INSTRUCTOR'S SOLUTIONS MANUAL

MATTHEW G. HUDELSON

BASIC TECHNICAL MATHEMATICS

AND

BASIC TECHNICAL MATHEMATICS WITH CALCULUS

ELEVENTH EDITION

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Chapter 1

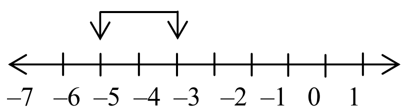
Basic Algebraic Operations

1.1 Numbers

1. The numbers –7 and 12 are integers. They are also rational numbers since they can be written as $\frac{-7}{1}$ and $\frac{12}{1}$.

2. The absolute value of –6 is 6, and the absolute value of –7 is 7. We write these as $|-6| = 6$ and $|-7| = 7$.

3. $-6 < -4$; –6 is to the left of –4.



4. The reciprocal of $\frac{3}{2}$ is $\frac{1}{3/2} = 1 \times \frac{2}{3} = \frac{2}{3}$.

5. 3 is an integer, rational $\left(\frac{3}{1}\right)$, and real.

$\sqrt{-4}$ is imaginary.

6. $\frac{\sqrt{7}}{3}$ is irrational (because $\sqrt{7}$ is an irrational number) and real.

-6 is an integer, rational $\left(\frac{-6}{1}\right)$, and real.

7. $-\frac{\pi}{6}$ is irrational (because π is an irrational number) and real.

$\frac{1}{8}$ is rational and real.

8. $-\sqrt{-6}$ is imaginary.

$-2.33 = \frac{-233}{100}$ is rational and real.

9. $|3| = 3$

$|-3| = 3$

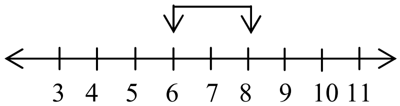
$\left|-\frac{\pi}{2}\right| = \frac{\pi}{2}$

10. $|-0.857| = 0.857$

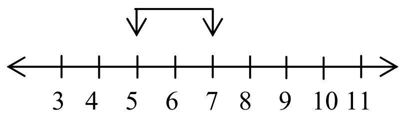
$\left|\sqrt{2}\right| = \sqrt{2}$

$\left|-\frac{19}{4}\right| = \frac{19}{4}$

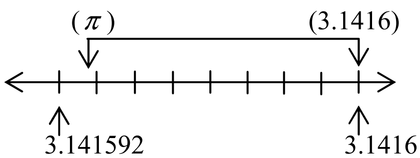
11. $6 < 8$; 6 is to the left of 8.



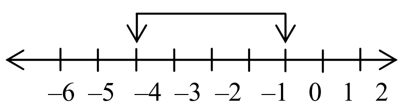
12. $7 > 5$; 7 is to the right of 5.



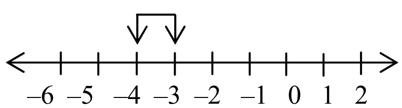
13. $\pi < 3.1416$; π (3.1415926…) is to the left of 3.1416.



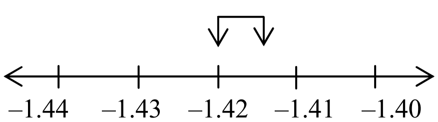
14. $-4 < 0$; -4 is to the left of 0.



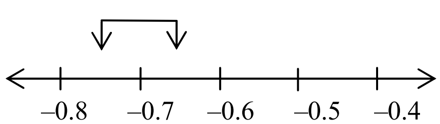
15. $-4 < -|-3|$; -4 is to the left of $-|-3|$, $\left(-|-3| = -(3) = -3\right)$.



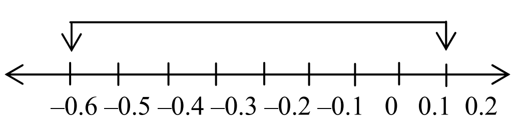
16. $-\sqrt{2} > -1.42$; $(-\sqrt{2} = -(1.414\ldots.) = -1.414\ldots), -\sqrt{2}$ is to the right of -1.42.



17. $-\dfrac{2}{3} > -\dfrac{3}{4}; -\dfrac{2}{3} = -0.666\ldots$ is to the right of $-\dfrac{3}{4} = -0.75$.



18. $-0.6 < 0.2$; -0.6 is to the left of 0.2.



19. The reciprocal of 3 is $\frac{1}{3}$.

The reciprocal of $-\frac{4}{\sqrt{3}}$ is $-\frac{1}{4/\sqrt{3}}=-\frac{\sqrt{3}}{4}$.

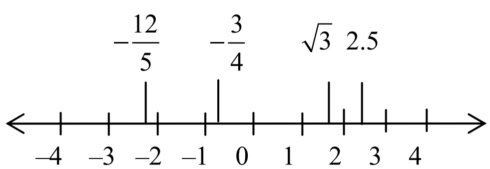
The reciprocal of $\frac{y}{b}$ is $\frac{1}{y/b}=\frac{b}{y}$.

20. The reciprocal of $-\frac{1}{3}$ is $-\frac{1}{1/3}=-\frac{3}{1}=-3$.

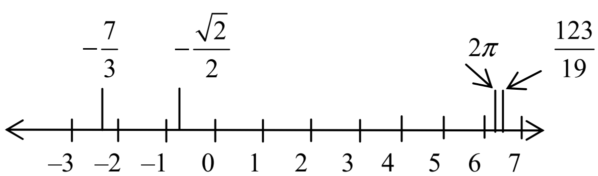
The reciprocal of $0.25=\frac{1}{4}$ is $\frac{1}{1/4}=\frac{4}{1}=4$.

The reciprocal of $2x$ is $\frac{1}{2x}$.

21. Find 2.5, $-\frac{12}{5}=-2.4; -\frac{3}{4}=-0.75; \sqrt{3}=1.732...$



22. Find $-\frac{7}{3}=-2.333...; -\frac{\sqrt{2}}{2}=-\frac{1.414\ldots}{2}=-0.707;\ 2\pi=2\times 3.14\ldots=6.28;\ \frac{123}{19}=6.47$.



23. An absolute value is not always positive, $|0|=0$ which is not positive.

24. Since $-2.17=-\frac{217}{100}$, it is rational.

25. The reciprocal of the reciprocal of any positive or negative number is the number itself. The reciprocal of n is $\frac{1}{n}$; the reciprocal of $\frac{1}{n}$ is $\frac{1}{1/n}=1\cdot\frac{n}{1}=n$.

26. Any repeating decimal is rational, so $2.\overline{72}$ is rational. It turns out that $2.\overline{72}=\frac{30}{11}$.

27. It is true that any nonterminating, nonrepeating decimal is an irrational number.

28. No, $|b-a| = |b| - |a|$, as shown below.

If $a > 0$, then $|a| = a$.

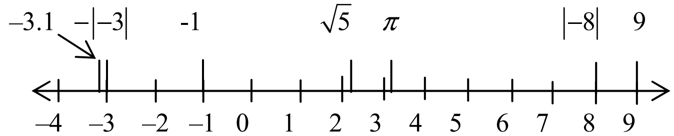
If $b > a$ and $a > 0$, then $|b| = b$.

If b $> a$ then $b - a > 0$, then $|b-a| = b - a$.

Therefore, $|b-a| = b - a = |b| - |a|$.

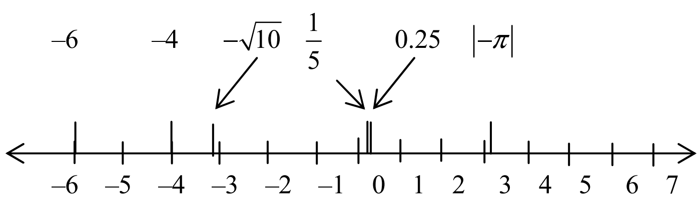
The two sides of the expression are equivalent, one side is not less than the other.

29. List these numbers from smallest to largest: $-1,\ 9,\ \pi = 3.14,\ \sqrt{5} = 2.236,\ |-8| = 8,\ -|-3| = -3,\ -3.1$.



So, from smallest to largest, they are $-3.1,\ -|-3|,\ -1,\ \sqrt{5},\ \pi,\ |-8|,\ 9$.

30. List these numbers from smallest to largest: $\frac{1}{5} = 0.20,\ -\sqrt{10} = -3.16...,\ -|-6| = -6,\ -4,\ 0.25,\ |-\pi| = 3.14...$.



So, from smallest to largest, they are $-|-6|,\ -4,\ -\sqrt{10},\ \frac{1}{5},\ 0.25,\ |-\pi|$.

31. If a and b are positive integers and $b > a$, then

(a) $b - a$ is a positive integer.

(b) $a - b$ is a negative integer.

(c) $\frac{b-a}{b+a}$, the numerator and denominator are both positive, but the numerator is less than the denominator, so the answer is a positive rational number than is less than 1.

32. If a and b are positive integers, then

(a) $a + b$ is a positive integer

(b) a / b is a positive rational number

(c) $a \times b$ is a positive integer

33. **(a)** Is the absolute value of a positive or a negative integer always an integer?

$|x| = x$, so the absolute value of a positive integer is an integer.

$|-x| = x$, so the absolute value of a negative integer is an integer.

(b) Is the reciprocal of a positive or negative integer always a rational number?

If x is a positive or negative integer, then the reciprocal of x is $\frac{1}{x}$. Since both 1 and x are integers, the reciprocal is a rational number.

34. **(a)** Is the absolute value of a positive or negative rational number rational?

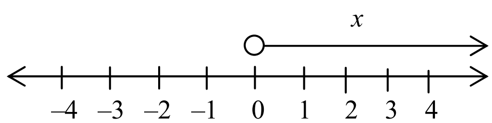
$|x| = x$, so if x is a positive or negative rational number, the absolute value of it is also a rational number.

(b) Is the reciprocal of a positive or negative rational number a rational number?

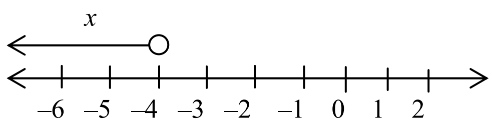
A rational number is a number that can be expressed as a fraction where both the numerator and denominator are integers and the denominator is not zero. So a rational number $\frac{\text{integer } a}{\text{integer } b}$ has a reciprocal of

$\dfrac{1}{\frac{\text{integer } a}{\text{integer } b}} = \dfrac{\text{integer } b}{\text{integer } a}$, which is also a rational number if integer a is not zero.

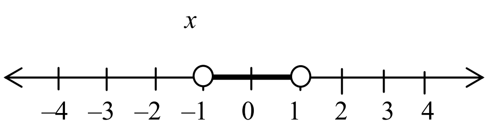
35. **(a)** If $x > 0$, then x is a positive number located to the right of zero on the number line.



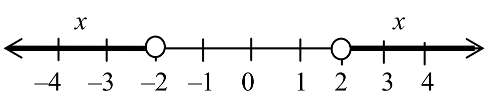
(b) If $x < -4$, then x is a negative number located to the left of –4 on the number line.



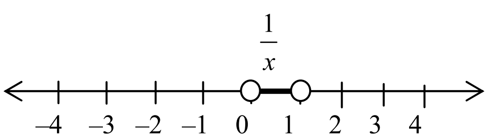
36. **(a)** If $|x| < 1$, then $-1 < x < 1$.



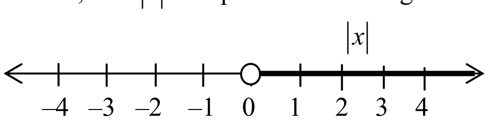
(b) $|x| > 2$, then $x < -2$ or $x > 2$.



37. If $x > 1$, then $\frac{1}{x}$ is a positive number less than 1. Or $0 < \frac{1}{x} < 1$.



38. If $x < 0$, then $|x|$ is a positive number greater than zero.



39. $a + bj = a + b\sqrt{-1}$ is a real number when $\sqrt{-1}$ is eliminated, which is when $b = 0$. So $a + bj$ is a real number for all real values of a and $b = 0$.

40. The variables are *w* and *t*.
The constants are *c*, 0.1, and 1.

41. $\frac{1}{C_T}=\frac{1}{C_1}+\frac{1}{C_2}$. Find C_T, where $C_1 = 0.0040\,\text{F}$ and $C_2 = 0.0010\,\text{F}$.

$$\frac{1}{C_T}=\frac{1}{0.0040}+\frac{1}{0.0010}$$

$$\frac{1}{C_T}=\frac{1(0.0040)+1(0.0010)}{0.0040\times 0.0010}$$

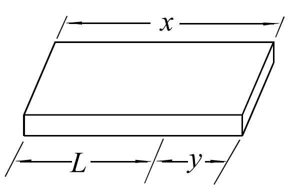
$$C_T=\frac{0.0040\times 0.0010}{0.0040+0.0010}=\frac{0.0000040}{0.0050}$$

$$C_T = 0.00080\text{ F}$$

42. $|100V| = 100V$
$|-200V| = 200V$
$|-200V| > |100V|$

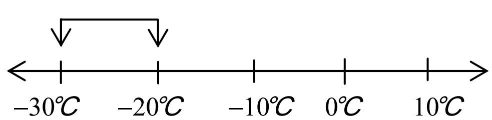
43. $N=\frac{a\text{ bits}}{\text{bytes}}\times\frac{1000\text{ bytes}}{1\text{ kilobyte}}\times n\,\text{kilobytes}$
$N = 1000\,an$ bits

44.



x = length of base in m
y = the shortened length in centimetres.
$100x$ = length of base in cm
$y + L = 100x$, all dimensions in cm
$L = 100x - y$

45. Yes, $-20\text{ °C} > -30\text{ °C}$ because -30 °C is found to the left of -20 °C on the number line.



46. For $I < 4$ A, $R > 12\ \Omega$.

1.2 Fundamental Operations of Algebra

1. $16-2\times(-2)=16-(-4)=16+4=20$

2. $\frac{-18}{-6}+5-(-2)(3)=3+5-(-6)=8+6=14$

3. $\frac{-12}{8-2}+\frac{5-1}{2(-1)}=\frac{-12}{6}+\frac{4}{-2}=-2+(-2)=-4$

4. $\frac{7\times6}{0\times0}=\frac{42}{0}=$ is undefined , not indeterminate.

5. $5+(-8)=5-8=-3$

6. $-4+(-7)=-4-7=-11$

7. $-3+9=6$ or alternatively
$-3+9=+(9-3)=+(6)=6$

8. $18-21=-3$ or alternatively
$18-21=-(21-18)=-(3)=-3$

9. $-19-(-16)=-19+16=-3$

10. $-8-(-10)=-8+10=2$

11. $7(-4)=-(7\times4)=-28$

12. $-9(3)=-27$

13. $-7(-5)=+(7\times5)=35$

14. $\frac{-9}{3}=-3$

15. $\frac{-6(20-10)}{-3}=\frac{-6(10)}{-3}=\frac{-60}{-3}=20$

16. $\frac{-28}{-7(5-6)}=\frac{-28}{-7(-1)}=\frac{-28}{7}=-4$

17. $-2(4)(-5)=-8(-5)=40$

18. $-3(-4)(-6)=12(-6)=-72$

19. $2(2-7)\div 10=2(-5)\div 10=-10\div 10=-1$

20. $\dfrac{-64}{-2|4-8|}=\dfrac{-64}{-2|-4|}=\dfrac{-64}{-2(4)}=\dfrac{-64}{-8}=8$

21. $16\div 2(-4)=8(-4)=-32$

22. $-20\div 5(-4)=-4(-4)=16$

23. $-9-|2-10|=-9-|-8|=-9-8=-17$

24. $(7-7)\div(5-7)=0\div(-2)=0$

25. $\dfrac{17-7}{7-7}=\dfrac{10}{0}$ is undefined

26. $\dfrac{(7-7)(2)}{(7-7)(-1)}=\dfrac{0(2)}{0(-1)}=\dfrac{0}{0}$ is indeterminate

27. $8-3(-4)=8+12=20$

28. $-20+8\div 4=-20+2=-18$

29. $-2(-6)+\left|\dfrac{8}{-2}\right|=12+|-4|=12+4=16$

30. $\dfrac{|-2|}{-2}=\dfrac{2}{-2}=-1$

31. $$\begin{aligned}10(-8)(-3)\div(10-50)&=10(-8)(-3)\div(-40)\\&=-80(-3)\div(-40)\\&=240\div(-40)\\&=-6\end{aligned}$$

32. $\dfrac{7-|-5|}{-1(-2)}=\dfrac{7-5}{2}=\dfrac{2}{2}=1$

33. $\dfrac{24}{3+(-5)}-4(-9)=\dfrac{24}{-2}+(4\times 9)=-12+36=24$

34. $\dfrac{-18}{3}-\dfrac{4-|-6|}{-1}=\dfrac{-18}{3}-\dfrac{4-6}{-1}=-6-\dfrac{-2}{-1}=-6-2=-8$

35. $-7-\frac{|-14|}{2(2-3)}-3|6-8|=-7-\frac{14}{2(-1)}-3|-2|$

$$=-7-\frac{14}{-2}-3(2)$$
$$=-7-(-7)-6$$
$$=-7+7-6$$
$$=-6$$

36. $-7(-3)+\frac{-6}{-3}-|-9|=+(7\times 3)+2-9$

$$=21+2-9$$
$$=14$$

37. $\frac{3|-9-2(-3)|}{1-10}=\frac{3|-9+6|}{-9}$

$$=\frac{3|-3|}{-9}$$
$$=\frac{9}{-9}$$
$$=-1$$

38. $\frac{20(-12)-40(-15)}{98-|-98|}=\frac{-240+600}{98-98}=\frac{360}{0}=$ is undefined

39. $6(7)=(7)6$ demonstrates the commutative law of multiplication.

40. $6+8=8+6$ demonstrates the commutative law of addition.

41. $6(3+1)=6(3)+6(1)$ demonstrates the distributive law.

42. $4(5\times\pi)=(4\times 5)\pi$ demonstrates the associative law of multiplication.

43. $3+(5+9)=(3+5)+9$ demonstrates the associative law of addition.

44. $8(3-2)=8(3)-8(2)$ demonstrates the distributive law.

45. $(\sqrt{5}\times 3)\times 9=\sqrt{5}\times(3\times 9)$ demonstrates the associative law of multiplication.

46. $(3\times 6)\times 7=7\times(3\times 6)$ demonstrates the commutative law of multiplication.

47. $-a+(-b)=-a-b$, which is expression (d).

48. $b-(-a)=b+a=a+b$, which is expression (a).

49. $-b-(-a)=-b+a=a-b$, which is expression (b).

50. $-a-(-b)=-a+b=b-a$, which is expression (c).

51. Since $|5-(-2)|=|5+2|=|7|=7$ and $|-5-(-2)|=|-5+2|=|-3|=3$,
$|5-(-2)|>|-5-(-2)|$.

52. Since $|-3-|-7||=|-3-7|=|-10|=10$ and $||-3|-7|=|3-7|=|-4|=4$,
$|-3-|-7|| > ||-3|-7|$.

53. **(a)** The sign of a product of an even number of negative numbers is positive. Example: $-3(-6)=18$

(b) The sign of a product of an odd number of negative numbers is negative.
Example: $-5(-4)(-2)=-40$

54. Subtraction is not commutative because $x-y\neq y-x$. Example: $7-5=2$ does not equal $5-7=-2$

55. Yes, from the definition in Section 1.1, the absolute value of a positive number is the number itself, and the absolute value of a negative number is the corresponding positive number. So for values of x where $x>0$ (positive) or $x=0$ (neutral) then $|x|=x$.

Example: $|4|=4$.

The claim that absolute values of negative numbers $|x|=-x$ is also true.

Example: if x is -6, then $|-6|=-(-6)=6$.

56. The incorrect answer was achieved by subtracting before multiplying or dividing which violates the order of operations.
$24-6\div2\times3\neq18\div2\times3=9\times3=27$
The correct value is:
$24-6\div2\times3=24-3\times3=24-9=15$

57. **(a)** $-xy=1$ is true for values of x and y that are negative reciprocals of each other or $y=-\frac{1}{x}$, providing that the number x in the denominator is not zero. So if $x=12$, then $y=-\frac{1}{12}$ and $-xy=-(12)\left(-\frac{1}{12}\right)=1$.

(b) $\frac{x-y}{x-y}=1$ is true for all values of x and y, providing that $x\neq y$ to prevent division by zero.

58. **(a)** $|x+y|=|x|+|y|$ is true for values where both x and y have the same sign or either are zero:

$|x+y|=|x|+|y|$, when $x\geq0$ and $y\geq0$ or when $x\leq0$ and $y\leq0$

Example:

$|6+3|=6+3=9$ and

$|6|+|3|=6+3=9$

Also,

$|-6+(-3)|=|-9|=9$

$|-6|+|-3|=6+3=9$

$|x+y|=|x|+|y|$ is not true however, when x and y have opposite signs

$|x+y|\neq|x|+|y|$, when $x>0$ and $y<0$; or $x<0$ and $y>0$.

Example:
$|-21+6| = |-15| = 15,$
$|-21| + |6| = 21+6 = 27 \neq 15$

$|4+(-5)| = |-1| = 1,$
$|4| + |-5| = 4+5 = 9 \neq 1$

(b) In order for $|x-y| = |x|+|y|$ it is necessary that they have opposite signs or either to be zero.
Symbolically, $|x-y| = |x|+|y|$ when $x \geq 0$ and $y \leq 0$; or when $x \leq 0$ and $y \geq 0$.

Example:
$|6-(-3)| = 6+3 = 9$ and
$|6| + |-3| = 6+3 = 9$

Example:
$|-11-7| = |-18| = 18$
$|-11| + |-7| = 11+7 = 18$

$|x-y| = |x|+|y|$ is not true, however, when x and y have the same signs.
$|x-y| \neq |x|+|y|$, when $x > 0$ and $y > 0$; or $x < 0$ and $y < 0$.
Example:
$|21-6| = |15| = 15,$
$|21| + |6| = 27 \neq 15$

59. The total change in the price of the stock is $-0.68+0.42+0.06+(-0.11)+0.02 = -0.29$.

60. The difference in altitude is $-86-(-1396) = 1396-86 = 1310$ m

61. The change in the meter energy reading E would be:
$$E_{change} = E_{used} - E_{generated}$$
$$E_{change} = 2.1 \text{ kW}\cdot\text{h} - 1.5 \text{ kW}(3.0 \text{ h})$$
$$E_{change} = 2.1 \text{ kW}\cdot\text{h} - 4.5 \text{ kW}\cdot\text{h}$$
$$E_{change} = -2.4 \text{ kW}\cdot\text{h}$$

62. Assuming that this batting average is for the current season only which is just starting, the number of hits is zero and the total number of at-bats is also zero giving us a $\text{batting average} = \frac{\text{number of hits}}{\text{at-bats}} = \frac{0}{0}$ which is indeterminate, not 0.000.

63. The average temperature for the week is:
$$T_{avg} = \frac{-7+(-3)+2+3+1+(-4)+(-6)}{7} \text{ °C}$$
$$T_{avg} = \frac{-7-3+2+3+1-4-6}{7} \text{ °C}$$
$$T_{avg} = \frac{-14}{7} \text{ °C} = -2.0 \text{ °C}$$

64. The vertical distance from the flare gun is
$d = (70)(5) + (-16)(25)$
$d = 350 + (-400)$
$d = 350 - 400$
$d = -50$ m
The flare is 50 m below the flare gun.

65. The sum of the voltages is
$V_{sum} = 6\text{V} + (-2\text{V}) + 8\text{V} + (-5\text{V}) + 3\text{V}$
$V_{sum} = 6\text{V} - 2\text{V} + 8\text{V} - 5\text{V} + 3\text{V}$
$V_{sum} = 10\text{V}$

66. **(a)** The change in the current for the first interval is the second reading – the first reading
$Change_1 = -2 \text{ lb/in}^2 - 7 \text{ lb/in}^2 = -9 \text{ lb/in}^2$.

(b) The change in the current for the middle intervals is the third reading – the second reading
$Change_2 = -9 \text{ lb/in}^2 - (-2 \text{ lb/in}^2) = -9 \text{ lb/in}^2 + 2 \text{ lb/in}^2 = -7 \text{ lb/in}^2$.

(c) The change in the current for the last interval is the last reading – the third reading
$Change_3 = -6 \text{ lb/in}^2 - (-9 \text{ lb/in}^2) = -6 \text{ lb/in}^2 + 9 \text{ lb/in}^2 = 3 \text{ lb/in}^2$.

67. The oil drilled by the first well is $100 \text{ m} + 200 \text{ m} = 300 \text{ m}$ which equals the depth drilled by the second well $200 \text{ m} + 100 \text{ m} = 300 \text{ m}$.
$100 \text{ m} + 200 \text{ m} = 200 \text{ m} + 100 \text{ m}$ demonstrates the commutative law of addition.

68. The first tank leaks $12\frac{\text{L}}{\text{h}}(7 \text{ h}) = 84 \text{ L}$ .The second tank leaks $7\frac{\text{L}}{\text{h}}(12\text{h}) = 84\text{L}$.
$12 \times 7 = 7 \times 12$ demonstrates the commutative law of multiplication.

69. The total time spent browsing these websites is the total time spent browsing the first site on each day + the total time spent browsing the second site on each day
$t = 7 \text{ days} \times 25 \frac{\text{minutes}}{\text{day}} + 7 \text{ days} \times 15 \frac{\text{minutes}}{\text{day}}$
$t = 175 \text{ min} + 105 \text{ min}$
$t = 280$ min
OR
$t = 7 \text{ days} \times (25 + 15) \frac{\text{minutes}}{\text{day}}$
$t = 7 \text{ days} \times 40 \frac{\text{minutes}}{\text{day}}$
$t = 280$ min
which illustrates the distributive law.

70. Distance = rate × time

$$d = \quad 600\frac{\text{km}}{\text{h}} + 50\frac{\text{km}}{\text{h}} \quad 3\text{ h}$$

$$d = 600\frac{\text{km}}{\text{h}}(3\text{h}) + 50\frac{\text{km}}{\text{h}}(3\text{h})$$

$$d = 1800\text{ km} + 150\text{ km} = 1950\text{ km}$$

OR

$$d = \quad 600\frac{\text{km}}{\text{h}} + 50\frac{\text{km}}{\text{h}} \quad 3\text{ h}$$

$$d = \quad 650\frac{\text{km}}{\text{h}} \quad 3\text{ h}$$

$$d = 1950\text{ km}$$

This illustrates the distributive law.

1.3 Calculators and Approximate Numbers

1. 0.390 has three significant digits since the zero is after the decimal. The zero is not necessary as a placeholder and should not be written unless it is significant.

2. 35.303 rounded off to four significant digits is 35.30.

3. In finding the product of the approximate numbers, $2.5 \times 30.5 = 76.25$, but since 2.5 has 2 significant digits, the answer is 76.

4. $38.3 - 21.9(-3.58) = 116.702$ using exact numbers; if we estimate the result, $40 - 20(-4) = 120$.

5. 8 cylinders is exact because they can be counted. 55 km/h is approximate since it is measured.

6. 0.002 mm thick is a measurement and is therefore an approximation. $7.50 is an exact price.

7. 24 hr and 1440 min (60 min/h × 24 h =1140 min) are both exact numbers.

8. 50 keys is exact because you can count them; 50 h of use is approximate since it is a measurement of time.

9. Both 1 cm and 9 g are measured quantities and so they are approximate.

10. The numbers 90 and 75 are exact counts of windows while 15 years is a measurement of time, hence it is approximate.

11. 107 has 3 significant digits; 3004 has 4 significant digits; 1040 has 3 significant digits (the final zero is a placeholder.)

12. 3600 has 2 significant digits; 730 has 2 significant digits; 2055 has 4 significant digits.

13. 6.80 has 3 significant digits since the zero indicates precision; 6.08 has 3 significant digits; 0.068 has 2 significant digits (the zeros are placeholders.)

14. 0.8730 has 4 significant digits; 0.0075 has 2 significant digits; 0.0305 has 3 significant digits.

15. 3000 has 1 significant digit; 3000.1 has 5 significant digits; 3000.10 has 6 significant digits.

16. 1.00 has 3 significant digits since the zeros indicate precision; 0.01 has 1 significant digit since leading zeros are not significant; 0.0100 has 3 significant digits, counting the trailing zeros.

17. 5000 has 1 significant digit; 5000.0 has 5 significant digits; $500\bar{0}$ has 4 significant digits since the bar over the final zero indicates that it is significant.

18. 200 has 1 significant digit; $20\bar{0}$ has 3 significant digits; 200.00 has 5 significant digits.

19. **(a)** 0.010 has more decimal places (3) and is more precise.
(b) 30.8 has more significant digits (3) and is more accurate.

20. **(a)** Both 0.041 and 7.673 have the same precision as they have the same number of decimal places (3).
(b) 7.673 is more accurate because it has more significant digits (4) than 0.041, which has 2 significant digits.

21. **(a)** Both 0.1 and 78.0 have the same precision as they have the same number of decimal places.
(b) 78.0 is more accurate because it has more significant digits (3) than 0.1, which has 1 significant digit.

22. **(a)** 0.004 is more precise because it has more decimal places (3).
(b) 7040 is more accurate because it has more significant digits (3) than 0.004, which has only 1 significant digit.

23. **(a)** 0.004 is more precise because it has more decimal places (3).
(b) Both have the same accuracy as they both have 1 significant digit.

24. The precision and accuracy of $|-8.914|$ and 8.914 are the same.
(a) Both 50.060 and 8.914 have the same precision as they have the same number of decimal places (3).
(b) 50.060 is more accurate because it has more significant digits (5) than 8.914, which has 4 significant digits.

25. **(a)** 4.936 rounded to 3 significant digits is 4.94.
(b) 4.936 rounded to 2 significant digits is 4.9.

26. **(a)** 80.53 rounded to 3 significant digits is 80.5.
(b) 80.53 rounded to 2 significant digits is 81.

27. **(a)** -50.893 rounded to 3 significant digits is -50.9.
(b) -50.893 rounded to 2 significant digits is -51.

28. **(a)** 7.004 rounded to 3 significant digits is 7.00.
(b) 7.004 rounded to 2 significant digits is 7.0.

29. **(a)** 5968 rounded to 3 significant digits is 5970.
(b) 5968 rounded to 2 significant digits is $6\bar{0}00$.

30. **(a)** 30.96 rounded to 3 significant digits is 31.0.
(b) 30.96 rounded to 2 significant digits is 31.

31. **(a)** 0.9449 rounded to 3 significant digits is 0.945.
(b) 0.9449 rounded to 2 significant digits is 0.94.

32. **(a)** 0.9999 rounded to 3 significant digits is 1.00.
(b) 0.9999 rounded to 2 significant digits is 1.0.

33. **(a)** Estimate: $13+1-2=12$
(b) Calculator: $12.78+1.0495-1.633=12.1965$, which is 12.20 to 0.01 precision

34. **(a)** Estimate: $4\times 17=68$
(b) Calculator: $3.64(17.06)=62.0984$, which is 62.1 to 3 significant digits

35. **(a)** Estimate $0.7\times 4-9=-6$
(b) Calculator: $0.6572\times 3.94-8.651=-6.061632$, which is -6.06 to 3 significant digits

36. **(a)** Estimate $40-26\div 4=40-6.5=34$
(b) Calculator: $41.5-26.4\div 3.7=34.3648649$, which is 34 to 2 significant digits

37. **(a)** Estimate $9+(1)(4)=9+4=13$
(b) Calculator: $8.75+(1.2)(3.84)=13.358$, which is 13 to 2 significant digits

38. **(a)** Estimate $30-\dfrac{20}{2}=30-10=20$
(b) Calculator: $28-\dfrac{20.955}{2.2}=18.475$, which is 18 to 2 significant digits

39. **(a)** Estimate $\dfrac{9(15)}{9+15}=\dfrac{135}{24}=6$, to 1 significant digit
(b) Calculator: $\dfrac{8.75(15.32)}{8.75+15.32}=5.569173$, which is 5.57 to 3 significant digits

40. **(a)** Estimate $\dfrac{9(4)}{2+5}=\dfrac{36}{7}=5$, to 1 significant digit
(b) Calculator: $\dfrac{8.97(4.003)}{2.0+4.78}=5.296$, which is 5.3 to 2 significant digits

41. **(a)** Estimate $4.5-\dfrac{2(300)}{400}=3.0$, to 2 significant digits
(b) Calculator: $4.52-\dfrac{2.056(309.6)}{395.2}=2.9093279$, which is 2.91 to 3 significant digits

42. **(a)** Estimate $8+\dfrac{15}{2+2}=12$, to 2 significant digits
(b) Calculator: $8.195+\dfrac{14.9}{1.7+2.1}=12.1160526$, which is 12 to 2 significant digits

43. $0.9788+14.9=15.8788$ since the least precise number in the question has 4 decimal places.

44. $17.311-22.98=-5.669$ since the least precise number in the question has 3 decimal places.

45. $-3.142(65)=-204.23$, which is -204.2 because the least accurate number has 4 significant digits.

46. $8.62\div 1728=0.004988$, which is 0.00499 because the least accurate number has 3 significant digits.

47. With a frequency listed as 2.75 MHz, the least possible frequency is 2.745 MHz, and the greatest possible frequency is 2.755 MHz. Any measurements between those limits would round to 2.75 MHz.

48. For an engine displacement stated at 2400 cm^3, the least possible displacement is 2350 cm^3, and the greatest possible displacement is 2450 cm^3. Any measurements between those limits would round to 2400 cm^3.

49. The speed of sound is $3.25 \text{ mi} \div 15 \text{ s} = 0.21666... \text{ mi/s} = 1144.0... \text{ ft/s}$. However, the least accurate measurement was time since it has only 2 significant digits. The correct answer is 1100 ft/s.

50. $4.4 \text{ s} - 2.72 \text{ s} = 1.68 \text{ s}$, but the answer must be given according to precision of the least precise measurement in the question, so the correct answer is 1.7 s.

51. **(a)** $2.2 + 3.8 \times 4.5 = 2.2 + (3.8 \times 4.5) = 19.3$
(b) $(2.2 + 3.8) \times 4.5 = 6.0 \times 4.5 = 27$

52. **(a)** $6.03 \div 2.25 + 1.77 = (6.03 \div 2.25) + 1.77 = 4.45$
(b) $6.03 \div (2.25 + 1.77) = 6.03 \div 4.02 = 1.5$

53. **(a)** $2 + 0 = 2$
(b) $2 - 0 = 2$
(c) $0 - 2 = -2$
(d) $2 \times 0 = 0$
(e) $2 \div 0 =$ error; from Section 1.2, an equation that has 0 in the denominator is undefined when the numerator is not also 0.

54. **(a)** $2 \div 0.0001 = 20\ 000$; $2 \div 0 =$ error
(b) $0.0001 \div 0.0001 = 1$; $0 \div 0 =$ error
(c) Any number divided by zero is undefined. Zero divided by zero is indeterminate.

55. $\pi = 3.14159265...$
(a) $\pi < 3.1416$
(b) $22 \div 7 = 3.1428$
$\pi < (22 \div 7)$

56. **(a)** $8 \div 33 = 0.2424... = 0.\overline{24}$
(b) $\pi = 3.14159265...$

57. **(a)** $1 \div 3 = 0.333...$ It is a rational number since it is a repeating decimal.
(b) $5 \div 11 = 0.454545...$ It is a rational number since it is a repeating decimal.
(c) $2 \div 5 = 0.400...$ It is a rational number since it is a repeating decimal (0 is the repeating part).

58. $124 \div 990 = 0.12525....$ the calculator may show the answer as 0.1252525253 because it has rounded up for the next 5 that doesn't fit on the screen.

59. $32.4 \text{ MJ} + 26.704 \text{ MJ} + 36.23 \text{ MJ} = 95.334 \text{ MJ}$. The answer must be to the same precision as the least precise measurement. The answer is 95.3 MJ.

60. We would compute $8(68.6) + 5(15.3) = 625.3$ and round to three significant digits for a total weight of 625 lb. The values 8 and 5 are exact.

61. We would compute $12(129) + 16(298.8) = 6328.8$ and round to three significant digits for a total weight of 6330 g. The values 12 and 16 are exact.

62. $V = (15.2\ \Omega + 5.64\ \Omega + 101.23\ \Omega) \times 3.55 \text{ A}$
$V = 122.07\ \Omega \times 3.55 \text{ A}$
$V = 433.3485 \text{ V}$
$V = 433 \text{ V}$ to 3 significant digits