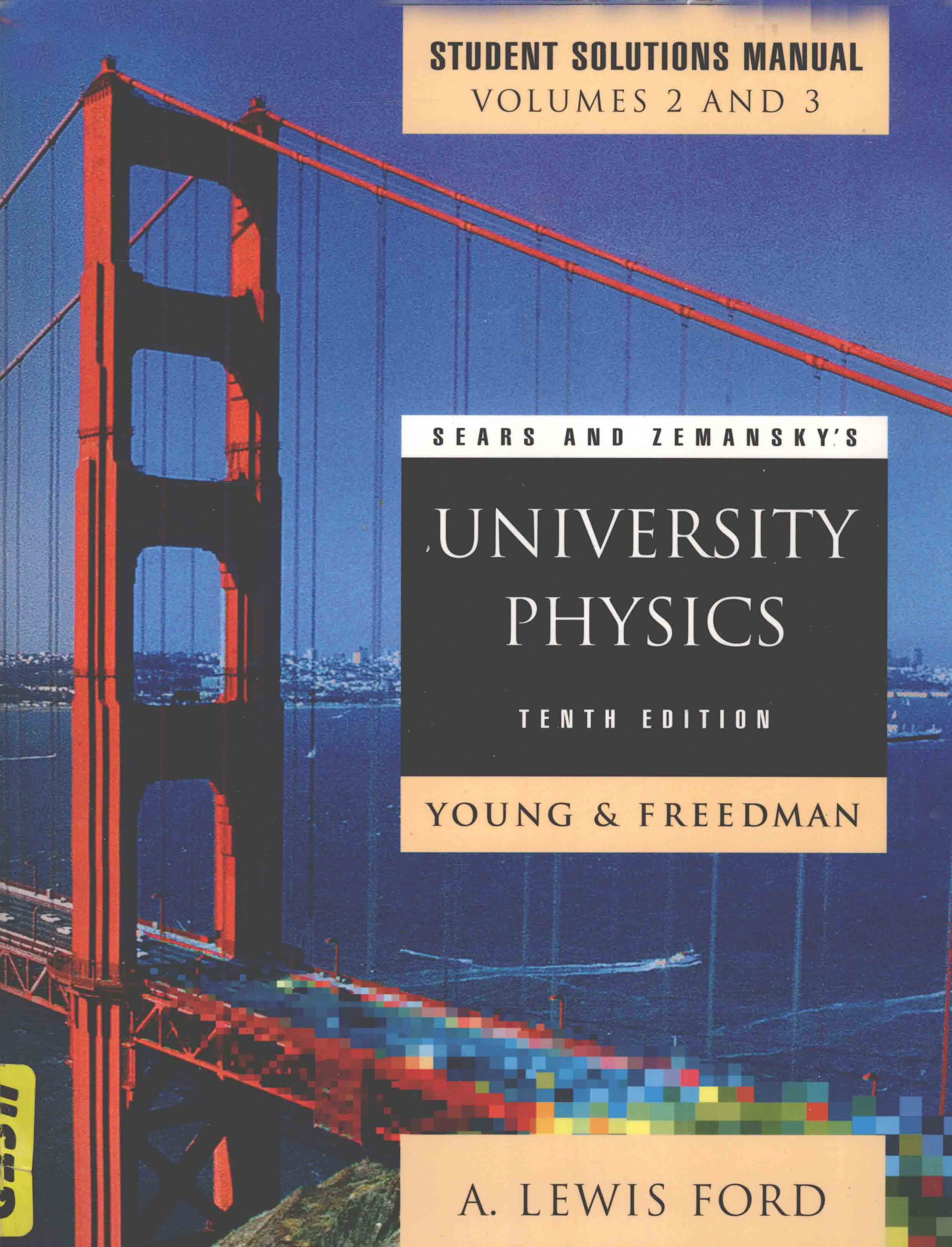


STUDENT SOLUTIONS MANUAL

VOLUMES 2 AND 3

SEARS AND ZEMANSKY'S

UNIVERSITY PHYSICS

TENTH EDITION

YOUNG & FREEDMAN

A. LEWIS FORD

Student Solutions Manual

SEARS AND ZEMANSKY'S

UNIVERSITY PHYSICS

TENTH EDITION

VOLUMES 2 & 3

YOUNG & FREEDMAN

A. LEWIS FORD
TEXAS A&M UNIVERSITY

ADDISON-WESLEY

An imprint of Addison Wesley Longman, Inc.

San Francisco • Reading, Massachusetts
New York • Harlow, England • Don Mills, Ontario
Sydney • Mexico City • Madrid • Amsterdam

ISBN 0-201-64395-2
1 2 3 4 5 6 7 8 9 10—CRS—03 02 01 00

Addison Wesley Longman, Inc.
1301 Sansome Street
San Francisco, California 94111

PREFACE

This *Student Solutions Manual,* Volumes 2 & 3, contains detailed solutions for approximately one third of the Exercises and Problems in Chapters 22 through 46 of the Tenth Edition of *University Physics*. The Exercises and Problems included in this manual are selected solely from the odd-numbered Exercises and Problems in the text (for which the answers are tabulated in the back of the textbook). The Exercises and Problems included were not selected at random but rather were carefully chosen to include at least one representative example of each problem type. The remaining Exercises and Problems, for which solutions are not given here, constitute an ample set of problems for you to tackle on your own. In addition, there are the Challenge Problems in the text for which no solutions are given here.

This manual greatly expands the set of worked-out examples that accompanies the presentation of physics laws and concepts in the text. This manual was written to provide you with models to follow in working physics problems. The problems are worked out in the manner and style in which you should carry out your own problem solutions.

The author will gratefully receive comments as to style, points of physics, errors, or anything else relating to this manual. The *Student Solutions Manual* Volume 1 companion volume is also available from your college bookstore.

A. Lewis Ford
Physics Department
Texas A&M University
College Station TX 77843
Email: ford@physics.tamu.edu

CONTENTS

Chapter 22: Electric Charge and Electric Field

Exercises 1
Problems 15

Chapter 23: Gauss's Law

Exercises 26
Problems 29

Chapter 24: Electric Potential

Exercises 43
Problems 52

Chapter 25: Capacitance and Dielectrics

Exercises 61
Problems 66

Chapter 26: Current, Resistance, and Electromotive Force

Exercises 75
Problems 80

Chapter 27: Direct-Current Circuits

Exercises 85
Problems 96

Chapter 28: Magnetic Field and Magnetic Forces

Exercises 109
Problems 116

Chapter 29: Sources of Magnetic Field

Exercises 125
Problems 133

Chapter 30: Electromagnetic Induction

Exercises 142
Problems 149

Chapter 31: Inductance

Exercises 156
Problems 160

Chapter 32: Alternating Current

Exercises 169

Problems 174

Chapter 33: Electromagnetic Waves

Exercises 179

Problems 182

Chapter 34: The Nature and Propagation of Light

Exercises 188

Problems 191

Chapter 35: Geometric Optics

Exercises 198

Problems 203

Chapter 36: Optical Instruments

Exercises 215

Problems 218

Chapter 37: Interference

Exercises 222

Problems 226

Chapter 38: Diffraction

Exercises 230

Problems 235

Chapter 39: Relativity

Exercises 238

Problems 243

Chapter 40: Photons, Electrons, and Atoms

Exercises 247

Problems 251

Chapter 41: The Wave Nature of Particles

Exercises 256

Problems 258

Chapter 42: Quantum Mechanics

Exercises 262

Problems 266

Chapter 43: Atomic Structure

Exercises 271
Problems 273

Chapter 44: Molecules and Condensed Matter

Exercises 278
Problems 282

Chapter 45: Nuclear Physics

Exercises 288
Problems 292

Chapter 46: Particle Physics and Cosmology

Exercises 297
Problems 300

CHAPTER 22

ELECTRIC CHARGE AND ELECTRIC FIELD

Exercises 1, 5, 7, 9, 13, 17, 19, 21, 23, 25, 29, 33, 35, 45, 47, 49
Problems 53, 55, 57, 59, 61, 65, 67, 69, 77, 81, 83

Exercises

22-1 **a)** The charge of one electron is $-e = -1.602 \times 10^{-19}$ C.

The number of excess electrons needed to produce net charge q is

$$\frac{q}{-e} = \frac{-3.20 \times 10^{-9}\ \text{C}}{-1.602 \times 10^{-19}\ \text{C/electron}} = 2.00 \times 10^{10}\ \text{electrons.}$$

b) Find the number of lead atoms in 8.00×10^{-3} kg of lead. The atomic mass of lead is 207×10^{-3} kg/mol, so the number of moles in 8.00×10^{-3} kg is

$$n = \frac{m_{\text{tot}}}{M} = \frac{8.00 \times 10^{-3}\ \text{kg}}{207 \times 10^{-3}\ \text{kg/mol}} = 0.03865\ \text{mol.}$$

N_A (Avogadro's number) is the number of atoms in 1 mole, so the number of lead atoms is $N = nN_A = (0.03865\ \text{mol})(6.022 \times 10^{23}\ \text{atoms/mol}) = 2.328 \times 10^{22}$ atoms.

The number of excess electrons per lead atom is

$$\frac{2.00 \times 10^{10}\ \text{electrons}}{2.328 \times 10^{22}\ \text{atoms}} = 8.59 \times 10^{-13}.$$

22-5 $N = nN_A = (1.80\ \text{mol})(6.022 \times 10^{23}\ \text{atoms/mol}) = 1.084 \times 10^{24}$ atoms

There is 1 electron per hydrogen atom and each electron has charge $-e = -1.602 \times 10^{-19}$ C, so $Q = (-1.602 \times 10^{-19}\ \text{C/electron})(1.084 \times 10^{24}\ \text{electrons}) = -1.74 \times 10^{5}$ C.

This is a large amount of charge.

22-7 **a)** $q_1 = q_2 = q$

$$F = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2} = \frac{q^2}{4\pi\epsilon_0 r^2}\ \text{so}$$

$$q = r\sqrt{\frac{F}{(1/4\pi\epsilon_0)}} = 0.150\ \text{m}\sqrt{\frac{0.220\ \text{N}}{8.988 \times 10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2}} = 7.42 \times 10^{-7}\ \text{C (on each)}$$

b) $q_2 = 4q_1$

$$F = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2} = \frac{4q_1^2}{4\pi\epsilon_0 r^2} \text{ so}$$

$$q_1 = r\sqrt{\frac{F}{4(1/4\pi\epsilon_0)}} = \tfrac{1}{2}r\sqrt{\frac{F}{(1/4\pi\epsilon_0)}} = \tfrac{1}{2}(7.42 \times 10^{-7}\ \text{C}) = 3.71 \times 10^{-7}\ \text{C}.$$

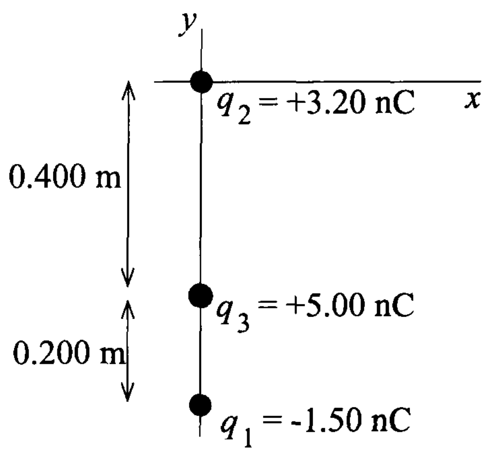
And then $q_2 = 4q_1 = 1.48 \times 10^{-6}$ C.

22-9 The weight of an electron is $m_e g$. The nucleus of a hydrogen atom is a single proton with charge $+e$. The Coulomb force between the electron and the nucleus is $\frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2}$.

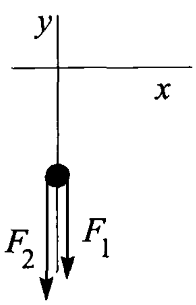
Equating these two forces gives $m_e g = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2}$.

$$r = e\sqrt{\frac{(1/4\pi\epsilon_0)}{m_e g}} = 1.602 \times 10^{-19}\ \text{C}\sqrt{\frac{8.988 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2}{(9.109 \times 10^{-31}\ \text{kg})(9.80\ \text{m/s}^2)}} = 5.08\ \text{m}$$

22-13 The three charges are placed as follows:



Like charges repel and unlike attract, so the free-body diagram for q_3 is



$$F_1 = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_3|}{r_{13}^2}$$

$$F_2 = \frac{1}{4\pi\epsilon_0}\frac{|q_2 q_3|}{r_{23}^2}$$

$$F_1 = (8.988 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{(1.50 \times 10^{-9}\ \text{C})(5.00 \times 10^{-9}\ \text{C})}{(0.200\ \text{m})^2} = 1.685 \times 10^{-6}\ \text{N}$$

$$F_2 = (8.988 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)\frac{(3.20 \times 10^{-9} \text{ C})(5.00 \times 10^{-9} \text{ C})}{(0.400 \text{ m})^2} = 8.988 \times 10^{-7} \text{ N}$$

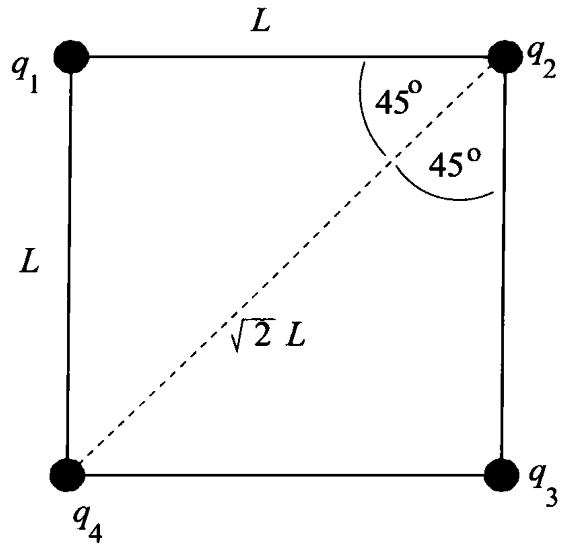
The resultant force is $\vec{\boldsymbol{R}} = \vec{\boldsymbol{F}}_1 + \vec{\boldsymbol{F}}_2$.

$R_x = 0$.

$R_y = F_1 + F_2 = 1.685 \times 10^{-6} \text{ N} + 8.988 \times 10^{-7} \text{ N} = 2.58 \times 10^{-6} \text{ N}$.

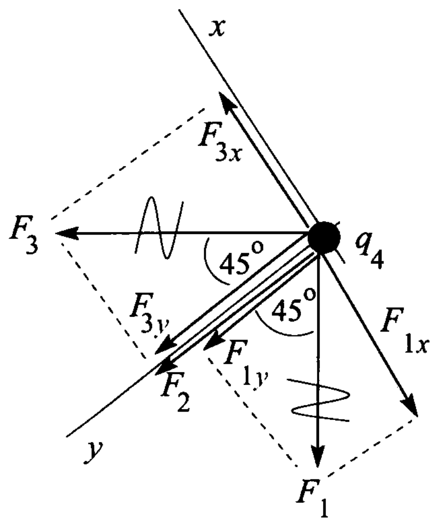
The resultant force has magnitude 2.58×10^{-6} N and is in the $-y$-direction.

22-17 **a)** The charges are placed as shown:



$q_1 = q_2 = q_3 = q_4 = q$

Consider forces on q_4. Take the y-axis to be parallel to the diagonal between q_2 and q_4 and let $+y$ be in the direction away from q_2. Then $\vec{\boldsymbol{F}}_2$ is in the $+y$-direction.



$$F_3 = F_1 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{L^2}$$

$$F_2 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{2L^2}$$

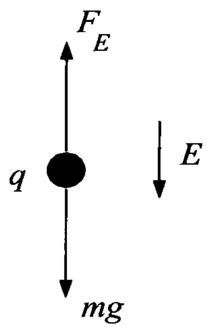
$F_{1x} = -F_1 \sin 45° = -F_1/\sqrt{2}$
$F_{1y} = +F_1 \cos 45° = +F_1/\sqrt{2}$
$F_{3x} = +F_3 \sin 45° = +F_3/\sqrt{2}$
$F_{3y} = +F_3 \cos 45° = +F_3/\sqrt{2}$
$F_{2x} = 0,\ F_{2y} = F_2$

b) $R_x = F_{1x} + F_{2x} + F_{3x} = 0$

$$R_y = F_{1y} + F_{2y} + F_{3y} = (2/\sqrt{2})\frac{1}{4\pi\epsilon_0}\frac{q^2}{L^2} + \frac{1}{4\pi\epsilon_0}\frac{q^2}{2L^2} = \frac{q^2}{8\pi\epsilon_0 L^2}(1 + 2\sqrt{2})$$

$R = \frac{q^2}{8\pi\epsilon_0 L^2}(1 + 2\sqrt{2})$. Same for all four charges. In general the resultant force on one of the charges is directed away from the opposite corner.

22-19 **a)** The gravity force is downward. For the net force to be zero the force exerted by the electric field must be upward. The electric field is downward. Since the electric field and the electric force are in opposite directions the charge of the particle is negative.



$$mg = |q|E$$

$$|q| = \frac{mg}{E} = \frac{(1.45 \times 10^{-3}\ \text{kg})(9.80\ \text{m/s}^2)}{650\ \text{N/C}} = 2.19 \times 10^{-5}\ \text{C and}$$

$q = -21.9\ \mu\text{C}$

b) The electrical force has magnitude $F_E = |q|E = eE$.

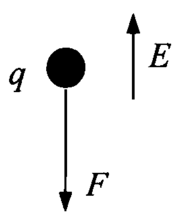
The weight of a proton is $w = mg$.

$F_E = w$ so $eE = mg$

$$E = \frac{mg}{e} = \frac{(1.673 \times 10^{-27}\ \text{kg})(9.80\ \text{m/s}^2)}{1.602 \times 10^{-19}\ \text{C}} = 1.02 \times 10^{-7}\ \text{N/C}.$$

This is a very small electric field.

22-21 **a)** For a negative charge $\vec{F}$ and field $\vec{E}$ are in opposite directions. $\vec{F}$ is downward so $\vec{E}$ is upward.

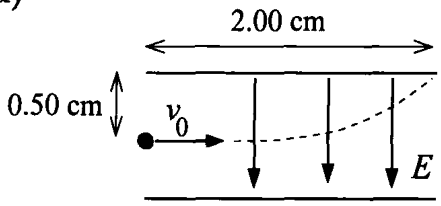


$$E = \frac{F}{|q|} = \frac{6.20 \times 10^{-9}\ \text{N}}{55.0 \times 10^{-6}\ \text{C}} = 1.13 \times 10^{-4}\ \text{N/C}$$

b) The copper nucleus has charge $+29e$. For a positive charge the field and force are in the same direction so $\vec{F}$ is upward when $\vec{E}$ is upward.

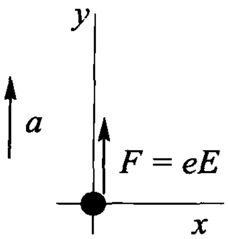
$F = |q|E = (29)(1.602 \times 10^{-19}\ \text{C})(1.13 \times 10^{-4}\ \text{N/C}) = 5.25 \times 10^{-22}\ \text{N}$

22-23 a)



For an electron $q = -e$.

$\vec{F} = q\vec{E}$ and q negative gives that $\vec{F}$ and $\vec{E}$ are in opposite directions, so $\vec{F}$ is upward.



$\sum F_y = ma_y$
$eE = ma$

Solve the kinematics to find the acceleration of the electron:

Just misses upper plate says that $x - x_0 = 2.00$ cm when $y - y_0 = +0.500$ cm.

<u>x-component</u>

$v_{0x} = v_0 = 1.60 \times 10^6$ m/s, $a_x = 0$, $x - x_0 = 0.0200$ m, $t = ?$

$x - x_0 = v_{0x}t + \frac{1}{2}a_x t^2$

$$t = \frac{x - x_0}{v_{0x}} = \frac{0.0200 \text{ m}}{1.60 \times 10^6 \text{ m/s}} = 1.25 \times 10^{-8} \text{ s}$$

In this same time t the electron travels 0.0050 m vertically:

<u>y-component</u>

$t = 1.25 \times 10^{-8}$ s, $v_{0y} = 0$, $y - y_0 = +0.0050$ m, $a_y = ?$

$y - y_0 = v_{0y}t + \frac{1}{2}a_y t^2$

$$a_y = \frac{2(y - y_0)}{t^2} = \frac{2(0.0050 \text{ m})}{(1.25 \times 10^{-8} \text{ s})^2} = 6.40 \times 10^{13} \text{ m/s}^2$$

(This analysis is very similar to that used in Chapter 3 for projectile motion, except that here the acceleration is upward rather than downward.)

This acceleration must be produced by the electric-field force:

$eE = ma$

$$E = \frac{ma}{e} = \frac{(9.109 \times 10^{-31} \text{ kg})(6.40 \times 10^{13} \text{ m/s}^2)}{1.602 \times 10^{-19} \text{ C}} = 364 \text{ N/C}$$

Note that the acceleration produced by the electric field is <u>much</u> larger than g, the acceleration produced by gravity, so it is perfectly ok to neglect the gravity force on the electron in this problem.

b) $a = \dfrac{eE}{m_\mathrm{p}} = \dfrac{(1.602 \times 10^{-19}\ \mathrm{C})(364\ \mathrm{N/C})}{1.673 \times 10^{-27}\ \mathrm{kg}} = 3.49 \times 10^{10}\ \mathrm{m/s^2}$

This is much less than the acceleration of the electron in part (a) so the vertical deflection is less and the proton won't hit the plates.

The proton has the same initial speed, so the proton takes the same time $t = 1.25 \times 10^{-8}$ s to travel horizontally the length of the plates. The force on the proton is downward (in the same direction as $\vec{E}$, since q is positive), so the accleration is downward and $a_y = -3.49 \times 10^{10}\ \mathrm{m/s^2}$.

$y - y_0 = v_{0y}t + \frac{1}{2}a_y t^2 = \frac{1}{2}(-3.49 \times 10^{10}\ \mathrm{m/s^2})(1.25 \times 10^{-8}\ \mathrm{s})^2 = -2.73 \times 10^{-6}\ \mathrm{m}$.

The displacement is 2.73×10^{-6} m, downward.

c) The displacements are in opposite directions because the electron has negative charge and the proton has positive charge. The electron and proton have the same magnitude of charge, so the force the electric field exerts has the same magnitude for each charge. But the proton has a mass larger by a factor of 1836 so its acceleration and its vertical displacement are smaller by this factor.

22-25 a) Gravitational force exerted by the earth is $w_\mathrm{e} = m_\mathrm{e} g$.

$w_\mathrm{e} = (9.109 \times 10^{-31}\ \mathrm{kg})(9.80\ \mathrm{m/s^2}) = 8.93 \times 10^{-30}\ \mathrm{N}$

In Examples 22-7 and 22-8, $E = 1.00 \times 10^4$ N/C, so the electric force on the electron has magnitude

$F_E = |q|E = eE = (1.602 \times 10^{-19}\ \mathrm{C})(1.00 \times 10^4\ \mathrm{N/C}) = 1.602 \times 10^{-15}\ \mathrm{N}$.

$\dfrac{w_\mathrm{e}}{F_E} = \dfrac{8.93 \times 10^{-30}\ \mathrm{N}}{1.602 \times 10^{-15}\ \mathrm{N}} = 5.57 \times 10^{-15}$

The gravitational force is much smaller than the electric force and can be neglected.

b) From part (a) we know that this object must have mass much greater than an electron's mass.

$mg = |q|E$

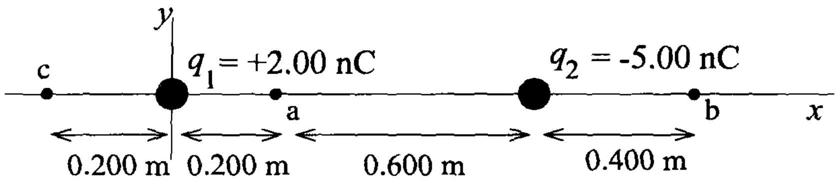
$m = |q|E/g = (1.602 \times 10^{-19}\ \mathrm{C})(1.00 \times 10^4\ \mathrm{N/C})/(9.80\ \mathrm{m/s^2}) = 1.63 \times 10^{-16}\ \mathrm{kg}$

$\dfrac{m}{m_\mathrm{e}} = \dfrac{1.63 \times 10^{-16}\ \mathrm{kg}}{9.109 \times 10^{-31}\ \mathrm{kg}} = 1.79 \times 10^{14}; \quad m = 1.79 \times 10^{14} m_\mathrm{e}$.

Thus, m is much larger than m_e.

c) The electric field in the region between the plates is uniform so the force it exerts on the charged object is independent of where between the plates the object is placed.

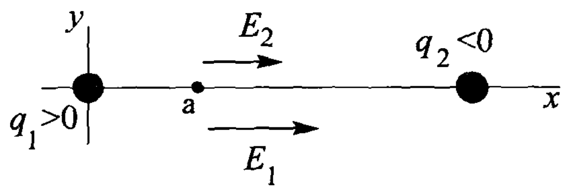
22-29 a)



The electric field of a point charge is directed away from the point charge if the charge is positive and toward the point charge if the charge is negative.

The magnitude of the electric field is $E = \dfrac{1}{4\pi\epsilon_0}\dfrac{|q|}{r^2}$, where r is the distance between the point where the field is calculated and the point charge.

(i) At point a the fields $\vec{E}_1$ of q_1 and $\vec{E}_2$ of q_2 are:



$$E_1 = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r_1^2} = (8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2})\frac{2.00 \times 10^{-9}\ \mathrm{C}}{(0.200\ \mathrm{m})^2} = 449.4\ \mathrm{N/C}$$

$$E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q_2|}{r_2^2} = (8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2})\frac{5.00 \times 10^{-9}\ \mathrm{C}}{(0.600\ \mathrm{m})^2} = 124.8\ \mathrm{N/C}$$

$E_{1x} = 449.4\ \mathrm{N/C}, \quad E_{1y} = 0$

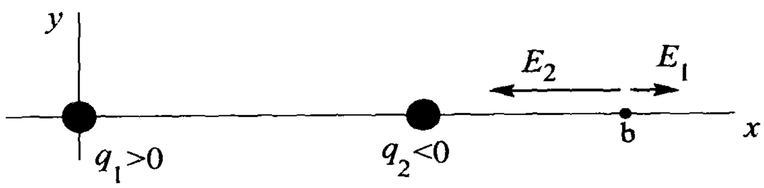
$E_{2x} = 124.8\ \mathrm{N/C}, \quad E_{2y} = 0$

$E_x = E_{1x} + E_{2x} = +449.4\ \mathrm{N/C} + 124.8\ \mathrm{N/C} = +574.2\ \mathrm{N/C}$

$E_y = E_{1y} + E_{2y} = 0$

The resultant field at point a has magnitude 574 N/C and is in the $+x$-direction.

(ii) At point b the fields $\vec{E}_1$ of q_1 and $\vec{E}_2$ of q_2 are:

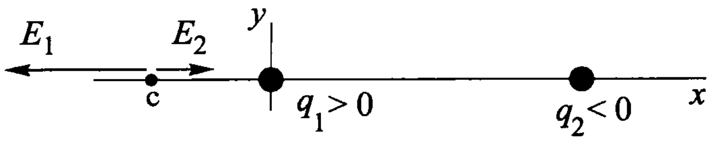


$$E_1 = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r_1^2} = (8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2})\frac{2.00 \times 10^{-9}\ \mathrm{C}}{(1.20\ \mathrm{m})^2} = 12.5\ \mathrm{N/C}$$

$$E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q_2|}{r_2^2} = (8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2})\frac{5.00 \times 10^{-9}\ \mathrm{C}}{(0.400\ \mathrm{m})^2} = 280.9\ \mathrm{N/C}$$

$E_{1x} = 12.5$ N/C, $\quad E_{1y} = 0$
$E_{2x} = -280.9$ N/C, $\quad E_{2y} = 0$
$E_x = E_{1x} + E_{2x} = +12.5$ N/C $- 280.9$ N/C $= -268.4$ N/C
$E_y = E_{1y} + E_{2y} = 0$
The resultant field at point b has magnitude 268 N/C and is in the $-x$-direction.

(iii) At point c the fields $\vec{E}_1$ of q_1 and $\vec{E}_2$ of q_2 are:



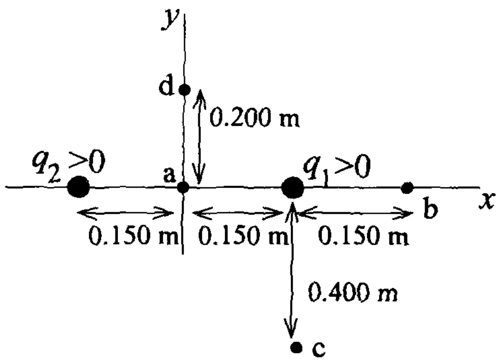
$$E_1 = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r_1^2} = (8.988 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{2.00 \times 10^{-9}\ \text{C}}{(0.200\ \text{m})^2} = 449.4\ \text{N/C}$$

$$E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q_2|}{r_2^2} = (8.988 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\frac{5.00 \times 10^{-9}\ \text{C}}{(1.00\ \text{m})^2} = 44.9\ \text{N/C}$$

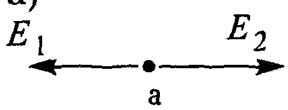
$E_{1x} = -449.4$ N/C, $\quad E_{1y} = 0$
$E_{2x} = +44.9$ N/C, $\quad E_{2y} = 0$
$E_x = E_{1x} + E_{2x} = -449.4$ N/C $+ 44.9$ N/C $= -404.5$ N/C
$E_y = E_{1y} + E_{2y} = 0$
The resultant field at point b has magnitude 404 N/C and is in the $-x$-direction.

b) Since we have calculated $\vec{E}$ at each point the simplest way to get the force is to use $\vec{F} = -e\vec{E}$.
(i) $F = (1.602 \times 10^{-19}\ \text{C})(574.2\ \text{N/C}) = 9.20 \times 10^{-17}$ N, $-x$-direction
(ii) $F = (1.602 \times 10^{-19}\ \text{C})(268.4\ \text{N/C}) = 4.30 \times 10^{-17}$ N, $+x$-direction
(iii) $F = (1.602 \times 10^{-19}\ \text{C})(404.5\ \text{N/C}) = 6.48 \times 10^{-17}$ N, $+x$-direction

22-33 The electric field of a positive charge is directed radially outward from the charge and has magnitude $E = \dfrac{1}{4\pi\epsilon_0}\dfrac{|q|}{r^2}$. The resultant electric field is the vector sum of the fields of the individual charges.



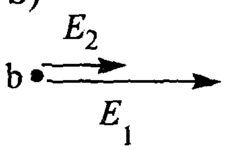
a)



$$E_1 = E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2} \text{ with } r = 0.150 \text{ m}.$$

$$E = E_2 - E_1 = 0;\ E_x = 0,\ E_y = 0$$

b)



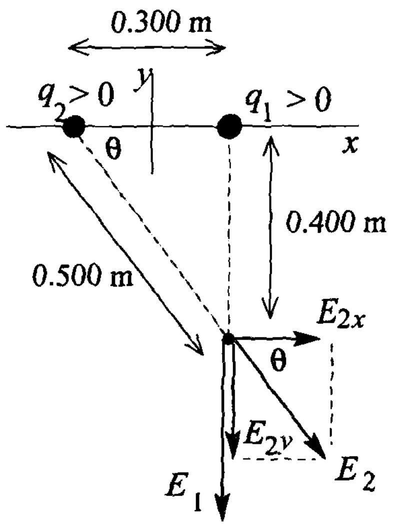
$E = E_1 + E_2$, in the $+x$-direction

$$E_1 = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r_1^2} = (8.988 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)\frac{6.00 \times 10^{-9}\ \text{C}}{(0.150\ \text{m})^2} = 2396.8\ \text{N/C}$$

$$E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q_2|}{r_2^2} = (8.988 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)\frac{6.00 \times 10^{-9}\ \text{C}}{(0.450\ \text{m})^2} = 266.3\ \text{N/C}$$

$$E = E_1 + E_2 = 2396.8\ \text{N/C} + 266.3\ \text{N/C} = 2660\ \text{N/C};\ E_x = +2260\ \text{N/C},\ E_y = 0$$

c)



$$\sin\theta = \frac{0.400\ \text{m}}{0.500\ \text{m}} = 0.800$$

$$\cos\theta = \frac{0.300\ \text{m}}{0.500\ \text{m}} = 0.600$$

$$E_1 = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r_1^2}$$

$$E_1 = (8.988 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)\frac{6.00 \times 10^{-9}\ \text{C}}{(0.400\ \text{m})^2} = 337.1\ \text{N/C}$$

$$E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q_2|}{r_2^2}$$

$$E_2 = (8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2})\frac{6.00 \times 10^{-9}\ \mathrm{C}}{(0.500\ \mathrm{m})^2} = 215.7\ \mathrm{N/C}$$

$$E_{1x} = 0, \quad E_{1y} = -E_1 = -337.1\ \mathrm{N/C}$$

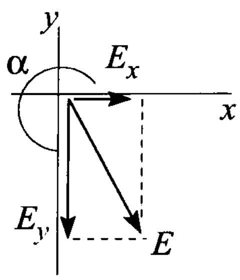
$$E_{2\mathrm{x}} = +E_2\cos\theta = +(215.7\ \mathrm{N/C})(0.600) = +129.4\ \mathrm{N/C}$$

$$E_{2\mathrm{y}} = -E_2\sin\theta = -(215.7\ \mathrm{N/C})(0.800) = -172.6\ \mathrm{N/C}$$

$$E_x = E_{1x} + E_{2x} = +129\ \mathrm{N/C}$$

$$E_y = E_{1y} + E_{2y} = -337.4\ \mathrm{N/C} - 172.6\ \mathrm{N/C} = -510\ \mathrm{N/C}$$

$$E = \sqrt{E_x^2 + E_y^2} = \sqrt{(129\ \mathrm{N/C})^2 + (-510\ \mathrm{N/C})^2} = 526\ \mathrm{N/C}$$

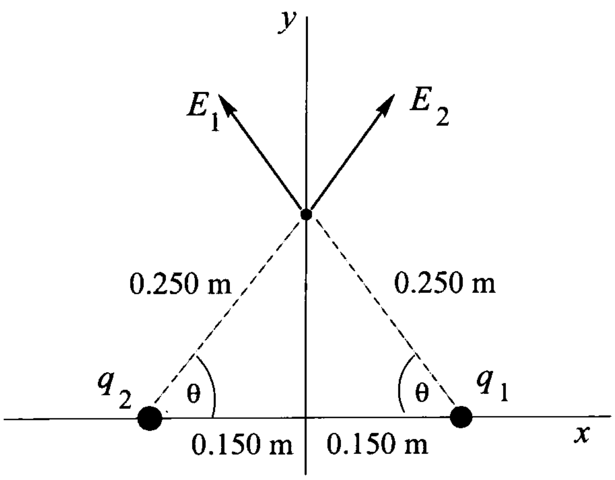


$$\tan\alpha = \frac{E_y}{E_x}$$

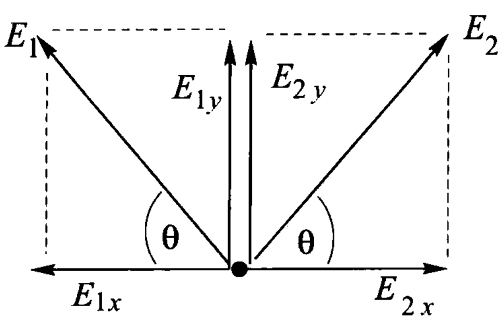
$$\tan\alpha = \frac{-510\ \mathrm{N/C}}{+129\ \mathrm{N/C}} = -3.953$$

$\alpha = 284°\mathrm{C}$, counterclockwise from $+x$-axis

d)



$$\sin\theta = \frac{0.200\ \mathrm{m}}{0.250\ \mathrm{m}} = 0.800$$



$$E_1 = E_2 = \frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2}$$

$$E_1 = (8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2})\frac{6.00 \times 10^{-9}\ \mathrm{C}}{(0.250\ \mathrm{m})^2}$$

$$E_1 = E_2 = 862.8\ \mathrm{N/C}$$