Complete Solutions Manual

Precalculus Functions and Graphs

THIRTEENTH EDITION

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Preface

This manual contains solutions/answers to all exercises in the text *Precalculus: Functions and Graphs, Thirteenth Edition*, by Earl W. Swokowski and Jeffery A. Cole. A *Student's Solutions Manual* is also available; it contains solutions for the odd-numbered exercises in each section and for the Discussion Exercises, as well as solutions for all the exercises in the Review Sections and for the Chapter Tests.

For most problems, a reasonably detailed solution is included. It is my hope that by merely browsing through the solutions, professors will save time in determining appropriate assignments for their particular class.

I appreciate feedback concerning errors, solution correctness or style, and manual style—comments from professors using previous editions have greatly strengthened the ancillary package as well as the text. Any comments may be sent directly to me at jeff-cole@comcast.net.

I would like to thank: Marv Riedesel and Mary Johnson for accuracy checking of the new exercises; Andrew Bulman-Fleming, for manuscript preparation; Brian Morris and the late George Morris, of Scientific Illustrators, for creating the mathematically precise art package; and Laura Gallus, of Cengage Learning, for checking the manuscript. I dedicate this manual to Carly, Eli, and Mason, my grandchildren.

Jeffery A. Cole

Table of Contents

To the Instructor

In the chapter review sections, the solutions are abbreviated since more detailed solutions were given in chapter sections. In easier groups of exercises, representative solutions are shown. When appropriate, only the answer is listed.

All figures have been plotted using computer software, offering a high degree of precision. The calculator graphs are from various TI screens. When possible, we tried to make each piece of art with the same scale to show a realistic and consistent graph.

This manual was prepared using $\mathbb{EXP}$: *The Scientific Word Processor*.

The following notations are used in the manual.

Note: Notes to the instructor/student pertaining to hints on instruction or conventions to follow.

{ }	{ comments to the reader are in braces }
LS	{ Left Side of an equation }
RS	{ Right Side of an equation }
$\Rightarrow$	{ implies, next equation, logically follows }
$\Leftrightarrow$	{ if and only if, is equivalent to }
•	{ bullet, used to separate problem statement from solution or explanation }
★	{ used to identify the answer to the problem }
§	{ *section* references }
$\forall$	{ Example: $\forall x$ means "for all x" }
$\mathbb{R} - \{a\}$	{ The set of all real numbers except a. }
$\therefore$	{ therefore }
QI–QIV	{ quadrants I, II, III, IV }

Chapter 1: Fundamental Concepts of Algebra

1.1 Exercises

1 **(a)** Since x and y have opposite signs, the product xy is negative.

(b) Since $x^2 > 0$ and $y > 0$, the product x^2y is positive.

(c) Since $x < 0$ $\{x$ is negative$\}$ and $y > 0$ $\{y$ is positive$\}$, the quotient $\dfrac{x}{y}$ is negative.

Thus, $\dfrac{x}{y} + x$ is the sum of two negatives, which is negative.

(d) Since $y > 0$ and $x < 0$, $y - x > 0$.

2 **(a)** Since x and y have opposite signs, the quotient $\dfrac{x}{y}$ is negative.

(b) Since $x < 0$ and $y^2 > 0$, the product xy^2 is negative.

(c) Since $x - y < 0$ and $xy < 0$, $\dfrac{x-y}{xy} > 0$.

(d) Since $y > 0$ and $y - x > 0$, $y(y - x) > 0$.

3 **(a)** Since -7 is to the left of -4 on a coordinate line, $-7 \boxed{<} -4$.

(b) Using a calculator, we see that $\frac{\pi}{2} \approx 1.57$. Hence, $\frac{\pi}{2} \boxed{>} 1.5$.

(c) $\sqrt{225} \boxed{=} 15$ ***Note:*** $\sqrt{225} \neq \pm 15$

4 **(a)** Since -3 is to the right of -6 on a coordinate line, $-3 \boxed{>} -6$.

(b) Using a calculator, we see that $\frac{\pi}{4} \approx 0.79$. Hence, $\frac{\pi}{4} \boxed{<} 0.8$.

(c) $\sqrt{289} \boxed{=} 17$ ***Note:*** $\sqrt{289} \neq \pm 17$

5 **(a)** Since $\frac{1}{11} = 0.\overline{09} = 0.0909\ldots$, $\frac{1}{11} \boxed{>} 0.09$.

(b) Since $\frac{2}{3} = 0.\overline{6} = 0.6666\ldots$, $\frac{2}{3} \boxed{>} 0.666$.

(c) Since $\frac{22}{7} = 3.\overline{142857}$ and $\pi \approx 3.141593$, $\frac{22}{7} \boxed{>} \pi$.

6 **(a)** Since $\frac{1}{7} = 0.\overline{142857}$, $\frac{1}{7} \boxed{<} 0.143$.

(b) Since $\frac{5}{6} = 0.8\overline{3} = 0.8333\ldots$, $\frac{5}{6} \boxed{>} 0.833$.

(c) Since $\sqrt{2} \approx 1.414$, $\sqrt{2} \boxed{>} 1.4$.

7 **(a)** "x is negative" is equivalent to $x < 0$. We symbolize this by writing "x is negative $\Leftrightarrow$ $x < 0$."

(b) y is nonnegative $\Leftrightarrow$ $y \geq 0$

(c) q is less than or equal to π $\Leftrightarrow$ $q \leq \pi$

(d) d is between 4 and 2 $\Leftrightarrow$ $2 < d < 4$

(e) t is not less than 5 $\Leftrightarrow$ $t \geq 5$

(f) The negative of z is not greater than 3 $\Leftrightarrow$ $-z \leq 3$

(g) The quotient of p and q is at most 7 $\Leftrightarrow$ $\dfrac{p}{q} \leq 7$

(h) The reciprocal of w is at least 9 $\Leftrightarrow$ $\dfrac{1}{w}$ 9

(i) The absolute value of x is greater than 7 $\Leftrightarrow$ $|x| > 7$

Note: An informal definition of absolute value that may be helpful is

$$|\textit{something}| = \begin{cases} \textit{itself} & \text{if } \textit{itself} \text{ is positive or zero} \\ -(\textit{itself}) & \text{if } \textit{itself} \text{ is negative} \end{cases}$$

8 **(a)** b is positive $\Leftrightarrow$ $b > 0$

(b) s is nonpositive $\Leftrightarrow$ $s \leq 0$

(c) w is greater than or equal to -4 $\Leftrightarrow$ $w \geq -4$

(d) c is between $\frac{1}{5}$ and $\frac{1}{3}$ $\Leftrightarrow$ $\frac{1}{5} < c < \frac{1}{3}$

(e) p is not greater than -2 $\Leftrightarrow$ $p \leq -2$

(f) The negative of m is not less than -2 $\Leftrightarrow$ $-m \geq -2$

(g) The quotient of r and s is at least $\frac{1}{5}$ $\Leftrightarrow$ $\frac{r}{s} \quad \frac{1}{5}$

(h) The reciprocal of f is at most 14 $\Leftrightarrow$ $\frac{1}{f} \leq 14$

(i) The absolute value of x is less than 4 $\Leftrightarrow$ $|x| < 4$

9 **(a)** $|-3-4| = |-7| = -(-7)$ {since $-7 < 0$} $= 7$

(b) $|-5| - |2| = -(-5) - 2 = 5 - 2 = 3$

(c) $|7| + |-4| = 7 + [-(-4)] = 7 + 4 = 11$

10 **(a)** $|-11+1| = |-10| = -(-10)$ { since $-10 < 0$ } $= 10$

(b) $|6| - |-3| = 6 - [-(-3)] = 6 - 3 = 3$

(c) $|8| + |-9| = 8 + [-(-9)] = 8 + 9 = 17$

11 **(a)** $(-5)|3-6| = (-5)|-3| = (-5)[-(-3)] = (-5)(3) = -15$

(b) $|-6|/(-2) = -(-6)/(-2) = 6/(-2) = -3$

(c) $|-7| + |4| = -(-7) + 4 = 7 + 4 = 11$

12 **(a)** $(4)|6-7| = (4)|-1| = (4)[-(-1)] = (4)(1) = 4$

(b) $5/|-2| = 5/[-(-2)] = 5/2$

(c) $|-1| + |-9| = -(-1) + [-(-9)] = 1 + 9 = 10$

13 **(a)** Since $(4 - \pi)$ is positive, $|4 - \pi| = 4 - \pi$.

(b) Since $(\pi - 4)$ is negative, $|\pi - 4| = -(\pi - 4) = 4 - \pi$.

(c) Since $\left(\sqrt{2} - 1.5\right)$ is negative, $\left|\sqrt{2} - 1.5\right| = -\left(\sqrt{2} - 1.5\right) = 1.5 - \sqrt{2}$.

14 **(a)** Since $\left(\sqrt{3} - 1.7\right)$ is positive, $\left|\sqrt{3} - 1.7\right| = \sqrt{3} - 1.7$.

(b) Since $\left(1.7 - \sqrt{3}\right)$ is negative, $\left|1.7 - \sqrt{3}\right| = -\left(1.7 - \sqrt{3}\right) = \sqrt{3} - 1.7$.

(c) $\left|\frac{1}{5} - \frac{1}{3}\right| = \left|\frac{3}{15} - \frac{5}{15}\right| = \left|-\frac{2}{15}\right| = -\left(-\frac{2}{15}\right) = \frac{2}{15}$

15 **(a)** $d(A, B) = |7 - 3| = |4| = 4$

(b) $d(B, C) = |-5 - 7| = |-12| = 12$

(c) $d(C, B) = d(B, C) = 12$

(d) $d(A, C) = |-5 - 3| = |-8| = 8$

16 **(a)** $d(A, B) = |-2 - (-6)| = |4| = 4$

(b) $d(B, C) = |4 - (-2)| = |6| = 6$

(c) $d(C, B) = d(B, C) = 6$

(d) $d(A, C) = |4 - (-6)| = |10| = 10$

17 **(a)** $d(A, B) = |1 - (-9)| = |10| = 10$

(b) $d(B, C) = |10 - 1| = |9| = 9$

(c) $d(C, B) = d(B, C) = 9$

(d) $d(A, C) = |10 - (-9)| = |19| = 19$

18 **(a)** $d(A, B) = |-4 - 8| = |-12| = 12$

(b) $d(B, C) = |-1 - (-4)| = |3| = 3$

(c) $d(C, B) = d(B, C) = 3$

(d) $d(A, C) = |-1 - 8| = |-9| = 9$

Note: Because $|a| = |-a|$, the answers to Exercises 19–24 could have a different form. For example, $|-3 - x| \geq 8$ is equivalent to $|x + 3| \geq 8$.

19 $A = x$ and $B = 7$, so $d(A, B) = |7 - x|$. Thus, "$d(A, B)$ is less than 2" can be written as $|7 - x| < 2$.

20 $d(A, B) = \left|-\sqrt{2} - x\right| \quad\Rightarrow\quad \left|-\sqrt{2} - x\right| > 1$

21 $d(A, B) = |-3 - x| \quad\Rightarrow\quad |-3 - x| \geq 8$

22 $d(A, B) = |4 - x| \quad\Rightarrow\quad |4 - x| \leq 5$

23 $d(A, B) = |x - 4| \quad\Rightarrow\quad |x - 4| \leq 3$

24 $d(A, B) = |x - (-2)| = |x + 2| \quad\Rightarrow\quad |x + 2| \geq 4$

Note: In Exercises 25–32, you may want to substitute a permissible value for the variable to first test if the expression inside the absolute value symbol is positive or negative.

25 Pick an arbitrary value for x that is less than -3, say -5.
Since $3 + (-5) = -2$ is negative, we conclude that if $x < -3$, then $3 + x$ is negative.
Hence, $|3 + x| = -(3 + x) = -x - 3$.

26 If $x > 5$, then $5 - x < 0$, and $|5 - x| = -(5 - x) = x - 5$.

27 If $x < 2$, then $2 - x > 0$, and $|2 - x| = 2 - x$.

28 If $x \geq -7$, then $7 + x \geq 0$, and $|7 + x| = 7 + x$.

29 If $a < b$, then $a - b < 0$, and $|a - b| = -(a - b) = b - a$.

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

31 Since $x^2 + 4 > 0$ for every x, $|x^2 + 4| = x^2 + 4$.

32 Since $-x^2 - 1 < 0$ for every x, $|-x^2 - 1| = -(-x^2 - 1) = x^2 + 1$.

33 $\text{LS} = \dfrac{ab + ac}{a} = \dfrac{ab}{a} + \dfrac{ac}{a} = b + c \boxed{\neq} \text{RS}$ (which is $b + ac$).

34 $\text{LS} = \dfrac{ab + ac}{a} = \dfrac{ab}{a} + \dfrac{ac}{a} = b + c \boxed{=} \text{RS}$.

35 $\text{LS} = \dfrac{b + c}{a} = \dfrac{b}{a} + \dfrac{c}{a} \boxed{=} \text{RS}$.

36 $\text{LS} = \dfrac{a + c}{b + d} = \dfrac{a}{b + d} + \dfrac{c}{b + d} \boxed{\neq} \text{RS} \left(\text{which is } \dfrac{a}{b} + \dfrac{c}{d}\right)$.

37 $\text{LS} = (a \div b) \div c = \dfrac{a}{b} \cdot \dfrac{1}{c} = \dfrac{a}{bc}$. $\text{RS} = a \div (b \div c) = a \div \dfrac{b}{c} = a \cdot \dfrac{c}{b} = \dfrac{ac}{b}$. $\text{LS} \boxed{\neq} \text{RS}$

38 $\text{LS} = (a - b) - c = a - b - c$. $\text{RS} = a - (b - c) = a - b + c$. $\text{LS} \boxed{\neq} \text{RS}$

39 $\text{LS} = \dfrac{a - b}{b - a} = \dfrac{-(b - a)}{b - a} = -1 \boxed{=} \text{RS}$.

40 $\text{LS} = -(a + b) = -a - b \boxed{\neq} \text{RS}$ (which is $-a + b$).

41 **(a)** On the TI-83/4 Plus, the absolute value function is choice 1 under MATH, NUM.
Enter abs(3.2^2-$\sqrt{}$(4.27)). $\left|3.2^2 - \sqrt{4.27}\right| \approx 8.1736$

(b) $\sqrt{(15.6 - 1.5)^2 + (4.3 - 5.4)^2} \approx 14.1428$

42 **(a)** $\dfrac{3.42 - 1.29}{5.83 + 2.64} \approx 0.2515$

(b) $\pi^3 \approx 31.0063$

43 **(a)** $\dfrac{1.2 \times 10^3}{3.1 \times 10^2 + 1.52 \times 10^3} \approx 0.6557 = 6.557 \times 10^{-1}$

Note: For the TI-83/4 Plus, use 1.2E3/(3.1E2 + 1.52E3), where E is obtained by pressing [2nd] [EE].

(b) $\left(1.23 \times 10^{-4}\right) + \sqrt{4.5 \times 10^3} \approx 67.08 = 6.708 \times 10^1$

44 **(a)** $\sqrt{|3.45 - 1.2 \times 10^4| + 10^5} \approx 334.7 = 3.347 \times 10^2$

(b) $(1.79 \times 10^2) \times (9.84 \times 10^3) = 1{,}761{,}360 \approx 1.761 \times 10^6$

45 Construct a right triangle with sides of lengths $\sqrt{2}$ and 1. The hypotenuse will have length $\sqrt{\left(\sqrt{2}\right)^2 + 1^2} = \sqrt{3}$. Next construct a right triangle with sides of lengths $\sqrt{3}$ and $\sqrt{2}$. The hypotenuse will have length $\sqrt{\left(\sqrt{3}\right)^2 + \left(\sqrt{2}\right)^2} = \sqrt{5}$.

46 Use $C = 2\pi r$ with $r = 1$, 2, and 10 to obtain 2π, 4π, and 20π units from the origin.

47 The large rectangle has area $=$ width $\times$ length $= a(b+c)$. The sum of the areas of the two small rectangles is $ab + ac$. Since the areas are the same, we have $a(b+c) = ab + ac$.

48 $x_1 = \dfrac{3}{2}$ and $n = 2 \Rightarrow x_2 = \dfrac{1}{2}\left(x_1 + \dfrac{n}{x_1}\right) = \dfrac{1}{2}\left(\dfrac{3}{2} + \dfrac{2}{\frac{3}{2}}\right) = \dfrac{1}{2}\left(\dfrac{3}{2} + \dfrac{4}{3}\right) = \dfrac{1}{2}\left(\dfrac{17}{6}\right) = \dfrac{17}{12}$.

$$x_3 = \frac{1}{2}\left(x_2 + \frac{2}{x_2}\right) = \frac{1}{2}\left(\frac{17}{12} + \frac{2}{\frac{17}{12}}\right) = \frac{1}{2}\left(\frac{17}{12} + \frac{24}{17}\right) = \frac{1}{2}\left(\frac{577}{204}\right) = \frac{577}{408}$$

49 **(a)** Since the decimal point is 5 places to the right of the first nonzero digit, $427{,}000 = 4.27 \times 10^5$.

(b) Since the decimal point is 8 places to the left of the first nonzero digit, $0.000\,000\,093 = 9.3 \times 10^{-8}$.

(c) Since the decimal point is 8 places to the right of the first nonzero digit, $810{,}000{,}000 = 8.1 \times 10^8$.

50 **(a)** $85{,}200 = 8.52 \times 10^4$ **(b)** $0.000\,005\,4 = 5.4 \times 10^{-6}$

(c) $24{,}900{,}000 = 2.49 \times 10^7$

51 **(a)** Moving the decimal point 5 places to the right, we have $8.3 \times 10^5 = 830{,}000$.

(b) Moving the decimal point 12 places to the left, we have $2.9 \times 10^{-12} = 0.000\,000\,000\,002\,9$.

(c) Moving the decimal point 8 places to the right, we have $5.64 \times 10^8 = 564{,}000{,}000$.

52 **(a)** $2.3 \times 10^7 = 23{,}000{,}000$ **(b)** $7.01 \times 10^{-9} = 0.000\,000\,007\,01$

(c) $1.25 \times 10^{10} = 12{,}500{,}000{,}000$

53 Since the decimal point is 24 places to the left of the first nonzero digit,

$$0.000\,000\,000\,000\,000\,000\,000\,001\,7 = 1.7 \times 10^{-24}.$$

54 $9.1 \times 10^{-31} = 0.000\,000\,000\,000\,000\,000\,000\,000\,000\,000\,91$

55 It is helpful to write the units of any fraction, and then "cancel" those units to determine the units of the final answer. $\dfrac{186{,}000 \text{ miles}}{\text{second}} \cdot \dfrac{60 \text{ seconds}}{1 \text{ minute}} \cdot \dfrac{60 \text{ minutes}}{1 \text{ hour}} \cdot \dfrac{24 \text{ hours}}{1 \text{ day}} \cdot \dfrac{365 \text{ days}}{1 \text{ year}} \cdot 1 \text{ year} \approx 5.87 \times 10^{12}$ mi

56 **(a)** 100 billion $= 100{,}000{,}000{,}000 = 1 \times 10^{11}$

(b) $d \approx (100{,}000 \text{ yr})\left(5.87 \times 10^{12} \dfrac{\text{mi}}{\text{yr}}\right) = 5.87 \times 10^{17}$ mi

57 $\dfrac{\dfrac{1.01 \text{ grams}}{\text{mole}}}{\dfrac{6.02 \times 10^{23} \text{ atoms}}{\text{mole}}} \cdot 1 \text{ atom} = \dfrac{1.01 \text{ grams}}{6.02 \times 10^{23}} \approx 0.1678 \times 10^{-23} \text{ g} = 1.678 \times 10^{-24} \text{ g}$

58 $(2.5 \text{ million})(0.00035\%) = (2.5 \times 10^6)(3.5 \times 10^{-6}) = 8.75 \approx 9$ halibut

59 $\dfrac{24 \text{ frames}}{\text{second}} \cdot \dfrac{60 \text{ seconds}}{1 \text{ minute}} \cdot \dfrac{60 \text{ minutes}}{1 \text{ hour}} \cdot 48 \text{ hours} = 4.1472 \times 10^6$ frames

60 $\dfrac{2 \times 10^{11} \text{ calculations}}{\text{second}} \cdot \dfrac{60 \text{ seconds}}{1 \text{ minute}} \cdot \dfrac{60 \text{ minutes}}{1 \text{ hour}} \cdot \dfrac{24 \text{ hours}}{1 \text{ day}} \cdot 60 \text{ days} = 1.0368 \times 10^{18}$ calculations

61 **(a)** $1 \text{ ft}^2 = 144 \text{ in}^2$, so the force on one square foot of a wall is $144 \text{ in}^2 \times 1.4 \text{ lb/in}^2 = 201.6$ lb.

(b) The area of the wall is $40 \times 8 = 320 \text{ ft}^2$, or $320 \text{ ft}^2 \times 144 \text{ in}^2/\text{ft}^2 = 46{,}080 \text{ in}^2$.

The total force is $46{,}080 \text{ in}^2 \times 1.4 \text{ lb/in}^2 = 64{,}512$ lb.

Converting to tons, we have $64{,}512 \text{ lb}/(2000 \text{ lb/ton}) = 32.256$ tons.

62 **(a)** We start with 400 adults, 150 yearlings, and 200 calves {total = 750}

Number of Adults = surviving adults + surviving yearlings
$= (0.90)(400) + (0.80)(150) = \underline{480}$

Number of Yearlings = surviving calves
$= (0.75)(200) = \underline{150}$

Number of Calves = number of female adults
$= (0.50)(480) = \underline{240}$

(b) 75% of last spring's calves equal the number of this year's yearlings (150), so the number of calves is $\underline{200}$.

The number of calves is equal to the number of adult females and this is one-half of the number of adults, so the number of adults is $\underline{400}$.

90% of these (360) are part of the 400 adults this year.

The other 40 adults represent 80% of last year's yearlings, so the number of yearlings is $\underline{50}$.

1.2 Exercises

1 $\left(-\frac{2}{3}\right)^4 = \left(-\frac{2}{3}\right) \cdot \left(-\frac{2}{3}\right) \cdot \left(-\frac{2}{3}\right) \cdot \left(-\frac{2}{3}\right) = \frac{16}{81}$

Note: Do not confuse $(-x)^4$ and $-x^4$ since $(-x)^4 = x^4$ and $-x^4$ is the negative of x^4.

2 $(-3)^3 = -27 = \frac{-27}{1}$

3 $\dfrac{2^{-3}}{3^{-2}} = \dfrac{3^2}{2^3} = \dfrac{9}{8}$

Note: Remember that negative exponents don't necessarily give negative results—that is, $2^{-3} = \dfrac{1}{2^3} = \dfrac{1}{8}$, not $-\dfrac{1}{8}$.

4 $\dfrac{2^0 + 0^2}{2 + 0} = \dfrac{1 + 0}{2} = \dfrac{1}{2}$

5 $-2^4 + 3^{-1} = -16 + \frac{1}{3} = -\frac{48}{3} + \frac{1}{3} = -\frac{47}{3}$

6 $\left(-\frac{3}{2}\right)^4 - 2^{-4} = \frac{81}{16} - \frac{1}{16} = \frac{80}{16} = \frac{5}{1}$

7 $9^{5/2} = \left(\sqrt{9}\right)^5 = 3^5 = \frac{243}{1}$

8 $16^{-3/4} = 1/16^{3/4} = 1/\left(\sqrt[4]{16}\right)^3 = 1/2^3 = \frac{1}{8}$

9 $(-0.008)^{2/3} = \left(\sqrt[3]{-0.008}\right)^2 = (-0.2)^2 = 0.04 = \frac{4}{100} = \frac{1}{25}$

10 $(0.008)^{-2/3} = 1/(0.008)^{2/3} = 1/\left(\sqrt[3]{0.008}\right)^2 = 1/(0.2)^2 = 1/(0.04) = \frac{25}{1}$

11 $\left(\frac{1}{2}x^4\right)(16x^5) = \left(\frac{1}{2} \cdot 16\right)x^{4+5} = 8x^9$

12 $(-3x^{-2})\left(4x^4\right) = (-3 \cdot 4)x^{-2+4} = -12x^2$

13 A common mistake is to write $x^3x^2 = x^6$, and another is to write $(x^2)^3 = x^5$.

The following solution illustrates the proper use of the exponent rules.

$$\frac{(2x^3)(3x^2)}{(x^2)^3} = \frac{(2 \cdot 3)x^{3+2}}{x^{2\cdot 3}} = \frac{6x^5}{x^6} = 6x^{5-6} = 6x^{-1} = \frac{6}{x}$$

14 $\dfrac{(2x^2)^3y^2}{4x^4y^2} = \dfrac{8x^6}{4x^4} = 2x^2$

15 $\left(\frac{1}{6}a^5\right)(-3a^2)\left(4a^7\right) = \frac{1}{6} \cdot (-3) \cdot 4 \cdot a^{5+2+7} = -2a^{14}$

16 $(-4b^3)\left(\frac{1}{6}b^2\right)\left(-9b^4\right) = (-4) \cdot \frac{1}{6} \cdot (-9) \cdot b^{3+2+4} = 6b^9$

17 $\dfrac{(6x^3)^2}{(2x^2)^3} \cdot \left(3x^2\right)^0 = \dfrac{6^2x^{3\cdot 2}}{2^3x^{2\cdot 3}} \cdot 1$ {an expression raised to the zero power is equal to 1} $= \dfrac{36x^6}{8x^6} = \dfrac{36}{8} = \dfrac{9}{2}$

18 $\dfrac{(3y^3)(2y^2)^2}{(y^4)^3} \cdot \left(5y^3\right)^0 = \dfrac{(3y^3)\left(4y^4\right)}{y^{12}} \cdot 1 = \dfrac{12y^7}{y^{12}} = \dfrac{12}{y^5}$

19 $\left(3u^7v^3\right)\left(4u^4v^{-5}\right) = 12u^{7+4}v^{3+(-5)} = 12u^{11}v^{-2} = \dfrac{12u^{11}}{v^2}$

20 $(x^2yz^3)(-2xz^2)(x^3y^{-2}) = -2x^{2+1+3}y^{1-2}z^{3+2} = -2x^6y^{-1}z^5 = \dfrac{-2x^6z^5}{y}$

21 $\left(8x^4y^{-3}\right)\left(\frac{1}{2}x^{-5}y^2\right) = 4x^{4-5}y^{-3+2} = 4x^{-1}y^{-1} = \dfrac{4}{xy}$

22 $\left(\dfrac{4a^2b}{a^3b^2}\right)\left(\dfrac{5a^2b}{2b^4}\right) = \dfrac{20a^{2+2}b^{1+1}}{2a^3b^{2+4}} = \dfrac{20a^4b^2}{2a^3b^6} = \dfrac{10a^{4-3}b^{2-6}}{1} = \dfrac{10a}{b^4}$

23 $\left(\dfrac{1}{3}x^4y^{-3}\right)^{-2} = \left(\dfrac{1}{3}\right)^{-2}\left(x^4\right)^{-2}\left(y^{-3}\right)^{-2} = \left(\dfrac{3}{1}\right)^2 x^{-8}y^6 = 3^2x^{-8}y^6 = \dfrac{9y^6}{x^8}$

24 $(-2xy^2)^5\left(\dfrac{x^7}{8y^3}\right) = (-32x^5y^{10})\left(\dfrac{x^7}{8y^3}\right) = -4x^{12}y^7$

25 $(3y^3)^4(4y^2)^{-3} = 3^4y^{12} \cdot 4^{-3}y^{-6} = 81y^6 \cdot \dfrac{1}{4^3} = \dfrac{81}{64}y^6$

26 $(-3a^2b^{-5})^3 = -27a^6b^{-15} = -\dfrac{27a^6}{b^{15}}$

27 $\left(-2r^4s^{-3}\right)^{-2} = (-2)^{-2}r^{-8}s^6 = \dfrac{s^6}{(-2)^2r^8} = \dfrac{s^6}{4r^8}$

28 $(2x^2y^{-5})(6x^{-3}y)\left(\frac{1}{3}x^{-1}y^3\right) = 4x^{-2}y^{-1} = \dfrac{4}{x^2y}$

29 $(5x^2y^{-3})\left(4x^{-5}y^4\right) = 20x^{2-5}y^{-3+4} = 20x^{-3}y^1 = \dfrac{20y}{x^3}$

30 $(-2r^2s)^5(3r^{-1}s^3)^2 = (-32r^{10}s^5)(9r^{-2}s^6) = -288r^8s^{11}$

31 $\left(\dfrac{3x^5y^4z}{x^0y^{-3}z}\right)^2$ {remember that $x^0=1$, cancel z} $= \dfrac{9x^{10}y^8}{y^{-6}} = 9x^{10}y^{8-(-6)} = 9x^{10}y^{14}$

32 $(4a^2b)^4\left(\dfrac{-a^3}{2b}\right)^2 = \left(256a^8b^4\right)\left(\dfrac{a^6}{4b^2}\right) = 64a^{14}b^2$

33 $\left(-5a^{3/2}\right)\left(2a^{1/2}\right) = -5\cdot 2a^{(3/2)+(1/2)} = -10a^{4/2} = 8a^2$

34 $\left(-6x^{7/5}\right)\left(2x^{8/5}\right) = -6\cdot 2x^{(7/5)+(8/5)} = -12x^{15/5} = -12x^3$

35 $\left(3x^{5/6}\right)\left(8x^{2/3}\right) = 3\cdot 8x^{(5/6)+(4/6)} = 24x^{9/6} = 24x^{3/2}$

36 $(8r)^{1/3}\left(2r^{1/2}\right) = \left(2r^{1/3}\right)\left(2r^{1/2}\right) = 4r^{(2/6)+(3/6)} = 4r^{5/6}$

37 $(27a^6)^{-2/3} = 27^{-2/3}a^{-12/3} = \dfrac{a^{-4}}{27^{2/3}} = \dfrac{1}{\left(\sqrt[3]{27}\right)^2a^4} = \dfrac{1}{3^2\,a^4} = \dfrac{1}{9a^4}$

38 $\left(25z^4\right)^{-3/2} = 25^{-3/2}z^{-12/2} = \dfrac{z^{-6}}{25^{3/2}} = \dfrac{1}{\left(\sqrt{25}\right)^3z^6} = \dfrac{1}{5^3\,z^6} = \dfrac{1}{125z^6}$

39 $\left(8x^{-2/3}\right)x^{1/6} = 8x^{(-4/6)+(1/6)} = 8x^{-3/6} = \dfrac{8}{x^{1/2}}$

40 $\left(3x^{1/2}\right)\left(-2x^{5/2}\right) = -6x^{(1/2)+(5/2)} = -6x^3$

41 $\left(\dfrac{-8x^3}{y^{-6}}\right)^{2/3} = \dfrac{(-8)^{2/3}(x^3)^{2/3}}{(y^{-6})^{2/3}} = \dfrac{\left(\sqrt[3]{-8}\right)^2x^{(3)(2/3)}}{y^{(-6)(2/3)}} = \dfrac{(-2)^2x^2}{y^{-4}} = \dfrac{4x^2}{y^{-4}} = 4x^2y^4$

42 $\left(\dfrac{-y^{3/2}}{y^{-1/3}}\right)^3 = \dfrac{-y^{9/2}}{y^{-1}} = -y^{11/2}$

43 $\left(\dfrac{x^6}{16y^{-4}}\right)^{-1/2} = \dfrac{x^{-3}}{16^{-1/2}y^2} = \dfrac{16^{1/2}}{x^3y^2} = \dfrac{4}{x^3y^2}$

44 $\left(\dfrac{c^{-4}}{81d^8}\right)^{3/4} = \dfrac{c^{-3}}{\left(\sqrt[4]{81}\right)^3d^6} = \dfrac{c^{-3}}{3^3d^6} = \dfrac{1}{27c^3d^6}$

45 $\dfrac{(x^6y^3)^{-1/3}}{(x^4y^2)^{-1/2}} = \dfrac{(x^6)^{-1/3}(y^3)^{-1/3}}{(x^4)^{-1/2}(y^2)^{-1/2}} = \dfrac{x^{-2}y^{-1}}{x^{-2}y^{-1}} = 1$

46 $a^{4/3}a^{-3/2}a^{1/6} = a^{(8/6)-(9/6)+(1/6)} = a^{0/6} = a^0 = 1$

47 $\sqrt[4]{x^4+y} = \left(x^4+y\right)^{1/4}$

48 $\sqrt[3]{x^3+y^2} = (x^3+y^2)^{1/3}$

49 $\sqrt[3]{(a+b)^2} = \left[(a+b)^2\right]^{1/3} = (a+b)^{2/3}$

50 $\sqrt{a+\sqrt{b}} = \left(a+b^{1/2}\right)^{1/2}$

51 $\sqrt{x^2+y^2} = (x^2+y^2)^{1/2}$ ***Note:*** $\sqrt{x^2+y^2} \neq x+y$

52 $\sqrt[3]{r^3-s^3} = (r^3-s^3)^{1/3}$

53 **(a)** $4x^{3/2} = 4x^1x^{1/2} = 4x\sqrt{x}$ **(b)** $(4x)^{3/2} = (4x)^1(4x)^{1/2} = (4x)^1\,4^{1/2}x^{1/2} = 4x\cdot 2\cdot x^{1/2} = 8x\sqrt{x}$

54 **(a)** $4+x^{3/2} = 4+x^1x^{1/2} = 4+x\sqrt{x}$ **(b)** $(4+x)^{3/2} = (4+x)^1(4+x)^{1/2} = (4+x)\sqrt{4+x}$