Student Workbook for Discovering Design with Physics

Property of:

____

Student Workbook for Discovering Design with Physics

Published by
Berean Builders
Muncie, IN
bereanbuilders.com

Printed in the United States of America
By
My Father's World

ISBN: 978-1-7350291-8-4

Table of Contents

Daily Assignments 1

Worksheets 9

Documenting Experiments 161

Laboratory Notebook 165

Daily Assignments

If your school year consists of 180 days, you can use this list of daily assignments to complete the course in one school year.

Week 1:

- ❑ Read the introduction to the book.
- ❑ Read from p. 1 to "Where Do We Start?" on p. 5, answering "Comprehension Check" questions 1-2.
- ❑ Read from "Where Do We Start?" on p. 5 to "Velocity is Relative" on page 9, answering "Comprehension Check" questions 3-4.
- ❑ Read from "Velocity is Relative" on p. 9 to p. 11, stopping after you complete Experiment 1.1.
- ❑ Read from the end of Experiment 1.1 on p. 11 to "Newton's First Law of Motion" on p. 15, answering "Comprehension Check" questions 5-7.

Week 2:

- ❑ Read from "Newton's First Law of Motion" on p. 15 to the end of p. 16, completing Experiment 1.2.
- ❑ Read from the top of p. 17 to p. 19, answering "Comprehension Check" questions 8-9. Stop once you have completed Experiment 1.3.
- ❑ Read from the end of Experiment 1.3 on p. 19 to p. 21, answering "Comprehension Check" question10. Stop once you have completed Experiment 1.4.
- ❑ Read p. 22-26, answering "Comprehension Check" questions 11-13.
- ❑ Work on the chapter review.

Week 3:

- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 1.
- ❑ Read pp. 35-37, stopping after you complete Experiment 2.1.
- ❑ Read from the end of Experiment 2.1 on p. 37 to p. 41, answering "Comprehension Check" questions 1-3. Stop right before Experiment 2.2.

Week 4:

- ❑ Complete Experiment 2.2 on p. 41 and read to "Equations of Motion (Part 1)" on p. 43, answering "Comprehension Check" questions 4-5.
- ❑ Read from "Equations of Motion (Part 1)" on p. 43 to "Equations of Motion (Part 2)" on p. 46, answering "Comprehension Check" questions 6-7.
- ❑ Read from "Equations of Motion (Part 2)" on p. 46 to the end of p. 49, answering "Comprehension Check" question 8.
- ❑ Read from the top of p. 50 to "More Analysis of Free Fall" on p. 51, completing Experiment 2.3 and answering "Comprehension Check" question 9.
- ❑ Read from "More Analysis of Free Fall" on p. 51 to the end of p. 55, answering "Comprehension Check" questions 10-13.

Week 5:

- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 2.
- ❑ Read pp. 65-67, completing Experiment 3.1 and answering "Comprehension Check" question 1. Stop after answering the question.

Week 6:

- ❑ Read from "Be Careful How You Apply Newton's Third Law" on p. 67 to p. 71, stopping right before Experiment 3.2. Answer "Comprehension Check" question 2.
- ❑ Perform Experiment 3.2 on p. 71. Stop when you finish the experiment.
- ❑ Read from the end of Experiment 3.2 on p. 72 to "Revisiting Some Old Friends" on p. 76. Answer "Comprehension Check" questions 3-4.
- ❑ Read from "Revisiting Some Old Friends" on p. 76 to the end of Experiment 3.3 on p. 78. Answer "Comprehension Check" questions 5-6 and complete the experiment.
- ❑ Read from the end of Experiment 3.3 on p. 78 to p. 81, stopping right before Experiment 3.4. Answer "Comprehension Check" questions 7-9.

Week 7:

- ❑ Perform Experiment 3.4 on p. 81. Stop when you have completed the experiment.
- ❑ Read pp. 82-84, answering "Comprehension Check" questions 10-11.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.

Week 8:

- ❑ Take the test for Chapter 3.
- ❑ Read pp. 91-93, stopping after you complete Experiment 4.1. Answer "Comprehension Check" question 1.
- ❑ Read from the end of Experiment 4.1 on p. 93 to the end of p. 97, answering "Comprehension Check" questions 2-3.
- ❑ Read from the top of p. 98 to the end of p. 100, answering "Comprehension Check" questions 4-5.
- ❑ Read from the top of p. 101 to p. 102, stopping right before Experiment 4.2. Answer "Comprehension Check" question 6.

Week 9:

- ❑ Perform Experiment 4.2 on pp. 102-104.
- ❑ Read from the end of Experiment 4.2 on p. 104 to the end of Example 4.5 on p. 107.
- ❑ Read from the end of Example 4.5 on p. 107 to the end of p. 110, answering "Comprehension Check" questions 7-9.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.

Week 10:
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 4.
- ❑ Read pp. 119-122, answering "Comprehension Check" questions 1-2.
- ❑ Read from the top of p. 123 to right before Example 5.3 on p. 125, completing Experiment 5.1
- ❑ Read from Example 5.3 on p. 125 to Equation (5.10) on p. 129, answering "Comprehension Check" questions 3-4.

Week 11:
- ❑ Read from Equation (5.10) on p. 129 to "Thinking About the Dimensions Independently" on p. 132. Complete Experiment 5.2 and answer "Comprehension Check" question 5.
- ❑ Read from "Thinking About the Dimensions Independently" on p. 132 to right before Experiment 5.3 on p. 136. Answer "Comprehension Check" questions 6-7.
- ❑ Complete Experiment 5.3 on pp. 136-137.
- ❑ Read from the end of Experiment 5.3 on p. 137 to the end of p. 138, answering "Comprehension Check" questions 8-10.
- ❑ Work on the chapter review.

Week 12:
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 5.
- ❑ Read pp. 149-150, completing Experiment 5.1 and stopping after the end of the experiment.
- ❑ Read from the end of Experiment 5.1 on p.150 to right before Example 6.2 on p. 154, answering "Comprehension Check" question 1.

Week 13:
- ❑ Read from Example 6.2 on p. 154 to right before Experiment 6.2 on p. 157, answering "Comprehension Check" questions 2-3.
- ❑ Complete Experiment 6.2 on p. 157 and read to the end of p. 158, answering "Comprehension Check" question 4.
- ❑ Read pp. 159-162, answering "Comprehension Check" questions 5-7.
- ❑ Read pp. 163-166, stopping right before Experiment 6.3.
- ❑ Perform Experiment 6.3 on pp. 166-167, stopping after you have finished the experiment.

Week 14:
- ❑ Read from the end of Experiment 6.3 on p. 167 to the end of p. 168, answering "Comprehension Check" questions 8-10. Start on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 6.
- ❑ Read pp. 177-179, stopping after you complete Experiment 7.1

Week 15:
- ❑ Read from the end of Experiment 7.1 on p. 179 to "Two Sources of Centripetal Force" on p. 182, answering "Comprehension Check" questions 1-4.
- ❑ Read from "Two Sources of Centripetal Force" on p. 182 to "Gravity: Another Source of Centripetal Force" on p. 185, answering "Comprehension Check" questions 5-6.
- ❑ Read from "Gravity: Another Source of Centripetal Force" on p. 185 to "But Isn't Gravity Constant Near the Surface of the Earth?" on p. 188, answering "Comprehension Check" questions 7-8.
- ❑ Read from "But Isn't Gravity Constant Near the Surface of the Earth?" on p. 188 to "Kepler's Laws" on p. 192, answering "Comprehension Check" questions 9-10.
- ❑ Read from "Kepler's Laws" on p. 192 to the end of p. 195, answering "Comprehension Check" questions 11-12.

Week 16:
- ❑ Read pp. 196 and 197, completing Experiment 7.2.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 7.

Week 17:
- ❑ Read pp. 203-205. Stop after you answer "Comprehension Check" questions 1-2.
- ❑ Perform Experiment 8.1 on p. 205 and read to "Different Forms of Energy" on p. 207
- ❑ Read from "Different Forms of Energy" on p. 207 to "The Interplay Between Kinetic and Potential Energy" on p. 210, answering "Comprehension Check" questions 3-4.
- ❑ Read from "The Interplay Between Kinetic and Potential Energy" on p. 210 to the end of p. 213, answering "Comprehension Check" questions 5-6.
- ❑ Perform Experiment 8.2 on p. 214 and read to the end of Example 8.4 on p. 216.

Week 18:
- ❑ Read from the end of Example 8.4 on p. 216 to the end of Experiment 8.3 on p. 218, completing the experiment and answering "Comprehension Check" questions 7-8.
- ❑ Read pp. 219-223, answering "Comprehension Check" questions 9-10.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.

Week 19:
- ❑ Take the test for Chapter 8.
- ❑ Read pp. 229-231, stopping at the end of Experiment 9.1. Answer "Comprehension Check" question 1 and complete the experiment.
- ❑ Read from the end of the experiment on p. 231 to right before Experiment 9.2 on p. 234, answering "Comprehension Check" questions 2-3.
- ❑ Complete Experiment 9.2 on p. 234 and read to "Using Momentum Conservation to Analyze Situations" on p. 237, answering "Comprehension Check" questions 4-5.
- ❑ Read from "Using Momentum Conservation to Analyze Situations" on p. 237 to "Energy Conservation in Collisions" on p. 240, answering "Comprehension Check" questions 6-7.

Week 20:

- ❑ Read from "Energy Conservation in Collisions" on p. 240 to the end of p. 244, answering "Comprehension Check" questions 8-9.
- ❑ Read from the top of p. 245 to the end of Experiment 9.3 on p. 246. Complete the experiment.
- ❑ Read from the end of Experiment 9.3 on p. 246 to the end of p. 249, answering "Comprehension Check" questions 10-11.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.

Week 21:

- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 9.
- ❑ Read pp. 257-259, stopping after step 11 in Experiment 10.1.
- ❑ Complete steps 12-19 in Experiment 10.1 and read to "Using Hooke's Law" on p. 126, answering "Comprehension Check" questions 1-2.
- ❑ Read from "Using Hooke's Law" on p. 261 to the beginning of Experiment 10.2 on p. 265, answering "Comprehension Check" questions 3-4.

Week 22:

- ❑ Complete Experiment 10.2 on p. 265 and read to "Terminology and the Use of Equation (10.5)" on p. 266, answering "Comprehension Check" questions 5-6.
- ❑ Read from "Terminology and the Use of Equation (10.5)" on p. 266 to the end of p. 271, answering "Comprehension Check" questions 7-10.
- ❑ Read p. 272, stopping after you complete Experiment 10.3.
- ❑ Read from the end of Experiment 10.3 on p. 272 to the end of p. 276, answering "Comprehension Check" question 11.
- ❑ Work on the chapter review.

Week 23:

- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 10.
- ❑ Read pp. 283-286, stopping at "Sound Waves" on p. 286. Answer "Comprehension Check" questions 1-2.
- ❑ Read from "Sound Waves" on p. 286 to the middle of p. 288, stopping at the phrase "You have just learned the basic…" Complete Experiment 11.1.

Week 24:

- ❑ Read from where you left off on p. 288 to the beginning of Example 11.3 on p. 293, answering "Comprehension Check" questions 3-5.
- ❑ Read from the beginning of Example 11.3 on p. 293 to "The Wave Nature of Light" on page 297, answering "Comprehension Check" questions 6-8.
- ❑ Read from "The Wave Nature of Light" on page 297 to "A Few Details about Light" on p. 300, answering "Comprehension Check" question 9.
- ❑ Read from "A Few Details about Light" on p. 300 to "Is Light a Particle or a Wave" on p. 304, answering "Comprehension Check" questions 10-12.
- ❑ Read from "Is Light a Particle or a Wave" on p. 304 to the end of p. 306.

Week 25:
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 11.
- ❑ Read pp. 311-313, stopping at "Reflection in Flat Mirrors." Complete Experiment 12.1.

Week 26:
- ❑ Read from "Reflection in Flat Mirrors" on p. 313 to the beginning of Example 12.1 on p. 317, answering "Comprehension Check" questions 1-2.
- ❑ Read from the beginning of Example 12.1 on p. 317 to "Ray Tracing With Convex Spherical Mirrors" on p. 322, answering "Comprehension Check" questions 3-4.

- ❑ Read from "Ray Tracing With Convex Mirrors" on p. 322 to the end of Experiment 12.2 on p. 325, completing the experiment.
- ❑ Read from the end of Experiment 12.2 on p. 325 to the end of Example 12.4 on p. 329, answering "Comprehension Check" question 5.
- ❑ Read from the end of Example 12.4 on p. 329 to the beginning of Example 12.5 on p. 333, answering "Comprehension Check" questions 6-8.

Week 27:
- ❑ Read from the beginning of Example 12.5 on p. 333 to the end of p. 337, answering "Comprehension Check" questions 9-10.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 12.

Week 28:
- ❑ Read from the top of p. 347 to the end of Experiment 13.1 on p. 349. Complete the experiment.
- ❑ Read from the end of Experiment 13.1 on p. 349 to the beginning of Example 13.1 on p. 353, answering "Comprehension Check" questions 1-2.
- ❑ Read from the beginning of Example 13.1 on p. 353 to "The Electrostatic Force with Multiple Charges" on p. 355, answering "Comprehension Check" questions 3-4.
- ❑ Read from "The Electrostatic Force With Multiple Charges" on p. 355 to "The Electric Field" on p. 358, answering "Comprehension Check" questions 5-6.
- ❑ Read from "The Electric Field" on p. 358 to "Conductors, Insulators, and the Reality of the Electric Field" on p. 362, answering "Comprehension Check" questions 7-11.

Week 29:
- ❑ Read from "Conductors, Insulators, and the Reality of the Electric Field" on p. 362 to "The Strength of the Electric Field" on p. 364, completing Experiment 13.2.
- ❑ Read from to "The Strength of the Electric Field" on p. 364, to the end of p. 336, answering "Comprehension Check" questions 12-13.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.

Week 30:
- ❑ Take the test for Chapter 13.
- ❑ Read from the top of p. 373 to "Potential Difference" on p. 375, answering "Comprehension Check" questions 1-2.
- ❑ Read from "Potential Difference" on p. 375 to right before Experiment 14.1 on p. 379, answering "Comprehension Check" question 3.
- ❑ Read from the beginning of Experiment 14.1 on p. 379 to the bottom of p. 380, completing the experiment and answering "Comprehension Check" question 4.
- ❑ Read from the top of p. 381 to right before Experiment 14.2 on p. 384, answering "Comprehension Check" questions 5-6.

Week 31:
- ❑ Read from the beginning of Experiment 14.2 on p. 384 to the end of p. 385, completing the experiment.
- ❑ Read from the top of p. 386 to the last two lines on p. 389, answering "Comprehension Check" question 7.
- ❑ Read from where you left off on p. 389 to the bottom of p. 392 , answering "Comprehension Check" questions 8-10.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.
- ❑ Check your work on the chapter review, and study for the test.

Week 32:
- ❑ Take the test for Chapter 14.
- ❑ Read from the top of p. 397 to the beginning of Example 15.1 on p. 400, answering "Comprehension Check" question 1.
- ❑ Read from the beginning of Example 15.1 on p. 400 to right before Experiment 15.1 on p. 403, answering "Comprehension Check" questions 2-3.
- ❑ Perform Experiment 15.1 on pp. 403-405, stopping after you complete the experiment.
- ❑ Read from the end of Experiment 15.1 on p. 405 to "More on Series and Parallel Circuits" on p. 407, answering "Comprehension Check" questions 4-6.

Week 33:
- ❑ Read from "More on Series and Parallel Circuits" on p. 407 to "This Can Get a Little Complicated" on p. 410, answering "Comprehension Check" questions 7-8.
- ❑ Read from "This Can Get a Little Complicated" on p. 410 to the end of Example 15.4 on p. 415, answering "Comprehension Check" question 9.
- ❑ Read from the end of Example 15.4 on p. 415 to the end of p. 418, answering "Comprehension Check" questions 10-11.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.

Week 34:

- ❑ Check your work on the chapter review, and study for the test.
- ❑ Take the test for Chapter 15.
- ❑ Read from the top of p. 425 to "The Relationship Between Electricity and Magnetism" on p. 429, answering "Comprehension Check" questions 1-3.
- ❑ Read from "The Relationship Between Electricity and Magnetism" on p. 429 to the end of Experiment 16.1 on p. 430, stopping once you complete the experiment.
- ❑ Read from the end of Experiment 16.1 on p. 430 to right before Experiment 16.2 on p. 432, answering "Comprehension Check" questions 4-5.

Week 35:

- ❑ Read from the beginning of Experiment 16.2 on p. 432 to the end of p. 433, completing the experiment.
- ❑ Read from the top of p. 434 to "A Consequence of Faraday's Law…" on p. 439, answering "Comprehension Check" questions 6-10.
- ❑ Read from "A Consequence of Faraday's Law…" on p. 439 to the end of p. 441, completing Experiment 14.3 if you choose to do it and answering "Comprehension Check" question 11.
- ❑ Work on the chapter review.
- ❑ Finish the chapter review.

Week 36:

- ❑ Take the test for Chapter 16.

Worksheets

Chapter 1 Comprehension Check Questions

1. The density of an object is its mass divided by its volume. What is the density of a rock if it has a mass of 3.40×10^{2} g and a volume of 1.215×10^{-4} m^3?

2. Use the factor-label method to convert 0.0231 g into mg.

3. A man walks for 570 m west and then turns around and walks 310 m east. What is his displacement from his original starting point?

4. A bicyclist rides 4.61 km east. He then stops and rides 4.92 km west. If the trip takes him 0.732 hours, what is his speed? What is his velocity?

5. In a long-distance race, the runner in the lead has a velocity of 2.9 m/s west. The runner in second place has a velocity of 2.8 m/s west. What is the velocity of the runner in second place relative to the runner in the lead?

6. A runner is moving east at 3.45 m/s. After 4.0 minutes, what will be his displacement?

7. Two trains are on the same track. One is traveling at 23 m/s east and the other at 19 m/s west. If the first train is 16.5 km west of the second, how long before they collide?

8. Suppose you are sitting in a plane that is coasting along. Suddenly, the plane drops a few hundred feet without warning. If you aren't wearing your seat belt, in what direction relative to the seat will you travel?

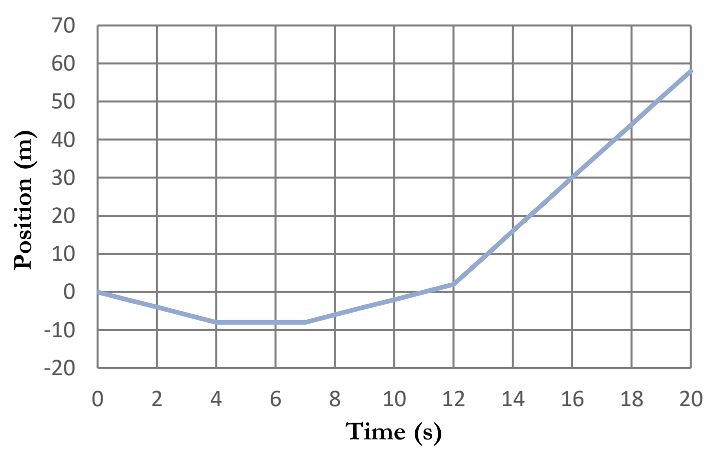
9. Two identical blocks traveling on two different flat surfaces are given the same velocity. Block A comes to rest in 2.1 meters, while block B comes to rest in 1.7 m. Which experienced a weaker frictional force?

10. Suppose you shoot an arrow straight up while riding in the back of a pickup truck that is traveling down the road at a constant velocity. Ignoring friction, where will the arrow land when it comes back down?

11. Suppose you did one more trial of the experiment, with the end of the ramp only 0.50 m away from the wall. Would the average velocity be greater than, less than, or the same as the velocity you measured when it was 1.00 m from the wall?

12. A policeman with a radar gun measures a car's instantaneous velocity to be 29 m/s west. Half a second later, he measures it to be 25 m/s west. What is the direction of the car's acceleration?

13. For the graph on the right, the positive direction is east.



a. Over what time interval is the velocity zero?

b. When does the object experience acceleration? For each acceleration, indicate the direction.

c. What is the instantaneous velocity at t = 11.0 seconds?

Chapter 1 Review Questions

1. Define the following terms:

   a. Vector quantity

   b. Scalar Quantity

   c. Friction

   d. Inertia

   e. Average velocity

   f. Instantaneous velocity

   g. Acceleration

2. You see the following entries in a lab notebook. Indicate what physical quantity was measured in each case:

   a. 17 m/s

   b. 12 inches

   c. 1.2 km north

   d. 25 seconds

   e. 22 miles/hr west

3. You ride your bicycle for 5.2 km west and then turn around and ride it 4.3 km east. What is the total distance you traveled? What is the total displacement?

4. Suppose you took 925 seconds to make the trip discussed in problem #3. What was your average speed? What was your average velocity?

5. A car is on a highway, traveling at 25 m/s west. A truck is on the same highway, traveling 29 m/s west. What is the velocity of the car relative to the truck? What is the velocity of the truck relative to the car? If the two vehicles eventually collide, which one was ahead?

6. You are walking with a constant velocity of 1.5 m/s north. If you walk for 15 minutes, what will be your displacement?

7. You ride your bicycle with a velocity of 11 m/s west. If you do that until your displacement is 7.8 km west, how long will it take you?

8. Two cars start next to one another on a road. One travels at 31 m/s north, while the other travels at 28 m/s south. How far will they be from each other in 22 minutes?

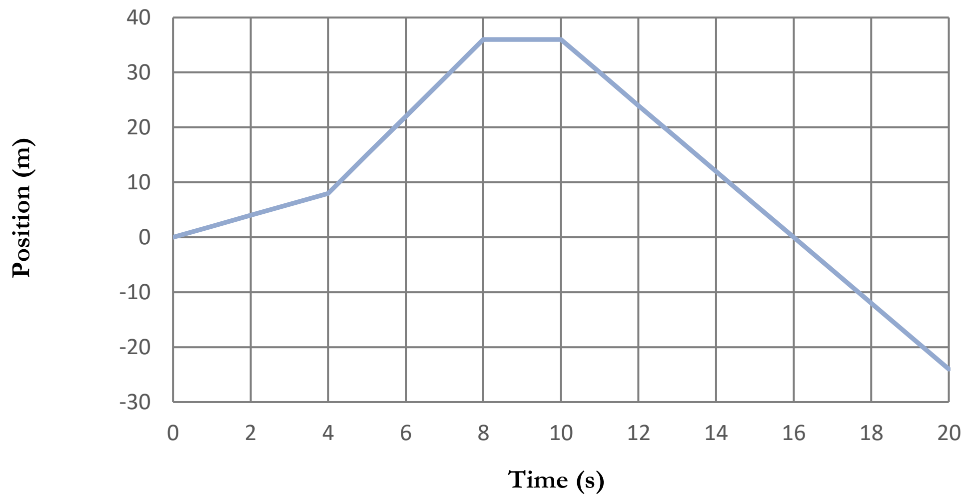
9. A car is traveling at a constant velocity. Is there a net force acting on it? How would your answer change if you only knew it was traveling at a constant speed?

10. A man is riding a horse with a constant velocity, when suddenly, the horse plants its feet and stops. When that happens, how will the man move relative to the horse?

11. You are told that object A has much more inertia than object B. If they are both traveling with the same velocity, which will be harder to stop?

12. A moving object is experiencing a net force. Is it accelerating or not?

Questions 13-17 refer to the graph below, for which the positive direction is east.



13. At what times does the object in the graph experience an acceleration? What direction is that acceleration?

14. During what time interval is the object not moving?

15. During what time interval is the object east of its starting position? For what time interval is it west of its starting position?

16. Are the instantaneous and average velocities the same from 2 seconds to 6 seconds? What about from 14 seconds to 18 seconds?

17. What is the instantaneous velocity at 1 second?

18. An experiment has only random errors in it. One student performs it ten times and averages her results. The other does it just one time and reports the result as his final answer. Most likely, which student will be more accurate?

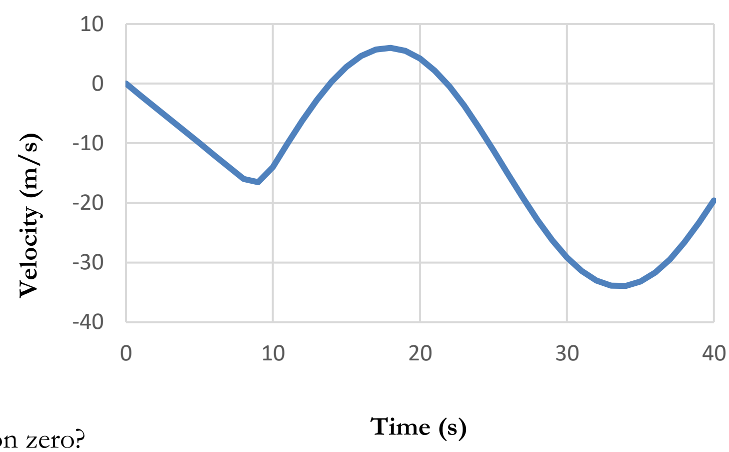
19. How would your answer to #18 change if the experiment had systematic errors in it?

Chapter 2 Comprehension Check Questions

1. A sprinter starts from rest, accelerating north at 3.1 m/s^2. How long does it take him to reach a velocity of 5.9 m/s north?

2. A car is traveling east when the brakes are applied. If the brakes provide an acceleration west of 33,000 km/hr^2 and it takes 6.2 s for the car to stop, what was its initial velocity?

3. In the graph on the right, positive means east.



a. Over what time intervals is the object slowing down?

b. At what times is the instantaneous acceleration zero?

c. Over what time interval is the instantaneous acceleration equal to the average acceleration?

d. What is the instantaneous acceleration at 4 seconds?

4. A force of 75 N west causes an object to accelerate west at 0.30 m/s^2. What is the object's mass?

5. A 1,200-kg car is traveling east at 23 m/s when the brakes are applied. If the brakes provide a force of 8,500 N to stop the car, how long before the car comes to rest?

6. A car is traveling west at 27 m/s. The driver hits the brakes and comes to a stop after traveling an additional 66 m. If the car's mass is 1,300 kg, what force did the brakes apply?

7. A box is sitting at rest on the floor. It is pushed with a force of 15.0 N north. After 4.5 seconds, it is moving north at 7.07 m/s. What is the mass of the box?

8. A 540-g toy car starts from rest and is pushed with a constant force of 2.55 N. How long will it take for the car to travel 10.0 m?

9. An object is falling near the surface of the earth with an acceleration of 12.3 m/s^2 downward. Is it being acted on by a force other than gravity? If so, what is the direction of that force?

10. An object is thrown with a velocity of 4.12 m/s upwards. How long will it take to return to the height from which it was launched?

11. For the object in the previous problem, what is its maximum height?

12. A rock is thrown upwards from a bridge at 3.40 m/s. It lands in the water 2.11 s later. How high above the water is the bridge?

13. The Mars Rover (a robotic vehicle) known as the "Curiosity" weighs 8,820 newtons on earth. What does it weigh on Mars, where the acceleration due to gravity is 3.7 m/s^2?

Chapter 2 Review Questions

1. Define the following terms:

   a. Free fall

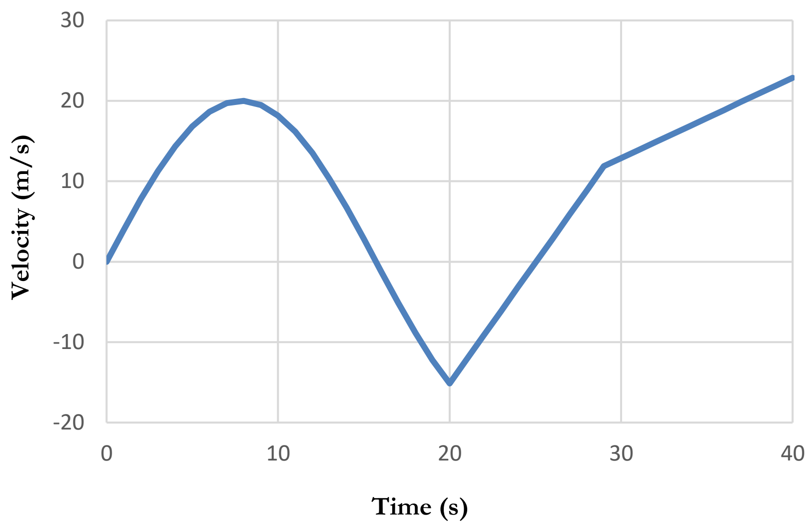
   b. Air resistance

2. State Newton's Second Law in words and in mathematical form.

3. An object is experiencing a net force that varies. Can the equations of motion derived in this chapter be used to analyze its motion?

4. An object starts off with an acceleration of 2.3 ft/s^2, but after 10 seconds, it begins travelling with a constant velocity. It travels at that constant velocity for a full minute. If you use Equation (2.1) to determine its acceleration over the entire 70 seconds, will your answer be 2.3 ft/s^2? If not, will be it greater than or less than 2.3 ft/s^2?

5. In the graph on the right, positive means north.



a. At what times is the acceleration zero?

b. During what time intervals is the object moving south?

c. During what time intervals is the object slowing down?

d. What is the instantaneous acceleration at 25 s?

e. Over what time intervals can our equations of motion be applied to this object?

6. An object is accelerating west at 3.40 m/s^2 due to a force pushing at 1.2 newtons. What is the object's mass? What is the direction of the force?

7. A 15.0-g object is being pushed west with a constant force of 1.76 N. If it started from rest, what will its velocity be after 5.1 seconds?

8. A 1,710-kg car is traveling north at 25.0 m/s. The driver hits the brakes, and the car stops in 69.1 m. What constant force did the brakes apply to the car?

9. A 560-g object is at rest. If a constant force of 2.1 N west is applied, what will be its displacement after 9.6 seconds?

10. If something is falling near the surface of the earth, what is necessary in order to treat it as if it were in free fall?

11. Three objects are dropped from the same height. Object A accelerates downward at 15.6 ft/s^2. Object B accelerates downward at 11.1 m/s^2. Object C accelerates downward at 9.81 m/s^2. Which object is in free fall? Which is being pushed down as it falls? Which is being strongly affected by air resistance?

12. A 9mm pistol shoots a bullet with a velocity of 1,150 ft/s straight up. Ignoring air resistance:

a. What is the bullet's velocity at its maximum height? What is its acceleration?

b. What is the bullet's velocity when it falls back down to the height at which it was shot?

c. What is the bullet's maximum height, relative to the height from which it was shot?

13. You drop a heavy ball off the top of a building, and it takes 1.28 seconds to hit the ground. What is the height of the building?

14. A rock is thrown with a velocity of 2.72 m/s downward. What is its velocity the instant it hits the ground, which is 12.1 m below the height from which the rock was thrown?

15. An object is in free fall for 13.1 s. If its final velocity is 98 m/s downward, what was its initial velocity?

16. A ball is put in free fall. It ends up hitting the ground, which is 6.1 ft below where it was launched, in 5.10 s. What was its initial velocity?

17. What is the weight of an object whose mass is 14.8 slugs?

18. An object weighs 170 newtons on earth. How much does it weigh on the moon, where the acceleration due to gravity is 1.6 m/s^2?

Chapter 3 Comprehension Check Questions

1. Suppose you are pushing on a car that is not moving. If the ground is slick (covered with ice, for example), the moment you push the car, you move backwards. Why? Why doesn't that happen when the ground isn't slick?

2. A 28-kg girl is on an elevator, standing on a scale. The elevator starts off at a high floor and accelerates downward at 0.68 m/s^2. What weight does the scale read while the elevator is accelerating? What weight does it read once the elevator starts moving at a constant velocity downward?

3. You see two coefficients of friction for the same two surfaces: 0.23 and 0.32. Which is the coefficient of static friction?

4. A 56.0-kg rock is at rest on the ground. Two men are pushing it in the same direction with a combined force of 355 N. If the coefficients of friction are 0.621 and 0.513, will it move at all? If so, what will be its acceleration?

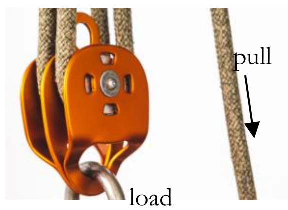
5. A 12.2-kg box is shoved so that it starts sliding across the floor with a velocity of 3.2 m/s west. Once it is moving, it is allowed to slide without being pushed. How far will it slide before it stops? The coefficients of friction are 0.45 and 0.29.

6. What force is required to make a 45.0-kg box start from rest and be pushed 3.78 m north in 2.20 seconds? The coefficients of friction are 0.51 and 0.40.

7. A rope that can withstand a tension of 650 pounds before breaking is being used to pull on a 1,200-pound rock. What is the maximum coefficient of static friction that could exist between the rock and the ground for the rope to successfully get the rock moving?

8. Suppose the rope didn't break in the previous problem and the rock began to move. After a few moments, it begins to move with a constant velocity. Is the tension in the rope equal to, greater than, or lower than the tension that was in the rope the instant it started moving?

9. A section of a block and tackle system is shown in the picture on the right. It shows the pulleys and the rope on which you pull. What is the mechanical advantage for this system? If a person pulls down on the rope with a force of 50 pounds, what force ends up lifting the load that is connected to the pulleys?



10. Two objects have roughly the same mass, but the first one is much larger. Which will have the higher terminal velocity?

11. Two objects have exactly the same shape and mass. However, when they are dropped from the same height, one falls more slowly than the other. What is the most likely explanation for this?

Chapter 3 Review Questions

1. Define the following terms:

    a. Static friction

    b. Kinetic friction

    c. Tension

    d. Streamlined shape

    e. Terminal velocity

2. State Newton's Third Law.

3. State the common phrase that is a less precise expression of Newton's Third Law.

4. Suppose someone throws a rock through a window. At the moment of impact, indicate the forces involved in the situation (besides the gravitational force and air resistance). Indicate the consequence of each force.

5. When someone fires a gun, the gun pushes back against that person. This is often referred to as the gun's "kick." Explain why a gun does this using Newton's Third Law.

6. A 72-kg person is standing on a floor. What is the strength of the normal force and its direction? What is exerting the normal force? What happens if the thing exerting the normal force isn't strong enough to exert that force?

7. A man is standing on a scale in an elevator. When the elevator is at rest, it reads 156 pounds. When the elevator accelerates upward, it reads 162 pounds. What is the acceleration of the elevator? What will the scale read when the elevator is traveling up with a constant velocity of 26 ft/sec?

8. A 112-g object is sitting at rest on a table. It takes a force just greater than 0.512 N to get it moving, and it takes a 0.345-N force to keep it moving at a constant velocity. What are the coefficients of static and kinetic friction?

9. A force of 451 N west is applied to a 125-kg box that is at rest. Will it move? If it does move and that same force continues to be exerted, what will be its acceleration? The coefficients of friction are 0.35 and 0.21.

10. A 24.3-kg box is being pushed across a floor. It starts from rest and takes 2.20 seconds to travel 5.00 m. What force is being used to push it? The coefficients of friction are 0.39 and 0.22.

11. A 95.0-kg box is being pushed across the floor with a constant force of 195 Newtons. It has an initial velocity of 2.6 m/s north. How far will it travel before coming to a rest? The coefficients of friction are 0.320 and 0.230.

12. A 567-g block is being pushed with a constant force of 4.11 N west. If it starts at rest and reaches a velocity of 12.0 m/s west in 3.11 s, what is the coefficient of kinetic friction?

13. An 891-g model airplane is hung from a ceiling by a string, as shown in the picture on the right. If the airplane just hangs there, what is the tension on the string? What happens if the string cannot withstand that amount of tension?

14. Suppose someone decides the string in the picture on the previous page is too visible, so the person wants to use thread to make it look less obvious. If the thread cannot withstand the tension required to hold the plane, what can the person do to successfully hang the airplane by the thread?

15. A man is pulling a 154-kg crate with a rope at a constant velocity south. The tension in the rope is 305 N. What is the coefficient of kinetic friction between the crate and the floor?

16. In the block and tackle system shown on the right, a load is attached to the lower hook. The load experiences a force of 112 N upward when a person pulls on the rope that is pointed out in the picture. With what force is the person pulling?

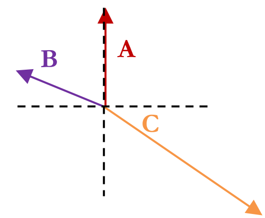
17. Two spherical objects of the same mass are dropped. The first falls more quickly than the second. Which sphere is larger?

18. Two objects that are identical in shape and size are dropped. The first has the higher terminal velocity. Which object has less mass?

19. What property of air resistance causes falling objects to have a terminal velocity?

Chapter 4 Comprehension Check Questions

1. Suppose the vectors shown on the right represent the velocities of different objects. Each arrow is labeled to indicate which object's velocity it represents.

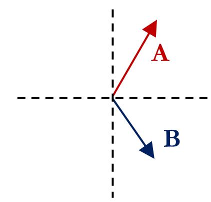


a. Which object is traveling the fastest?

b. Which object's direction is roughly 160°?

c. Which object is headed due north?

2. Given vectors **A** and **B** on the right, draw **A** + **B** and **B** – **A**.



3. Two people are pushing on the same object. The first exerts a 5-N force at an angle of 30 degrees, and the other exerts a force of 10 N at 310 degrees. Which of the vectors below is roughly the sum of those forces?

6 N at 250° 12 N at 330° 6 N at 330° 12 N at 250°

4. A car's velocity is 87 km/hr at 57^o. What are the velocity's horizontal and vertical components?

5. A force has the following components: $A_x = -9.5$ N, $A_y = -2.5$ N. What is its magnitude and direction?

6. Force A is 4.55 N at 225^o, while Force B is 5.19 N at 125^o. What is the sum of those two forces?

7. A ship is traveling in water that has a current whose velocity is 7.0 km/hr at 265^o. The ship's engines are giving it a velocity of 19.0 km/hr at 65^o. What is the actual velocity of the ship?

8. An airplane needs an actual velocity of 715 km/hr at 35.0^o. The wind blows with a velocity of 55 km/hr at 195.0^o. What velocity must the airplane's engines supply?

9. An airplane's engines are giving it a velocity of 675 km/hr at 325°. If the actual velocity is 695 km/hr at 315°, what is the velocity of the wind?

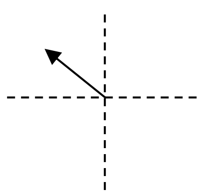
Chapter 4 Review Questions

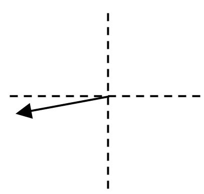
1. When representing a vector by an arrow, what does the length of the arrow represent? How do we give the vector's direction?

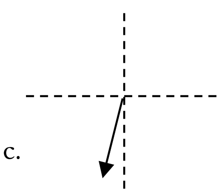
2. Is the magnitude of a vector ever negative?

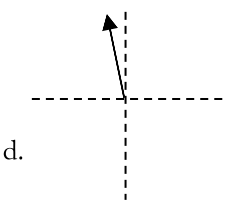
3. A student writes a velocity vector as 4.5 m/s at -45°. What is wrong with the way the student is reporting the vector?

4. Which of the following could represent a velocity of 15.0 m/s at 256°?

a. 

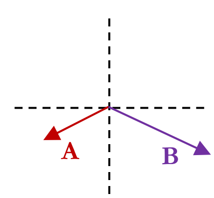
b. 

c. 

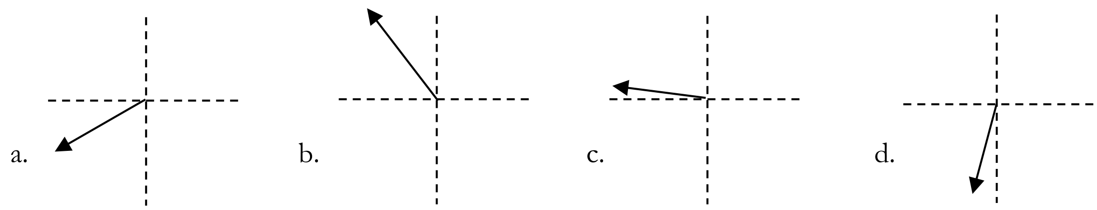
d. 

5. Compared to the correct answer in #4, what would change if the force was 7.5 N at 256°?

6. Given vectors **A** and **B** on the right, draw **A** + **B** and **A** – **B**.



7. One force acting on an object is 10.0 N at 105°. A second force of 5.0 N at 180° is acting on the same object. If those are the only two forces at play, which of the following answers shows the net force?



8. What are the x- and y-components of an acceleration of 3.47 m/s^2 at 301°?

9. A person walks 3.66 km due west and then 2.14 km due north. What is the magnitude and direction of the person's displacement vector?

10. A man in a rowboat is crossing a river. The river's current is due east. The man wants to land directly south of the place from which he launches his boat. Which of the following angles for the rowboat's velocity would possibly allow him to reach his goal?

a. 270^{o} b. 315^{o} c. 135^{o} d. 260^{o} e. 65^{o}

11. Displacement vector **A** is 5.66 m at 235^{o}, and displacement vector **B** is 3.89 m at 115^{o}. What is the sum of those two displacement vectors?

12. A ship's captain gives her ship a velocity of 17.3 m/s at 47°. The current has a velocity of 3.4 m/s at 231°. What is the actual velocity of the ship?

13. An airplane needs to travel with a velocity of 756 km/hr at 158°. The wind has a velocity of 25 km/hr at 268°. What velocity should the pilot give the airplane?

14. A ship is traveling with an actual velocity of 13.8 km/hr at 66°. The engines are giving it a velocity of 12.9 km/hr at 59°. What is the velocity of the current?

Chapter 5 Comprehension Check Questions

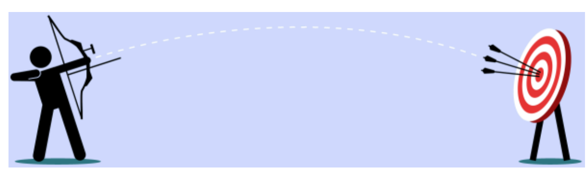
1. A hiker travels with a velocity of 1.4 m/s at 317° for 15.0 min. He then keeps the same speed but turns to a heading of 63° for 11.5 min. What is his final displacement?

2. A ship's engines give it a constant velocity of 12.0 km/hr at 108^{o}, while the current has a constant velocity of 2.6 km/hr at 351^{o}. If these conditions prevail for 117 minutes, what will be the ship's displacement?

3. A pistol shoots a bullet with a speed of 230 m/s at an unknown angle. It reaches a maximum height relative to the ground of 590 m. Ignoring the height from which it was fired, at what angle was it fired?

4. Ignoring the height from which it was fired, how long will it take for the bullet in the previous problem to hit the ground?

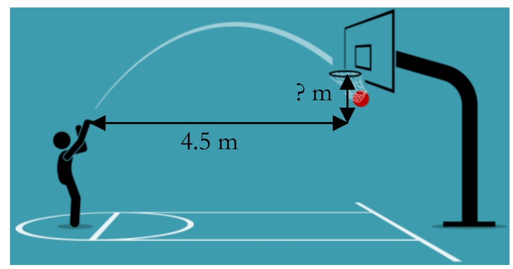
5. An archer is shooting at a target that is 50.0 m away. The spot that he wants to hit is at the same height as the arrow in his bow. If the arrow leaves the bow at 65 m/s, at what angle must he aim his bow to hit the target?



6. Suppose the archery competition I just described were changed so that the target is shot straight up in the air, and the archer can shoot it at any time while it is in the air. If the archer wants to aim directly at the target when she fires, at what point in the target's path should the archer release her arrow?

7. A pistol is aimed perfectly horizontally so that when it is fired, the bullet's initial velocity is 700 ft/s at 0^{o}. If a bullet is dropped at the same time and from the same height, how do the times at which they hit the ground compare, assuming the ground is level?

8. A basketball player is shooting a free throw. He is 4.5 meters from the center of the basket and releases the ball with a velocity of 7.2 m/s at 55^{o}. The ball goes straight through the center of the basket, as shown on the left. How high is the basket above the point where he releases the ball?



9. A bullet is shot from a pistol with a velocity of 205 m/s at 0^o. If it hits a target 125 m away, how far will it drop along the way?

10. A baseball is thrown horizontally ($\theta=0^o$). It is caught 18.5 m away and 84.5 cm below the spot from which it was released. At what speed was it thrown?

Chapter 5 Review Questions

1. Define the following terms:

   a. Projectile

   b. Parabolic motion

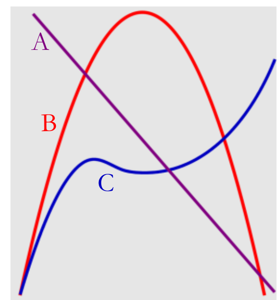
2. A hiker walks with a velocity of 1.3 m/s at 55^{o} for 96 minutes and then changes to a velocity of 1.2 m/s at 245^{o} for 157 minutes. What is the hiker's final displacement?

3. A 915-g object experiences two forces. The first is 15.0 N at 299°, and the second is 22.5 N at 276°. What is the acceleration of the object?

4. What can you say about the x-component of a projectile's velocity throughout the course of its travel? What about the y-component of the projectile's velocity? Ignore air resistance.

5. Answer question 4 again, but this time, include air resistance.

6. The drawing on the right depicts the two-dimensional paths of three different objects flying through the air. Which one is a projectile?



7. A projectile is fired with a velocity of 175 m/s at 55°. If it lands at the same height from which it is released, what are the final x- and y-components of its velocity?

8. A sharpshooter is aiming at a target. If the target is stationary, where should he aim to hit the target? If he knows the target will be dropped at the same time he shoots, how should he aim to hit the target?

9. A projectile is fired with a velocity of 5.2 m/s at 33°. If it takes 0.29 seconds to reach its maximum height, how long will it take to reach the height from which it was launched?

10. What is the maximum height of the projectile discussed in the previous problem? What are the values of the x- and y-components of its velocity at that height?

11. What is the range of the projectile discussed in problem 9?

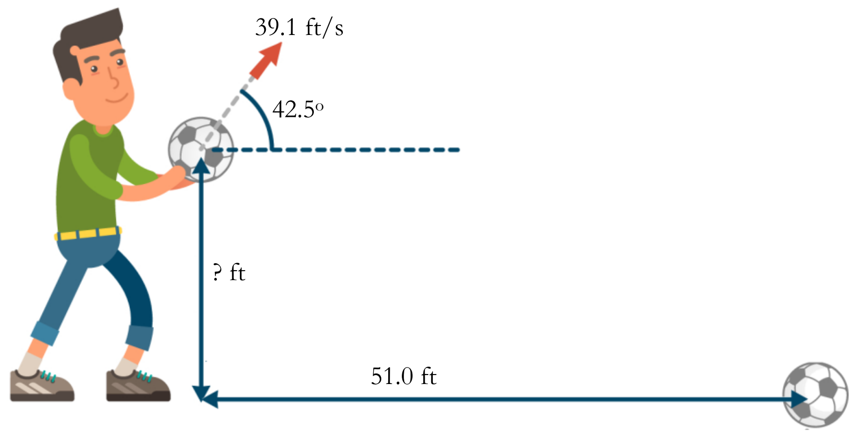
12. One player throws a baseball to another player. If the angle at which the ball was released is 39^{o} and the other player catches it 45 feet away at the same height, what was the speed of the pitch?

13. A gun on a ship fires its shells at a speed of 775 m/s. If it is trying to hit another ship that is the same height and is 8.55 km away, at what angle should the gun be fired?

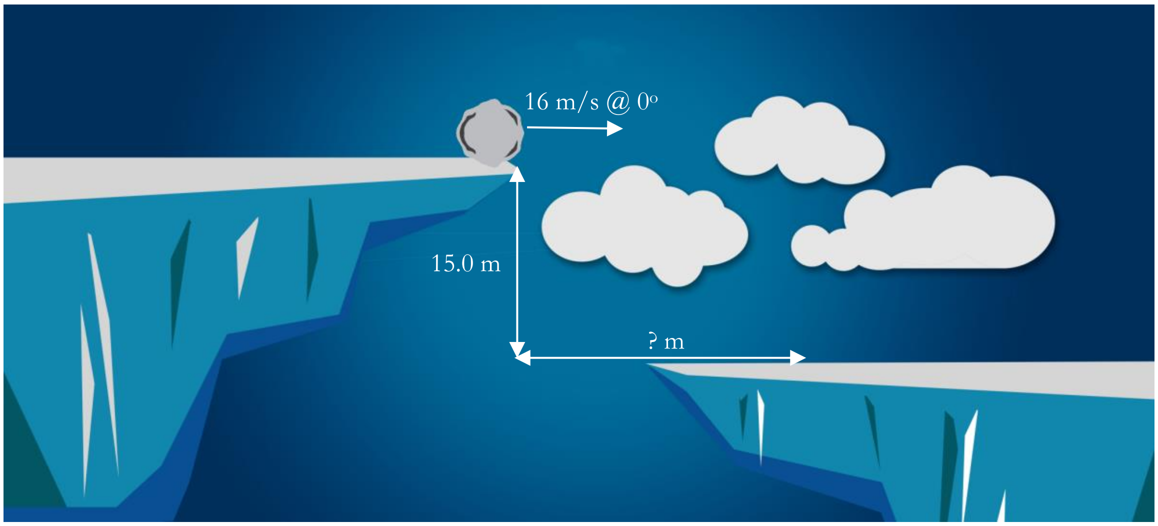
14. If you want to maximize the range of a projectile, at what angle should it be released?

15. An archer's bow can shoot an arrow so that its range is 51.0 m. If the archer uses a bow that shoots the same arrows with three times as much speed and shoots at the same angle, what will the new range be?

16. A man throws a ball with a velocity of 39.1 ft/s at 42.5°. It lands on the ground 51.0 ft from where it was thrown. How far off the ground was the ball released? See the drawing below.



17. A boulder rolls off a cliff with a velocity of 16 m/s at 0º. If the cliff is 15.0 m above the surface on which the boulder lands, how far from the edge of the cliff will it first hit the new surface?



18. A sniper rifle shoots its bullet horizontally ($\theta=0^o$), hitting a target 1.1 km away. If it ends up 7.22 m below the height at which it was fired, what is the speed at which the rifle shoots its bullets?

Chapter 6 Comprehension Check Questions

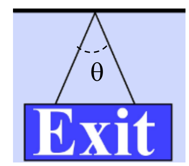
1. Indicate whether each situation described below is an example of static translational equilibrium, dynamic translational equilibrium, or neither.

a. An object in free fall

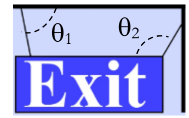
b. A box being pushed on a floor with a force equal to but opposite of the kinetic frictional force

c. A box at rest on the floor

2. A 25.0-kg sign is hung as shown in the diagram on the right. If the two strings are equal in length and $\theta = 65.0^{o}$, what is the tension in each string?



3. Suppose the same sign were hung as shown on the right, with $\theta_1 = 75.0^o$ and $\theta_2 = 135.0^o$. What would be the tension in each string now?



4. A 25.0-kg wooden box is on an incline. What angle is required for it to slide down with a constant velocity of 3.4 m/s? ($\mu_s = 0.35$, $\mu_k = 0.19$)

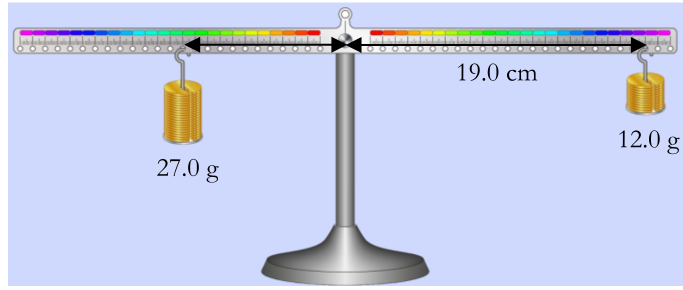
5. A box is placed on an incline that has an angle of 15° and then given a shove. After the shove, will it be in either form of translational equilibrium? If not, what is its acceleration? ($\mu_s = 0.42$, $\mu_k = 0.27$)

6. A box is accelerating down a 31.5° incline at 2.25 m/s². What is the coefficient of kinetic friction?

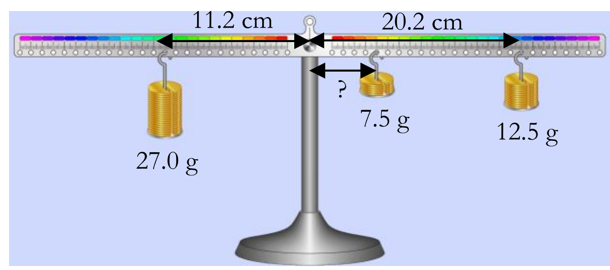
7. A young girl is pulling two wagons that are connected together with a chain, as shown in the drawing on the right. The mass of the red wagon with its dog is 11kg, and the mass of the other wagon with its dog is 13 kg. If the wagons are accelerating at 0.56 m/s^2 to the right, what horizontal force is the girl using to pull them, and what is the tension in the chain?

8. These days, automobiles have power steering, which means there is a mechanical device that assists the driver in turning the wheel. However, prior to the 1950s, there was no power steering, so the driver had to do all the work while turning the wheel. In those days, heavier automobiles had much larger steering wheels than lighter ones. Why?

9. Two masses are placed on a balance as shown on the right. The 12.0-g mass is placed 19.0 cm from the axis of rotation on one side, while the 27.0-g mass is placed on the other side. What distance is necessary to keep the system from moving?



10. Three masses are hung on a balance as shown on the right. The 27.0 g mass is hung 11.2 cm from the axis of rotation, while the 12.5 g mass is placed 20.2 cm from the axis of rotation. Where must a 7.5-g mass be placed so that the system is motionless?



Chapter 6 Review Questions

1. Define the following terms:

a. Translational equilibrium

b. Static translational equilibrium

c. Dynamic translational equilibrium

d. Accelerometer

e. Axis of rotation

f. Lever arm

g. Rotational equilibrium

2. For each situation, indicate whether or not the object is in translational equilibrium. If it is, indicate whether the equilibrium is dynamic or static.

a. An object moving in a circle with a constant speed

b. An object moving due east with a constant speed

c. An object at rest

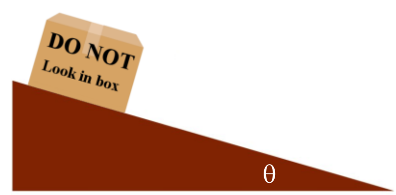
3. In most automobiles, the seat belt is loose so that it can move with the person as he or she adjusts position. However, when the brakes are hit hard or a collision occurs, the seat belt locks so that it holds the person in place. What must the seat belt system have in order for this to work?

4. A sign is hung as shown in the diagram on the right. If the sign has a mass of 5.60 kg and the strings are of equal length, what is the tension on each string?

5. Another sign is hung as shown in the diagram on the right. If the tension in the string on the right is 11.6 N, what is the mass of the sign and the tension in the string on the left?

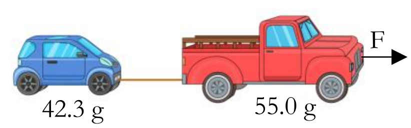
6. The coefficients of friction between a 15-kg box and a ramp are 0.42 and 0.29. At what angle will a box at rest just start sliding down the ramp? At what angle will a box slide down the ramp with a constant velocity of 4.1 m/s?

7. A box is placed on an incline in which $\theta = 25.4^{o}$. Will it begin to slide down the ramp? If it is given a shove, will it achieve either form of translational equilibrium? If not, what is its acceleration? (The coefficients of friction are 0.59 and 0.37)



8. A box accelerates down a ramp at 2.6 m/s^2. If $\theta = 31.3^o$, what is the coefficient of kinetic friction?

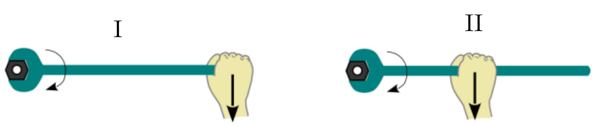
9. A toy truck (m=55.0 g) is pulled east with a force of 1.75 N. It is attached by a string to a toy car (m = 42.3 g). What is the acceleration of the cars and the tension in the string? Ignore friction.



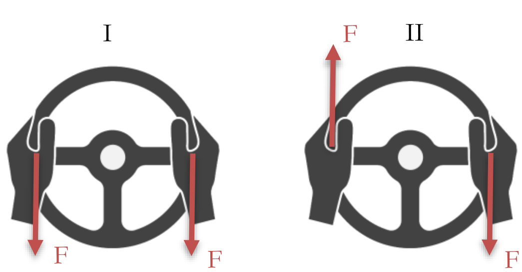
10. The force in problem 9 is changed so that the same system produces a tension of 0.93 N in the string. What is the magnitude of this new force? Continue to ignore friction.

11. A strong man tries to unscrew a pipe with a wrench. He uses all his strength, but the pipe will not unscrew. A young girl uses a different wrench and unscrews the pipe easily. Compare the lengths of the two wrenches.

12. For each of the following situations, indicate which diagram (I or II) shows the larger net torque.

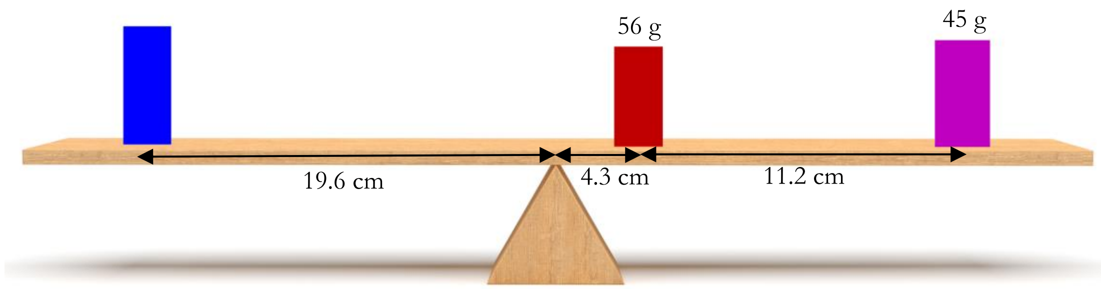
a.


b.


c.


13. Two objects are placed on a balance so that it doesn't tilt. The first (m = 214 g) is put 12.1 cm left of the axis of rotation, while the second is put 7.1 cm right of the axis of rotation. What is the mass of the second object?

14. Three objects are placed on a balance as illustrated below. What is the mass of the blue object?



Chapter 7 Comprehension Check Questions

1. You tie a mass to the end of a thread and start twirling it as you did in the experiment. If you continue to increase the speed without stopping, what will eventually happen?

2. Suppose you repeat the experiment above with a much heavier mass and the same thread. If you increase the speed at the same rate as before, will that same thing happen sooner than, later than, or at roughly the same time as before?

3. A ball is being twirled in a circle ($r = 0.75$ m) on a string with a frequency of 1.5 Hz. What is the centripetal acceleration of the ball?

4. An object is in uniform circular motion with a period of 3.5 s and a radius of 1.1 m. If this requires a centripetal force of 114 N, what is the mass of the object?

5. A ball is being twirled on a string in a circle (r = 55 cm) with a frequency of 2.21 Hz. If the maximum tension the string can support is 75 N, what is the maximum mass the ball can have?

6. A car is taking a curve, whose radius of curvature is 0.101 km. If the coefficients of friction between the road and tires are 0.351 and 0.223, what is the maximum speed the car can have and stay on the road?

7. Which will alter the gravitational force between two objects more: changing one object's mass or changing the distance between the objects. Why?

8. The gravitational force between two masses (34.5 g and 145 g) is 1.27×10^{-13} N. How far apart are the centers of the two masses?

9. Jupiter has a mass of $1.90\text{x}10^{27}$ kg. One of its natural satellites (Io) has a speed of 17,300 m/s. What is the radius of Io's orbit around Jupiter? ($G = 6.67\times10^{-11}\ N\cdot m^2/kg^2$)

10. Galileo discovered four natural satellites orbiting Jupiter. We now know that the largest one (Ganymede) orbits it at a speed of 10,900 m/s. The second-largest (Callisto) at 8,200 m/s, the second-smallest (Io) at 17,300 m/s, and the smallest (Europa) at 13,700 m/s. Order them in terms of increasing distance from Jupiter's center.

11. When the earth is farthest from the sun in its elliptical orbit, astronomers say it is at aphelion. When it is closest to the sun, it is at perihelion. Is the earth traveling faster at aphelion or perihelion? (The suffix "-helion" is based on Helios, the Greek god that personified the sun.)

12. The semi-major axis of Mars's orbit is 228.0 million km, while its semi-minor axis is 226.9 million km. For Mercury, the semi-major axis is 57.90 million km, while the semi-minor axis is 56.65 million km. Which of these two planets has the more circular orbit?

Chapter 7 Review Questions

1. Define the following terms:

a. Centripetal force

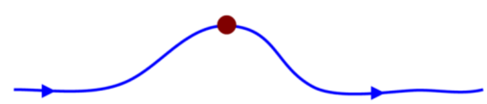
b. Period (T)

c. Frequency (f)

d. Gravity

e. Satellite

2. An object (the red circle) is traveling at constant speed along the path shown by the blue curve on the left. Draw its velocity vector and the vector for the force it is currently experiencing.



3. An object travels in a circle (r = 1.22 m) at a frequency of 0.0791 Hz. What are its speed and period?

4. If the mass of the object in problem 3 is 459 g, what centripetal force does it experience (in newtons)?

5. A 25-g object in uniform circular motion experiences a centripetal force of 15.8 N. If the radius of the circle is 73.2 cm, what is its speed? What is its period?

6. An object is traveling in a circle with a constant speed. If the speed is doubled, what happens to the centripetal force it experiences? What happens to the force if the radius is doubled?

7. A 275-g ball is attached to a thread that can withstand a tension of 4.51 N. If the ball is twirled on the string with a constant speed of 2.34 m/s, what is the minimum radius the string can have?

8. A car takes a curve with a radius of curvature of 72 m. If the coefficients of friction are 0.34 and 0.21, what is the maximum speed at which the car can travel and stay on the road?

9. A 97.8-g saltshaker and 88.6-g peppershaker are sitting with their centers 5.49 cm apart. What is their gravitational attraction ($G = 6.67\times10^{-11}\ N\cdot m^2/kg^2$)? Why don't they move towards each other?

10. The gravitational force between two objects is measured. If the mass of one object is tripled, what happens to the force? If the distance between their centers is tripled, what happens to the force?

11. Why do we treat the gravitational force an object experiences near the surface of the earth as constant, even though we know it depends on the distance between the object and the center of the earth?

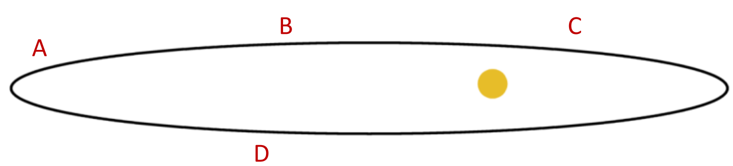
12. An artificial satellite is put in orbit. If its speed is 4,920 m/s, what is the radius of its orbit? The mass of the earth is $5.97\text{x}10^{24}$ kg, and $G = 6.67\times10^{-11}\ N\cdot m^2/kg^2$.

13. Titan, a natural satellite of Saturn, has a period of 15.9 days and an orbital radius of 1.22×10^9 m. What is the mass of Saturn?

14. What is the relationship between the speed at which a planet travels and its distance from the sun?

15. State Kepler's three laws.

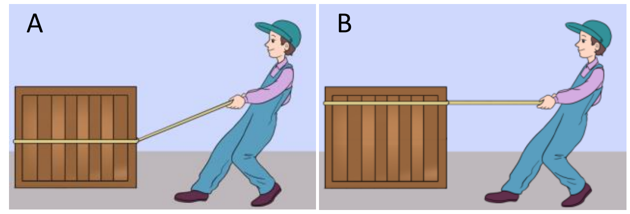
16. The drawing on the right shows the orbit of a planet around its star (the yellow circle). At which point in the orbit (A, B, C, or D) is it traveling the fastest? Why?



17. While most people think the shape of the earth is spherical, what is its actual shape? Why?

Chapter 8 Comprehension Check Questions

1. In both situations pictured on the right, the worker is pulling with the same amount of force in order to move the box the same amount of distance horizontally. In which situation is more work being done on the box?



2. A machine moves a heavy load, giving that load 15,000 J of energy. What happened to the energy in the machine as a result of this work?

3. Relative to the water she is about to dive into, a 68.9-kg swimmer has a potential energy of 4,730 J. How high is she relative to the water?

4. A 1,419-kg car has a kinetic energy of 467,000 J. What is its speed?

5. When you push a dart into a dart gun, you are compressing the spring, which causes it to store potential energy. When you pull the trigger, the spring works on the dart, causing it to move. Suppose a dart gun's spring stores 50.0 joules of energy. If all of that energy is transferred to the 75.0-g dart, how fast will it be traveling when it leaves the gun?

6. A bicyclist gets to the top of a 17.3-m hill and has a speed of 2.5 m/s. She then lets the bicycle coast to the bottom of the hill. How fast will she be going when she gets there?

7. A rollercoaster's car (m = 357 kg) starts essentially from rest on a hill that is 34.2 m higher than the place where the brakes are applied to stop it. When it reaches the point just before the brakes start being applied to stop it, friction has done 45,000 J of work. How fast was it going at that point?

8. A box is given a shove so that it has an initial velocity of 6.18 m/s. After it slides 5.00 m across a level floor, how fast will it be going? (The coefficients of friction are 0.318 and 0.221.)

9. A block is given a push so that it slides across a horizonal surface. A ball is also given a push so that it rolls across the same surface. In each case, the push does 10 J of work. Ignoring friction, compare the speeds of the ball and the block moving across the surface.

10. In order to keep the assembly line running, a machine must lift an object 13.2 meters at a constant velocity in 15.0 seconds. If the machine is rated at 150 watts, what is the maximum mass the object can have?

Chapter 8 Review Questions

1. Define the following terms:

a. Energy

b. Work

c. Potential energy

d. Kinetic energy

e. The First Law of Thermodynamics

f. Power

2. A person does 100.0 J of work on an object. How did the object's total energy change? How did the person's total energy change?

3. Someone pulls a load horizontally, using a rope tied around the load. How does the work being done when the person pulls the rope at an angle of 45 degrees relative to the horizontal compare to when it is pulled at an angle of 15 degrees relative to the horizontal? The magnitude of the force is the same in both cases.

4. A diver stands at the edge of a diving board and takes a step off it, falling into the water below. When is the diver's potential energy the greatest? When is the diver's kinetic energy the greatest?

5. An object has a potential energy of 154 J when it is at a height of 24.5 cm. What is its mass?

6. A car has a kinetic energy of 11,000 J while traveling at 2.5 m/s. What is its mass?

7. A rollercoaster starts from rest at a hill that is 65.8 m high. It rolls to the bottom and then rises to the top of another hill that is 16.4-m high. Ignoring friction, what is its speed at the top of the second hill?

8. A bicyclist pedals her bike to a speed of 6.75 m/s. She then stops pedaling and starts to ride up a steep incline. How far will her bike climb before it stops? If she just lets the bike go, how fast will she be traveling when it rolls back to the bottom of the incline? Ignore friction.

9. When friction works on an object, what happens to the sum of the object's potential and kinetic energy? What happens to the temperature of the object and its surroundings?

10. Someone pushes on a 2.5-kg block horizontally, doing 150.0 J of work on it. What will its initial velocity be? If the coefficients of friction are 0.441 and 0.298, how far will it slide before it comes to rest, assuming the floor continues to be horizontal the entire time?

11. A 817-g block slides down a ramp, starting from rest at a height of 2.16 m. It reaches the bottom after sliding for 5.22 m and has a speed of 4.98 m/s. What frictional force did the block experience?

12. If the block in question 11 took 1.67 seconds to slide down the incline, what power did friction exert?

13. A crane lifts a 3,125-kg load straight up in the air at a constant velocity. If the crane uses 1,632 watts, how long will it take for the load to reach a height of 24.5 m?

14. Which of the following is an energy unit: newton, watt, kilowatt·hour, m/s^2?

15. The lights in your house suddenly dim and stay dim for a while. However, when you turn off the oven, the lights go back to normal. What explains this kind of situation?

Chapter 9 Comprehension Check Questions

1. An object has a momentum of 1,500 $\frac{\text{kg}\cdot\text{m}}{\text{s}}$ north. If its mass is 756 g, what is its velocity?

2. A tennis player is serving the ball (m=59.4 g). She throws it in the air and hits it at its maximum height, so the ball's initial speed is zero. If she uses 611 N of force, and the racquet is in contact with the ball for 0.0047 s, what is the velocity at which she serves the ball?

3. A baseball player hits a pitch that is coming towards him at a speed of 39 m/s. The ball (m=0.145 kg) and bat are in contact for 0.00071 s. If the ball leaves the bat at a speed of 42 m/s in the opposite direction, what force does the bat exert on the ball?

4. Two ice skaters are skating towards each other. One jumps, and the other catches her. Ignoring friction, will momentum be conserved in this collision?

5. In a violent thunderstorm, the wind blows many objects around. When those objects collide with one another, will momentum be conserved?

6. 50-caliber Mark 7 guns on a battleship have a mass of 122,000 kg. They fire 10,500-kg shells that leave the gun at 752 m/s. What is the recoil velocity for such a gun?

7. Two cars are approaching one another head-on. The 1,250-kg car is traveling with a speed of 22.4 m/s, while the 1,590-kg car is traveling at 21.1 m/s. They stick together when they collide. What is the velocity of the two cars stuck together, assuming friction doesn't stop them right away?

8. Two billiard balls (m = 0.17 kg) collide head on. The first is moving at 5.4 m/s, while the second is moving at 2.3 m/s. Afterwards, the first is moving in the opposite direction at 2.3 m/s. What is the velocity of the second? Is this an elastic collision?

9. The muzzle velocity of a gun is 299 m/s, and the bullets it shoots have a mass of 0.00544 kg. If the gun is fired at a 0.446-kg ballistic pendulum, what will be the maximum height the bullet/block system reaches? Is the collision elastic?

10. A ball is attached to a string and twirled in a circle with a radius of 2.35 m at a speed of 15.9 m/s. The radius is suddenly changed with no external torque exerted, and the new speed is 10.2 m/s. What is the new radius of motion?

11. The child from the example is twirling his airplane once again. The mass of the airplane is 0.255 kg, and it is being twirled at a speed of 9.33 m/s. A 0.101-kg bird lands on top of the plane, but the radius of motion doesn't change. Ignoring any torques exerted, what is the new speed of the airplane and bird together?

Chapter 9 Review Questions

1. Define the following terms:

a. Momentum

b. Law of Momentum Conservation

c. Elastic collision

d. Inelastic collision

e. Law of Angular Momentum Conservation

2. A car is driving down the road with a velocity of 28.4 m/s west. The magnitude of its momentum is 37,500 $\frac{\text{kg}\cdot\text{m}}{\text{s}}$ west. What is its mass? What is the direction of its momentum?

3. Two objects are moving with the same velocity. The first has three times as much mass as the second. Compare their momenta (plural of momentum). Be as detailed as possible.

4. Two identical objects slam into two different obstacles with the same velocity. The first hits a hard wall. The second hits a soft cushion. They both end up stopping. Compare the impulses the objects experience. Compare the time over which they experience those impulses. Compare the forces that they experience.

5. A 59.4-g tennis ball is traveling at a speed of 47.0 m/s is hit by a racquet. It leaves the racquet with a speed of 51.7 m/s, but it is now traveling in the opposite direction. If the racquet exerted a force of 617 N, how long was it in contact with the ball?

6. Two objects collide while they are in free fall. Will momentum be conserved?

7. Two objects collide while they are falling at their terminal velocities. Will momentum be conserved?

8. A 15.9-kg sniper rifle has a recoil velocity of 2.25 m/s. If it fires 42.0-gram bullets, how fast do those bullets leave the rifle?

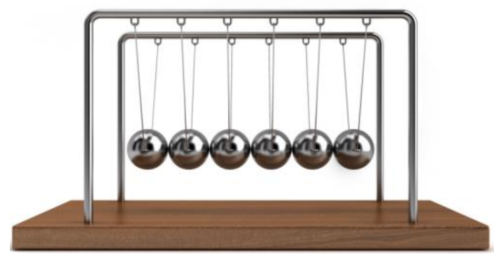
9. A pistol fires 1.95-gram bullets with a muzzle velocity of 319 m/s. If its recoil velocity is 5.3 m/s, what is the mass of the pistol?

10. A 87.2-kg man in roller skates is standing still. Someone throws him a 566-g basketball at 13.3 m/s. When he catches it, ignoring friction, what will be his velocity? Is this an elastic or inelastic collision?

11. Two balls are rolling towards one another on a level surface. The first has a mass of 1.2 kg and a speed of 3.7 m/s. The second has a mass of 3.1 kg and is rolling at 1.2 m/s. They collide head-on. After the collision, the first one is rolling with a speed of 3.4 m/s in the opposite direction compared to how it was rolling initially. What is the velocity of the second ball? Is this an elastic or inelastic collision?

12. An astronaut is working on the outside of the space station. A small asteroid hits him, knocking him off the space station. To his horror, he sees that the asteroid also broke the line holding him to the space station, so he is drifting away from it at 1.5 m/s. Because he knows physics, he calmly spins around so that his back is to the station and throws his 14-kg tool directly in front of him at 25.0 m/s. If he and his space suit have a mass of 195 kg, what happens? What will be his velocity?

13. In the Newton's Cradle pictured on the right, two balls are lifted to a specific height. They are released and allowed to crash into the other balls. What will happen after the collision? Describe both the number of balls that will move and the maximum height they will reach. Ignore air resistance.



14. A man is shopping with his daughter. She pushes the grocery cart so that it is rolling on its own. As the cart passes him, the man places a heavy item in the cart. Assuming he places it there with essentially no velocity, what will happen to the speed of the cart? Why?

15. A gun is used to shoot a 5.66-g bullet into a 678-g ballistic pendulum. The pendulum rises to a height of 0.15 m. At what speed did the bullet leave the gun?

16. Use angular momentum to explain why it is easier to keep a bicycle upright when it is rolling compared to when it is standing still.

17. A charged particle is traveling in a circle of radius 15.0 cm with a speed of 156 m/s. The magnetic field that is holding it is changed so that the circle decreases to a radius of 7.5 cm. If the magnetic field exerted no torque on the particle, what is its new speed?

18. A 22.0-kg object is traveling in a circle with a radius of 5.12 m. Suddenly, the radius decreases to 3.56 m, but the speed is unchanged. Assuming no torques were exerted, what happened to make the change? Be as detailed as possible.

Chapter 10 Comprehension Check Questions

1. Suppose a spring is attached to a wall and pulled horizontally to the left. What is the direction of the restoring force that the spring exerts?

2. Another student did the same experiment as you, but her spring had a force constant of 117 N/m. Compare how hard it would be to stretch your spring and her spring.

3. A spring is hung vertically, and a 50.0-kg mass is attached to it. It stretches 15.0 cm from its unstretched length. What is the spring's force constant?

4. In the previous problem, you used one mass and one stretch distance to determine the force constant of a spring. In the experiment, you used six stretches and a graph to do the same thing. Why couldn't you have just used one amount of water and measured one stretch to determine your spring's force constant? Why did I make you use a graph? There are actually two answers to this question.

5. Suppose you measure the period of a mass/spring system, and then you add more mass so that the new mass is four times the original mass. How will the new period compare to the one you measured before?

6. How does the period of a mass/spring system change when you replace the spring with a stronger one?

7. A 15.0-kg mass is hung on a spring. The spring stretches until the mass comes to rest. It is then put in periodic motion with an amplitude of 17.0 cm. If the period is 1.09 s, what is the force constant of the spring?

8. In the mass/spring system above, how much is the spring stretched when the mass is moving the fastest? What about when its speed is zero?

9. A 575-g mass is hung on a spring and put in periodic motion with a period of 1.22 seconds and an amplitude of 4.55 cm. When the mass is at its amplitude, what is the potential and kinetic energy? What is the potential and kinetic energy at the equilibrium position?

10. An 11.7-kg mass is attached to a spring with a force constant of 189 N/m. It is put in periodic motion with an amplitude of 22.0 cm. How far from its equilibrium is it when it has a speed of 0.500 m/s?

11. An astronaut is on another planet. To test the gravitational acceleration, she uses a simple pendulum with a 15.0-cm long string. Initiating motion with a small angle, she measures the period to be 1.75 s. What is this planet's acceleration due to gravity?

Chapter 10 Review Questions

1. Define the following terms:

   a. Periodic motion

   b. Hooke's Law

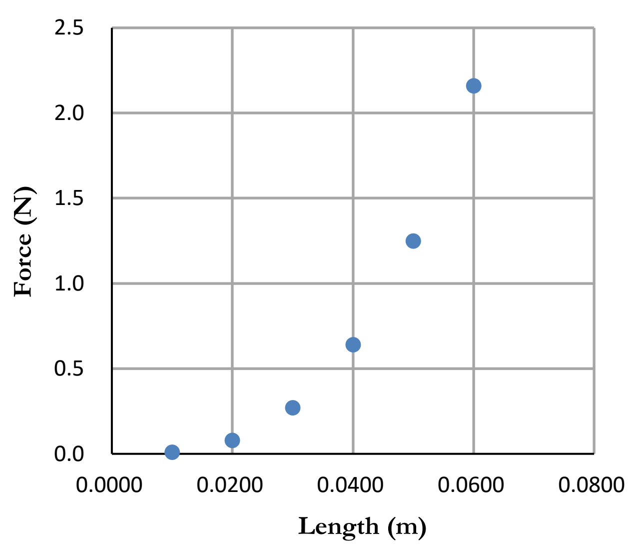
   c. Amplitude

   d. Simple harmonic motion

   e. Damped harmonic motion

2. A system is displaced from equilibrium, and it exerts a restoring force. If the displacement is up, what is the direction of the restoring force?

3. The graph on the right shows you the results of an experiment similar to Experiment 10.1. Do the results of the experiment demonstrate Hooke's Law? Why or why not?



4. Spring A has a force constant of 13.5 N/m. Spring B has a force constant of 1.56 N/m. Spring C has a force constant of 245 N/m. Which spring is hardest to stretch?

5. A spring is hung vertically, and then a 175-g mass is hung from it. If the spring constant is 12.4 N/m, how far from its unstretched length will it stretch?

6. You have two scales that measure weight. The first one says it works best for objects that weigh less than 500 pounds. The second says it works best for objects that weigh less than 50 pounds. Which one uses a spring with a larger spring constant?

7. Why is there a π in the equation for the period of a mass/spring system?

8. A spring is hung vertically, and then a 1.49-kg mass is hung from it. The spring stretches 4.51 cm as a result. Then, someone pulls the mass down an additional 15.0 cm and releases it.

a. What will be the amplitude of the motion?

b. What will be the period of the motion?

c. Taking friction into account, what will happen to the amplitude of the motion as time goes on?

d. Taking friction into account, what will happen to the period of the motion as time goes on?

e. Suppose you did the same experiment with a larger mass. Would the period be shorter, longer or the same?

f. Suppose you did the same experiment with a spring whose force constant was 100 N/m. Would the period be shorter, longer or the same?

9. You are observing a mass/spring system in periodic motion. Using "amplitude" and "equilibrium position," answer the following questions.

a. At what position will the mass be traveling the fastest?

b. At what position will the mass be traveling the slowest?

c. At what position is the net force on the mass zero?

d. At what position is the net force on the mass largest?

10. A mass/spring system with a 150-g mass has a period of 1.5 seconds. What is the force constant of the spring?

11. What characteristic of the restoring force is necessary for simple harmonic motion to occur?

12. When is the potential energy of a mass/spring system greatest? When is the kinetic energy greatest?

13. A spring with a force constant of 87.2 N/m is compressed 10.5 cm from its equilibrium position.

a. What is the total energy in the system?

b. If a 2.5-kg mass is attached, how fast will it be moving at the equilibrium position?

c. How fast will that mass be moving when it is 5.0 cm from the equilibrium position?

14. A 512-g mass is hung from a vertical spring, and the mass causes the spring to stretch 4.5 cm. The mass is then pulled down farther and released. When the mass reaches the equilibrium position, it is moving with a speed of 2.1 m/s. How far was the mass pulled down?

15. Two simple pendulums are made. The first has a length of 15.0 cm and uses a bob whose mass is 12.0 g. The second has a length of 11.5 cm and uses a mass of 25.0 g. Which has the shorter period?

16. A simple pendulum is displaced 11.0 degrees from its equilibrium position and then released. After being observed, it is stopped. It is then displaced 35.0 degrees from its equilibrium position and then released. In which case will it exhibit simple harmonic motion? Why?

17. Mr. Spock is on a planet whose acceleration due to gravity is 15.6 m/s^2. He whips out his handy 15.0-cm simple pendulum and puts it in simple harmonic motion. What is its period?

18. A grandfather clock is made so that each time the bob reaches the amplitude of the motion, 1.0 seconds have passed. In other words, a "tick" indicates 1.0 seconds have passed, and the following "tock" indicates another 1.0 seconds have passed. What is the length of the pendulum on the clock?

19. What is the purpose of winding a clock that uses a pendulum to keep time?

Chapter 11 Comprehension Check Questions

1. Two waves have the same wavelength, but the first has a slower translational speed. Which wave has the higher frequency?

2. Two waves have the same translational speed, but the first has a longer wavelength. Which wave has the lower frequency?

3. In a choir, sopranos sing the high notes, while basses sing the low notes. Suppose a soprano is singing her notes softly, while a bass is singing his notes loudly. Compare the amplitudes and frequencies of the sound waves made by the two singers.

4. Sound is measured to have a speed of 349.7 m/s in air. What is the temperature of that air?

5. What is the frequency of a sound wave in 25.0 °C air if its compressions are 0.991 m apart?

6. You are riding your bike as fast as you can, and one of your friends is in a car parked on the side of the road. She sees you riding towards her and honks the horn. While she is still honking, you pass her and end up riding away from her. Does the pitch of the horn increase, decrease, or stay the same once you pass her?

7. On a cool day (T = 12 °C), you are driving a car at 14 m/s. Someone in front of you who is traveling toward you tries to get your attention and honks his horn. If he is traveling at 11 m/s and his horn's frequency is 559 Hz, what frequency do you hear?

8. You don't hear your own voice from the sound waves you make in the air. After all, the sound waves you make in the air travel away from you. You hear your own voice because the sound waves travel through your bones to your eardrum. However, when you are singing, you hear the same pitch that everyone else hears. What does that tell you about the frequency of the sound waves traveling through your bones compared to the ones traveling through the air? What about the wavelength?

9. Commercial radio stations work on two different sets of frequencies. AM radio operates at frequencies between 540,000 Hz and 1,700,000 hertz. FM radio operates between 88,000,000 Hz and 108,000,000 Hz. Which set of electromagnetic waves (AM or FM) have the longer wavelengths?

10. You see lightning but hear the thunder 1.5 seconds later. If it is 9.0 °C, how far away was the strike?

11. The wavelength of light produced by a violet laser pointer is 445 nm. What is its frequency? Would orange light have a higher or lower frequency? ($c = 2.998 \times 10^8$ m/s)

12. When light of frequency 2.15×10^{15} Hz is shone on iron, electrons are ejected with a maximum kinetic energy of 4.40 eV. What is the work function of iron?

Chapter 11 Review Questions

Given Information: $c = 2.998\times10^{8}$ m/s, $h = 4.14\times10^{-15}$ eV·s

1. Define the following terms:

a. Oscillations

b. Transverse wave

c. Wavelength

d. Longitudinal wave

e. Doppler effect

f. Sonic waves

g. Ultrasonic waves

h. Infrasonic waves

i. Timbre

j. Wave-particle duality

2. Two waves have the same speed. The first has a longer wavelength. Which has the higher frequency?

3. Which of the two basic types of waves is a sound wave? What about a light wave?

4. What does the amplitude of a sound wave determine? What about the frequency?

5. A sound wave is traveling with a speed of 329 m/s. What is the temperature of the air?

6. A sound wave is traveling through 27.8 °C air. If its frequency is 540 Hz, what is its wavelength?

7. At rest, a siren produces waves with a frequency of 915 Hz. If you are driving away from the stationary siren at 17.5 m/s and it is 15.0 °C outside, what frequency do you hear? If the car that has the siren then starts driving towards you at 22.4 m/s and you don't change your velocity, what frequency do you hear?

8. A whistle has a pitch that is too high for you to hear, but your dog hears it. What kind of sound waves does it produce?

9. Sound travels faster in nitrogen than it does in air. Which of those two gases has the lower density?

10. The speed of sound is measured as it travels through a substance. The phase of the substance is then changed, and the speed is remeasured. If the new speed is faster and the two phases were gas and solid, which time was the substance a gas and which time was it a solid?

11. What medium do sound waves oscillate? What medium do light waves oscillate?

12. What was important about Thomas Young's double-slit experiment?

13. What was important about James Clerk Maxwell's calculation of the speed of electromagnetic waves?

14. What was important about Einstein's explanation of the photoelectric effect?

15. You see bright yellow light and a dim indigo light. Compare their frequencies and amplitudes.

16. You see a lightning bolt, and 0.75 seconds later, you hear the thunder. If the temperature is 21.0 °C outside, how far away did the lightning strike?

17. The frequency of a laser beam is 4.31×10^{14} Hz. What is the wavelength of the light it makes? Give your answer in nanometers.

18. A metal has a work function of 5.1 eV. When light is shone on it, the maximum kinetic energy of the electrons released is 2.1 eV. What frequency of light was used?

Chapter 12 Comprehension Check Questions

1. You are looking in a mirror and see a magnified version of yourself. Are you looking in a flat mirror? Why or why not?

2. When you look in a flat mirror, you see your right hand on your image's left side. Why?

3. An object is placed 9.0 cm from a concave spherical mirror with a radius of curvature equal to 8.0 cm. Use ray tracing to see what the image will look like.

4. An object is placed 6.0 cm away from a concave spherical mirror with a radius of curvature of 8.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

5. An object is placed 3.0 cm away from a convex spherical mirror with a radius of curvature of 8.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

Medium	Index of Refraction
air	1.0003
water	1.333
ethanol	1.361
ice	1.309
glass, crown	1.52
glass, flint	1.66
fused quartz	1.458
diamond	2.419

6. Looking at the table of indexes of refraction on the right, in which substance does light travel the slowest?

7. Light is traveling through alcohol (n=1.361) and hits a new medium at an angle of 14.5° relative to the perpendicular. If the angle it now makes with the perpendicular is 17.0°, what is the index of refraction of the new medium?

8. Light is traveling in diamond (n=2.419). If it hits the boundary between the diamond and air, what angles relative to the perpendicular will cause total internal reflection?

9. An object is placed 4.0 cm from the center of a converging lens that has a focal length of 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) will form?

10. An object is placed 4.0 cm from the center of a diverging lens that has a focal length of 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) will form?

Chapter 12 Review Questions

1. Define the following terms:

   a. Law of Reflection

   b. Virtual image

   c. Real image

   d. Refraction

   e. Spherical aberration

   f. Chromatic aberration

2. If you are looking at yourself in a flat mirror, what kind of image (real or virtual, upright or inverted, magnified or reduced) do you see? If you are 2 feet from the mirror, how deep in the mirror does the image appear?

3. You are looking at horizontal light rays reflecting off a concave spherical mirror. They all converge at a point that is 4.0 cm from the mirror. What is the mirror's focal length? What is the radius of the sphere?

4. An object is placed 9.0 cm from a concave spherical mirror whose radius is 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

5. An object is placed 4.0 cm from a concave spherical mirror whose radius is 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

6. An object is placed 6.0 cm from a convex spherical mirror whose radius is 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

7. An object is placed 2.0 cm from a convex spherical mirror whose radius is 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

8. You look at an object and see your reflection in it. Is that the result of specular or diffuse reflection?

9. You see a list of substances and their indexes of refraction. How can you tell the substance in which light travels the slowest?

10. Light is traveling through air and hits flint glass ($n=1.66$) at an angle of 31.0° relative to the perpendicular. What is its angle relative to the perpendicular after it is refracted?

11. Light traveling in liquid (n=1.48) encounters a new substance. If the angle relative to the perpendicular in the liquid is 41°, and the angle relative to the perpendicular in the new substance is 22°, what is the new index of refraction?

12. Light travels through a plastic tube (n=1.78) and hits air at an angle of 44.5° relative to the perpendicular. What is its angle relative to the perpendicular after it is refracted?

13. An object is placed 9.0 cm from a converging lens whose focal length is 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

14. An object is placed 3.0 cm from a converging lens whose focal length is 6.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

15. An object is placed 6.0 cm from a diverging lens whose focal length is 3.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

16. An object is placed 2.0 cm from a diverging lens whose focal length is 3.0 cm. What kind of image (real or virtual, upright or inverted, magnified or reduced) is formed?

Chapter 13 Comprehension Check Questions

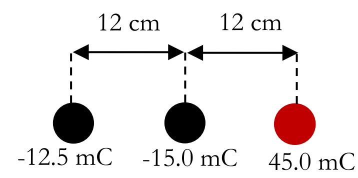
1. A positively-charged object is used to make another object negatively charged. What method was used?

2. Two objects initially have no charge, but they end up developing opposite charges. Which of the methods discussed in this section were used to charge them?

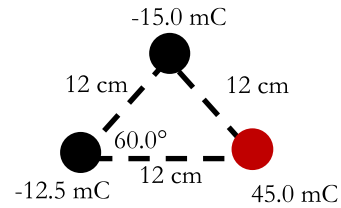
3. A 25.0-mC charge is placed next to a 12.0-mC charge. Each charge exerts a force of 15,500 N on the other. What is the distance between them? Is the force repulsive or attractive? ($k = 8.99\times10^9 \frac{N\cdot m^2}{C^2}$)

4. A 75.0-mC charge (m = 4.38 kg) is orbiting a -99.0-mC charge in a circle with a speed of 1,250 m/s. What is the radius of its orbit? ($k = 8.99\times10^9 \frac{N\cdot m^2}{C^2}$)

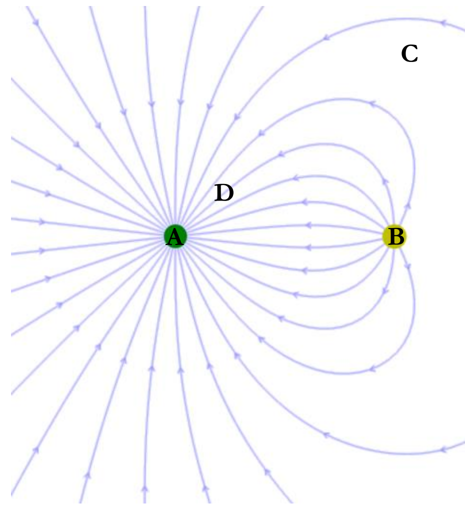
5. Three charges are arranged as shown in the diagram on the right. What is the magnitude and direction of the electrostatic force acting on the -12.5-mC charge?



6. Three charges are arranged as shown in the diagram on the right. What is the magnitude and direction of the electrostatic force acting on the -12.5-mC charge?



Questions 7-11 refer to the electric field diagram on the right.



7. Which particle (A or B) is positively charged?

8. Suppose the particle you just identified has a charge of 2 mC. What is the charge of the other particle?

9. A positively-charged particle is placed where the C is found in the diagram. In which direction will it accelerate? (Combine left/right and up/down to give a general direction.)

10. A negatively-charged particle is placed where the D is found in the diagram. In which direction will it accelerate? (Combine left/right and up/down to give a general direction.)

11. Compare the magnitude of the force exerted on a charged particle placed at C to the force exerted on a charged particle placed at D.

12. A 35.0-g particle with a charge of 4.5 mC is completely surrounded by a container and feels no electrostatic force. What is the container most likely made from?

13. That same particle is completely surrounded by another container and begins accelerating at 7.5 m/s^s south.

a. What is this container made from?

b. What is the electric field in the container at the point where the particle is placed?

Chapter 13 Review Questions

Given Information: $k = 8.99 \times 10^9 \frac{N \cdot m^2}{C^2}$

1. Define the following terms:

   a. Electrostatic force

   b. Triboelectric charging

   c. Charging by conduction

   d. Charging by induction

   e. Conductor

   f. Insulator

2. Identify the type of charging that was done in each situation:

   a. A negatively-charged rod is used to give a negative charge to a metal box.

   b. A glass rod is rubbed against silk, making the glass rod positively charged.

   c. A negatively-charged rod is used to give a positive charge to a metal box.

3. In which of the three cases above did the rod and the other object definitely not come into contact with one another?

4. In (2b), what charge did the silk develop?

5. Are you a conductor or an insulator?

6. A particle has a charge of 15.7 μC. How many Coulombs is that?

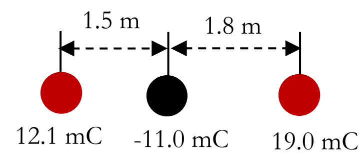
7. A particle with a charge of 15.0 μC is placed 19.0 cm away from a particle with a -99.0 μC charge. What is the force that exists between them? In what directions are the particles accelerated by the force?

8. Two equal charges are placed 47.6 cm from one another, and they are pushed away from each other by a force of 196 N. What is the magnitude of each charge? Do the charges have the same sign or opposite signs?

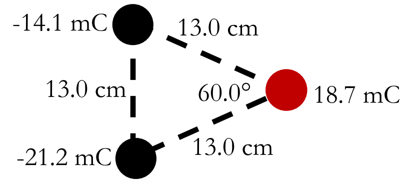
9. An He^+ ion has a nucleus whose charge is 3.20×10^{-19} C. Its single electron ($m = 9.11\times10^{-31}$ kg, $q = -1.60\times10^{-19}$ C) orbits the nucleus with a radius of 2.65×10^{-11} m. What is the speed of the electron in its orbit?

10. A 77.1 mC charge (m = 1.12 kg) is orbiting a -32.8 mC charge with a speed of 7,750 m/s. What is the radius of its orbit?

11. Three charges are arranged as shown in the drawing on the right. What is the force that the black charge experiences?



12. Three charges are arranged as shown in the drawing on the right. What is the force that the red charge experiences? (remember that a perpendicular line dropped from any vertex to the opposite side bisects the vertex angle in an equilateral triangle.)

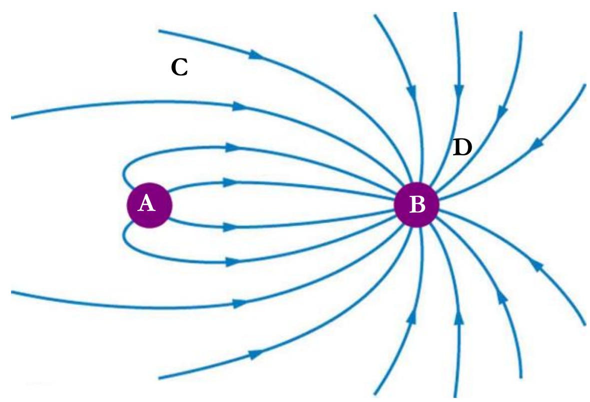


13. List the four rules that electric field lines follow.

14. Do electric field lines actually exist?

15. Does the electric field actually exist?

16. The electric field generated by two stationary charges is shown on the right.



a. What is the sign of charge A?

b. What is the sign of charge B?

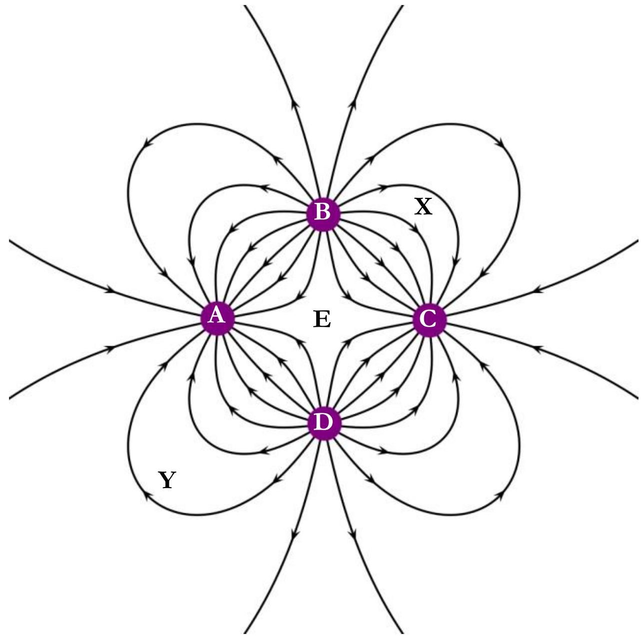
c. If the magnitude of the charge on B is 16 mC, what is the magnitude of the charge on A?

d. Using up, down, right, and left, describe the direction of the acceleration a positive charge would have if it were placed at C.

e. Using up, down, right, and left, describe the direction of the acceleration a negative charge would have if it were placed at D.

f. Is the magnitude of the acceleration caused by the field greater at C or D?

17. The electric field generated by four stationary charges is given on the right.



a. Which of the charges are positive?

b. What can you say about the magnitudes of all four charges?

c. What would be the magnitude and direction of the force a positive charge would experience if it were placed at E, which is the midpoint of all four charges?

d. The magnitude of the electric field at X and Y is measured. One of them is 15.0 N/C, while the other is 25.0 N/C. Which is which?

e. A charged particle is placed at point Y and experiences a force of 7.6 N down and to the right. What is the charge on the particle?

f. A 0.500 C charge with a mass of 156 g is placed at point X. What is the magnitude of the acceleration that it experiences?

18. Electromagnetic waves cannot travel inside an object. Is the object most likely made of a conductor or an insulator?

19. Suppose you made an electroscope like the one you made in Experiment 13.1, but in this case, you used a paperclip covered in plastic and used strips of plastic instead of strips of aluminum foil. Would the electroscope work? Why or why not?

Chapter 14 Comprehension Check Questions

1. A 5.1-μC charge is placed in an electric field, and its potential energy is -4,500 J. What is the electric potential at that point?

2. The electric field from problem 1 is generated by a stationary particle that is 37 cm away. What is the charge on the particle? (k = 8.99x10^9 $\frac{\mathrm{N{\cdot}m^2}}{\mathrm{C^2}}$)

3. A -1.4 mC charge (m=0.500 kg) is shot into an electric field 15.0 cm away from the -3.9 mC stationary charge that is generating the field. If its velocity is 1,500 m/s towards the stationary charge, what will be its speed when it is 10.0 cm away from the stationary charge?

4. The potential difference in a battery is defined between the negative side of a battery (which is low potential) and the positive side (high potential). If a +1.0-C particle travels from the positive side of a 1.5-volt battery to the negative side, what would be the potential difference it experiences? What would be the change in potential energy? Does it slow down or speed up as it makes that trip?

5. In any lightning bolt, do the negative charges experience a positive or negative potential difference? What about the positive charges in the same bolt?

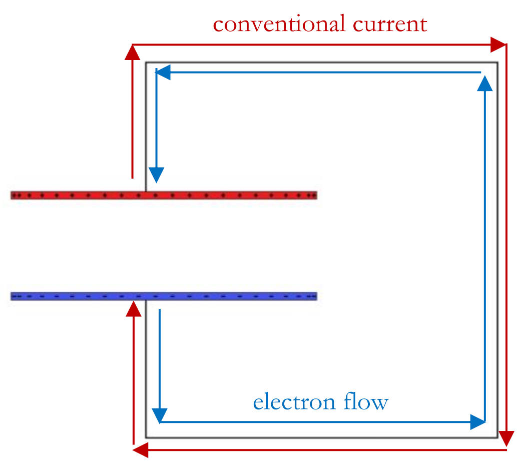
6. What kind of charging takes place to produce the charges that eventually lead to a lightning strike?

7. A 5.6 μF parallel plate capacitor uses a dielectric in which $\varepsilon = 2.11\times10^{-7}$ F/m. If the dielectric is 0.14 mm thick, what is the area of the plates?

8. How much voltage is required to charge a 19.1 μF capacitor with 1.00 coulomb of charge?

9. A parallel-plate capacitor uses a ceramic dielectric ($\varepsilon = 1.95\times10^{-7}$ F/m) that is 0.100 mm thick. If it can store 10.0 mC when charged to 1,550 volts, what is the area of one plate?

10. What happens to the electric current in the diagram on the right when Q = 0 on the capacitor?



Chapter 14 Review Questions

Given Information: $k = 8.99 \times 10^9 \frac{N \cdot m^2}{C^2}$

1. Define the following terms:

a. Electric potential

b. Electron volt

c. Capacitor

d. Capacitance

e. Electric permittivity (ε)

b. Ground (electrical)

c. Law of Charge Conservation

d. Electric current

e. Electric circuit

2. A particle with a charge of -7.2 mC is placed in an electric field. If its potential energy is -5,600 J, what is the electric potential at that point in the field?

3. In the problem on the previous page, the particle was placed 45.0 cm away from the stationary particle that is generating the electric field. What is the charge of that stationary particle, including its sign?

4. A particle (m = 1.1 g, q = 3.2 μC) is placed 22.5 cm away from a stationary 12.1 μC charge. If the particle starts at rest, how fast it is traveling when it is 35.0 cm away from the stationary charge?

5. A particle (m = 9.5 kg, q = -4.1 mC) is shot towards a stationary -8.2 mC charge with a speed of 714 m/s. If it begins 35.0 cm from the charge, how far will it be from the stationary charge when it stops?

6. A charged particle travels from the positive side of a 9.0-volt battery to the negative side. If it gains potential energy as a result, what is the sign of the particle's charge?

7. Right before a lightning bolt strikes, what would be the sign of ΔV for anything that travels from the ground to the bottom of the cloud?

8. What kind of charging happens to make lightning? What is the stepped leader? What about the return stroke? How does the energy of the stepped leader compare to the return stroke?

9. What two types of capacitors were discussed in this chapter?

10. What can you say about the electric field found near the center of a charged parallel plate capacitor? Does that apply to the edges as well?

11. A parallel plate capacitor is made of 1.2x1.2-cm plates that are separated by a 0.20 mm dielectric. If its capacitance is 15.3 μF, what is the electric permittivity of the dielectric?

12. The capacitor in question 11 is charged by a 6.0-volt battery. What is the charge stored on each plate?

13. A parallel plate capacitor uses a 0.0955-mm-thick dielectric with $\varepsilon = 1.56\times10^{-7}$ F/m. If each plate has an area of 0.0045 m^2, what will be its potential difference when each plate holds 15.0 μC of charge?

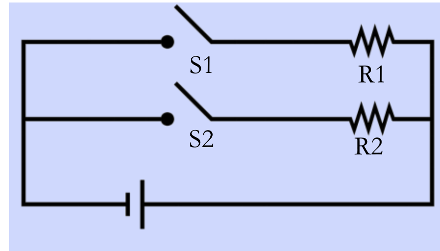
14. Suppose you have an object that is positively charged. If you connect it to ground, what will happen to its charge? What is coming from the ground to make that happen?

15. When both sides of a capacitor are connected with a conductor, what flows through the conductor and in what direction is the flow?

16. When both sides of a capacitor are connected with a conductor, in what direction does conventional current flow?

Chapter 15 Comprehension Check Questions

1. Consider the circuit shown on the right.



a. When S1 is closed and S2 is open, through which resistor or resistors does electricity flow?

b. When S1 is open and S2 is closed, through which resistor or resistors does electricity flow?

c. When both S1 and S2 are closed, through which resistor or resistors does electricity flow?

d. When electricity flows through either resistor, is conventional current flowing from right to left or from left to right?

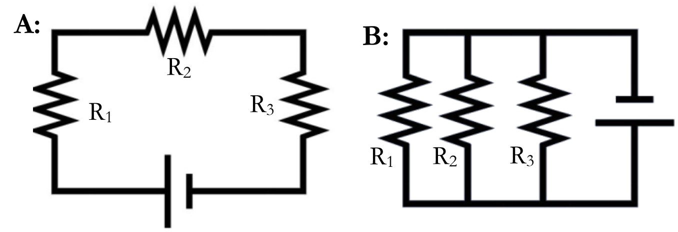
2. An electric circuit has 0.45 amps running through it. If its battery has a potential difference of 12.0 volts, what is the resistance in the circuit?

3. A circuit is run by a 9.0-volt battery and produces 25.0 W of power. What is the resistance of the circuit?

4. Think about what you just learned. Now suppose you could precisely compare the number of bubbles formed in step 19 of the experiment (where current flowed through only one glass) to the number of bubbles formed in a single glass in step 31 (the parallel circuit). How would they compare?

In the circuit diagrams shown below, each of the resistors will act like an open switch if it stops working.

5. Suppose R_2 stops working in diagram **A**. What will happen to R_1 and R_3?



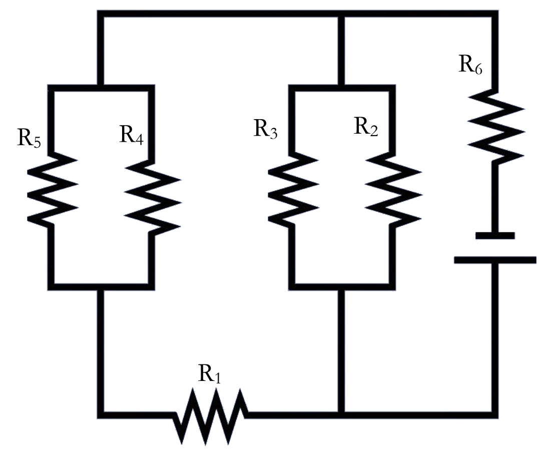
6. Suppose R_2 stops working in diagram **B**. What will happen to R_1 and R_3?

7. Suppose R_1=3.4 Ω, R_2=1.7 Ω, and R_3 = 5.1 Ω in Diagram A above. What is the effective resistance in circuit A?

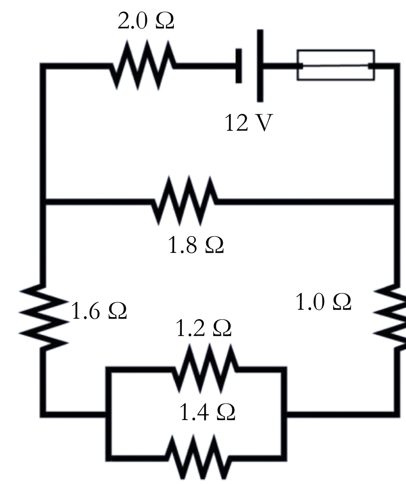
8. Suppose three resistors in diagram B are the same as they were in problem 7. Also, assume the battery has a potential difference of 9.0 volts. What is the current coming from the battery in circuit B?

9. What is the effective resistance of the circuit shown on the right when the resistors are as follows:

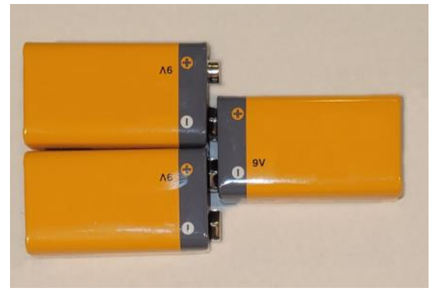
R_1=10.0 Ω, R_2=20.0 Ω, R_3=30.0 Ω, R_4=30.0 Ω, R_5=50.0 Ω, R_6=60.0 Ω



10. Which of the following fuses should be placed in the circuit shown on the right: 1A, 3 A, 5 A, 7 A, 9 A?



11. Look at the three 9.0-volt batteries pictured to the right. What is the potential difference between the positive terminal at the top of the picture and the negative terminal at the bottom? Arranged as shown, can the batteries provide a higher current than a single battery?

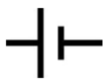


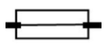
Chapter 15 Review Questions

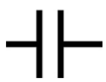
1. Define drift velocity.

2. Give the name of the electrical device each symbol represents:

a. 

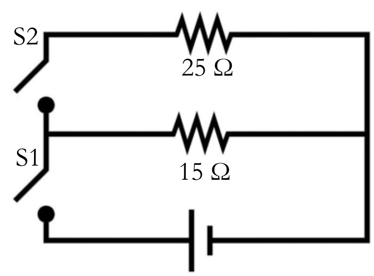
b. 

c. 

d. 

e. 

3. In the circuit shown on the right:



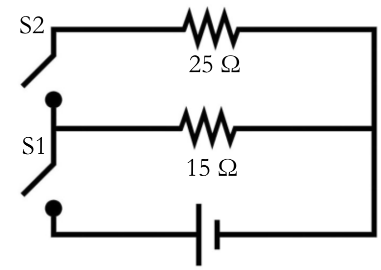
a. Through which resistor(s) is (are) current flowing as it is drawn?

b. Through which resistor(s) is (are) current flowing when S2 is open but S1 is closed?

c. Through which resistor(s) is (are) current flowing when S1 is open but S2 is closed?

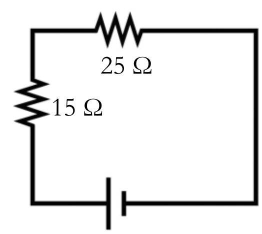
d. Which switch(es) should be closed to produce the lowest resistance?

4. In the circuit on the right, suppose S1 is closed and S2 is open. If the battery shown is 9.0 volts, what is the current that flows from the battery?



5. If both switches in the circuit drawn above are closed, what is the effective resistance of the circuit?

6. For the circuit shown on the right:

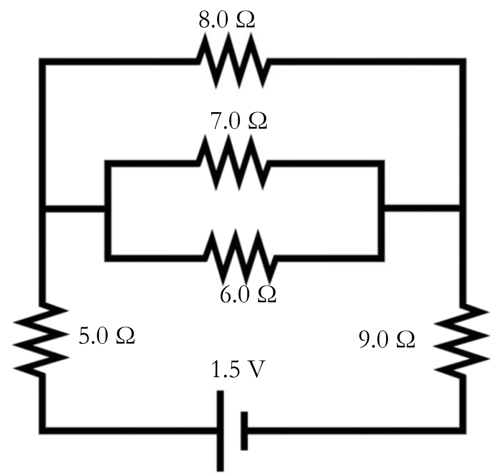


a. What is the effective resistance?

b. If it draws 160 watts, what is the current?

c. What is the voltage of the battery?

7. For the circuit shown on the right:



a. What is the effective resistance?

b. What is the current in the circuit on the previous page?

c. How much power does the circuit on the previous page draw from the battery?

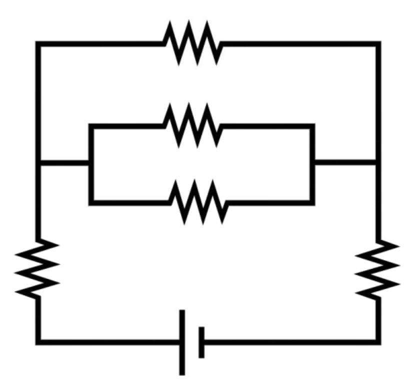
d. Suppose the device represented by the 7.0-Ω resistor in the circuit on the previous page ends up breaking. Which resistors will still have current flowing through them?

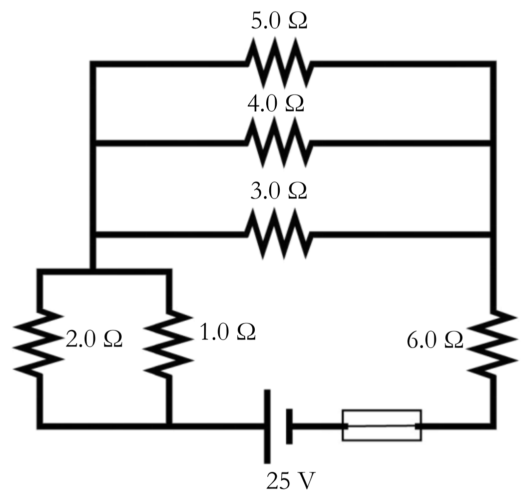
e. Suppose the device represented by the 9.0-Ω resistor in the circuit on the previous page ends up breaking. Which resistors will still have current flowing through them?

8. What is the purpose of a fuse?

9. How is a fuse similar to a circuit breaker? How are the two devices different?

10. In the circuit diagram shown on the right, indicate the positions where you could put in a fuse or circuit breaker so that it would stop all current from flowing out of the battery.



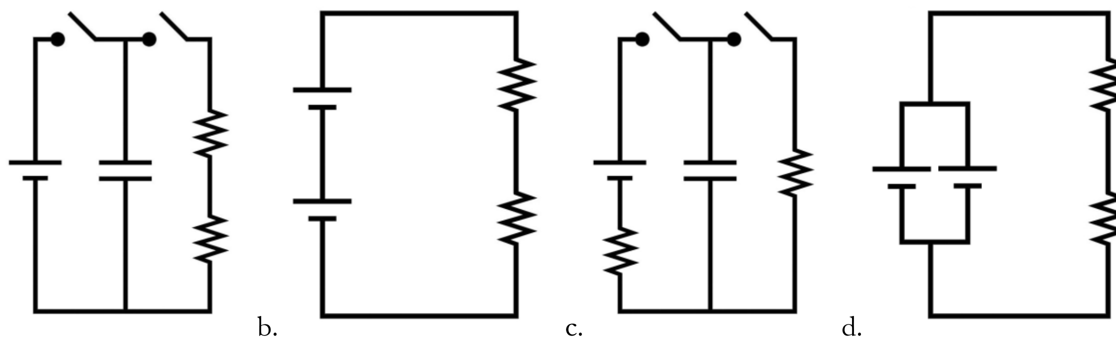


11. In the circuit diagram on the right:

   a. If you have fuses that have integral values for current (1 A, 2 A, etc.), what value fuse would you use?

b. What power does the circuit on the previous page draw from the battery?

Questions 12-14 refer to the circuit diagrams drawn below:



a. b. c. d.

12. Which one represents a circuit that has one resistor that requires more current than the battery can supply and another that doesn't require as much current?

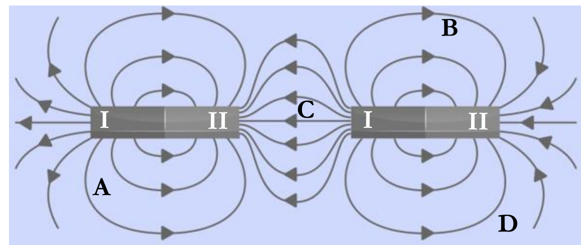
13. Assuming that each battery symbol represents the same amount of voltage, which circuit can have the largest amount of sustained current?

14. Assuming that each battery symbol represents the same amount of voltage, which circuit has the largest potential difference?

Chapter 16 Comprehension Check Questions

1. In Chapter 13, you made an electroscope. The pieces of foil moved when a charged object (like the balloon you rubbed in your hair) was brought near it. How would the pieces of foil behave if you held a magnet close to them?

2. For the magnetic field shown on the right:

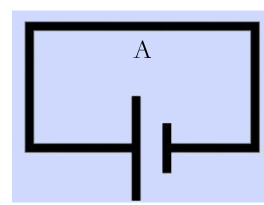


a. Which poles (I or II) are the north poles?

b. Use "up," or "down" and "left" or "right" to describe how the south pole of a magnet would point at the spot labelled "A"?

c. Of the points labeled with letters, which would produce the strongest magnetic force?

3. The index of refraction of glass is 1.5. Is the product ε·μ in glass smaller than, larger than, or equal to the product ε·μ in a vacuum?



4. Draw a circle with an arrow that represents a magnetic field line produced by the circuit on the right at point A.

5. There is evidence that Mars at one time had a magnetic field, but it currently does not have one. What must have been happening in the interior of Mars at one time that no longer happens?

6. An object doesn't act like a magnet, but it is attracted to a magnet. A student says this indicates the object is made out of a paramagnetic substance. Why is the student not necessarily correct? What test could you perform to see if the student is correct?

7. Two identical permanent magnets are stored in two different places. The first is stored in a cool room, while the other is stored in a warm room. Over time, will there be any difference in their magnetic strengths? If so, what will be the difference?

8. In some instances, electrical power plants can be converted to use a different energy source. For example, it has become popular to switch some existing power plants to burn natural gas. If your choices are a solar power plant, a coal power plant, or a hydroelectric power plant, which would be a candidate for switching to natural gas?

9. In Europe, a standard household outlet is rated at 220 volts. Is that the maximum voltage it produces?

10. Suppose you are able to measure the voltage of a wall socket very quickly. How many times per second would you see zero voltage?

11. You are given a bar magnet and a coil made out of an unknown diamagnetic substance. The coil must remain horizontal at all times. How could you use the magnet to determine whether or not the substance can conduct electricity?

Chapter 16 Review Questions

1. Define the following terms:

   a. Basic Law of Magnetism

   b. Magnetic permeability (μ)

   c. Right-hand rule

   d. Diamagnetic substance

   e. Paramagnetic substance

   b. Ferromagnetic substance

   c. Faraday's Law of Magnetic Induction

   d. Electromotive force

   e. Alternating current

   f. Direct current

   g. Rectifier

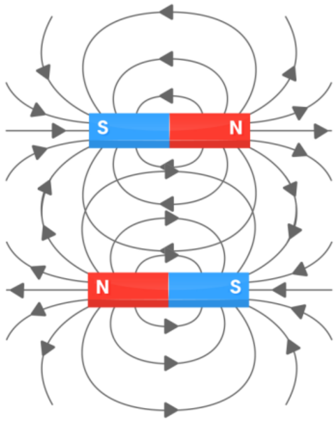
   h. Inverter

   i. Lenz's Law

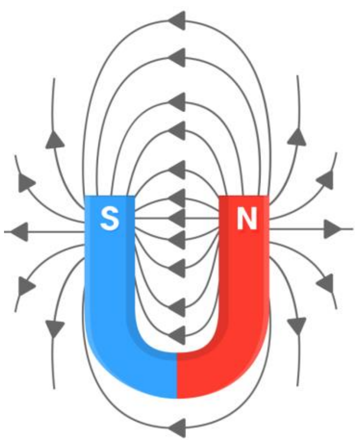
2. Do magnets exert a force on stationary charges? What about moving charges?

3. Do electric monopoles exist? What about magnetic monopoles?

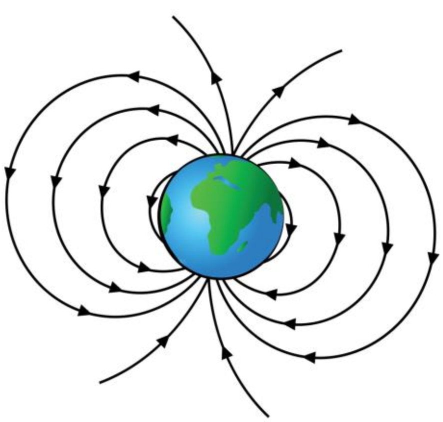
4. What is wrong with the magnetic field lines drawn in each of the following diagrams?



a.

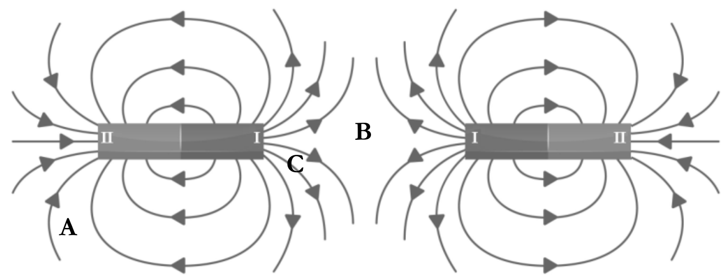


b.



c.

5. Consider the magnetic field drawn on the right:



a. Which pole (I or II) is the south pole of the magnets?

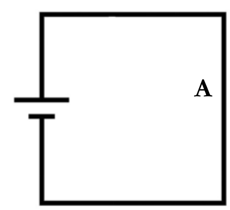
b. Using "up" or "down" and "right" or "left," describe how the north pole of a magnet would point if placed at location A in the drawing.

c. Which location (A, B, or C) would produce the most magnetic force on another magnet?

6. Maxwell's equation for the speed of light is given below. Suppose you measure the speed of light in two different media. The first one (A) has a higher electric permittivity and higher magnetic permeability than the other one (B). In which medium is the speed of light faster?

$$\text{speed} = \frac{1}{\sqrt{\varepsilon \cdot \mu}}$$

7. Draw the magnetic field line produced by the circuit on the right at point A.



8. A bar is made with a ferromagnetic substance. If it is not a magnet, how would you make it a magnet? If it is already a magnet, what could you do so that it wouldn't act like a magnet anymore?

9. An object is attracted to a magnet but isn't acting as a magnet. What are the possible types of substances (diamagnetic, paramagnetic, or ferromagnetic) out of which it could be made? How could you determine which of those possibilities is correct?

10. Excluding solar power plants, how do power plants generate their electricity? What kind of current is produced as a result?

11. What is the main difference among coal power plants, gas power plants, hydroelectric power plants, wind power plants, and nuclear power plants?

12. What are the main differences between all of the power plants listed above and a solar power plant?

13. A light that needs 25 volts in order to turn on is hooked up to a standard American electric outlet. Will the light stay on continuously? Why or why not?

14. What is the difference between the voltage at which an electric outlet is rated and the maximum voltage it produces?

15. Suppose a device requires direct current in order to work. What must be put between the device and the plug if it is going to be powered by the electricity from a wall socket?

16. A constant force is used to make a magnet move through a pipe. Compare the magnet's acceleration in a pipe made of an insulator to its acceleration in a pipe made of a conductor.

Documenting Experiments

The problem with learning things is that you can forget them pretty easily. As a result, it is important to document what you learn. That way, you can always go back later and review the material. When it comes to documenting what you learned by taking this course, you answer questions and take tests. How do you document what you learned in an experiment? By recording important aspects of the experiment in your laboratory notebook.

Start your record by writing the number and title of the experiment. Then write “Data:” underneath the title. That’s how you should start to document every lab you do. You should write the experiment number and its title. Underneath, you should write “Data:” to indicate that what follows will be all the data you collect from the experiment.

What are the data you collect in an experiment? Those are your *observations*. Every experiment has data, because every experiment requires you to make observations as the experiment progresses. So under “Data:” you should list every observation you make. Each new observation should be written underneath the previously-made observation. Some experiments require more than just observations. Some require measurements. If the experiment instructions tell you to measure how long something is, that measurement is also considered data and should be written down along with your observations.

Each piece of data needs to have a short explanation regarding when you collected it in the experiment. That allows you to remember what you did right before you made the observation. It doesn’t need to be a long explanation. It just needs to be a short note that will help remind you of what was done right before the observation was made.

The data section of each lab report, then, contains the quick notes you make while you are doing the experiment. They help remind you what you saw at each important step in the experiment. You write these things down while you are doing the lab so that they are fresh in your mind.

But that’s not all you need to do to document your lab. So far, I have discussed things you write down *while you are doing the lab*. Once the lab is over, you need to finish documenting it. How do you do that? You add another section to your lab report that is labeled “Summary:”. In that section of the lab, you write your own summary of what you did. It should not be a step-by-step listing of the instructions, and it *cannot* be a copy of the lab instructions that are in the book. Instead, it needs to be your “story” about what you did in the experiment.

Once you have finished your summary, there is one more section you need to add. Label this section "Conclusions:", and it should contain a discussion of what you were supposed to learn by doing the experiment. This is actually easy, because I always explain that after the experiment. So all you have to do is give that same explanation, but in your own words. Once you've done that, you are finished documenting your lab.

While this might seem like a lot of work, it's important for three reasons. First, it gives you something you can review later so that you can remember what you learned. Second, when you write something out in your own words, you think through it. As a result, you learn it better. Finally, there are times where you have to actually show evidence that you did experiments. Most universities, for example, require that students do experiments as a part of their high-school science courses. If you apply to a university, the people who decide whether or not you can come to the university might ask you to demonstrate that you did experiments. A lab notebook is exactly what they are looking for.

Now remember, the main goal for doing this is so that you can go back and review it later to recall what you did, what you saw, and what you learned. However, it is also possible that you will need to use this report to give evidence that you did laboratory work in your science course. Since that's one of the goals, you need to write your report so that someone who has never seen the book can understand what you did and what you learned. Obviously, just reading the data section will be confusing to someone who doesn't have access to the instructions, but that's why you add a summary after the data. It helps someone who has not read the book to understand what you did, what you saw, and what you learned.

Now please understand that there is no standard among science courses regarding how you should document your labs. Some high school science courses require you to write at least a few of your experiments the way you would write about them in a scientific journal. This is usually called a "formal laboratory report."

I don't think students in middle school and high school should do those kinds of reports. First, most students who take science will never actually write such a report in real life. As a result, it seems like a waste of time for most students. More importantly, the way you write a formal lab report changes depending on the kind of science you are doing. As a nuclear chemist, for example, the papers that I have published in the scientific literature follow a completely different format than the papers my wife (a biophysicist) has published in the scientific literature. In my opinion, you should determine what kind of science you will be doing before you start worrying about writing a formal laboratory report.

Other science courses want you to follow the scientific method when you document your lab work. They want you to start your report with a hypothesis and end your report with a conclusion about whether or not your hypothesis was confirmed. I don't see that as reasonable for most situations involving students.

After all, that's not what you are doing. You aren't making or testing a hypothesis. You are simply following my instructions. Also, when you make a hypothesis, you should design your experiment to address the hypothesis. Making a hypothesis for an already-designed experiment is backwards when it comes to the scientific method.

If you follow my method for documenting your labs, you will practice the most important aspect of laboratory work: making a record of what you did, what you saw, and what you learned. No matter what kind of science you end up doing, you will have to do that. Thus, by getting experience documenting labs in this way, you will be honing a skill that you will use if you pursue any kind of science.

This is important, since a scientist's laboratory notebook can become a legal document. If you discover something new and need to demonstrate that you were the one who discovered it, you can do that with your laboratory notebook. In addition, if someone disputes what you have concluded based on your experiments, your laboratory notebook can be used to resolve that dispute. In the end, then, getting used to properly documenting your experiments is an important part of science education.

Laboratory Notebook