Chapter 1

Introduction

Answers to Even-numbered Conceptual Questions

2. The quantity $T + d$ does not make sense physically, because it adds together variables that have different physical dimensions. The quantity d/T does make sense, however; it could represent the distance d traveled by an object in the time T.

4. **(a)** Consistent; **(b)** inconsistent; **(c)** inconsistent; **(d)** consistent.

6. **(a)** 10^7 s; **(b)** 10,000 s; **(c)** 1 s; **(d)** 10^{17} s; **(e)** 10^8 s to 10^9 s.

Solutions to Problems

1. **(a)** $\$114,000,000 \times \dfrac{1 \text{ gigadollar}}{1 \times 10^9 \text{ dollars}}$ $\boxed{= 1.14 \times 10^{-1} \text{ gigadollar}}$

   (b) $\$114,000,000 \times \dfrac{1 \text{ teradollar}}{1 \times 10^{12} \text{ dollars}}$ $\boxed{= 1.14 \times 10^{-4} \text{ teradollar}}$

2. **(a)** $(70 \ \mu\text{m}) \left(\dfrac{10^{-6} \text{ m}}{\mu\text{m}} \right) = 70 \times 10^{-6} \text{ m} = \boxed{7 \times 10^{-5} \text{ m}}$

   (b) $(70 \ \mu\text{m}) \left(\dfrac{10^{-9} \text{ km}}{\mu\text{m}} \right) = 70 \times 10^{-9} \text{ km} = \boxed{7 \times 10^{-8} \text{ km}}$

3. $\left(0.3 \ \dfrac{\text{Gm}}{\text{s}} \right) \left(\dfrac{10^9 \text{ m}}{\text{Gm}} \right) = 0.3 \times 10^9 \ \dfrac{\text{m}}{\text{s}} = \boxed{3 \times 10^8 \text{ m/s}}$

4. $2 \dfrac{\text{gigacalculations}}{\text{second}} = 2 \times 10^9 \ \dfrac{\text{calc}}{\text{s}}$

   $\left(2 \times 10^9 \ \dfrac{\text{calc}}{\text{s}} \right) \left(\dfrac{10^{-6} \text{ s}}{\mu\text{s}} \right) = 2 \times 10^3 \ \dfrac{\text{calc}}{\mu\text{s}} = \boxed{2 \ \dfrac{\text{kilocalculations}}{\text{microsecond}}}$

5. $v^2 = 2ax^p$, in dimensions

   $\dfrac{[\text{L}^2]}{[\text{T}^2]} = \dfrac{[\text{L}]}{[\text{T}^2]} [\text{L}^p] = \dfrac{[\text{L}^{p+1}]}{[\text{T}^2]}$

   matching exponents gives

   $2 = p + 1$

   $\boxed{p = 1}$

6. $a = 2xt^p$, in dimensions

$$\frac{[L]}{[T^2]} = [L][T^p]$$

matching exponents gives $\boxed{p = -2}$

7. $v = v_0 + at$, in dimensions

$$\frac{[L]}{[T]} = \frac{[L]}{[T]} + \frac{[L]}{[T^2]}[T] = \frac{[L]}{[T]} + \frac{[L]}{[T]}$$

8. Acceleration $\propto \dfrac{\text{Force}}{\text{Mass}}$

So, $F \propto ma$ and in dimensions $\boxed{[F] = [M]\dfrac{[L]}{[T^2]}.}$

9. $T = 2\pi\sqrt{\dfrac{m}{k}}$

$T^2 = 4\pi^2 \dfrac{m}{k}$

$k = 4\pi^2 \dfrac{m}{T^2}$, in dimensions

$\boxed{[k] = \dfrac{[M]}{[T^2]}}$

10. **(a)** $\boxed{3.14}$

    (b) $\boxed{3.1416}$

    (c) $\boxed{3.141593}$

11. $\boxed{3.00 \times 10^8 \text{ m/s}}$

12. Perimeter $= 2(\text{Length} + \text{Width}) = 2(115.1 \text{ m} + 39.24 \text{ m}) = 2(154.34 \text{ m}) = \boxed{308.7 \text{ m}}$

13. Total $=$ bass $+$ rock cod $+$ salmon $= 2.45 \text{ lb} + 10.1 \text{ lb} + 16.13 \text{ lb} = \boxed{28.7 \text{ lb}}$

14. **(a)** $\boxed{\text{2 significant figures}}$

    (b) $\boxed{\text{4 significant figures}}$

15. $A = \pi r^2$

    (a) $A = (3.1416(5.142 \text{ m})^2 = \boxed{83.06 \text{ m}^2}$

    (b) $A = (3.14)(1.7 \text{ m})^2 = \boxed{9.1 \text{ m}^2}$

16. $(301 \text{ m})\left(\dfrac{3.281 \text{ ft}}{1 \text{ m}}\right) = \boxed{988 \text{ ft}}$

17. (a) $V = lwh = (20.0 \text{ yd})(10.0 \text{ yd})(15.0 \text{ ft}) = (3000 \text{ yd}^2 \cdot \text{ft})\left(\dfrac{3 \text{ ft}}{\text{yd}}\right)^2 = \boxed{2.70 \times 10^4 \text{ ft}^3}$

   (b) $(2.70 \times 10^4 \text{ ft}^3)\left(\dfrac{1 \text{ m}}{3.281 \text{ ft}}\right)^3 = \boxed{764 \text{ m}^3}$

18. $V = lwh = (2.5 \text{ cubits})(1.5 \text{ cubits})^2 = (5.625 \text{ cubits}^3)\left(\dfrac{17.7 \text{ in.}}{1 \text{ cubit}}\right)^3\left(\dfrac{1 \text{ ft}}{12 \text{ in.}}\right)^3 = \boxed{18 \text{ ft}^3}$

19. $\text{Time} = \left(\dfrac{1 \text{ s}}{9,192,631,770 \text{ cycles}}\right)(1,000,000 \text{ cycles}) = \boxed{1.087828 \times 10^{-4} \text{ s}}$

20. $\text{Distance} = (3212 \text{ ft})\left(\dfrac{1 \text{ km}}{3281 \text{ ft}}\right) = \boxed{0.9790 \text{ km}}$

21. $(1 \text{ wk})\left(\dfrac{604,800 \text{ s}}{\text{wk}}\right)\left(\dfrac{1 \text{ repetition}}{8 \text{ s}}\right) = \boxed{75,600 \text{ repititions}}$

22. $\left(\dfrac{1 \text{ y}}{365 \text{ d}}\right)\left(\dfrac{1 \text{ d}}{24 \text{ h}}\right)\left(\dfrac{1 \text{ h}}{60 \text{ min}}\right)\left(\dfrac{1 \text{ min}}{60 \text{ s}}\right) = \boxed{\dfrac{1 \text{ y}}{3.15 \times 10^7 \text{ s}}}$

23. $(530.2 \text{ carats})\left(\dfrac{0.20 \text{ g}}{\text{carat}}\right)\left(\dfrac{1 \text{ kg}}{1000 \text{ g}}\right)\left(\dfrac{2.21 \text{ lb}}{1 \text{ kg}}\right) = \boxed{0.23 \text{ lb}}$

24. (a) $\boxed{\text{greater than}}$

   (b) $\left(\dfrac{55 \text{ mi}}{\text{h}}\right)\left(\dfrac{5280 \text{ ft}}{\text{mi}}\right)\left(\dfrac{1 \text{ km}}{3281 \text{ ft}}\right) = \boxed{89 \text{ km/h}}$

25. $\left(\dfrac{3.00 \times 10^8 \text{ m}}{\text{s}}\right)\left(\dfrac{3.281 \text{ ft}}{\text{m}}\right)\left(\dfrac{1 \text{ mi}}{5280 \text{ ft}}\right)\left(\dfrac{3600 \text{ s}}{\text{h}}\right) = \boxed{6.71 \times 10^8 \text{ mi/h}}$

26. $\left(\dfrac{65 \text{ km}}{\text{h}}\right)\left(\dfrac{\text{mi}}{1.61 \text{ km}}\right) = \boxed{40 \text{ mi/h}}$

27. $\text{Area} = \dfrac{\text{Volume}}{\text{Height}} = \dfrac{1.0 \text{ m}^3}{0.50 \text{ } \mu\text{m}} = \dfrac{1.0 \text{ m}^3}{0.50 \times 10^{-6} \text{ m}} = \boxed{2.0 \times 10^6 \text{ m}^2}$

28. (a) $(8.5 \text{ in.})(11 \text{ in.})\left(\dfrac{1 \text{ m}}{39.4 \text{ in.}}\right)^2 = \boxed{6.0 \times 10^{-2} \text{ m}^2}$

(b) $\dfrac{A_a}{A_b} = \dfrac{(8.5 \text{ in.})(11 \text{ in.})}{\left(\dfrac{8.5 \text{ in.}}{2}\right)\left(\dfrac{11 \text{ in.}}{2}\right)} = \boxed{4 \text{ times less area}}$

29. (a) $\left(\dfrac{20.0 \text{ m}}{\text{s}}\right)\left(\dfrac{3.28 \text{ ft}}{\text{m}}\right) = \boxed{65.6 \text{ ft/s}}$

(b) $\left(\dfrac{65.6 \text{ ft}}{\text{s}}\right)\left(\dfrac{1 \text{ mi}}{5280 \text{ ft}}\right)\left(\dfrac{3600 \text{ s}}{\text{h}}\right) = \boxed{44.7 \text{ mi/h}}$

30. $\left(\dfrac{9.81 \text{ m}}{\text{s}^2}\right)\left(\dfrac{3.28 \text{ ft}}{\text{m}}\right) = \boxed{32.2 \text{ ft/s}^2}$

31. A typical major league park can hold tens of thousands of spectators.
$\boxed{10^4 \text{ seats}}$

32. If each person drinks one gallon of milk per week and the U.S. has on the order of 10^8 people.
$\left(\dfrac{1 \text{ gal milk}}{\text{wk} \cdot \text{person}}\right)\left(\dfrac{10^8 \text{ persons}}{1}\right)\left(\dfrac{10^2 \text{ wk}}{\text{y}}\right) = \boxed{10 \text{ billion gallons of milk purchased per year}}$

If it is assumed that a plastic gallon milk container weighs approximately 10^{-1} lb, we have

$(10 \times 10^9 \text{ containers})\left(\dfrac{10^{-1} \text{ lb}}{\text{container}}\right) = \boxed{1 \times 10^9 \text{ lb of plastic}}$

33. (a) $x = vt$
$v = \dfrac{x}{t} = \dfrac{3000 \text{ mi}}{3 \text{ h}} = \boxed{1000 \text{ mi/h}}$

(b) The earth completes one rotation in 24 hours.
$C = \text{Circumference} = \left(\dfrac{1000 \text{ mi}}{\text{h}}\right)(24 \text{ h}) = \boxed{24{,}000 \text{ mi}}$

(c) $C = 2\pi r$
$r = \dfrac{C}{2\pi} = \dfrac{24{,}000 \text{ mi}}{2\pi} = \boxed{4000 \text{ mi}}$

34. (a) Assuming that a quarter weighs on the order of 10^{-3} kg, we have
$\left(\dfrac{10^6 \text{ dollars}}{1}\right)\left(\dfrac{4 \text{ quarters}}{\text{dollar}}\right)\left(\dfrac{10^{-3} \text{ kg}}{\text{quarter}}\right) = \boxed{4 \times 10^3 \text{ kg.}}$

(b) Assume a dollar weighs 10^{-4} kg, then $\left(\dfrac{10^6 \text{ dollars}}{1}\right)\left(\dfrac{10^{-4} \text{ kg}}{\text{dollar}}\right) = \boxed{10^2 \text{ kg.}}$

35. (a) $\left(\dfrac{12 \text{ m}}{\text{s}^2}\right)\left(\dfrac{3.28 \text{ ft}}{\text{m}}\right) = \boxed{39 \text{ ft/s}^2}$

   (b) $\left(\dfrac{12 \text{ m}}{\text{s}^2}\right)\left(\dfrac{1 \text{ km}}{1000 \text{ m}}\right)\left(\dfrac{3600 \text{ s}}{\text{h}}\right)^2 = \boxed{1.6 \times 10^5 \text{ km/h}^2}$

36. (a) $\left(\dfrac{140 \text{ m}}{\text{s}}\right)\left(\dfrac{3600 \text{ s}}{\text{h}}\right)\left(\dfrac{3.28 \text{ ft}}{\text{m}}\right)\left(\dfrac{1 \text{ mi}}{5280 \text{ ft}}\right) = \boxed{310 \text{ mi/h}}$

   (b) $(5.0 \text{ ms})\left(\dfrac{10^{-3} \text{ s}}{1 \text{ ms}}\right)\left(\dfrac{140 \text{ m}}{\text{s}}\right) = \boxed{0.70 \text{ m}}$

37. (a) $\left(1.6 \ \dfrac{\text{mg}}{\text{min}}\right)\left(\dfrac{60 \text{ min}}{1 \text{ hr}}\right)\left(\dfrac{24 \text{ hr}}{1 \text{ day}}\right) = 2304 \text{ mg} = \boxed{2.3 \text{ g}}$

   (b) $\dfrac{2.5 \text{ g}}{2.3 \text{ g/day}} = 1.1 \text{ days}$

38. $a = v^p t^q$, in dimensions

$$\frac{[\text{L}]}{[\text{T}^2]} = \frac{[\text{L}^p]}{[\text{T}^p]}[\text{T}^q]$$

matching exponents gives

$\boxed{p = 1}$

$-2 = q - p = q - 1$

$\boxed{q = -1}$

39. $T = 2\pi L^p g^q$, in dimensions

$$[\text{T}] = [\text{L}^p]\frac{[\text{L}^q]}{[\text{T}^{2q}]}$$

Matching exponents gives

$-2q = 1 \qquad\qquad p = -q$

$\boxed{q = -\dfrac{1}{2} \qquad p = \dfrac{1}{2}}$

40. $x = vt$

The distance traveled both before and after the speed increase is 1 mile, so $vt = \left(v + 5.0 \ \dfrac{\text{mi}}{\text{h}}\right)(t - 11 \text{ s}) = x = 1 \text{ mi}$.

The units are inconsistent, so the time should be converted to hours from seconds.

$(11 \text{ s})\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right) = 3.056 \times 10^{-3} \text{ h}$

Inserting the result and multiplying gives

$$vt = vt - (3.056 \times 10^{-3} \ \text{h})v + \left(5.0 \ \frac{\text{mi}}{\text{h}}\right)t - (1.528 \times 10^{-2} \ \text{mi})$$

$$0 = -(3.056 \times 10^{-3} \ \text{h})v + \left(5.0 \ \frac{\text{mi}}{\text{h}}\right)t - (1.528 \times 10^{-2} \ \text{mi})$$

Multiplying by v and dividing by $(-3.056 \times 10^{-3} \ \text{h})$ gives

$$0 = v^2 - \left(1.636 \times 10^3 \ \frac{\text{mi}}{\text{h}^2}\right)vt + \left(5.0 \ \frac{\text{mi}}{\text{h}}\right)v$$

Recall that $x = vt = 1$ mi.
Substituting this gives

$$0 = v^2 + \left(5.0 \ \frac{\text{mi}}{\text{h}}\right)v - \left(1.636 \times 10^3 \ \frac{\text{mi}^2}{\text{h}^2}\right)$$

This is a quadratic equation and can be solved for v using the formula $v = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ where, in this case,

$$a = 1, \ b = 5.0 \ \frac{\text{mi}}{\text{h}}, \ \text{and} \ c = -1.636 \times 10^3 \ \frac{\text{mi}^2}{\text{h}^2}.$$

$$v = \frac{-5.0 \ \frac{\text{mi}}{\text{h}} \pm \sqrt{\left(5.0 \ \frac{\text{mi}}{\text{h}}\right)^2 - (4)(1)\left(-1.636 \times 10^3 \ \frac{\text{mi}^2}{\text{h}^2}\right)}}{2(1)}$$

$$= -2.5 \ \frac{\text{mi}}{\text{h}} \pm \frac{\sqrt{25 \ \frac{\text{mi}^2}{\text{h}^2} + 6544 \ \frac{\text{mi}^2}{\text{h}^2}}}{2}$$

$$= -2.5 \ \frac{\text{mi}}{\text{h}} \pm 40.5 \ \frac{\text{mi}}{\text{h}}$$

$$= \boxed{38 \ \text{mi/h}}$$

where the positive sign was chosen because the initial speed is positive.