CHAPTER

1 A Physics Toolkit

Practice Problems

1.1 Mathematics and Physics pages 3–10

page 5

For each problem, give the rewritten equation you would use and the answer.

1. A lightbulb with a resistance of 50.0 ohms is used in a circuit with a 9.0-volt battery. What is the current through the bulb?

$$I = \frac{V}{R} = \frac{9.0\text{ volt}}{50.0\text{ ohms}} = 0.18\text{ ampere}$$

2. An object with uniform acceleration a, starting from rest, will reach a speed of v in time t according to the formula $v = at$. What is the acceleration of a bicyclist who accelerates from rest to 7 m/s in 4 s?

$$a = \frac{v}{t} = \frac{7\text{ m/s}}{4\text{ s}} = 1.75\text{ m/s}^2$$

3. How long will it take a scooter accelerating at 0.400 m/s^2 to go from rest to a speed of 4.00 m/s?

$$t = \frac{v}{a} = \frac{4.00\text{ m/s}}{0.400\text{ m/s}^2} = 10.0\text{ s}$$

4. The pressure on a surface is equal to the force divided by the area: $P = F/A$.
A 53-kg woman exerts a force (weight) of 520 Newtons. If the pressure exerted on the floor is 32,500 N/m^2, what is the area of the soles of her shoes?

$$A = \frac{F}{P} = \frac{520\text{ N}}{32{,}500\text{ N/m}^2} = 0.016\text{ m}^2$$

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Use dimensional analysis to check your equation before multiplying.

5. How many megahertz is 750 kilohertz?

$$750\ \cancel{\text{kHz}}\left(\frac{1000\ \cancel{\text{Hz}}}{1\ \cancel{\text{kHz}}}\right)\left(\frac{1\text{ MHz}}{1{,}000{,}000\ \cancel{\text{Hz}}}\right) =$$

0.75 MHz

6. Convert 5021 centimeters to kilometers.

$$5021\ \cancel{\text{cm}}\left(\frac{1\ \cancel{\text{m}}}{100\ \cancel{\text{cm}}}\right)\left(\frac{1\text{ km}}{1000\ \cancel{\text{m}}}\right) =$$

5.021×10^{-2} **km**

7. How many seconds are in a leap year?

$$366\ \cancel{\text{days}}\left(\frac{24\ \cancel{\text{h}}}{1\ \cancel{\text{day}}}\right)\left(\frac{60\ \cancel{\text{min}}}{1\ \cancel{\text{h}}}\right)\left(\frac{60\text{ s}}{1\ \cancel{\text{min}}}\right) =$$

31,622,400 s

8. Convert the speed 5.30 m/s to km/h.

$$\left(\frac{5.30\ \cancel{\text{m}}}{1\ \cancel{\text{s}}}\right)\left(\frac{60\ \cancel{\text{s}}}{1\ \cancel{\text{min}}}\right)\left(\frac{60\ \cancel{\text{min}}}{1\text{ h}}\right)\left(\frac{1\text{ km}}{1000\ \cancel{\text{m}}}\right) =$$

19.08 km/h

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Solve the following problems.

9. a. 6.201 cm + 7.4 cm + 0.68 cm + 12.0 cm

6.201 cm
7.4 cm
0.68 cm
+ 12.0 cm
26.281 cm
= 26.3 cm after rounding

b. 1.6 km + 1.62 m + 1200 cm

1.6 km = 1600 m
1.62 m = 1.62 m
1200 cm = + 12 m
1613.62 m
= 1600 m or 1.6 km after rounding

10. a. 10.8 g − 8.264 g

10.8 g
− 8.264 g
2.536 g
= 2.5 g after rounding

b. 4.75 m − 0.4168 m

$$\begin{array}{r} \textbf{4.75}\quad\ \textbf{m} \\ \underline{-\textbf{0.4168 m}} \\ \textbf{4.3332 m} \end{array}$$

= 4.33 m after rounding

11. **a.** 139 cm × 2.3 cm

320 cm^2 or 3.2×10^2 cm^2

b. 3.2145 km × 4.23 km

13.6 km^2

12. **a.** 13.78 g ÷ 11.3 mL

1.22 g/mL

b. 18.21 g ÷ 4.4 cm^3

4.1 g/cm^3

Section Review

1.1 Mathematics and Physics pages 3–10

page 10

13. **Math** Why are concepts in physics described with formulas?

The formulas are concise and can be used to predict new data.

14. **Magnetism** The force of a magnetic field on a charged, moving particle is given by $F = Bqv$, where F is the force in kg·m/s^2, q is the charge in A·s, and v is the speed in m/s. B is the strength of the magnetic field, measured in teslas, T. What is 1 tesla described in base units?

$$F = Bqv, \text{ so } B = \frac{F}{qv}$$

$$\mathrm{T} = \frac{\mathrm{kg{\cdot}m/s^2}}{\mathrm{(A{\cdot}s)(m/s)}} = \frac{\mathrm{kg}}{\mathrm{A{\cdot}s^2}}$$

1 T = 1 kg/A·s^2

15. **Magnetism** A proton with charge 1.60×10^{-19} A·s is moving at 2.4×10^{5} m/s through a magnetic field of 4.5 T. You want to find the force on the proton.

a. Substitute the values into the equation you will use. Are the units correct?

$$F = Bqv$$
$$= (4.5\ \mathrm{kg/A{\cdot}s^2})(1.60\times10^{-19}\ \mathrm{A{\cdot}s})(2.4\times10^{5}\ \mathrm{m/s})$$

Force will be measured in kg·m/s^2, which is correct.

b. The values are written in scientific notation, $m\times10^n$. Calculate the 10^n part of the equation to estimate the size of the answer.

$10^{-19}\times10^{5} = 10^{-14}$; the answer will be about 20×10^{-14}, or 2×10^{-13}.

c. Calculate your answer. Check it against your estimate from part **b.**

1.7×10^{-13} kg·m/s^2

d. Justify the number of significant digits in your answer.

The least-precise value is 4.5 T, with 2 significant digits, so the answer is rounded to 2 significant digits.

16. **Magnetism** Rewrite $F = Bqv$ to find v in terms of F, q, and B.

$$v = \frac{F}{Bq}$$

17. **Critical Thinking** An accepted value for the acceleration due to gravity is 9.801 m/s^2. In an experiment with pendulums, you calculate that the value is 9.4 m/s^2. Should the accepted value be tossed out to accommodate your new finding? Explain.

No. The value 9.801 m/s^2 has been established by many other experiments, and to discard the finding you would have to explain why they were wrong. There are probably some factors affecting your calculation, such as friction and how precisely you can measure the different variables.

Section Review

1.2 Measurement pages 11–14

page 14

18. Accuracy Some wooden rulers do not start with 0 at the edge, but have it set in a few millimeters. How could this improve the accuracy of the ruler?

As the edge of the ruler gets worn away over time, the first millimeter or two of the scale would also be worn away if the scale started at the edge.

19. Tools You find a micrometer (a tool used to measure objects to the nearest 0.01 mm) that has been badly bent. How would it compare to a new, high-quality meterstick in terms of its precision? Its accuracy?

It would be more precise but less accurate.

20. Parallax Does parallax affect the precision of a measurement that you make? Explain.

No, it doesn't change the fineness of the divisions on its scale.

21. Error Your friend tells you that his height is 182 cm. In your own words, explain the range of heights implied by this statement.

His height would be between 181.5 and 182.5 cm. Precision of a measurement is one-half the smallest division on the instrument. The height 182 cm would range ± 0.5 cm.

22. Precision A box has a length of 18.1 cm and a width of 19.2 cm, and it is 20.3 cm tall.

a. What is its volume?

7.05×10^3 cm^3

b. How precise is the measure of length? Of volume?

nearest tenth of a cm; nearest 10 cm^3

c. How tall is a stack of 12 of these boxes?

243.6 cm

d. How precise is the measure of the height of one box? Of 12 boxes?

nearest tenth of a cm; nearest tenth of a cm

23. Critical Thinking Your friend states in a report that the average time required to circle a 1.5-mi track was 65.414 s. This was measured by timing 7 laps using a clock with a precision of 0.1 s. How much confidence do you have in the results of the report? Explain.

A result can never be more precise than the least precise measurement. The calculated average lap time exceeds the precision possible with the clock.

Practice Problems

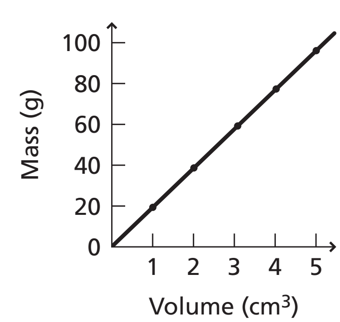
1.3 Graphing Data pages 15–19

page 18

24. The mass values of specified volumes of pure gold nuggets are given in **Table 1-4.**

Table 1-4	
Mass of Pure Gold Nuggets	
Volume (cm^3)	**Mass (g)**
1.0	19.4
2.0	38.6
3.0	58.1
4.0	77.4
5.0	96.5

a. Plot mass versus volume from the values given in the table and draw the curve that best fits all points.



b. Describe the resulting curve.

a straight line

c. According to the graph, what type of relationship exists between the mass of the pure gold nuggets and their volume?

The relationship is linear.

d. What is the value of the slope of this graph? Include the proper units.

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{96.5 \text{ g} - 19.4 \text{ g}}{5.0 \text{ cm}^3 - 1.0 \text{ cm}^3}$$

$$= 19.3 \text{ g/cm}^3$$

e. Write the equation showing mass as a function of volume for gold.

$m = (19.3 \text{ g/cm}^3)V$

f. Write a word interpretation for the slope of the line.

The mass for each cubic centimeter of pure gold is 19.3 g.

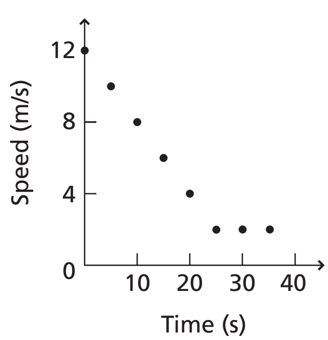
Section Review

1.3 Graphing Data pages 15–19

page 19

25. Make a Graph Graph the following data. Time is the independent variable.

Time (s)	0	5	10	15	20	25	30	35
Speed (m/s)	12	10	8	6	4	2	2	2



26. Interpret a Graph What would be the meaning of a nonzero y-intercept to a graph of total mass versus volume?

There is a nonzero total mass when the volume of the material is zero. This could happen if the mass value includes the material's container.

27. Predict Use the relation illustrated in Figure 1-16 to determine the mass required to stretch the spring 15 cm.

16 g

28. Predict Use the relation in Figure 1-18 to predict the current when the resistance is 16 ohms.

7.5 A

29. Critical Thinking In your own words, explain the meaning of a shallower line, or a smaller slope than the one in Figure 1-16, in the graph of stretch versus total mass for a different spring.

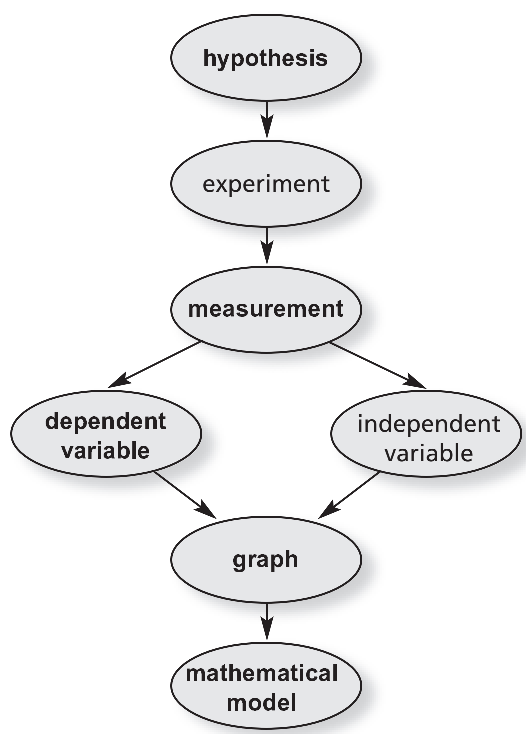
The spring whose line has a smaller slope is stiffer, and therefore requires more mass to stretch it one centimeter.

Chapter Assessment

Concept Mapping

page 24

30. Complete the following concept map using the following terms: *hypothesis, graph, mathematical model, dependent variable, measurement.*



Mastering Concepts

page 24

31. Describe a scientific method. (1.1)

Identify a problem; gather information about it by observing and experimenting; analyze the information to arrive at an answer.

32. Why is mathematics important to science? (1.1)

Mathematics allows you to be quantitative, to say "how fast," not just "fast."

33. What is the SI system? (1.1)

The International System of Units, or SI, is a base 10 system of measurement that is the standard in science. The base units are the meter, kilogram, second, kelvin, mole, ampere, and candela.

34. How are base units and derived units related? (1.1)

The derived units are combinations of the base units.

35. Suppose your lab partner recorded a measurement as 100 g. (1.1)

a. Why is it difficult to tell the number of significant digits in this measurement?

Zeros are necessary to indicate the magnitude of the value, but there is no way of knowing whether or not the instrument used to measure the values actually measured the zeros. The zeros may serve only to locate the 1.

b. How can the number of significant digits in such a number be made clear?

Write the number in scientific notation, including only the significant digits.

36. Give the name for each of the following multiples of the meter. (1.1)

a. $\frac{1}{100}$ m

centimeter

b. $\frac{1}{1000}$ m

millimeter

c. 1000 m

kilometer

37. To convert 1.8 h to minutes, by what conversion factor should you multiply? (1.1)

$\frac{\mathbf{60\ min}}{\mathbf{1\ h}}$**, because the units will cancel correctly.**

38. Solve each problem. Give the correct number of significant digits in the answers. (1.1)

a. 4.667×10^4 g + 3.02×10^5 g

$\mathbf{3.49\times10^5\ g}$

b. $(1.70\times10^2\ \text{J}) \div (5.922\times10^{-4}\ \text{cm}^3)$

$\mathbf{2.87\times10^5\ J/cm^3}$

39. What determines the precision of a measurement? (1.2)

the precision of a measuring device, which is limited by the finest division on its scale

40. How does the last digit differ from the other digits in a measurement? (1.2)

The final digit is estimated.

41. A car's odometer measures the distance from home to school as 3.9 km. Using string on a map, you find the distance to be 4.2 km. Which answer do you think is more accurate? What does *accurate* mean? (1.2)

The most accurate measure is the measure closest to the actual distance. The odometer is probably more accurate as it actually covered the distance. The map is a model made from measurements, so your measurements from the map are more removed from the real distance.

42. How do you find the slope of a linear graph? (1.3)

The slope of a linear graph is the ratio of the vertical change to the horizontal change, or rise over run.

43. For a driver, the time between seeing a stoplight and stepping on the brakes is called reaction time. The distance traveled during this time is the reaction distance. Reaction distance for a given driver and vehicle depends linearly on speed. (1.3)

a. Would the graph of reaction distance versus speed have a positive or a negative slope?

Positive. As speed increases, reaction distance increases.

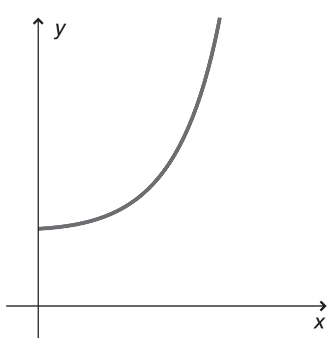
b. A driver who is distracted has a longer reaction time than a driver who is not. Would the graph of reaction distance versus speed for a distracted driver have a larger or smaller slope than for a normal driver? Explain.

Larger. The driver who was distracted would have a longer reaction time and thus a greater reaction distance at a given speed.

44. During a laboratory experiment, the temperature of the gas in a balloon is varied and the volume of the balloon is measured. Which quantity is the independent variable? Which quantity is the dependent variable? (1.3)

Temperature is the independent variable; volume is the dependent variable.

45. What type of relationship is shown in **Figure 1-20?** Give the general equation for this type of relation. (1.3)



■ **Figure 1-20**

quadratic; $y = ax^2 + bx + c$

46. Given the equation $F = mv^2/R$, what relationship exists between each of the following? (1.3)

a. F and R

inverse relationship

b. F and m

linear relationship

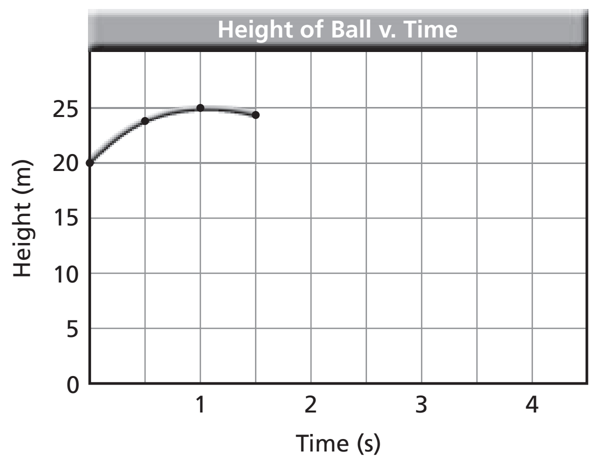
c. F and v

quadratic relationship

Applying Concepts

pages 25–26

47. **Figure 1-21** gives the height above the ground of a ball that is thrown upward from the roof of a building, for the first 1.5 s of its trajectory. What is the ball's height at $t = 0$? Predict the ball's height at $t = 2$ s and at $t = 5$ s.



■ **Figure 1-21**

When $t = 0$ and $t = 2$, the ball's height will be about 20 m. When $t = 5$, the ball will have landed on the ground so the height will be 0 m.

48. Is a scientific method one set of clearly defined steps? Support your answer.

There is no definite order of specific steps. However, whatever approach is used, it always includes close observation, controlled experimentation, summarizing, checking, and rechecking.

49. Explain the difference between a scientific theory and a scientific law.

A scientific law is a rule of nature, where a scientific theory is an explanation of the scientific law based on observation. A theory explains why something happens; a law describes what happens.

50. Density The density of a substance is its mass per unit volume.

a. Give a possible metric unit for density.

possible answers include g/cm^3 or kg/m^3

b. Is the unit for density a base unit or a derived unit?

derived unit

51. What metric unit would you use to measure each of the following?

a. the width of your hand

cm

b. the thickness of a book cover

mm

c. the height of your classroom

m

d. the distance from your home to your classroom

km

52. Size Make a chart of sizes of objects. Lengths should range from less than 1 mm to several kilometers. Samples might include the size of a cell, the distance light travels in 1 s, and the height of a room.

sample answer:
radius of the atom, 5×10^{-11} m; virus, 10^{-7} m; thickness of paper, 0.1 mm; width of paperback book, 10.7 cm; height of a door, 1.8 m; width of town, 7.8 km; radius of Earth, 6×10^{6} m; distance to the Moon, 4×10^{8} m

53. Time Make a chart of time intervals. Sample intervals might include the time between heartbeats, the time between presidential elections, the average lifetime of a human, and the age of the United States. Find as many very short and very long examples as you can.

sample answer:
half-life of polonium-194, 0.7 s; time between heartbeats, 0.8 s; time to walk between physics class and math class, 2.4 min; length of school year, 180 days; time between elections for the U.S. House of Representatives, 2 years; time between U.S. presidential elections, 4 years; age of the United States, (about) 230 years

54. Speed of Light Two students measure the speed of light. One obtains $(3.001 \pm 0.001)\times10^{8}$ m/s; the other obtains $(2.999 \pm 0.006)\times10^{8}$ m/s.

a. Which is more precise?

$(3.001 \pm 0.001)\times10^{8}$ m/s

b. Which is more accurate?

$(2.999 \pm 0.006)\times10^{8}$ m/s

55. You measure the dimensions of a desk as 132 cm, 83 cm, and 76 cm. The sum of these measures is 291 cm, while the product is 8.3×10^{5} cm^3. Explain how the significant digits were determined in each case.

In addition and subtraction, you ask what place the least precise measure is known to: in this case, to the nearest cm. So the answer is rounded to the nearest cm. In multiplication and division, you look at the number of significant digits in the least precise answer: in this case, 2. So the answer is rounded to 2 significant digits.

56. Money Suppose you receive $5.00 at the beginning of a week and spend $1.00 each day for lunch. You prepare a graph of the amount you have left at the end of each day for one week. Would the slope of this graph be positive, zero, or negative? Why?

negative, because the change in vertical distance is negative for a positive change in horizontal distance

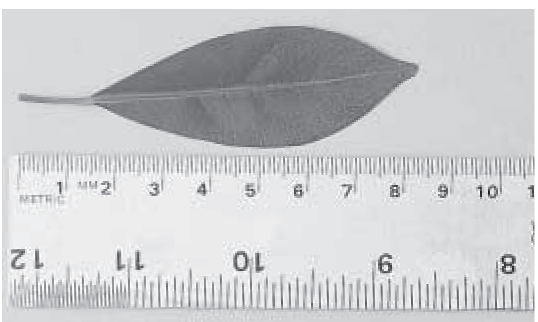
57. Data are plotted on a graph, and the value on the y-axis is the same for each value of the independent variable. What is the slope? Why? How does y depend on x?

Zero. The change in vertical distance is zero. *y* does not depend on *x*.

58. Driving The graph of braking distance versus car speed is part of a parabola. Thus, the equation is written $d = av^2 + bv + c$. The distance, d, has units in meters, and velocity, v, has units in meters/second. How could you find the units of a, b, and c? What would they be?

The units in each term of the equation must be in meters because distance, *d*, is measured in meters.
$av^2 = a(\text{m/s})^2$, so a is in s^2/m;
$bv = b(\text{m/s})$, so b is in s^{-1}.

59. How long is the leaf in **Figure 1-22?** Include the uncertainty in your measurement.



■ **Figure 1-22**

8.3 cm ± 0.05 cm, or 83 mm ± 0.5 mm

60. The masses of two metal blocks are measured. Block A has a mass of 8.45 g and block B has a mass of 45.87 g.

a. How many significant digits are expressed in these measurements?

A: three; B: four

b. What is the total mass of block A plus block B?

54.32 g

c. What is the number of significant digits for the total mass?

four

d. Why is the number of significant digits different for the total mass and the individual masses?

When adding measurements, the precision matters: both masses are known to the nearest hundredth of a gram, so the total should be given to the nearest hundredth of a gram. Significant digits sometimes are gained when adding.

61. History Aristotle said that the speed of a falling object varies inversely with the density of the medium through which it falls.

a. According to Aristotle, would a rock fall faster in water (density 1000 kg/m^3), or in air (density 1 kg/m^3)?

Lower density means faster speed, so the rock falls faster in air.

b. How fast would a rock fall in a vacuum? Based on this, why would Aristotle say that there could be no such thing as a vacuum?

Because a vacuum would have a zero density, the rock should fall infinitely fast. Nothing can fall that fast.

62. Explain the difference between a hypothesis and a scientific theory.

A scientific theory has been tested and supported many times before it becomes accepted. A hypothesis is an idea about how things might work—it has much less support.

63. Give an example of a scientific law.

Newton's laws of motion, law of conservation of energy, law of conservation of charge, law of reflection

64. What reason might the ancient Greeks have had not to question the hypothesis that heavier objects fall faster than lighter objects? *Hint: Did you ever question which falls faster?*

Air resistance affects many light objects. Without controlled experiments, their everyday observations told them that heavier objects did fall faster.

65. **Mars** Explain what observations led to changes in scientists' ideas about the surface of Mars.

As telescopes improved and later probes were sent into space, scientists gained more information about the surface. When the information did not support old hypotheses, the hypotheses changed.

66. A graduated cylinder is marked every mL. How precise a measurement can you make with this instrument?

±0.5 mL

Mastering Problems

pages 26–28

1.1 Mathematics and Physics

67. Convert each of the following measurements to meters.

a. 42.3 cm

0.423 m

b. 6.2 pm

6.2×10^{-12} m

c. 21 km

2.1×10^{4} m

d. 0.023 mm

2.3×10^{-5} m

e. 214 μm

2.14×10^{-4} m

f. 57 nm

5.7×10^{-8} m

68. Add or subtract as indicated.

a. 5.80×10^{9} s + 3.20×10^{8} s

6.12×10^{9} s

b. 4.87×10^{-6} m − 1.93×10^{-6} m

2.94×10^{-6} m

c. 3.14×10^{-5} kg + 9.36×10^{-5} kg

1.250×10^{-4} kg

d. 8.12×10^{7} g − 6.20×10^{6} g

7.50×10^{7} g

69. Rank the following mass measurements from least to greatest: 11.6 mg, 1021 μg, 0.000006 kg, 0.31 mg.

0.31 mg, 1021 µg, 0.000006 kg, 11.6 mg

70. State the number of significant digits in each of the following measurements.

a. 0.00003 m

1

b. 64.01 fm

4

c. 80.001 m

5

d. 0.720 μg

3

e. 2.40×10^{6} kg

3

f. 6×10^{8} kg

1

g. 4.07×10^{16} m

3

71. Add or subtract as indicated.

a. 16.2 m + 5.008 m + 13.48 m

34.7 m

b. 5.006 m + 12.0077 m + 8.0084 m

25.022 m

c. 78.05 cm^2 − 32.046 cm^2

46.00 cm^2

d. 15.07 kg − 12.0 kg

3.1 kg

72. Multiply or divide as indicated.

a. $(6.2\times10^{18}\ \text{m})(4.7\times10^{-10}\ \text{m})$

$2.9\times10^{9}\ \text{m}^2$

b. $(5.6\times10^{-7}\ \text{m})/(2.8\times10^{-12}\ \text{s})$

$2.0\times10^{5}\ \text{m/s}$

c. $(8.1\times10^{-4}\ \text{km})(1.6\times10^{-3}\ \text{km})$

$1.3\times10^{-6}\ \text{km}^2$

d. $(6.5\times10^{5}\ \text{kg})/(3.4\times10^{3}\ \text{m}^3)$

$1.9\times10^{2}\ \text{kg/m}^3$

73. **Gravity** The force due to gravity is $F = mg$ where $g = 9.80\ \text{m/s}^2$.

a. Find the force due to gravity on a 41.63-kg object.

$408\ \text{kg·m/s}^2$

b. The force due to gravity on an object is $632\ \text{kg·m/s}^2$. What is its mass?

64.5 kg

74. **Dimensional Analysis** Pressure is measured in pascals, where $1\ \text{Pa} = 1\ \text{kg/m·s}^2$. Will the following expression give a pressure in the correct units?

$$\frac{(0.55\ \text{kg})(2.1\ \text{m/s})}{9.8\ \text{m/s}^2}$$

No; it is in kg/s^3

1.2 Measurement

75. A water tank has a mass of 3.64 kg when it is empty and a mass of 51.8 kg when it is filled to a certain level. What is the mass of the water in the tank?

48.2 kg

76. The length of a room is 16.40 m, its width is 4.5 m, and its height is 3.26 m. What volume does the room enclose?

$2.4\times10^{2}\ \text{m}^3$

77. The sides of a quadrangular plot of land are 132.68 m, 48.3 m, 132.736 m, and 48.37 m. What is the perimeter of the plot?

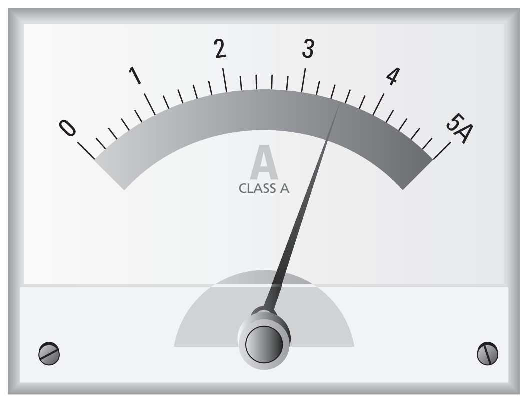
362.1 m

78. How precise a measurement could you make with the scale shown in **Figure 1-23?**

■ **Figure 1-23**

±0.5 g

79. Give the measure shown on the meter in **Figure 1-24** as precisely as you can. Include the uncertainty in your answer.



■ **Figure 1-24**

3.6 ± 0.1 A

80. Estimate the height of the nearest door frame in centimeters. Then measure it. How accurate was your estimate? How precise was your estimate? How precise was your measurement? Why are the two precisions different?

A standard residential doorframe height is 80 inches, which is about 200 cm. The precision depends on the measurement instrument used.

81. Base Units Give six examples of quantities you might measure in a physics lab. Include the units you would use.

Sample: distance, cm; volume, mL; mass, g; current, A; time, s; temperature, °C

82. Temperature The temperature drops from 24°C to 10°C in 12 hours.

a. Find the average temperature change per hour.

1.2°C/h

b. Predict the temperature in 2 more hours if the trend continues.

8°C

c. Could you accurately predict the temperature in 24 hours?

No. Temperature is unlikely to continue falling sharply and steadily that long.

1.3 Graphing Data

83. Figure 1-25 shows the masses of three substances for volumes between 0 and 60 cm^3.

a. What is the mass of 30 cm^3 of each substance?

(a) 80 g, (b) 260 g, (c) 400 g

b. If you had 100 g of each substance, what would be their volumes?

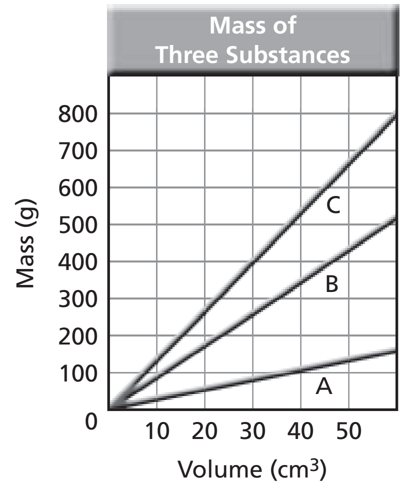
(a) 36 cm^3, (b) 11 cm^3, (c) 7 cm^3

c. In one or two sentences, describe the meaning of the slopes of the lines in this graph.

The slope represents the increased mass of each additional cubic centimeter of the substance.

d. What is the y-intercept of each line? What does it mean?

The y-intercept is (0,0). It means that when $V = 0$ cm^3, there is none of the substance present ($m = 0$ g).



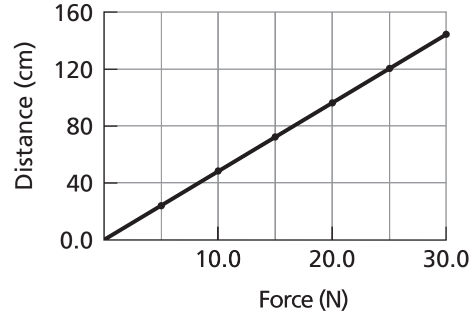
■ **Figure 1-25**

84. During a class demonstration, a physics instructor placed a mass on a horizontal table that was nearly frictionless. The instructor then applied various horizontal forces to the mass and measured the distance it traveled in 5 seconds for each force applied. The results of the experiment are shown in **Table 1-5.**

Table 1-5
Distance Traveled with Different Forces

Force (N)	Distance (cm)
5.0	24
10.0	49
15.0	75
20.0	99
25.0	120
30.0	145

a. Plot the values given in the table and draw the curve that best fits all points.



b. Describe the resulting curve.

a straight line

c. Use the graph to write an equation relating the distance to the force.

$d = 4.9F$

d. What is the constant in the equation? Find its units.

The constant is 4.9 and has units cm/N.

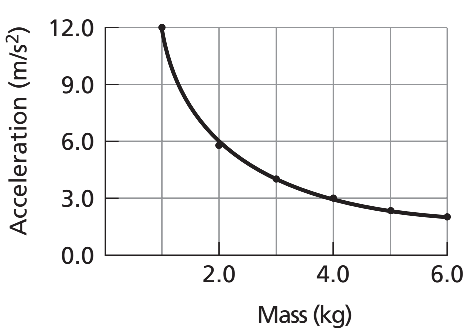
e. Predict the distance traveled when a 22.0-N force is exerted on the object for 5 s.

108 cm or 110 cm using 2 significant digits

85. The physics instructor from the previous problem changed the procedure. The mass was varied while the force was kept constant. Time and distance were measured, and the acceleration of each mass was calculated. The results of the experiment are shown in **Table 1-6.**

Table 1-6	
Acceleration of Different Masses	
Mass (kg)	**Acceleration (m/s^2)**
1.0	12.0
2.0	5.9
3.0	4.1
4.0	3.0
5.0	2.5
6.0	2.0

a. Plot the values given in the table and draw the curve that best fits all points.



b. Describe the resulting curve.

a hyperbola

c. According to the graph, what is the relationship between mass and the acceleration produced by a constant force?

Acceleration varies inversely with mass.

d. Write the equation relating acceleration to mass given by the data in the graph.

$a = \frac{12}{m}$

e. Find the units of the constant in the equation.

kg·m/s^2

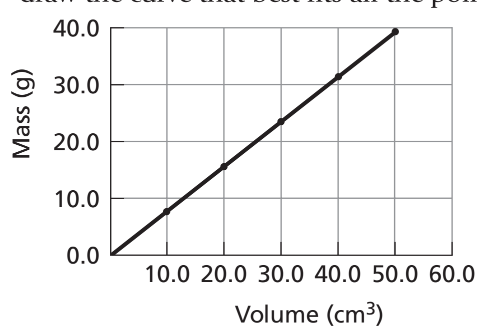
f. Predict the acceleration of an 8.0-kg mass.

1.5 m/s^2

86. During an experiment, a student measured the mass of 10.0 cm^3 of alcohol. The student then measured the mass of 20.0 cm^3 of alcohol. In this way, the data in **Table 1-7** were collected.

Table 1-7	
The Mass Values of Specific Volumes of Alcohol	
Volume (cm^3)	**Mass (g)**
10.0	7.9
20.0	15.8
30.0	23.7
40.0	31.6
50.0	39.6

a. Plot the values given in the table and draw the curve that best fits all the points.



b. Describe the resulting curve.

a straight line

c. Use the graph to write an equation relating the volume to the mass of the alcohol.

$\boldsymbol{m = 0.79V}$

d. Find the units of the slope of the graph. What is the name given to this quantity?

g/cm^3; density

e. What is the mass of 32.5 cm^3 of alcohol?

25.7 g

Mixed Review

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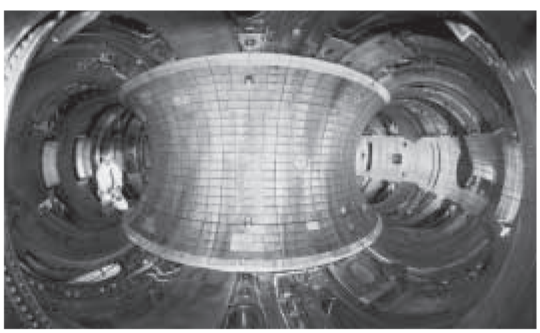
87. Arrange the following numbers from most precise to least precise

0.0034 m 45.6 m 1234 m

0.0034 m, 45.6 m, 1234 m

88. **Figure 1-26** shows the toroidal (doughnut-shaped) interior of the now-dismantled Tokamak Fusion Test Reactor. Explain why a width of 80 m would be an unreasonable value for the width of the toroid. What would be a reasonable value?



■ **Figure 1-26**

80 meters is equivalent to about 260 feet, which would be very large. 10 meters would be a more reasonable value.

89. You are cracking a code and have discovered the following conversion factors: 1.23 longs = 23.0 mediums, and 74.5 mediums = 645 shorts. How many shorts are equal to one long?

$$\text{1 long}\left(\frac{\text{23.0 med}}{\text{1.23 long}}\right)\left(\frac{\text{645 short}}{\text{74.5 med}}\right) = \text{162 shorts}$$

90. You are given the following measurements of a rectangular bar: length = 2.347 m, thickness = 3.452 cm, height = 2.31 mm, mass = 1659 g. Determine the volume, in cubic meters, and density, in g/cm^3, of the beam. Express your results in proper form.

volume = 1.87$\times$10^{-4} m^3, or 187 cm^3; density = 8.87 g/cm^3

91. A drop of water contains 1.7$\times$10^{21} molecules. If the water evaporated at the rate of one million molecules per second, how many years would it take for the drop to completely evaporate?

$$\frac{1.7\times10^{21}\text{ molecules}}{\left(\frac{1{,}000{,}000\text{ molecules}}{1\text{ s}}\right)} = 1.7\times10^{15}\text{ s}$$

$$(1.7\times10^{15}\text{ s})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1\text{ day}}{24\text{ h}}\right)\left(\frac{1\text{ y}}{365\text{ days}}\right) =$$

$$5.4\times10^{7}\text{ y}$$

92. A 17.6-gram sample of metal is placed in a graduated cylinder containing 10.0 cm^3 of water. If the water level rises to 12.20 cm^3, what is the density of the metal?

$$\text{density} = \frac{m}{V} = \frac{17.6\text{ g}}{12.20\text{ cm}^3 - 10.0\text{ cm}^3} = 8.00\text{ g/cm}^3$$

Thinking Critically

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93. **Apply Concepts** It has been said that fools can ask more questions than the wise can answer. In science, it is frequently the case that one wise person is needed to ask the right question rather than to answer it. Explain.

The "right" question is one that points to fruitful research and to other questions that can be answered.

94. **Apply Concepts** Find the approximate mass of water in kilograms needed to fill a container that is 1.40 m long and 0.600 m wide to a depth of 34.0 cm. Report your result to one significant digit. (Use a reference source to find the density of water.)

V_w = (140 cm)(60.0 cm)(34.0 cm) = 285,600 cm^3. Because the density of water is 1.00 g/cm^3, the mass of water in kilograms is 286 kg.

95. **Analyze and Conclude** A container of gas with a pressure of 101 kPa has a volume of 324 cm^3 and a mass of 4.00 g. If the pressure is increased to 404 kPa, what is the density of the gas? Pressure and volume are inversely proportional.

Pressure and volume are inversely proportional. Since the pressure is 4 times greater, the volume will be $\frac{1}{4}$ of the original volume.

$$\frac{324\ \text{cm}^3}{4} = 81.0\ \text{cm}^3$$

$$\frac{4.00\ \text{g}}{81.0\ \text{cm}^3} = 0.0494\ \text{g/cm}^3$$

96. **Design an Experiment** How high can you throw a ball? What variables might affect the answer to this question?

mass of ball, footing, practice, and conditioning

97. **Calculate** If the Sun suddenly ceased to shine, how long would it take Earth to become dark? (You will have to look up the speed of light in a vacuum and the distance from the Sun to Earth.) How long would it take the surface of Jupiter to become dark?

$$t_E = \frac{d_E}{v} = \frac{1.496\times10^{11}\ \text{m}}{3.00\times10^{8}\ \text{m/s}}$$
$$= 499\ \text{s} = 8.31\ \text{min}$$

$$t_J = \frac{d_J}{v} = \frac{7.78\times10^{11}\ \text{m}}{3.00\times10^{8}\ \text{m/s}}$$
$$= 2593\ \text{s} = 43.2\ \text{min}$$

Writing in Physics

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98. Research and describe a topic in the history of physics. Explain how ideas about the topic changed over time. Be sure to include the contributions of scientists and to evaluate the impact of their contributions on scientific thought and the world outside the laboratory.

Answers will vary.

99. Explain how improved precision in measuring time would have led to more accurate predictions about how an object falls.

Answers will vary. For example, students might suggest that improved precision can lead to better observations.

Challenge Problem

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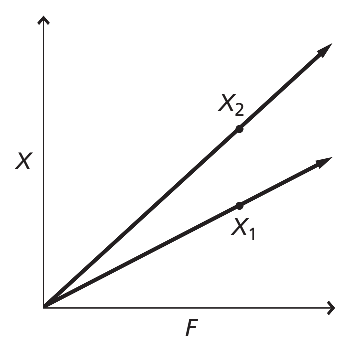
An object is suspended from spring 1, and the spring's elongation (the distance it stretches) is X_1. Then the same object is removed from the first spring and suspended from a second spring. The elongation of spring 2 is X_2. X_2 is greater than X_1.

1. On the same axes, sketch the graphs of the mass versus elongation for both springs.



2. Is the origin included in the graph? Why or why not?

Yes; the origin corresponds to 0 elongation when the force is 0.

3. Which slope is steeper?

The slope for X_2 is steeper.

4. At a given mass, $X_2 = 1.6\ X_1$. If X_2 = 5.3 cm, what is X_1?

$$X_2 = 1.6X_1$$
$$5.3\ \text{cm} = 1.6X_1$$
$$3.3\ \text{cm} = X_1$$