Suggested problems

Study Guide 1: Units and Significant Figures

Chapter 1: 15, 17, 21, 23, 25, 27, 31, 33 (answer 4:0 106), 35, 71, 73.

15. A hydrogen atom is about $0.1\,\text{nm}$ in diameter. How many hydrogen atoms lined up side by side would make a line $1\,\text{cm}$ long?

17. Making a turn, a jetliner flies $2.1\,\text{km}$ on a circular path of radius $3.4\,\text{km}$ Through what angle does it turn?

21. How many cubic centimeters are in a cubic meter?

23. A gallon of paint covers $350\,\text{ft}^2$. What's its coverage in m^2/L?

25. One m/s is how many km/h?

27. A radian is how many degrees?

31. Divide $4.2 \times 10^3\,\text{m/s}$ by $0.57\,\text{ms}$, and express your answer in m/s^2.

33. Find the cube root of 6.4×10^{19} without a calculator.

35. You're asked to specify the length of an updated aircraft model for a sales brochure. The original plane was $41\,\text{m}$ long; the new model has a 3.6-cm-long radio antenna added to its nose. What length do you put in the brochure?

BIO The human body contains about 10^{14} cells, and the diameter of a typical cell is about $10\,\mu\text{m}$. Like all ordinary matter, cells are made of atoms; a typical atomic diameter is $0.1\,\text{nm}$.

71. The volume of a cell is about

a. $10^{-10}\,\text{m}^3$.
b. $10^{-15}\,\text{m}^3$.
c. $10^{-20}\,\text{m}^3$.
d. $10^{-30}\,\text{m}^3$.

73. The number of atoms in the body is closest to

a. 10^{14}.
b. 10^{20}.
c. 10^{30}.
d. 10^{40}.

Study Guide 2: Waves and Sound

Chapter 14: 12 (answers 0.19 s, 6.5 cm), 13, 15, 21, 23, 37, 39, 51, 53, 59, 65, 77

12. Ripples in a shallow puddle propagate at 34 cm/s. If the wave frequency is 5.2 Hz, find (a) the period and (b) the wavelength.

13. An 89.5-MHz FM radio wave propagates at the speed of light. What's its wavelength?

15. **BIO** Medical ultrasound waves travel at about 1500 m/s in soft tissue. Higher frequencies provide clearer images but don't penetrate to deeper organs. Find the wavelengths of (a) 8.0-MHz ultrasound used in fetal imaging and (b) 3.5-MHz ultrasound used to image an adult's kidneys.

21. The main cables supporting New York's George Washington Bridge have a mass per unit length of 4100 kg/m and are under 250-MN tension. At what speed would a transverse wave propagate on these cables?

23. Transverse waves propagate at 18 m/s on a string under 14-N tension. What will be the wave speed if the tension is increased to 40 N?

37. **BIO** A crude model of the human vocal tract treats it as a pipe closed at one end. Find the effective length of a vocal tract whose fundamental tone is 620 Hz. Take $v_{\text{sound}} = 354\ \text{m/s}$ at body temperature.

39. A fire station's siren is blaring at 85 Hz. What's the frequency perceived by a firefighter racing toward the station at 120 km/h?

51. Find the maximum speed for transmission of waves on a rope with $\mu = 68.4\ \text{g/m}$ if the rope's breaking tension is 415 N.

53. Light intensity 3.3 m from a lamp is $0.73\ \text{W/m}^2$. Find the lamp's power output, assuming it radiates equally in all directions.

59. At a point 15 m from a source of spherical sound waves, you measure the intensity $750\ \text{mW/m}^2$. How far do you need to walk, directly away from the source, until the intensity is $270\ \text{mW/m}^2$?

65. Show that a doubling of sound intensity corresponds to approximately a 3-dB increase in the decibel level.

77. You're in court, trying to argue your way out of a speeding ticket. You were stopped going 120 km/h in a 90-km/h zone. A technical expert testifies that the 70-GHz police radar signal underwent a 15.6-kHz frequency shift when it reflected off your car. You claim that corresponds to an impossible 240 km/h, so the radar must be defective. How should the judge rule?

Study Guide 3: Kinematics, Vectors, and Projectile Motion

Chapter 2: 15, 21, 23, 25, 29, 33, 35, 37, 39, 51, 57, 59, 61, 63, 65, 67, 69, 71, 77, 87

Chapter 3: 11, 15, 17, 19, 23, 25, 33, 39, 53, 65

15. Gwen Jorgensen of the United States won the 2016 Olympic triathlon, completing the 1.5-km swim, 40-km bicycle ride, and 10-km run in 1 h, 56 min, 16 s. What was her average speed?

21. Starting from rest, a subway train first accelerates to 25 m/s, then brakes. Forty-eight seconds after starting, it's moving at 17 m/s. What's its average acceleration in this 48-s interval?

23. An egg drops from a second-story window, taking 1.12 s to fall and reaching 11.0 m/s just before hitting the ground. On contact, the egg stops completely in 0.131 s. Calculate the magnitudes of its average acceleration (a) while falling and (b) while stopping.

25. ThrustSSC, the world's first supersonic car, accelerates from rest to 1000 km/h in 16 s. What's its acceleration?

29. A rocket starts from rest and rises with constant acceleration to a height h, at which point it's rising at speed v. Find expressions for (a) the rocket's acceleration and (b) the time it takes to reach height h.

33. California's Bay Area Rapid Transit System (BART) uses an automatic braking system triggered by earthquake warnings. The system is designed to prevent disastrous accidents involving trains traveling at a maximum of 112 km/h and carrying a total of some 45,000 passengers at rush hour. If it takes a train 24 s to brake to a stop, how much advance warning of an earthquake is needed to bring a 112-km/h train to a reasonably safe speed of 42 km/h when the earthquake strikes?

35. A delivery drone drops a package onto a customer's porch. If the package can withstand a maximum impact speed of 8.00 m/s, what's the maximum height from which the drone can drop the package?

37. A model rocket leaves the ground, heading straight up with speed v. Find expressions for (a) its maximum altitude and (b) its speed when it's at half the maximum altitude.

39. A Frisbee is lodged in a tree 6.5 m above the ground. A rock thrown from below must be going at least 3 m/s to dislodge the Frisbee. How fast must such a rock be thrown upward if it leaves the thrower's hand 1.3 m above the ground?

51. You can run **9.0 m/s, 20%** faster than your brother. How much head start should you give him in order to have a tie race over **100 m**?

57. During the complicated sequence that landed the rover *Curiosity* on Mars in 2012, the spacecraft reached an altitude of **142 m** above the Martian surface, moving vertically downward at **32.0 m/s**. It then entered a so-called constant deceleration (CD) phase, during which its velocity decreased steadily to **0.75 m/s** while it dropped to an altitude of **23 m**. What was the magnitude of the spacecraft's acceleration during this CD phase?

59. A fireworks rocket explodes at a height of **82.0 m**, producing fragments with velocities ranging from **7.68 m/s** downward to **16.7 m/s** upward. Over what time interval are fragments hitting the ground?

61. On packed snow, computerized antilock brakes can reduce a car's stopping distance by **55%**. By what percentage is the stopping time reduced?

63. A hockey puck moving at **32 m/s** slams through a wall of snow **35 cm** thick. It emerges moving at **18 m/s**. Assuming constant acceleration, find (a) the time the puck spends in the snow and (b) the thickness of a snow wall that would stop the puck entirely.

65. A jetliner touches down at **220 km/h** and comes to a halt **29 s** later. What's the shortest runway on which this aircraft can land?

67. A racing car undergoing constant acceleration covers **140 m** in **3.6 s**. (a) If it's moving at **53 m/s** at the end of this interval, what was its speed at the beginning of the interval? (b) How far did it travel from rest to the end of the **140-m** distance?

69. After **35 min** of running, at the **9-km** point in a **10-km** race, you find yourself **100 m** behind the leader and moving at the same speed. What should your acceleration be if you're to catch up by the finish line? Assume that the leader maintains constant speed.

71. Airbags cushioned the Mars rover *Spirit*'s landing, and the rover bounced some **15 m** vertically after its first impact. Assuming no loss of speed at contact with the Martian surface, what was *Spirit*'s impact speed?

77. **CH** Two divers jump from a **3.00-m** platform. One jumps upward at **1.80 m/s**, and the second steps off the platform as the first passes it on the way down. (a) What are their speeds as they hit the water? (b) Which hits the water first and by how much?

87. A police radar's effective range is $1.0\ \text{km}$, and your radar detector's range is $1.9\ \text{km}$. You're going $110\ \text{km/h}$ in a $70\ \text{km/h}$ zone when the radar detector beeps. At what rate must you slow to avoid a speeding ticket?

Chapter 3: 11, 15, 17, 19, 23, 25, 33, 39, 53, 65

11. You walk $1.57\ \text{km}$ north, then $0.846\ \text{km}$ east. Find (a) the magnitude of your displacement vector and (b) its direction, expressed as an angle relative to the northward direction.

15. Use unit vectors to express a displacement of $120\ \text{km}$ at 29° counterclockwise from the x-axis.

17. (a) What's the magnitude of $\hat{i} + \hat{j}$? (b) What angle does it make with the x-axis?

19. An object's velocity vector $\vec{v}$ has components related by $v_y = -v_x$. What are the possible values for the angle that $\vec{v}$ makes with the x-axis?

23. What are (a) the average velocity and (b) the average acceleration of the tip of the 2.4-cm-long hour hand of a clock in the interval from noon to 6 PM? Use unit vector notation, with the x-axis pointing toward 3 and the y-axis toward noon.

25. An object is moving in the x-direction at $1.3\ \text{m/s}$ when it undergoes an acceleration $\vec{a} = 0.52\hat{j}\ \text{m/s}^2$. Find its velocity vector after $4.4\ \text{s}$.

33. A carpenter tosses a shingle horizontally off an 8.8-m-high roof at $11\ \text{m/s}$. (a) How long does it take the shingle to reach the ground? (b) How far does it move horizontally?

39. The minute hand of a clock is $7.50\ \text{cm}$ long. Find the magnitude of the acceleration of its tip.

53. Let $\vec{A} = 15\hat{i} - 40\hat{j}$ and $\vec{B} = 31\hat{j} - 18\hat{k}$. Find $\vec{C}$ such that $\vec{A} + \vec{B} + \vec{C} = \vec{0}$.

65. A kid fires a squirt gun horizontally from $1.6\ \text{m}$ above the ground. It hits another kid $2.1\ \text{m}$ away square in the back, $0.93\ \text{m}$ above the ground. What was the water's initial speed?

Study Guide 4: One-Dimensional Dynamics

Chapter 4: 15, 17, 35, 45, 47, 49, 51, 55, 61, 63, 67, 73

15. BIO Kinesin is a "motor protein" responsible for moving materials within living cells. If it exerts a 6.0-pN force, what acceleration will it give a molecular complex with mass 3.0×10^{-18} kg?

17. In an egg-dropping contest, a student encases an 85-g egg in a large Styrofoam block. If the force on the egg can't exceed 28 N, and if the block hits the ground at 12 m/s, by how much must the Styrofoam compress on impact? **NOTE:** The acceleration associated with stopping the egg is so great that you can neglect gravity while the Styrofoam block is slowing due to contact with the ground.

35. A spring with spring constant $k = 340\ \mathrm{N/m}$ is used to weigh a 6.7-kg fish. How far does the spring stretch?

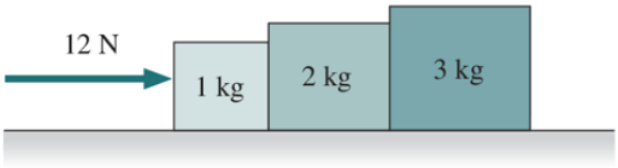
45. An airplane encounters sudden turbulence, and you feel momentarily lighter. If your apparent weight seems to be about 70% of your normal weight, what are the magnitude and direction of the plane's acceleration?

47. A dancer executes a vertical jump during which the floor pushes up on his feet with a force 50% greater than his weight. What's his upward acceleration?

49. An elevator moves upward at $5.2\ \mathrm{m/s}$. What's its minimum stopping time if the passengers are to remain on the floor?

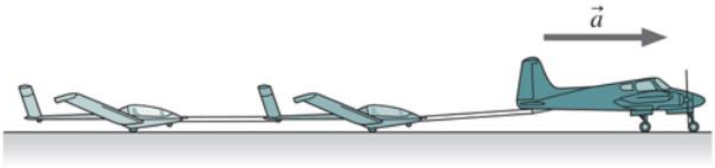
51. Blocks of 1.0, 2.0, and 3.0 kg are lined up on a frictionless table, as shown in Fig. 4.21, with a 12-N force applied to the leftmost block. What's the magnitude of the force that the rightmost block exerts on the middle one?

Figure 4.21 Problem 51



55. A 2200-kg airplane pulls two gliders, the first of mass 310 kg and the second of mass 260 kg, down the runway with acceleration $1.9\ \mathrm{m/s^2}$ (Fig. 4.22). Neglecting the mass of the two ropes and any frictional forces, determine the magnitudes of (a) the horizontal thrust of the plane's propeller, (b) the tension force in the first rope, (c) the tension force in the second rope, and (d) the net force on the first glider.

Figure 4.22 ~~Problem 56~~ Problem 55



61. Two large crates, with masses 640 kg and 490 kg, are connected by a stiff, massless spring ($k = 8.1\ \mathrm{kN/m}$) and propelled along an essentially frictionless factory floor by a horizontal force applied to the more massive crate. If the spring compresses 5.1 cm, what's the applied force?

63. With its fuel tanks half full, an F-35A jet fighter has mass 18 Mg and engine thrust 191 kN. An Airbus A-380 has mass 560 Mg and total engine thrust 1.5 MN. Could either aircraft climb vertically with no lift from its wings? If so, what vertical acceleration could it achieve?

67. A block 20% more massive than you hangs from a rope that goes over a frictionless, massless pulley. With what acceleration must you climb the other end of the rope to keep the block from falling?

73. Two masses are joined by a massless string. A 30-N force applied vertically to the upper mass gives the system a constant upward acceleration of $3.2\ \mathrm{m/s^2}$. If the string tension is 18 N, what are the two masses?

Study Guide 5: Statics and Inclined Planes – Chapter 5

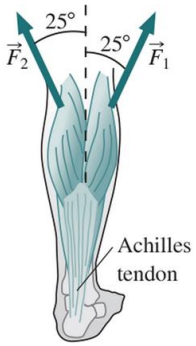
Chapter 5: 11, 13, 15, 19, 39, 41

11. Two forces, both in the $x - y$ plane, act on a **3.25-kg** mass that accelerates at $5.48\ \text{m/s}^2$ in a direction 38.0° counterclockwise from the x-axis. One force has magnitude **8.63 N** and points in the $+x$-direction. Find the other force.

13. At what angle should you tilt an air table (on Earth) to simulate free fall at the surface of Mars, where $g = 3.71\ \text{m/s}^2$?

15. **BIO** Studies of gymnasts show that their high rate of injuries to the Achilles tendon is due to tensions in the tendon that typically reach 10 times body weight. That force is provided by a pair of muscles, each exerting a force at 25° to the vertical, with their horizontal components opposite. For a **55-kg** gymnast, find the force in each of these muscles.

Figure 5.30 Exercise 5.15



19. Two unfortunate climbers, roped together, are sliding freely down an icy mountainside. The upper climber (mass **75 kg**) is on a slope at 12° to the horizontal, but the lower climber (mass **63 kg**) has gone over the edge to a steeper slope at 38°. (a) Assuming frictionless ice and a massless rope, what's the acceleration of the pair? (b) The upper climber manages to stop the slide with an ice ax. After the climbers have come to a complete stop, what force must the ax exert against the ice?

39. A block is launched with initial speed $2.2\ \text{m/s}$ up a 35° frictionless ramp. How far up the ramp does it slide?

41. A **14.6-kg** monkey hangs from the middle of a massless rope, each half of which makes an 11.0° angle with the horizontal. What's the rope tension? Compare with the monkey's weight.

Chapter 1

15. 10^8
17. $0.62\ \text{rad} = 35^\circ$
21. 10^6
23. $8.6\ \text{m}^2/\text{L}$
25. $3.6\ \text{km/h}$
27. 57.3°
31. $7.4 \times 10^6\ \text{m/s}^2$
33. 4×10^6
35. 41 m
71. b
73. c

Chapter 14

13. 3.35 m
15. **a.** 0.19 mm
    b. 0.43 mm
21. $250\ \text{m/s}$
23. $30\ \text{m/s}$
37. 14 cm
39. 93 Hz
51. $77.9\ \text{m/s}$
53. $1.0 \times 10^2\ \text{W}$
59. 10 m
77. radar worked properly

Chapter 2

15. $26.6\ \text{km/h}$
21. $0.35\ \text{m/s}^2$
23. falling: $9.82\ \text{m/s}^2$, stopping: $84.0\ \text{m/s}^2$
25. $17\ \text{m/s}^2$
29. **a.** $a = v^2/2h$
    b. $t = 2h/v$
33. 15 s
35. 3.26 m
37. **a.** $v^2/2g$
    b. $v/\sqrt{2}$
39. $11\ \text{m/s}$
51. 2.2 s
57. 4.3m/s^2
59. 2.75 s
61. 55%
63. **a.** 0.014 s
    b. 51 cm
65. 0.89 km
67. **a.** $25\ \text{m/s}$
    b. 180 m
69. $0.0051\ \text{m/s}^2$
71. $11\ \text{m/s}$
77. **a.** $7.88\ \text{m/s}, 7.67\ \text{m/s}$
    b. 0.162 s
87. $0.3\ \text{m/s}$

Chapter 3

11. **a.** 1.78 km
    b. 28.3° east of north
15. $105\hat{i} + 58\hat{j}\ \text{km}$
17. 1.414, $\theta = 45^\circ$
19. 135° or 315° (equivalently, -45°)
23. **a.** $\vec{v} = -2.2 \times 10^{-6}\,\hat{j}\ \text{m/s}$
    b. $\vec{a} = -3.2 \times 10^{-10}\,\hat{i}\ \text{m/s}^2$
25. $\vec{v}_2 = 1.3\hat{i} + 2.3\hat{j}\ \text{m/s}$
33. **a.** 1.3 s
    b. 15 m
39. $2.28 \times 10^{-7}\text{m/s}^2$
53. $\vec{C} = -15\hat{i} + 9\hat{j} - 18\hat{k}$
65. $5.7\ \text{m/s}$

Chapter 4

15. $2.0 \times 10^6\ \text{m/s}^2$
17. 22 cm
35. 19 cm
45. 2.94m/s^2, downward
47. $4.9\ \text{m/s}^2$
49. 0.53 s
51. 6.0 N
55. **a.** 5.3 kN
    b. 1.1 kN
    c. 0.49 kN
    d. 0.59 kN
61. 950 N
63. F-35A: yes, 0.81m/s^2; A-380: no
67. 1.96m/s^2
73. 0.92 kg, 1.4 kg

Chapter 5

11. $5.40\hat{i} + 11.0\hat{j}\ \text{N}$
13. 22.2°
15. 3.0 kN
19. **a.** $3.9\ \text{m/s}^2$
    b. 530 N
39. 0.43 m
41. about 2.62 times

R. Wolfson, *Essential University Physics Vol. 1*, Essential University Physics (Pearson Addison-Wesley, 2007).

Suggested problems

Study Guide 6: Friction and Circular Motion
Chapter 5: 23, 25, 27, 39, 45, 47, 49, 57, 59, 61, 67

23. You're investigating a subway accident in which a train derailed while rounding an unbanked curve of radius **150 m**, and you're asked to determine whether the train exceeded the 50-km/h speed limit for this curve. You interview a passenger who had been standing and holding a strap; she noticed that an unused strap was hanging at about a **15°** angle to the vertical just before the accident. What do you conclude?

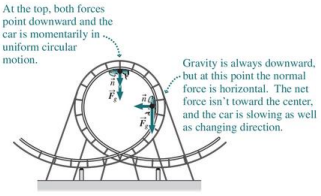
25. An airplane goes into a turn **3.6 km** in radius. If the banking angle required is **28°** from the horizontal, what's the plane's speed?

27. A hockey puck is given an initial speed of **14 m/s**. If it comes to rest in **56 m**, what's the coefficient of kinetic friction?

39. A block is launched with initial speed **2.2 m/s** up a **35°** frictionless ramp. How far up the ramp does it slide?

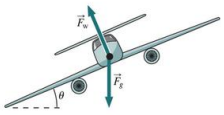
45. Riders on the "Great American Revolution" loop-the-loop roller coaster of Example 5.7 wear seatbelts as the roller coaster negotiates its **6.3-m**-radius loop at **9.7 m/s**. At the top of the loop, what are the magnitude and direction of the force exerted on a **60-kg** rider (a) by the roller-coaster seat and (b) by the seatbelt? (c) What would happen if the rider unbuckled at this point?

Figure 5.15 **Forces on the roller-coaster car.**



47. When a plane turns, it banks as shown in Fig. 5.35 to give the wings' lifting force $\vec{F}_w$ a horizontal component that turns the plane. If a plane is flying level at **950 km/h** and the banking angle θ is not to exceed **40°**, what's the minimum curvature radius for the turn?

Figure 5.35 Problem 47



49. A child sleds down an 8.5° slope at constant speed. What's the frictional coefficient between slope and sled?

57. In a typical front-wheel-drive car, 70% of the car's weight rides on the front wheels. If the coefficient of friction between tires and road is 0.61, what's the car's maximum acceleration?

59. A slide inclined at 35° takes bathers into a swimming pool. With water sprayed onto the slide to make it essentially frictionless, a bather spends only one-third as much time on the slide as when it's dry. What's the coefficient of friction on the dry slide?

61. A block is shoved up a 22° slope with an initial speed of $1.4\ \mathrm{m/s}$. The coefficient of kinetic friction is 0.70. (a) How far up the slope will the block get? (b) Once stopped, will it slide back down?

67. An astronaut is training in an earthbound centrifuge that consists of a small chamber whirled horizontally at the end of a 5.1-m-long shaft. The astronaut places a notebook on the vertical wall of the chamber and it stays in place. If the coefficient of static friction is 0.62, what's the minimum rate, expressed in revolutions per minute, at which the centrifuge must be revolving?

Study Guide 7: Work and Energy

Chapter 6: 11, 13, 15, 19, 21, 23, 25, 27, 29, 31, 34 (answer 2.1 kW), 49, 51, 53, 61, 63, 69
Chapter 7: 12 (answers 1.3 MJ and -59 kJ), 15, 17, 19, 21, 47, 55, 59, 61

11. How much work do you do as you exert a 75-N force to push a shopping cart through a 12-m-long supermarket aisle?

13. A crane lifts a 650-kg beam vertically upward 23 m and then swings it eastward 18 m. How much work does the crane do? Neglect friction, and assume the beam moves with constant speed.

15. A meteorite plunges to Earth, embedding itself 75 cm in the ground. If it does 140 MJ of work in the process, what average force does the meteorite exert on the ground?

19. To push a stalled car, you apply a 470-N force at 17° to the car's motion, doing 860 J of work in the process. How far do you push the car?

21. How much work does it take to stretch a spring with $k = 200\ \text{N/m}$ (a) 10 cm from equilibrium and (b) from 10 cm to 20 cm from equilibrium?

23. You do 8.5 J of work to stretch a spring with $k = 190\ \text{N/m}$, starting with the spring unstretched. How far does the spring stretch?

25. What's the kinetic energy of a 2.4×10^5-kg airplane cruising at 900 km/h?

27. At what speed must a 950-kg subcompact car be moving to have the same kinetic energy as a 3.2×10^4-kg truck going 20 km/h?

29. After a tornado, a 0.50-g drinking straw was found embedded 4.5 cm in a tree. Subsequent measurements showed that the tree exerted a stopping force of 70 N on the straw. What was the straw's speed?

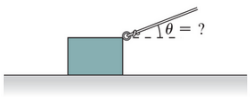
31. A typical human diet is "2000 calories" per day, where the "calorie" describing food energy is actually 1 kilocalorie. Express 2000 kcal/day in watts.

34. A sprinter completes a 100-m dash in 10.6 s, doing 22.4 kJ of work. What's her average power output?

49. You slide a box of books at constant speed up a 30° ramp, applying a force of 200 N directed up the slope. The coefficient of sliding friction is 0.18. (a) How much work have you done when the box has risen 1 m vertically? (b) What's the mass of the box?

51. You pull a box 23 m horizontally, using the rope shown in Fig. 6.18. If the rope tension is 120 N, and if the rope does 2500 J of work on the box, what angle θ does the rope make with the horizontal?

Figure 6.18 Problem 51



53. (a) Find the scalar product of the vectors $a\hat{\imath} + b\hat{\jmath}$ and $b\hat{\imath} - a\hat{\jmath}$, where a and b are arbitrary constants. (b) What's the angle between the two vectors?

61. BIO *E. coli* bacteria swim by means of flagella that rotate about 100 times per second. A typical *E. coli* bacterium swims at $22\ \mu m/s$, its flagella exerting a force of 0.57 pN to overcome the resistance due to its liquid environment. (a) What's the bacterium's power output? (b) How much work would it do in traversing the 25-mm width of a microscope slide?

63. An elevator ascends from the ground floor to the 10th floor, a height of 41 m, in 35 s. If the mass of the elevator and passengers is 840 kg, what's the power necessary to lift the elevator? (Your answer is greater than the actual power needed because elevators are counterweighted, thus reducing the work the motor needs to do.)

69. ENV The United States imports about 400 million gallons of oil each day. Use the "Energy Content of Fuels" table in Appendix C to estimate the corresponding power, measured in gigawatts.

Chapter 7: 12 (answers 1.3 MJ and -59 kJ), 15, 17, 19, 21, 47, 55, 59, 61

12. Find the potential energy associated with a 70-kg hiker (a) atop New Hampshire's Mount Washington, 1900 m above sea level, and (b) in Death Valley, California, 86 m below sea level. Take the zero of potential energy at sea level.

15. How far would you have to stretch a spring with $k = 1.4\ \text{kN/m}$ for it to store 210 J of energy?

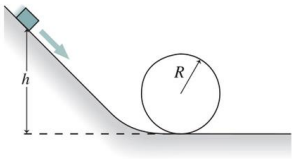
17. A skier starts down a frictionless 32° slope. After a vertical drop of 25 m, the slope temporarily levels out and then slopes down at 20°, dropping an additional 38 m vertically before leveling out again. Find the skier's speed on the two level stretches.

19. A 120-g arrow is shot vertically from a bow whose effective spring constant is 430 N/m. If the bow is drawn 71 cm before shooting, to what height does the arrow rise?

21. You work for a toy company, and you're designing a spring-launched model rocket. The launching apparatus has room for a spring that can be compressed 14 cm, and the rocket's mass is 65 g. If the rocket is to reach an altitude of 35 m, what should you specify for the spring constant?

47. CH A block slides on the frictionless loop-the-loop track shown in Fig. 7.19. Find the minimum height h at which it can start from rest and still make it around the loop.

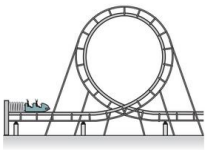
Figure 7.19 Problem 47



55. A spring of constant $k = 340\ \text{N/m}$ is used to launch a 1.5-kg block along a horizontal surface whose coefficient of sliding friction is 0.27. If the spring is compressed $18\ \text{cm}$, how far does the block slide?

59. CH An 840-kg roller-coaster car is launched from a giant spring with $k = 31\ \text{kN/m}$ into a frictionless loop-the-loop track of radius $6.2\ \text{m}$, as shown in Fig. 7.22. What's the minimum spring compression that will ensure the car stays on the track?

Figure 7.22 Problem 59



61. A child sleds down a frictionless hill whose vertical drop is $7.2\ \text{m}$. At the bottom is a level but rough stretch where the coefficient of kinetic friction is 0.51. How far does she slide across the level stretch?

Study Guide 8: Momentum and Collisions

Chapter 9: 25, 27, 31, 49, 89

25. In a totally inelastic collision between two equal masses, with one initially at rest, show that half the initial kinetic energy is lost.

27. Two identical trucks have mass $5500\ \text{kg}$ when empty, and the maximum permissible load for each is $8000\ \text{kg}$. The first truck, carrying $3800\ \text{kg}$, is at rest. The second truck plows into it at $65\ \text{km/h}$, and the pair moves away at $37\ \text{km/h}$. As an expert witness, you're asked to determine whether the second truck was overloaded. What do you report?

31. A proton moving at $6.9\ \text{Mm/s}$ collides elastically head-on with a second proton moving in the opposite direction at $11\ \text{Mm/s}$. Find their subsequent velocities.

49. An $11,000$-kg freight car rests against a spring bumper at the end of a railroad track. The spring has constant $k = 0.32\ \text{MN/m}$. The car is hit by a second car of 9400-kg mass moving at $8.5\ \text{m/s}$, and the two couple together. Find (a) the maximum compression of the spring and (b) the speed of the two cars when they rebound together from the spring.

89. An 80-kg astronaut has become detached from the safety line connecting her to the International Space Station. She's $200\ \text{m}$ from the station, at rest relative to it, and has $4\ \text{min}$ of air remaining. To get herself back, she tosses a 10-kg tool kit away from the station at $8.0\ \text{m/s}$. Will she make it back in time?

Study Guide 9: Fluids

Chapter 15: 11, 13, 15, 17, 19, 21, 23, 25, 27, 31, 41, 42 (answer: no, as it's equivalent to trying to lift a 1250 kg mass), 43, 45, 53, 55

11. The density of molasses is $1600\ \text{kg/m}^3$. Find the mass of the molasses in a $0.75\ \text{L}$ jar.

13. Compressed air with mass $8.8\ \text{kg}$ is stored in a 0.050-m^3 cylinder. (a) What's the density of the compressed air? (b) What volume would the same gas occupy at a typical atmospheric density of $1.2\ \text{kg/m}^3$?

15. The *diamond anvil* is used by scientists and engineers to study matter under extreme pressures, simulating conditions such as those found at the centers of planets. A typical anvil consists of two diamonds with parallel faces measuring some $200\ \mu\text{m}$ in diameter. The sample under study is placed between the diamonds, and a force is applied to the diamonds. Estimate the pressure that results when the force on the diamonds is $6\ \text{kN}$.

17. What's the density of a fluid whose pressure increases at the rate of $100\ \text{kPa}$ for every $6.0\ \text{m}$ of depth?

19. BIO Scuba equipment provides a diver with air at the same pressure as the surrounding water. But at pressures higher than about $1\ \text{MPa}$, the nitrogen in air becomes dangerously narcotic. At what depth does nitrogen narcosis become a hazard?

21. A child attempts to drink water through a 36-cm-long straw but finds that the water rises only $25\ \text{cm}$. By how much has the child reduced the pressure in her mouth below atmospheric pressure?

23. On land, the most massive concrete block you can carry is $25\ \text{kg}$. Given concrete's 2200-kg/m^3 density, how massive a block could you carry underwater?

25. Styrofoam's density is $160\ \text{kg/m}^3$. What percent error is introduced by weighing a Styrofoam block in air (density $1.2\ \text{kg/m}^3$), which exerts an upward buoyancy force, rather than in vacuum?

27. Water flows through a **2.5-cm-diameter** pipe at $1.8\ \text{m/s}$. If the pipe narrows to **2.0-cm** diameter, what's the flow speed in the constriction?

31. **BIO** A typical human aorta, the main artery from the heart, is $1.8\ \text{cm}$ in diameter and carries blood at $35\ \text{cm/s}$. Find the flow speed around a clot that reduces the flow area by 80%.

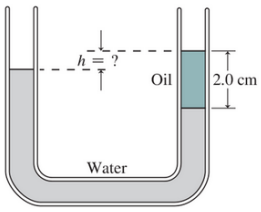
41. A fully loaded Volvo station wagon has mass $1950\ \text{kg}$. If each of its four tires is inflated to a gauge pressure of $230\ \text{kPa}$, what's the total tire area in contact with the road?

42. You're stuck in the exit row on a long flight, and you suddenly worry that your seatmate, who's next to the window, might pull the emergency window inward while you're in flight. The window measures $40\ \text{cm}$ by $55\ \text{cm}$. Cabin pressure is $0.77\ \text{atm}$, and atmospheric pressure at the plane's altitude is $0.22\ \text{atm}$. Should you worry?

43. A vertical tube $1.0\ \text{cm}$ in diameter and open at the top contains $5.0\ \text{g}$ of oil (density $0.82\ \text{g/cm}^3$) floating on $5.0\ \text{g}$ of water. Find the gauge pressure (a) at the oil–water interface and (b) at the bottom.

45. A U-shaped tube open at both ends contains water and a quantity of oil occupying a **2.0-cm** length of the tube, as shown in Fig. 15.24. If the oil's density is 82% of water's, what's the height difference h?

Figure 15.24 Problem 45



53. (a) How much helium (density $0.18\ \text{kg/m}^3$) is needed to lift a balloon carrying two people, if the total mass of people, basket, and balloon (but not gas) is $280\ \text{kg}$? (b) Repeat for a hot-air balloon whose air density is 10% less than that of the surrounding atmosphere.

55. BIO If the blood pressure in the unobstructed artery of Exercise 31 is **16 kPa** gauge (about **120 mm** of mercury, the unit commonly reported by doctors), what will it be at the clot? (**NOTE**: Blood's density is **1.06 g/cm³**.)

Chapter 5

23. Train was speeding at **71 km/h**
25. **490 km/h**
27. 0.18
39. 0.43 m
45. 310 N downward
(b) $-m_{SB}v^2/R$ (c) nothing
47. 8.5 km
49. 0.15
57. **4.2 m/s²**
59. 0.62
61. **a.** 9.8 cm
b. no
67. **17 rev/min**

Chapter 6

11. 900 J
13. 150 kJ
15. 190 MN
19. 1.9 m
21. **a.** 1 J
b. 3 J
23. 30 cm
25. 7.5 GJ
27. **±120 km/h**
29. **110 m/s**
31. 97 W
49. **a.** 400 J
b. 31 kg
51. **25°**
53. **a.** 0
b. **90°**
61. **a.** 1.3×10^{-17} **W**
b. 1.4×10^{-14} **J**
63. 9.6 kW
69. about 700 GW

Chapter 7

15. 55 cm
17. **±22 m/s, ±35 m/s**
19. 92 m
21. **2.3 kN/m**
47. $h \geq 5R/2$
55. 1.4 m
59. 2.9 m
61. 14 m

Chapter 9

27. The truck's load was 6800 kg, 1200 kg under the limit.
31. $v_{1f} = -11$ **Mm/s**, $v_{2f} = +6.9$ **Mm/s**, velocities are exchanged
49. **a.** 0.99 m
b. **3.9 m/s**
89. 3.75 min

Chapter 15

11. 1.2 kg
13. **a.** **180 kg/m³**
b. **7.3 m³**
15. 200 GPa
17. 1.7×10^3 **kg/m³**
19. 92 m
21. 2.4%
23. 46 kg
25. 0.75%
27. **2.8 m/s**
31. **1.8 m/s**
41. **830 cm²**
43. **a.** 620 Pa
b. 1.2 kPa
45. 3.6 mm
53. **a.** 49 kg
b. 2500 kg
55. 14 kPa

R. Wolfson, *Essential University Physics Vol. 1*, Essential University Physics (Pearson Addison-Wesley, 2007).

Suggested problems

Study Guide 10: Electric Circuits

Chapter 24: 11, 13, 21, 27, 29

Chapter 25: 15, 17, 19, 21, 23, 43, 45, 46 (answer is yes, as it would drive 120 mA), 49, 50 (answer is 3/7 A)

11. A wire carries 1.5 A. How many electrons pass through the wire in one second?

13. **BIO** Biologists measure the total current due to potassium ions moving through the membrane of a rock crab neuron cell as 30 nA. How many ions pass through the membrane each second?

21. What voltage does it take to drive 300 mA through a $1.2\text{-k}\Omega$ resistance?

27. A 4.5-W flashlight bulb draws 750 mA. (a) At what voltage does it operate? (b) What's its resistance?

29. A $35-\Omega$ electric stove burner consumes 1.5 kW of power. At what voltage does it operate?

Chapter 25: 15, 17, 19, 21, 23, 43, 45, 46 (answer is yes, as it would drive 120 mA), 49, 50 (answer is 3/7 A)

15. A 1.5-V battery stores 4.5 kJ of energy. How long can it light a flashlight bulb that draws 0.60 A?

17. A $47\text{-k}\Omega$ resistor and a $39\text{-k}\Omega$ resistor are in parallel, and the pair is in series with a $22\text{-k}\Omega$ resistor. What's the resistance of the combination?

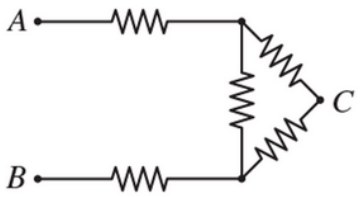
19. A defective starter motor draws 285 A from a car's 12.6-V battery, dropping the voltage at the battery terminals to 7.33 V. A good starter motor should draw only 112 A. Find the battery terminal voltage with a good starter.

21. When a 9-V battery is temporarily short-circuited, a 200-mA current flows. What's the battery's internal resistance?

23. Find all three currents in the circuit of Fig. 25.13, but now with $\mathscr{E}_2 = 1.0\,\text{V}$.

43. In Fig. 25.28, take all resistors to be $1.0\,\text{k}\Omega$. Find the current in the vertical resistor when a 6.0-V battery is connected between A and B.

Figure 25.28 Problems 42 and 43

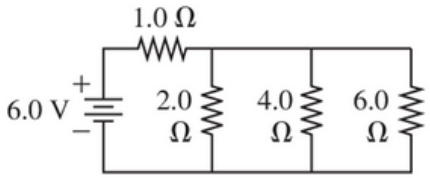


45. A partially discharged car battery can be modeled as a 9.0-V emf in series with an $85\text{-m}\Omega$ internal resistance. Jumper cables connect this battery to a fully charged battery, modeled as a 12-V emf in series with a $22\text{-m}\Omega$ internal resistance. The cables connect + to + and − to −. How much current flows through the discharged battery?

46. **BIO** Your company is designing a battery-based backup power source, and your job is to assess its safety. You know that under damp or sweaty conditions, the resistance between two points of unbroken skin on the human body can be as low as $500\,\Omega$. Your product uses a 72-V battery whose internal resistance is $100\,\Omega$. Is it capable of passing a fatal 100 mA (Table 24.3) through a damp human body?

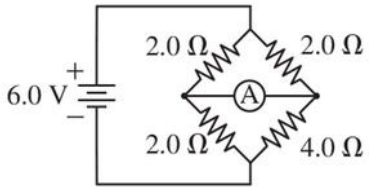
49. In Fig. 25.29, how much power is dissipated in the $4\text{-}\Omega$ resistor?

Figure 25.29 Problems 47 and 49



50. What's the ammeter reading in Fig. 25.30?

Figure 25.30 Problem 50



Study Guide 11: Geometrical and Physical Optics

Chapter 30: 11, 17, 19, 23, 25, 37

Chapter 31: 17, 19, 45, 47, 49, 51

Chapter 32: 11, 13, 42 (answer: m = 4 for the 550 nm bright fringe, and m = 5 for the 400 nm dark fringe)

11. Through what angle should you rotate a mirror so that a reflected ray rotates through 30°?

17. Light is incident on an air–glass interface, and the refracted light in the glass makes a 40° angle with the normal to the interface. The glass has refractive index 1.52. Find the incidence angle.

19. Light propagating in the glass $(n = 1.52)$ wall of an aquarium tank strikes the wall's interior surface with incidence angle 12.4°. What's the angle of refraction in the water?

23. A drop of water is trapped in a block of ice. What's the critical angle for total internal reflection at the water–ice interface?

25. Total internal reflection occurs at an interface between plastic and air at incidence angles greater than 37°. Find the plastic's refractive index.

37. **BIO** The refractive index of a human cornea is 1.40. If 550-nm light strikes a cornea at incidence angle 25°, find (a) the angle of refraction and (b) the wavelength in the cornea.

Chapter 31: 17, 19, 45, 47, 49, 51

17. By what factor is the image magnified for an object 1.5 focal lengths from a converging lens? Is the image upright or inverted?

19. By holding a magnifying glass 25 cm from your desk lamp, you can focus an image of the lamp's bulb on a wall 1.6 m from the lamp. What's the focal length of your magnifying glass?

45. How far from a page should you hold a lens with 32-cm focal length in order to see the print magnified 1.6 times?

47. A lens has focal length $f = 35$ cm. Find the type and height of the image produced when a 2.2-cm-high object is placed at distances (a) $f + 10$ cm and (b) $f - 10$ cm.

49. A candle and a screen are 70 cm apart. Find two points between candle and screen where you could put a convex lens with 17-cm focal length to give a sharp image of the candle on the screen.

51. How far from a 25-cm-focal-length lens should you place an object to get an upright image magnified 1.8 times?

Chapter 32: 11, 13, 42 (answer: m = 4 for the 550 nm bright fringe, and m = 5 for the 400 nm dark fringe)

11. A double-slit experiment with $d = 0.025\ \text{mm}$ and $L = 75\ \text{cm}$ uses 550-nm light. Find the spacing between adjacent bright fringes.

13. The interference pattern from two slits separated by 0.37 mm has bright fringes with angular spacing 0.065°. Find the light's wavelength.

42. A tube of glowing gas emits light at 550 nm and 400 nm. In a double-slit apparatus, what's the lowest-order 550-nm bright fringe that will fall on a 400-nm dark fringe, and what are the fringes' corresponding orders?

Study Guide 12: Modern Physics

Chapter 34: 17, 19, 25, 27, 47

17. BIO The human eye is sensitive to wavelengths from about 400 nm to 700 nm. What's the corresponding range of photon energies?

19. A red laser at 650 nm and a blue laser at 450 nm emit photons at the same rate. How do their total power outputs compare?

25. Find the de Broglie wavelength of (a) Earth, orbiting the Sun at 30 km/s, and (b) an electron moving at 10 km/s.

27. A proton and electron have the same de Broglie wavelength. How do their speeds compare, assuming $v \ll c$ for both?

47. Find the rate of photon production by (a) a radio antenna broadcasting 1.0 kW at 89.5 MHz, (b) a laser producing 1.0 mW of 633-nm light, and (c) an X-ray machine producing 0.10-nm X-rays with total power 2.5 kW.

Chapter 24

11. 9.4×10^{18}
13. 1.9×10^{11}
21. 360 V
27. **a.** 6.0 V
    b. 8.0 Ω
29. 230 V

Chapter 25

15. 1.4 h
17. 43 kΩ
19. 10.5 V
21. 50 Ω
23. $I_1 = 2\text{A}$, $I_2 = 0.2\text{A}$, $I_3 = 2\text{A}$
43. 1.5 mA
45. 30 A
49. 2.4 W

Chapter 30

11. 15°
17. 77.7°
19. 14.2°
23. 79.1°
25. 1.66
37. **a.** 18°
    b. 390 nm

Chapter 31

17. −2
19. 21 cm
45. 12 cm
47. **a.** −7.7 cm, inverted, real
    b. +7.7 cm, upright, virtual
49. 29 cm or 41 cm
51. 11 cm

Chapter 32

11. 1.7 cm
13. 420 nm

Chapter 34

17. 2.8×10^{-19} J to 5.0×10^{-19} J
19. 1.44
25. **a.** 3.7×10^{-63} m
    b. 73 nm
27. The electron moves 1836 times faster than the proton.
47. **a.** $1.7 \times 10^{28}\ \text{s}^{-1}$
    b. $3.2 \times 10^{15}\ \text{s}^{-1}$
    c. $1.3 \times 10^{18}\ \text{s}^{-1}$

R. Wolfson, *Essential University Physics Vol. 1*, Essential University Physics (Pearson Addison-Wesley, 2007).