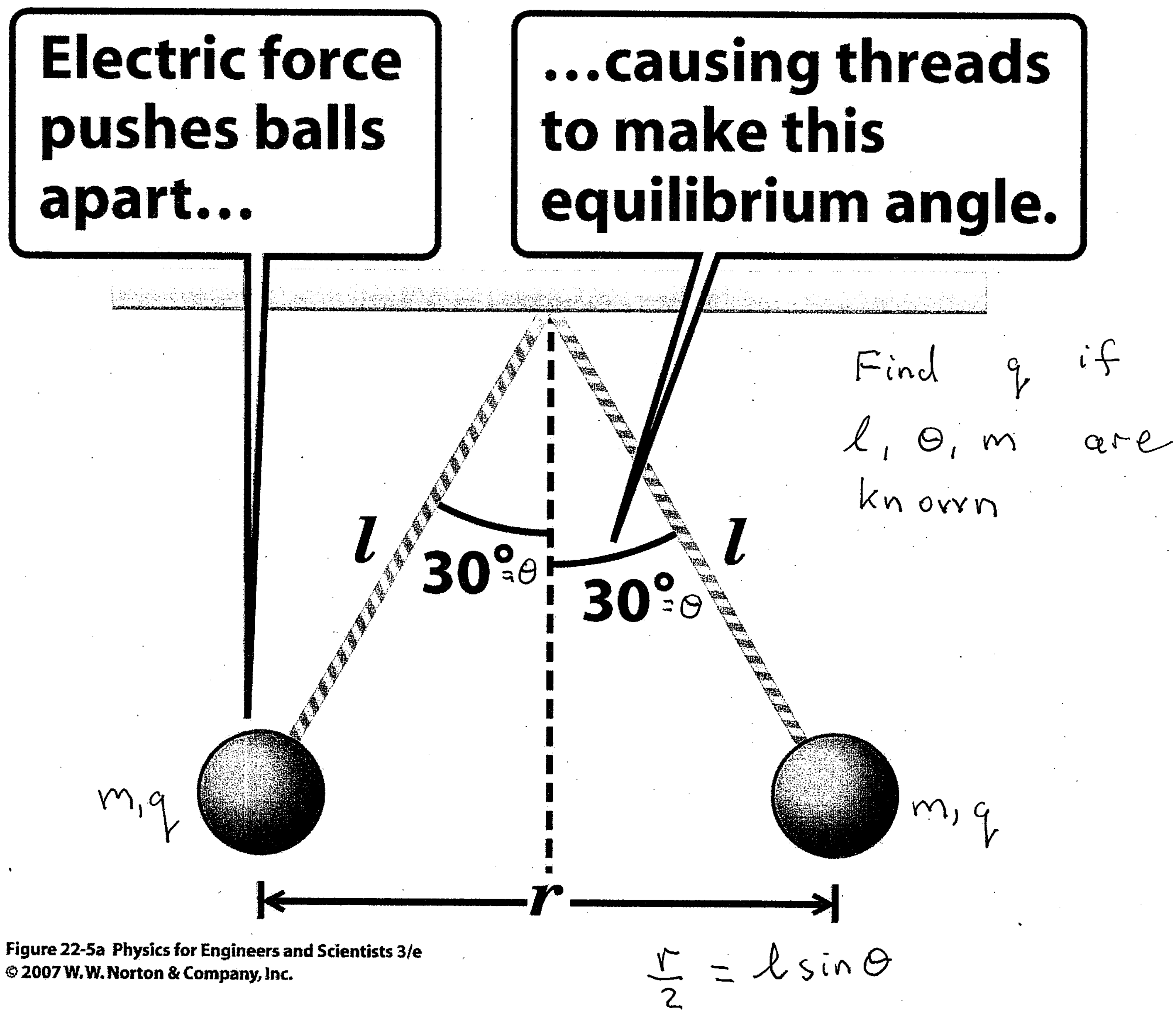


Figure 22-5a Physics for Engineers and Scientists 3/e

$T\cos\theta = mg$

$T\sin\theta = \frac{kq^2}{r^2} = \frac{kq^2}{(2\ell\sin\theta)^2}$

eliminate T by dividing both terms

$$\frac{\sin\theta}{\cos\theta} = \frac{kq^2}{4\ell^2\sin^2\theta} \Big/ mg$$

$$q^2 = 4\ell^2\sin^3\theta\, mg / k\cos\theta$$

for $\theta = 30°$

$\cos\theta = \sqrt{3}/2$

$\sin\theta = 1/2$

$$q^2 = \frac{2}{\sqrt{3}} \frac{\ell^2 mg}{k}$$

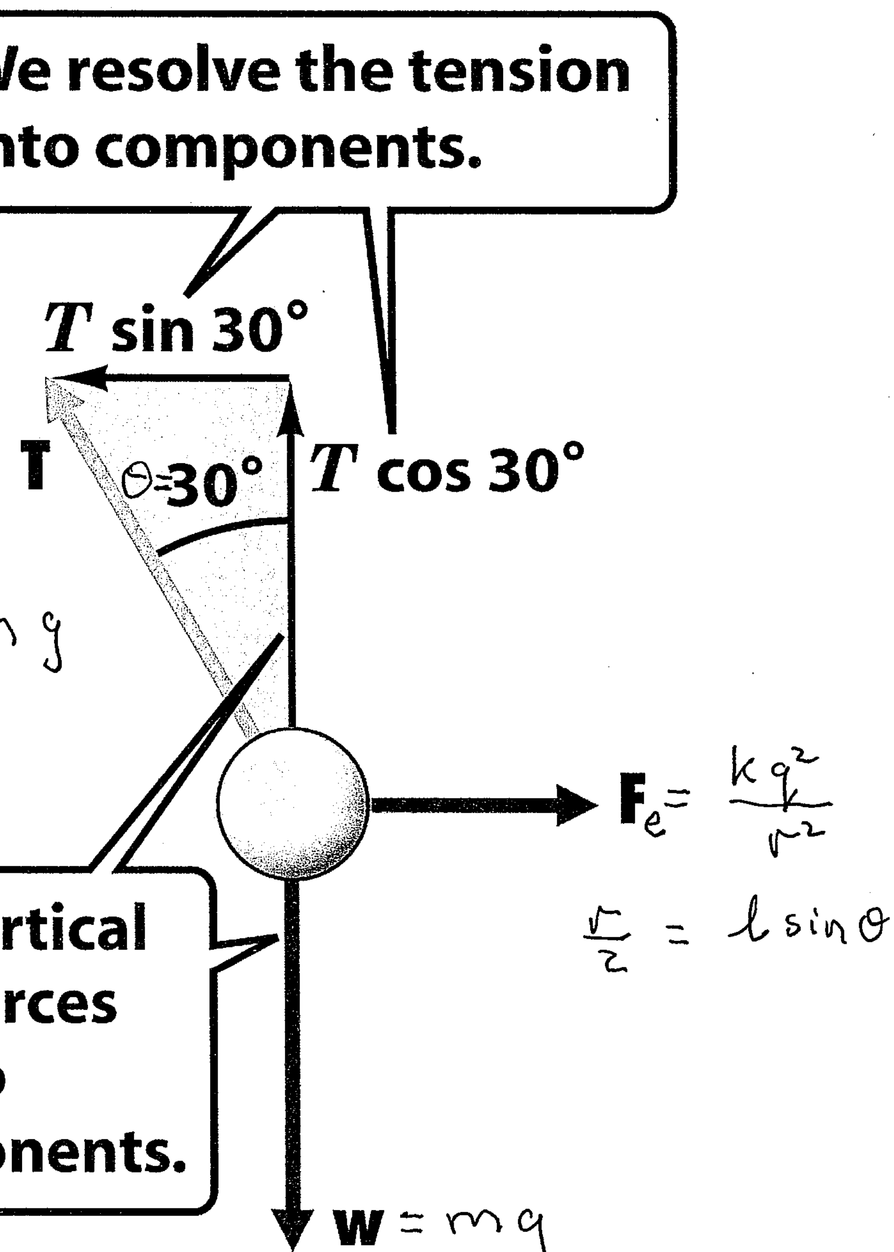


Figure 22-5b Physics for Engineers and Scientists 3/e

COULOMB CONSTANT

$$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \ \mathrm{N \cdot m^2/C^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \ C^2/N\,m^2$$

$\equiv$ permitivity of free space

Equation 22-4 derivatives Physics for Engineers and Scientists 3/e