Chapter 1—Physics and Measurement

MULTIPLE CHOICE

1. Which of the following products of ratios gives the conversion factor to convert miles per hour $\left(\frac{\text{mi}}{\text{h}}\right)$ to meters per second $\left(\frac{\text{m}}{\text{s}}\right)$?

a. $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{1\text{ in}}{2.54\text{ cm}} \cdot \frac{1\text{ m}}{100\text{ cm}} \cdot \frac{1\text{ h}}{3\,600\text{ s}}$

b. $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{2.54\text{ cm}}{1\text{ in}} \cdot \frac{100\text{ cm}}{1\text{ m}} \cdot \frac{1\text{ h}}{3\,600\text{ s}}$

c. $\frac{1\text{ mi}}{5\,280\text{ f}} \cdot \frac{1\text{ f}}{12\text{ in}} \cdot \frac{1\text{ in}}{2.54\text{ cm}} \cdot \frac{100\text{ cm}}{1\text{ m}} \cdot \frac{3\,600\text{ s}}{1\text{ h}}$

[✓ d.] $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{2.54\text{ cm}}{1\text{ in}} \cdot \frac{1\text{ m}}{100\text{ cm}} \cdot \frac{1\text{ h}}{3\,600\text{ s}}$

e. $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{2.54\text{ cm}}{1\text{ in}} \cdot \frac{1\text{ m}}{100\text{ cm}} \cdot \frac{3\,600\text{ s}}{1\text{ h}}$

$\frac{mi}{h} = ?\ \frac{m}{s}$

$1\ \frac{mi}{h} = 1 \times \frac{5280\ ft}{60 \times 60\ s}$

$= \frac{1 \times 5280 \times 12\ in}{3600\ s} = \frac{1 \times 5280 \times 12 \times 2.54\ cm}{3600\ s}$

$= \frac{1 \times 5280 \times 12 \times 2.54 \times 10^{-2}\ m}{3600\ s}$

ANS: D PTS: 2 DIF: Average

2. The density of an object is defined as:

a. the volume occupied by each unit of mass.
[✓ b.] the amount of mass for each unit of volume.
c. the weight of each unit of volume.
d. the amount of the substance that has unit volume and unit mass.
e. the amount of the substance that contains as many particles as 12 grams of the carbon-12 isotope.

$\rho = \frac{m}{V}$, $\rho = m$ at $V =$ unity

ANS: B PTS: 1 DIF: Easy

3. If you drove day and night without stopping for one year without exceeding the legal highway speed limit in the United States, the maximum number of miles you could drive would be closest to:

a. 8 700.
b. 300 000.
[✓ c.] 500 000.
d. 1 000 000.
e. 32 000 000.

Speed $\sim 60\ mi/h$, $1\ y = 365 \times 24\ h$

Speed $= \frac{d}{t} \rightarrow d = t\ V = 365 \times 24\ \cancel{h} \times 60\ \frac{mi}{\cancel{h}}$

$\approx 5 \times 10^{5}\ mi$

ANS: C PTS: 2 DIF: Average

4. The term $\frac{1}{2}\rho v^2$ occurs in Bernoulli's equation in Chapter 15, with ρ being the density of a fluid and v its speed. The dimensions of this term are

a. $M^{-1}L^{5}T^{2}$
b. MLT^{2}
[✓ c.] $ML^{-1}T^{-2}$
d. $M^{-1}L^{9}T^{-2}$
e. $M^{-1}L^{3}T^{-2}$

$\frac{1}{2}\rho V^2 = \frac{1}{2} M L^{-3} \frac{L^2}{T^2} = \frac{1}{2} M L^{-1} T^{-2}$

$\Rightarrow M L^{-1} T^{-2}$

ANS: C PTS: 2 DIF: Average

5. Which of the following quantities has the same dimensions as kinetic energy, $\frac{1}{2}mv^2$?

Note: $[a] = [g] = LT^{-2}$; $[h] = L$ and $[v] = LT^{-1}$.

a. ma
b. mvx
c. mvt
[✓ d.] mgh
e. mgt

$\frac{1}{2}mv^2 \to M\frac{L^2}{T^2} \to m\frac{L}{T^2}L$

$\to mgh$

ANS: D PTS: 2 DIF: Average

6. The quantity with the same units as force times time, Ft, with dimensions MLT^{-1} is

[✓ a.] mv
b. mvr
c. mv^2r
d. ma
e. $\frac{mv^2}{r}$

$MLT^{-1} \to mv$

ANS: A PTS: 2 DIF: Average

7. The equation for the change of position of a train starting at $x = 0$ m is given by $x = \frac{1}{2}at^2 + bt^3$. The dimensions of b are

a. T^{-3}
[✓ b.] LT^{-3}
c. LT^{-2}
d. LT^{-1}
e. $L^{-1}T^{-1}$

$x \to L$, each term must $\to L$

$bt^3 = L \to b = LT^{-3}$

ANS: B PTS: 2 DIF: Average

8. One mole of the carbon-12 isotope contains 6.022×10^{23} atoms. What volume in m^3 would be needed to store one mole of cube-shaped children's blocks 2.00 cm long on each side?

a. 4.8×10^{18}
b. 1.2×10^{22}
c. 6.0×10^{23}
d. 1.2×10^{24}
e. 4.8×10^{24}

$6.022 \times 10^{23} \times 8 \times 10^{-6}\ m^3$

$\sim 4.8 \times 10^{18}\ m^3$ Indeed, Silly!!!

ANS: A PTS: 2 DIF: Average

9. Which of the following products of ratios gives the conversion factors to convert meters per second $\left(\frac{m}{s}\right)$ to miles per hour $\left(\frac{mi}{h}\right)$?

a. $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{2.54\text{ cm}}{1\text{ in}} \cdot \frac{100\text{ cm}}{1\text{ m}} \cdot \frac{3\,600\text{ s}}{1\text{ h}}$
b. $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{1\text{ in.}}{2.54\text{ cm}} \cdot \frac{1\text{ m}}{100\text{ cm}} \cdot \frac{1\text{ h}}{3\,600\text{ s}}$
c. $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{2.54\text{ cm}}{1\text{ in}} \cdot \frac{100\text{ cm}}{1\text{ m}} \cdot \frac{1\text{ h}}{3\,600\text{ s}}$

$\frac{m}{s} = ?\ \frac{mi}{h}$

$1\,\frac{m}{s} = \frac{100\text{ cm}}{\frac{1}{60\times60}h} = \frac{100\times3600}{2.54}\ in/h$

$= \frac{100\times3600}{2.54\times12}\,\frac{ft}{h} = \frac{100\times3600}{2.54\times12\times5280}\,\frac{mi}{h}$

[✓ d.] $\frac{1\text{ mi}}{5\,280\text{ f}}\cdot\frac{1\text{ f}}{12\text{ in}}\cdot\frac{1\text{ in}}{2.54\text{ cm}}\cdot\frac{100\text{ cm}}{1\text{ m}}\cdot\frac{3\,600\text{ s}}{1\text{ h}}$

e. $\frac{1\text{ mi}}{5\,280\text{ f}}\cdot\frac{1\text{ f}}{12\text{ in}}\cdot\frac{1\text{ in}}{2.54\text{ cm}}\cdot\frac{1\text{ m}}{100\text{ cm}}\cdot\frac{3\,600\text{ s}}{1\text{ h}}$

ANS: D PTS: 2 DIF: Average

10. One U.S. fluid gallon contains a volume of 231 cubic inches. How many liters of gasoline would you have to buy in Canada to fill a 14-gallon tank? (Note: 1L = 10^{+3} cm^3.)

[✓ a. 53]
b. 21
c. 14
d. 8.0
e. 4.0

$1\text{ gallon} = 231\text{ in}^3$; $14\text{ gallon} = 14 \times 231\text{ in}^3$

$= 14 \times 231 \times (2.54)^3\text{ cm}^3$

$= \frac{14 \times 231 \times (2.54)^3}{1000}\text{ L} \approx 53\text{L}$

ANS: A PTS: 3 DIF: Challenging

11. At the end of a year, a motor car company announces that sales of a pickup are down 43% for the year. If sales continue to decrease by 43% in each succeeding year, how long will it take for sales to decrease to zero?

a. 1 year
b. 2 years
c. 3 years
d. 4 years
[✓ e. More than four years]

ANS: E PTS: 2 DIF: Average

12. John and Linda are arguing about the definition of density. John says the density of an object is proportional to its mass. Linda says the object's mass is proportional to its density and to its volume. Which one, if either, is correct?

a. They are both wrong.
b. John is correct, but Linda is wrong.
c. John is wrong, but Linda is correct.
d. They are both correct.
e. They are free to redefine density as they wish.

Meaningless ?

ANS: D PTS: 1 DIF: Easy

13. Spike claims that dimensional analysis shows that the correct expression for change in velocity, $\vec{v}_f - \vec{v}_i$, is $\vec{v}_f - \vec{v}_i = \frac{mt}{F}$, where m is mass, t is time, and F is the magnitude of force. Carla says that can't be true because the dimensions of force are $\left[\frac{\text{ML}}{\text{T}^2}\right]$. Which one, if either, is correct?

a. Spike, because $[\vec{v}] = \left[\frac{\text{ML}}{\text{T}}\right]$.

b. Spike, because $[\vec{v}] = \left[\frac{\text{T}^2}{\text{L}}\right]$.

[✓ c.] Carla, because $[\vec{v}] = \left[\frac{\text{L}}{\text{T}}\right]$.

$$\frac{L}{T} \overset{?}{=} \frac{\cancel{M}T}{\frac{\cancel{M}L}{T^2}} \overset{?}{=} \frac{T^3}{L}$$

$$\frac{L}{T} \neq \frac{T^3}{L}$$

d. Carla, because $[\vec{v}] = \left[\frac{L}{MT}\right]$.

e. Spike, because the dimensions of force are $\left[\vec{F}\right] = \left[\frac{T^2}{ML}\right]$.

ANS: C PTS: 2 DIF: Average

14. Which one of the quantities below has dimensions equal to $\left[\frac{ML}{T^2}\right]$?

a. mv $\rightarrow \boxed{ML/T}$

b. mv^2 $\rightarrow \boxed{ML^2/T^2}$

[✓ c.] $\frac{mv^2}{r}$ $\rightarrow ML^2/T^2L = \boxed{ML/T^2}$

d. mrv $\rightarrow MLL/T = \boxed{ML^2/T}$

e. $\frac{mv^2}{r^2}$ $\rightarrow ML^2/T^2L^2 = \boxed{M/T^2}$

ANS: C PTS: 2 DIF: Average

15. The standard exam page is 8.50 inches by 11.0 inches. Its area in cm^2 is

a. 19.5

b. 36.8

c. 93.5

d. 237.

[✓ e.] 603.

1 in = 2.54 cm

Area = 8.5 in X 11 in

$= 8.5\ \cancel{in} \times \frac{2.54\,cm}{\cancel{in}} \times 11\ \cancel{in} \times \frac{2.54\,cm}{\cancel{in}}$

$= 8.5 \times 11 \times (2.54)^2\ cm^2$

ANS: E PTS: 2 DIF: Average

16. A standard exam page is 8.5 inches by 11 inches. An exam that is 2.0 mm thick has a volume of

a. 1.9×10^4 mm³.

b. 4.7×10^4 mm³.

[✓ c.] 1.2×10^5 mm³.

d. 3.1×10^5 mm³.

e. 3.1×10^3 mm³.

V = 8.5 in X 11 in X 2.0 mm

$= 8.5\ in \times \frac{2.54\,cm}{in} \times \frac{10\,mm}{1\,cm} \times 11\ in \times \frac{2.54\,cm}{in} \times \frac{10\,mm}{1\,cm}$

$\times 2.0\ mm = \bigcirc\ mm^3$

ANS: C PTS: 3 DIF: Challenging

17. Which quantity can be converted from the English system to the metric system by the conversion factor $\frac{5\,280\text{ f}}{\text{mi}} \cdot \frac{12\text{ in}}{\text{f}} \cdot \frac{2.54\text{ cm}}{1\text{ in}} \cdot \frac{1\text{ m}}{100\text{ cm}} \cdot \frac{1\text{ h}}{3\,600\text{ s}}$?

a. feet per second

b. feet per hour

c. miles per second

[✓ d.] miles per hour

e. miles per minute

$\frac{5280\,\cancel{f}}{1\,mi} \cdot \frac{12\,\cancel{in}}{\cancel{f}} \cdot \frac{2.54\,\cancel{cm}}{1\,\cancel{in}} \cdot \frac{1\,m}{100\,\cancel{cm}} \cdot \frac{1\,h}{3600\,s}$

$mi/h \rightarrow m/s$

ANS: D PTS: 2 DIF: Average

18. The answer to a question is [MLT^{-1}]. The question is "What are the dimensions of

a. mr?"

b. mvr?"

c. ma?"

$M\frac{L}{T} \rightarrow mv = mat$

[✓ d.] *mat*?"

e. $\frac{mv^2}{r}$?"

ANS: D PTS: 2 DIF: Average

19. If each frame of a motion picture film is 35 cm high, and 24 frames go by in a second, estimate how many frames are needed to show a two hour long movie.
    a. 1 400
    b. 25 000
    c. 50 000
    [✓ d.] 170 000
    e. This cannot be determined without knowing how many reels were used.

$\sim 24 \frac{\text{frames}}{\cancel{s}} \times 2 \times 3600 \cancel{s} \simeq 17 \times 10^4$ frams

ANS: D PTS: 2 DIF: Average

20. One number has three significant figures and another number has four significant figures. If these numbers are added, subtracted, multiplied, or divided, which operation can produce the greatest number of significant figures?
    [✓ a.] the addition
    b. the subtraction
    c. the multiplication
    d. the division
    e. All the operations result in the same number of significant figures.

ANS: A PTS: 2 DIF: Average

21. A rectangle has a length of 1.323 m and a width of 4.16 m. Using significant figure rules, what is the area of this rectangle?
    a. 5.503 68 m^2
    b. 5.503 7 m^2
    c. 5.504 m^2
    [✓ d.] 5.50 m^2
    e. 5.5 m^2

$\text{Area} = 1.323 \times 4.\underline{16}\ m^2$

$= 5.60$

ANS: D PTS: 2 DIF: Average

PROBLEM

22. The standard kilogram is a platinum-iridium cylinder 39 mm in height and 39 mm in diameter. What is the density of the material?

$$\rho = \frac{\text{mass}}{\text{Volume}} = \frac{1\ kg}{\pi r^2 h} = \frac{1\ kg}{\pi (\frac{d}{2})^2 h}$$

$$= \frac{1}{\pi(\frac{39 \times 10^{-3}}{2})^2 \times 39 \times 10^{-3}}\ kg/m^3$$

ANS:
21 475 kg/m^3

PTS: 2 DIF: Average

23. A 2.00 m by 3.00 m plate of aluminum has a mass of 324 kg. What is the thickness of the plate? (The density of aluminum is 2.70 × 10^3 kg/m^3.)

$$\rho = \frac{m}{V} = \frac{m}{Ad}, \quad d = \frac{m}{\rho A} = \frac{324\ \cancel{kg}}{2.70 \times 10^3 \frac{\cancel{kg}}{m^3} \times 2\ m \times 3\ m}$$

$$= \bigcirc\ m$$

$$= \bigcirc\ \cancel{m} \frac{100\ cm}{1\ \cancel{m}}$$

ANS:
2.00 cm

PTS: 2 DIF: Average

24. What is the mass of air in a room that measures 5.0 m × 8.0 m × 3.0 m? (The density of air is 1/800 that of water).

$\rho_w = 10^3 \text{ kg/m}^3$; $m = \rho(\text{Volume}) = \frac{1}{800} \times 10^3 \frac{\text{kg}}{\cancel{\text{m}^3}} \times 5 \times 8 \times 3 \cancel{\text{m}^3}$

$m = \frac{120 \times 10^3}{800} \text{ kg} \cancel{/\text{m}^3}$

$= 150 \text{ kg}$

ANS:
150 kg

PTS: 2 DIF: Average

25. The basic function of a carburetor of an automobile is to atomize the gasoline and mix it with air to promote rapid combustion. As an example, assume that 30 cm^3 of gasoline is atomized into N spherical droplets, each with a radius of 2.0 × 10^{-5} m. What is the total surface area of these N spherical droplets?

Spherical shape ≈ lowes A per V ratio

$$\frac{V}{A} = \frac{\frac{\cancel{4}}{3}\cancel{\pi} r^3}{\cancel{4\pi} r^2} = \frac{r}{3}$$

$$\text{Area} = \frac{3V}{r} = \frac{3 \times 30 \text{ cm}^3}{2 \times 10^{-5} \times 10^2 \text{ cm}}$$

$$= 45 \times 10^3 \text{ cm}^2$$

ANS:
45 000 cm^2

PTS: 3 DIF: Challenging