Welcome back, Bill Wiecking

>>Working in AP Physics B (SC651)

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chapter 1

measurement

Chapter 1: Measurement and Mathematics

Conceptual problems

1.C.1 (7.00) Why do scientists **not** define the standard for the second to be a fraction of a day?

1.C.2 (5.00) What are the pitfalls in attempting to convert pounds into kilograms?

1.C.3 (5.00) You take two measurements in a lab. The first measurement is in units called zorbs. The second measurement is in different units called zargs. Both zorbs and zargs have the same dimensions. Can you directly add these measurements together? If not, what additional information do you need in order to add them?

Yes No

1.C.4 (5.00) When multiplying by a conversion factor, how do you determine which unit belongs in the numerator and which in the denominator?

1.C.5 (5.00) The following variables are commonly seen in equations. The name of the quantity represented by each variable, and its dimension(s), are also shown.

x distance (L)
t time (T)
m mass (M)
a acceleration (L/T^2)
v speed (L/T)
F force (ML/T^2)

Using the information above, check the boxes of the equations that are dimensionally correct.

Select all that apply.

- ☐ $F = ma$
- ☐ $v^2 = 2ax$
- ☐ $v = at^2$
- ☐ $F/v = m/t$

1.C.6 (5.00) Give an example of a pair of different units with the same dimension.

1.C.7 (5.00) You have verified that an equation is dimensionally correct. Is the equation necessarily true? Why?

○ Yes ○ No

1.C.8 (5.00) Can a leg of a right triangle be longer than the hypotenuse? Why or why not?

○ Yes ○ No

1.C.9 (5.00) Consider the sine and cosine functions. (a) As an angle increases from 0° to 90°, does the sine of the angle increase or decrease? (b) How about the cosine?

(a) ○ Increases ○ Decreases
(b) ○ Increases ○ Decreases

1.C.10 (5.00) You walk along the edge of a large circular lawn. You walk clockwise from your starting location until you have moved an angle of π radians. What geometric shape is defined by the following three points: your starting position, your final position, and the center point of the lawn?

Section 2: Prefixes

1.2.1 (5.00) How many centimeters are there in a kilometer?

cm

1.2.2 (5.00) A carbon-carbon triple bond has a length of 120 picometers. What is its length in nanometers?

nm

1.2.3 (5.00) The 2000 Gross Domestic Product of the United States was $9,966 billion. If you were to regard the dollar as a scientific unit, how would you write this using the standard prefixes?

dollars

1.2.4 (5.00) A gremlin is a tiny mythical creature often blamed for mechanical failures. Suppose for a moment that a shrewd physicist catches one such gremlin and makes it work for her instead of against her. She determines that the gremlin can produce 24 milliwatts of power. How many gremlins are required to produce 24,000 megawatts of power?

gremlins

1.2.5 (5.00) A drug company has just manufactured 50.0 kg of acetylsalicylic acid for use in aspirin tablets. If a single tablet contains 500 mg of the drug, how many tablets can the company make out of this batch?

tablets

1.2.6 (5.00) The diameter of an aluminum atom is about 0.24 nm, and the nuclear diameter is about 7.2 fm (femtometer = 10^{-15} meter). (a) If the atom's diameter were expanded to the length of an American football field (91.44 m) and the nuclear diameter expanded proportionally, what would be the nuclear diameter in meters? (b) Is the saying that "the atom is mostly empty space" confirmed by these figures?

(a) m

(b) Yes No

Section 3: Scientific notation

1.3.1 (5.00) An electron can tunnel through an energy barrier with probability 0.0000000000375. (This is a concept used in quantum mechanics.) Express this probability in scientific notation.

1.3.2 (5.00) An atom of uranium-235 has a mass 235.043924 amu (atomic mass units). Using scientific notation, state the mass in amu of ten million such atoms.

amu

1.3.3 (5.00) Sara has lived 18.0 years. How many seconds has she lived? Express the answer in scientific notation. Use 365.24 days per year for your calculations.

s

1.3.4 (5.00) Assume a typical hummingbird has a lifespan of 4.0 years and an average heart rate of 1300 beats per minute. (a) Calculate the number of times a hummingbird's heart beats in its life, and express it in scientific notation. Use 365.24 days per year. (b) A long-lived elephant lives for 61 years, and has an average heart rate of 25 beats per minute. Calculate the number of heartbeats in that elephant's lifetime in scientific notation.

(a) beats

(b) beats

1.3.5 (5.00) A PC microprocessor runs at 2.40 GHz. A hertz (Hz) is a unit meaning "one cycle per second." A movie projector displays images at a rate of 24.0 Hz. What is the ratio of the microprocessor's rate in cycles per second to the update rate of a movie projector? Answer the question using scientific notation.

Section 5: Length

1.5.1 (5.00) Which of the following coins has a diameter of 17.91 mm: a nickel, a dime or a quarter?

Section 8: Converting units

1.8.1 (5.00) *v* meters per second is how many miles per hour?

mi/h

1.8.2 (5.00) Freefall acceleration *g* is the acceleration due to gravity. It equals 9.80 meters per second squared near the Earth's surface. (a) What does it equal in feet

per second squared? (b) In miles per second squared? (c) In miles per hour squared?

(a) ____ ft/s^2

(b) ____ mi/s^2

(c) ____ mi/h^2

1.8.3 **(5.00)** A historian tells you that a cubit is an ancient unit of length equal to 0.457 meters. If you traveled 585 kilometers from Venice, Italy to Frankfurt, Germany, how many cubits did you cover?

____ cubits

1.8.4 **(5.00)** You are on the phone with a friend in Greece, who tells you that he has just caught a fish *L* cm long in the Mediterranean Sea. Assuming he is telling the truth, what is the length of the fish in inches?

____ in

1.8.5 **(5.00)** In an attempt to rid yourself of your little brother's unwanted attention, you tell him to count to a million and then come find you. If he were to start counting at a rate of one number per second, would he be finished in a year?

◯ Yes ◯ No

1.8.6 **(5.00)** Light travels at 3.0×10^8 m/s in a vacuum. Find its speed in furlongs per fortnight. There are roughly 201 meters in a furlong, and a fortnight is equal to 14 days.

____ furlongs/fortnight

1.8.7 **(5.00)** Mercury orbits the Sun at a mean distance of 57,900,000 kilometers. (a) What is this distance in meters? Use scientific notation to express your answer and state it with three significant figures. (b) Pluto orbits at a mean distance of 5.91×10^{12} meters from the Sun. What is this distance in kilometers?

(a) ____ m

(b) ▾

1.8.8 **(5.00)** In 2003, Bill Gates was worth 40.7 billion dollars. (a) Express this figure in dollars in scientific notation. (b) Assume a dollar is worth 2,060 Italian lire. State Bill Gates's net worth in lire in scientific notation.

(a) ____ dollars

(b) ____ lire

1.8.9 (5.00) The world's tallest man was Robert Pershing Wadlow, who was 8 feet, 11.1 inches tall. There are 2.54 centimeters in an inch and 12 inches in a foot. How tall was Robert in meters?

m

1.8.10 (5.00) Romans and Greeks used their stadium as a unit of measure. An estimate of the ancient Roman unit stadium is 185 m. A heroic epic describes a battle in which the Roman army marched 201 stadia to defend Rome from invading barbarians. In kilometers, how far did they march?

km

1.8.11 (7.00) You are carrying a *V* gallon jug full of cold water. Given that the water has a density of 1.0 grams per milliliter, and one gallon is equal to 3.8 liters, state the mass of the water in kilograms.

kg

Section 9: Interactive problem: converting units

1.9.1 (5.00) Use the simulation in the interactive problem in Section 1.9 to convert the speed of the car from miles per hour to meters per second.

m/s

Section 10: Dimensional analysis

1.10.1 (5.00) The dimensions for force are the product of mass and length divided by time squared. Newton's second law states that force equals the product of mass and acceleration. What are the dimensions of acceleration?

- T^2
- T^2/L
- L/T^2
- L/T

1.10.2 (5.00) The dimensions for force are the product of mass and length, divided by time squared. Newton's law of gravitation states that the gravitational force between two objects equals a constant, *G*, times the product of the mass of each object, divided by the square of the distance between them. What must the dimensions of the constant be?

- L^3/MT^2
- L^2/T^3
- M^2T

1.10.3 **(5.00)** The variables x, v, and a have dimensions L, L/T, and L/T^2, respectively. An equation relating these variables under particular conditions is $v^n = 2ax$, where n is a positive integer. What must n be?

1.10.4 **(5.00)** The kinetic energy of an object is given by the equation $KE = (1/2)mv^2$, where m is mass and v is speed, with dimensions L/T. What are the dimensions of KE?

- ML^2/T^2
- L^2/T^2
- LM/T

1.10.5 **(10.00)** Here is a famous example worked out by the British physicist G.I. Taylor. In a nuclear explosion there is an essentially instantaneous release of energy (units: $kg \cdot m^2/s^2$). This produces a spherical shock wave. Taylor deduced that the radius of the sphere (units: meters) must depend only on the energy, the time t (units: seconds), and the undisturbed air density ρ (units: kg/m^3), with an undetermined constant. The constant is dimensionless (it has no units). Show how to combine the units of energy, density and time to obtain the units of length.

Submit answer on paper.

Section 11: Multiplying numbers in scientific notation

1.11.1 **(5.00)** Multiply 3.65×10^{23} by 4.12×10^{154} by 1.11×10^{-11} and express the answer in scientific notation.

1.11.2 **(5.00)** Evaluate $(5.7\times10^6$ kg) × $(6.3\times10^{-2}$ m/s$^2)$ and express the answer in scientific notation.

$kg \cdot m/s^2$

1.11.3 **(5.00)** What is $(9.80\times10^8) \times (-2.02\times10^{-4})$? Express the answer in scientific notation.

1.11.4 **(5.00)** There are many estimates of the number of stars in the universe. One estimate is that there are 10^{10} stars in the Milky Way galaxy, and that there are 10^{10} galaxies in the universe. Assuming that the number of stars in the Milky Way is the average number of stars in a galaxy, estimate how many stars there are in the universe. It perhaps goes without saying: Express your answer in scientific notation.

Section 12: Dividing numbers in scientific notation

1.12.1 **(5.00)** According to the CIA, about 2.69×10^{6} people were living in Jamaica in 2003. The organization estimated the gross domestic product (GDP) of Jamaica as $10.1 billion at about this time. (a) Express the GDP in scientific notation. (b) What was the GDP per person? Express the number in scientific notation.

(a) _____ dollars

(b) _____ dollars per person

1.12.2 **(5.00)** Evaluate $(4.9\times10^{-8}) / (7.0\times10^{-3})$. Express the answer in scientific notation.

_____

1.12.3 **(5.00)** Newton's second law states that the net force equals the product of mass and acceleration. A boat's mass of is 9.6×10^{5} kg and it experiences a net force of 1.5×10^{4} kg·m/s^2. State its acceleration.

_____ m/s^2

1.12.4 **(5.00)** Average speed equals distance divided by time. On a journey to the Alpha Centauri star system, a space probe travels a distance of 4.12×10^{16} meters in 1.73×10^{10} seconds. (a) Find its average speed in meters per second. (b) How long did the journey take in years? Use 365.24 days per year.

(a) _____ m/s

(b) _____ years

1.12.5 **(5.00)** An estimate for the number of cells in a human body is 50 million million (yes, that is two millions in a row). What percentage of your body mass does one average cell constitute? Express your answer in scientific notation.

_____ %

1.12.6 **(7.00)** The force of gravitation can be calculated with the equation $F = Gm_1m_2/r^2$ where $G = 6.67\times10^{-11}$ N·m^2/kg^2. Given that $m_1 = 1.50\times10^{15}$ kg, $m_2 = 2.40\times10^{15}$ kg, and $r = 6.20\times10^{6}$ m, find F.

_____ N

Section 13: Adding and subtracting numbers in scientific notation

1.13.1 A 3.70×10^{6} kg piece splits off an iceberg of mass of 5.96×10^{7} kg. Calculate

(5.00) the mass of the remaining iceberg and express the answer in scientific notation.

kg

1.13.2 **(5.00)** The answer to each of the following computations in scientific notation is incorrect. Give the correct answer for each part, and explain the error made in the computation shown.

(a) $(6.0\times10^{5}) / (3.0\times10^{3}) = 2.0\times10^{8}$

(b) $(3.7\times10^{8}) / (7.6\times10^{4}) = 0.5\times10^{4}$

(c) $(4.8\times10^{13}) + (4.8\times10^{12}) = 9.6\times10^{13}$

(d) $(2.3\times10^{3}) \times (1.4\times10^{3}) = 3.2\times10^{9}$

(a)

(b)

(c)

(d)

1.13.3 **(5.00)** The silicon chip in a microelectronic component has a mass of 1.37×10^{-3} kg. To complete the wiring, 6.79×10^{-5} kg of solder is added to the chip. Compute the final mass of the circuit.

kg

1.13.4 **(5.00)** You have $\$1.14\times10^{4}$ in your checking account but must pay $\$3.30\times10^{3}$ in tuition. What is the balance in your checking account after you pay your tuition? Express the answer in scientific notation.

dollars

1.13.5 **(5.00)** A small metal chamber contains 5.632×10^{-9} mol of oxygen gas at very low pressure. An additional 4.379×10^{-8} mol of oxygen gas are added. Find the total amount of gas in the chamber.

mol

1.13.6 An auto transport truck has a mass of 2.50×10^{4} kg. A car has a mass of

(5.00) 1.31×10^3 kg. The car is loaded onto the truck. What is their total mass?

kg

1.13.7 (5.00) Harry carries a backpack that weighs 8.03×10^3 g. He steps on a scale wearing his backpack and the scale reads 7.62×10^4 g. What is Harry's mass in grams?

g

Section 17: Pythagorean theorem

1.17.1 (5.00) A crew of piano movers uses a 6.5-foot ramp to move a 990 lb Steinway concert grand up onto a stage that is *h* feet higher than the floor. How far away from the base of the stage should they set the end of the ramp so that the other end exactly reaches the stage?

ft

1.17.2 (5.00) Suzy is holding her kite on a string 25.0 m long when the kite hits the top of a flagpole, which is *f* m higher than her hands. Assuming that the string is taut and forms a straight line, what is the horizontal distance from her hands to the flagpole?

m

1.17.3 (5.00) A right triangle has a hypotenuse of length 17 cm and a leg of length 15 cm. What is the length of the other leg?

cm

1.17.4 (7.00) A Pythagorean triple is a set of three integers (a,b,c) that could form three sides of a right triangle. (3,4,5) and (5,12,13) are two examples. There exists a Pythagorean triple of the form $(7,n,n+1)$. Find n.

1.17.5 (7.00) A hapless motorist is trying to find his friend's house, which is located *x* miles west of the intersection of State Street and First Avenue. He sets out from the intersection, and drives the same number of kilometers due south instead. How far in kilometers is he from his intended destination? The sketch is not to scale.

km

Section 18: Trigonometric functions

1.18.1 **(5.00)** You want to estimate the height of the Empire State Building. You start at its base and walk 15 m away. Then you approximate the angle from the ground at that point to the top to be 88 degrees. How tall do you estimate the Empire State Bulding to be?

m

1.18.2 **(5.00)** For an angle θ, write tan θ in terms of sin θ and cos θ.

- tan θ = cos θ / sin θ
- tan θ = sin θ / cos θ
- tan θ = (sin θ)(cos θ)

1.18.3 **(5.00)** A window washer is climbing up a ladder to wash a window. The end of the *L*-foot ladder exactly touches the windowsill and the ladder makes a 70.0° angle with the ground. How far off the ground is the windowsill?

ft

1.18.4 **(5.00)** The 28 ft flagpole outside Martin Luther King, Jr. Elementary School casts a *L* ft shadow. In degrees, at what angle above the horizon is the Sun? The diagram may not be to scale.

°

1.18.5 **(10.00)** A superhero is running toward a skyscraper to stop a villain from getting away. As he is moving, he looks up at the top of the building and his line of sight makes a 33.0° angle with the ground. After having moved *d* m, he looks at the top of the building again, and notices that his line of sight makes a 52.0° angle with the horizontal. How tall is the skyscraper?

m

Section 19: Radians

1.19.1 **(7.00)** Find the radian measure of one of the angles of a regular pentagon. (The angles are all the same in a regular pentagon.) In degrees, the formula for the sum of the interior angles of an n-sided polygon is $(n - 2) \times 180°$.

radians

1.19.2 **(7.00)** A right triangle has sides of length 1, 2 and the square root of 3. In radians, what is its smallest angle?

- π/3 radians
- π/6 radians
- π/12 radians

Section 22: Interactive summary problem: dock the shuttle

1.22.1 **(5.00)** Use the simulation in the interactive problem in Section 1.22 to convert the acceleration from mi/hr^2 to m/s^2.

_____ m/s^2

Additional problems

1.A.1 **(7.00)** You are playing a game of laser tag with a friend who is on a balcony *h* meters off the ground. You are standing so your laser is 20.0 meters away from your friend (measured horizontally), and 1.50 meters off the ground. (a) At what angle from the horizontal should you aim the laser to hit your friend? Express your answer in degrees. (b) What is this angle in radians? (c) What distance does the laser light travel?

(a) _____ °

(b) _____ rad

(c) _____ m

1.A.2 **(10.00)** A freight version of Boeing's 747 airliner has 2.7×10^4 cubic feet of cargo space. A CD in its jewel case has a volume of 10.8 cubic inches. Assume that each CD holds 650 megabytes of information. (a) If you packed the aircraft with as many CDs as it could hold, how much information could you store in megabytes? (b) A "56K" modem typically transmits information at 45 kilobits per second. In computer terminology, a kilobit is 1024 bits, and a megabyte is 1,048,576 bytes. One byte equals eight bits of information. How long would it take to transmit the amount of information contained in one 747 planeful of CDs through a modem? (c) A T3 high-speed internet connection transmits information at 45.0 megabits per second. As with bytes and bits, one megabyte equals eight megabits of information. Assume that it takes 12 hours to load, fly and unload the 747. How many T3 connections would it take to transmit this information in 12 hours?

(a) _____ megabytes

(b) seconds

(c) connections

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