CHAPTER 5

Exponents

CONTENTS

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1 REVISION

In this chapter, you will revise work on exponents that you have done in previous grades. You will extend the laws of exponents to include exponents that are negative numbers.

You will also solve simple equations in exponential form.

In Grade 8 you learnt about scientific notation.In this chapter we will extend the scientific notation to include very small numbers such as 0,0000123.

Example : Exponent Laws

Remember that exponents are a shorthand way of writing repeated multiplication of the same number by itself. For example: $5 \times 5 \times 5 = 5^3$.

The **exponent**, which is 3 in this example, stands for however many times the value is being multiplied.The number that is being multiplied, which is 5 in this example, is called the **base**.

If there are mixed operations, then the powers should be calculated before multi-plication and division. For example: $5^2 \times 3^2 = 25 \times 9$

You learnt these laws for working with exponents in previous grades:

Law	Example
$a^m \times a^n = a^{m+n}$	$3^2 \times 3^3 = 3^{2+3} = 3^5$
$a^m \div a^n = a^{m-n}$	$5^4 \div 5^2 = 5^{4-2} = 5^2$
$(a^m)^n = a^{m+n}$	$(2^3)^2 = 2^{3\times 2} = 2^6$
$(a \times t)^n = a^n \times t^n$	$(3 \times 4)^2 = 3^2 \times 4^2$
$a^0 = 1$	$32^0 = 1$

2 INTEGER EXPONENTS

5^4 means $5 \times 5 \times 5 \times 5$. The exponent 4 indicates the number of appearances of the repeated factor. What may a negative exponent mean, for example what may 5^{-4} mean?
Mathematicians have decided to use negative exponents to indicate repetition of the multiplicative inverse of the base, for example 5^{-4} is used to indicate $\frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5}$ or $(\frac{1}{5})^4$ and x^{-3} is used to indicate $(\frac{1}{x})^3$ which is $\frac{1}{x} \times \frac{1}{x} \times \frac{1}{x}$.

Example : Negative Exponents

This decision was not taken blindly - mathematicians were well aware that it makes good sense to use negative exponents in this meaning. One major advantage is that the negative exponents, when used in this meaning, have the same properties as positive exponents, for example:
$2^{-3} \times 2^{-4} = 2^{(-3)+(-4)} = 2^{-7}$ and because $2^{-3} \times 2^{-4}$ means $(\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}) \times (\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2})$ which is $(\frac{1}{2})^{-7}$.
$2^{-3} \times 2^{4} = 2^{(-3)+(1)} = 2^{1}$ because $2^{-3} \times 2^{4}$ means $(\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}) \times (2 \times 2 \times 2 \times 2)$ which is 2.

3 SOLVING SIMPLE EXPONENTIAL EQUATIONS

An exponential equation is an equation in which the variable is in the exponent. So when you solve exponential equations, you are solving questions of the form **"To what power must the base be raised for the statement to be true?"**

To solve this kind of equation, remember that:
If $a^m = a^n$ then $m = n$.

In other words, if the base is the same on either side of the equation, then the exponents are the same.

Example:
$3^x = 243$
$3^x = 3^5$ (rewrite using the same base)
$x = 5$ (since the bases are the same, we equate the exponents)

Some exponential equations are slightly more complex:

Example:

$3^{x+3} = 243$

$3^{x+3} = 3^5$ (rewrite using the same base)

$x + 3 = 5$ (equate the exponents)

$x = 2$

Check :

LHS $3^{2+3} = 3^5 = 243$

Remember that the exponent can also be negative. However, you follow the same method to solve these kinds of equations.

Example:

$2^x = \frac{1}{32}$

$2^x = 2^{-5}$ (rewrite using the same base)

$x = -5$ (equate the exponents)

4 SCIENTIFIC NOTATION

Scientific notation is a way of writing numbers that are too big or too small to be written clearly in decimal form. The diameter of a hydrogen atom, for example, is a very small number. It is $0,000000053$ mm. The distance from the sun to the earth is, on average, 150000000 km.

In scientific notation the diameter of the hydrogen molecule is written as $5,3 \times 10^{-8}$ and the distance from the sun to the earth as $1,5 \times 10^8$. It is easier to compare and to calculate numbers like these, as it is very cumbersome to count the zeros when you work with these numbers.

Look at more examples below:

Decimal Notation	Scientific Notation
6 130 000	$6,13 \times 10^6$
0,00001234	$1,234 \times 10^{-5}$

NOTE

A number written in scientific notation is written as the product of two numbers, in the form $a \times 10^n$ where a is a decimal number between 1 and 10 and n is an integer.

Any number can be written in scientific notation, for example:

$40 = 4,0 \times 10$

$2 = 2 \times 10^0$

NOTE

The decimal number $324\ 000\ 000$ is written as $3,24 \times 10^8$ in scientific notation, because the decimal comma is moved 8 places to the left to form $3,24$.

The decimal number $0,00000065$ written in scientific notation is $6,5 \times 10^{-7}$, because the decimal point is moved 7 places to the right to form the number $6,5$.

4.1 Calculations using scientific notation

Example : Calculations using Scientific Notation

$123\ 000 \times 4\ 560\ 000$
$= 1,23 \times 10^5 \times 4,56 \times 10^6$ (write in scientific notation)
$1,23 \times 4,56 \times 10^5 \times 10^6$ (multiplication is commutative)
$= 5,6088 \times 10^{11}$ (Use a calculator to multiply the decimals, but add the powers mentally.)

5 EXERCISES

5.1 Exercise 1

1. Write the following in exponential notation:

   1.1 $2 \times 2 \times 2 \times 2 \times 2$

   1.2 $s \times s \times s \times s$

   1.3 $(-6) \times (-6) \times (-6)$

   1.4 $2 \times 2 \times 2 \times 2 \times s \times s \times s \times s$

   1.5 $3 \times 3 \times 3 \times 7 \times 7$

   1.6 $500 \times (1,02) \times (1,02)$

2. Write each of the numbers in simplified exponential notation:

   2.1 81

   2.2 125

   2.3 1000

   2.4 64

   2.5 216

   2.6 1024

5.2 Exercise 2

1. Calculate the value of $7^2 – 4$.

2. Bathabile did the calculation like this:
   $7^2 – 4 = 14 – 4 = 10$

   Nathaniel did the calculation differently:
   $7^2 – 4 = 49 – 4 = 45$

   Which learner did the calculation correctly? Give reasons for your answer.

3. Calculate: $5 + 3 \times 2^2 – 10$, with explanations.

4. Explain how to calculate $2^6 – 6^2$

5. Explain how to calculate $(4 + 1)^2 + 8 \times \sqrt[3]{64}$

5.3 Exercise 3

1. Use the laws of exponents to calculate the following:

   1.1 $2^2 \times 2^4$

   1.2 $3^4 \div 3^2$

   1.3 $3^0 + 3^4$

   1.4 $\left(2^3\right)^2$

   1.5 $(2 \times 5)^2$

   1.6 $\left(2^2 \times 7\right)^3$

2. Complete the table. Substitute the given number for y. The first column has been done as an example.

y	2	3	4	5
$y \times y^4$	2×2^4 $= 2^{1+4}$ $= 2^5$ $= 32$			
$y^2 \times y^3$	$2^2 \times 2^3$ $= 2^{2+3}$ $= 4 \times 8$ $= 32$			
y^5	$2^5 = 32$			

3. Are the expressions $y \times y^4; y^2 \times y^3; y^5$ and equivalent? Explain.

4. Complete the table. Substitute the given number for y. The first column has been done as an example.

y	2	3	4	5
$y^4 \div y^2$	$2^4 \div 2^2$ $= 16 \div 4$ $= 4$			
$y^3 \div y$	$2^3 \div 2$ $= 8 \div 2$ $= 4$			
y^2	$2^2 = 4$			

5. Is $y^4 \div y^2 = y^3 \div y^1 = y^2$ Explain why?

6. Evaluate $y^4 \div y^2$ for $y = 15$

7. Complete the table:

x	2	3	4	5
2×5^x	2×5^2 $= 2 \times 25$ $= 50$			
$(2 \times 5)^x$	$(2 \times 5)^2$ $= 10^2$ $= 100$			
$2^x \times 5^x$	$2^2 \times 5^2$ $= 4 \times 25$ $= 100$			

8. Is $2 \times 5^x = (2 \times 5)^x$, Explain? newpage

9. Which of the following expressions are equivalent?
   2×5^x
   $(2 \times 5)^x$
   $2^x \times 5^x$

10. Below is a calculation that Wilson did as homework. Mark each problem correct or incorrect and explain the mistakes.

    12.1 $b^3 \times b^8 = b^{24}$

    12.2 $(5x)^2 = 5x^2$

    12.3 $(-6a) \times (-6a) \times (-6a) = (-6a)^3$

5.4 Exercise 4

1. Express each of the following in the exponential notation in two ways: with positive exponents and with negative exponents.

   1.1 $\frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5}$

1.2 $\frac{1}{3} \times \frac{1}{3} \times \frac{1}{3} \times \frac{1}{3}$

2. In each case, check whether the statement is true or false. If it is false, write a correct statement. If it is true, give reasons why you say so.

   2.1 $10^{-3} = 0.001$

   2.2 $3^{-5} \times 9^2 = 3$

2.3 $25^2 \times 10^{-6} \times 2^6 = 5$

2.4 $(\frac{1}{5})^{-4} = 5^4$

3. Calculate each of the following without using a calculator:

3.1 $10^{-3} \times 20^4$

3.2 $(\frac{1}{5})^{-4}$

4. Use a scientific calculator to determine the decimal values of the given powers.

Power	2^{-1}	5^{-1}	$(-2)^{-1}$	$(0,3)^{-1}$	0^{-1}	10^{-1}	10^{-2}
Decimal value							

5. Explain the meaning of 10^{-3}.

6. Determine the value of each of the following in two ways:
A: By using the definition of powers (For example, $5^2 \times 5^0 = 25 \times 1 = 25$.)
B: By using the properties of exponents (For example, $5^2 \times 5^0 = 5^{2+0} = 5^2 = 25$.)

6.1 $(3^3)^{-2}$

6.2 $4^2 \times 4^{-2}$

6.3 $5^{-2} \times 5^{-1}$

7. Calculate the value of each of the following. Express your answers as common fractions.

7.1 2^{-3}

7.2 $3^2 \times 3^{-2}$

7.3 $(2+3)^{-2}$

7.4 $3^2 \times 2^{-3}$

7.5 $2^{-3} + 3^{-3}$

7.6 10^{-3}

7.7 $2^3 + 2^{-3}$

7.8 $(3^{-1})^{-1}$

7.9 $(2^{-3})^2$

8. Which of the following are true? Correct any false statement.

8.1 $6^{-1} = -6$

8.2 $3x^{-2} = \frac{1}{3x^2}$

8.3 $3^{-1}x^{-2} = \frac{1}{3x^2}$

8.4 $(ab)^{-2} = \frac{1}{a^2b^2}$

8.5 $(\frac{2}{3})^{-2} = (\frac{3}{2})^2$

8.6 $(\frac{1}{3})^{-1} = 3$

5.5 Exercise 5

1 Use the table to answer questions that follow:

x	2	3	4	5
2^x	4	8	16	32
3^x	9	27	81	243
5^x	25	125	625	3125

For which value of x is:

1.1 $2^x = 32$

1.2 $3^x = 81$

1.3 $5^x = 3125$

1.4 $2^x = 8$

1.5 $5^x = 625$

1.6 $3^x = 9$

1.7 $5^{x+1} = 25$

1.8 $3^{x+2} = 27$

1.9 $2^{x-1} = 8$

2 Solve these exponential equations. You may use your calculator if necessary.

2.1 $4^x = \frac{1}{64}$

2.2 $6^{2x} = 1296$

2.3 $2^{x-1} = \frac{1}{8}$

2.4 $3^{x+2} = \frac{1}{729}$

2.5 $5^{x+1} = 15625$

2.6 $2^{x+3} = \frac{1}{4}$

2.7 $4^{x+3} = \frac{1}{256}$

2.8 $3^{2-x} = 81$

2.9 $5^{3x} = \frac{1}{125}$

5.6 Exercise 6

1 Express the following numbers in scientific notation:

1.1 $134,56$

1.2 $0,0000005678$

1.3 876500000

1.4 $0,0000000000321$

1.5 $0,006789$

1.6 89100000000000

1.7 $0,001$

1.8 100

2 Express the following numbers in ordinary decimal notation:

2.1 $1,234 \times 10^6$

2.2 5×10^{-1}

2.3 $4,5 \times 10^5$

2.4 $6,543 \times 10^{-11}$

3 Why do we say that 34×10^3 is not written in scientific notation? Rewrite it in scientific notation.

4 Is each of these numbers written in scientific notation? If not, rewrite it so that it is in scientific notation.

4.1 $90,3 \times 10^{-5}$

4.2 100×10^2

4.3 $1,36 \times 10^{-5}$

4.4 $2,01 \times 10^{-2}$

4.5 $0,01 \times 10^3$

4.6 $0,6 \times 10^8$

5.7 Exercise 7

1. Use scientific notation to calculate each of the following. Give the answer in scientific notation.

   1.1 135000×235

   1.2 987654×123456

   1.3 $0,000065 \times 0.000216$

   1.4 $0,000000639 \times 0,0000587$

2. Calculate the following. Leave the answer in scientific notation.

   2.1 $7,16 \times 10^5 + 2,13 \times 10^3$

   2.2 $2,3 \times 10^{-4} + 6,5 \times 10^{-3}$

   2.3 $4,31 \times 10^7 + 1,57 \times 10^6$

   2.4 $6,13 \times 10^{-10} + 3,89 \times 10^{-8}$

5.8 Exercise 8

1 Write the following in exponential form:

1.1 $3 \times 3 \times 3 \times 3$

1.2 $(-5) \times (-5) \times (-5)$

1.3 $9 \times 9 \times 5 \times 5 \times 5$

1.4 $3^0 + 3^0 + 3^0$

1.5 $2^0 + 2^5$

1.6 $4^3 \div 4^1$

1.7 $\left(3 \times 7^2\right)^2$

1.8 $(-1)^{20}$

1.9 $(-1)^{151}$

1.10 $\frac{3^5}{3^2}$

2 Write the following in exponential form:

2.1 $x \times x \times x \times x$

2.2 $x \times x \times x \times x \times x \times x$

3 Simplify the following, leaving your answer as a fraction if needed:

3.1 $(ab)^4$

3.2 $a^3 \times b^5$

3.3 $\frac{x^2}{x^4}$

3.4 $\frac{3x}{6x^3}$

3.5 $\left(2b^0\right)$

3.6 $5x^0$

3.7 $\left(-3x^2yz^3\right)^3$

3.8 $\left(-2x^2z^0\right)^2 \times 4x^2$

3.9 $3(-3x)^2(2xy)^3$

3.10 $\left[\left(2xy^3z\right)^2\right]^3$

3.11 $\left[\left(-3x^3\right) \times \left(-2y^5\right)\right]^3$

3.12 $2x^3 \times \frac{3y}{4x^2}$

3.13 $5m^2 \times \frac{n}{10m^3} \times \left(-\frac{4m}{x^2}\right)$

3.14 $\frac{-6x^2yz^3}{2xyz^4}$

3.15 $\frac{\left(-9yx^2\right)^2}{(3y^2x)^3}$

3.16 $\frac{3y}{6y^2z^3} \times \frac{4yz^2}{2y^2z}$

5.9 Exercise 9

1. Simplify each of the following, leaving your answers as fractions:

1.1 3^{-2}

1.2 x^{-3}

1.3 $4x^{-3}$

1.4 $2y^3 \times (-5y^{-5})$

1.5 $\left(-2x^4\right)^{-3} \times \left(2x^6\right)^3$

1.6 $\left(-3x^{-3}\right)^{-3} \times \left(-2x^2\right)^{-2}$

1.7 $\frac{2}{x^{-5}}$

1.8 $\frac{-1}{3x^{-3}}$

1.9 $(\frac{x}{y})^{-1}$

1.10 $(5x^2y^{-3})^{-2}$

1.11 $[(-4x^{-3}y^3)^3]^{-2}$

1.12 $(\frac{m^2n^4}{p^{-2}})^2$

1.13 $(\frac{5x^2y^3z^{-1}}{20x^{-2}yz^{-4}})^{-1}$

1.14 $(\frac{12x^{-2}y^{-5}}{3x^1y^{-5}})^2$

1.15 $(\frac{8rst^4}{4rst^2})^2$

1.16 $(\frac{3^2a^2b^3}{6ab^2})^{-2}$

1.17 $(\frac{2x^{-3}y^4}{x^{-2}})^2 \times (\frac{y^2}{x^3})^{-2}$

1.18 $(\frac{p^{-1}q^{-1}r^{-1}}{p^2qr^3})^2$

1.19 $(-\frac{x^2 \cdot xy^4}{x^{-3}y^2})^{-3}$

1.20 $\frac{(2x^2y)^2 \times (-3x^{-1}y^3)^{-3}}{6x^3y^{-6}}$

6 ANSWERS TO EXERCISES

6.1 Exercise 1

1.1 2^5

1.2 s^4

1.3 -6^3

1.4 $2^4 \times s^4$

1.5 $3^3 \times 7^2$

1.6 $500 \times (1,02)^2$

2.1 3^4

2.2 5^3

2.3 10^3

2.4 2^6

2.5 4^5

2.6 6^3

6.2 Exercise 2

1. 45
2. Nathaniel
3. 7
4. Multiply the 2's together 6 times to obtain the first value, then multiply the 6's together twice to obtain the second value, then subtract the second value from the first value.
5. 57

6.3 Exercise 3

1.1 64

1.2 9

1.3 82

1.4 64

1.5 21952

2

y	2	3	4	5
$y \times y^4$	2×2^4 $= 2^{1+4}$ $= 2^5$ $= 32$	3×3^4 $= 3^{1+4}$ $= 3^5$ $= 243$	4×4^4 $= 4^{1+4}$ $= 4^5$ $= 1024$	5×5^4 $= 5^{1+4}$ $= 5^5$ 3125
$y^2 \times y^3$	$2^2 \times 2^3$ $= 2^{2+3}$ $= 4 \times 8$ $= 32$	$3^2 \times 3^3$ $= 3^{2+3}$ $= 9 \times 27$ $= 243$	$4^2 \times 4^3$ $= 4^{2+3}$ $= 16 \times 64$ $= 1024$	$5^2 \times 5^3$ $= 5^{2+3}$ $= 25 \times 125$ $= 3125$
y^5	$2^5 = 32$	$3^5 = 243$	$4^5 = 1024$	$5^5 = 3125$

3 Yes

4

y	2	3	4	5
$y^4 \div y^2$	$2^4 \div 2^2$ $= 16 \div 4$ $= 4$	$3^4 \div 3^2$ $= 81 \div 9$ $= 9$	$4^4 \div 4^2$ $= 256 \div 16$ $= 16$	$5^4 \div 5^2$ $= 625 \div 25$ $= 25$
$y^3 \div y$	$2^3 \div 2$ $= 8 \div 2$ $= 4$	$3^3 \div 3$ $= 27 \div 3$ $= 9$	$4^3 \div 4$ $= 64 \div 4$ $= 16$	$5^3 \div 5$ $= 125 \div 5$ $= 25$
y^2	$2^2 = 4$	$3^2 = 9$	$4^2 = 16$	$5^2 = 25$

5 Yes

6 225

7

x	2	3	4	5
2×5^x	2×5^2 $= 2 \times 25$ $= 100$	2×5^3 $= 2 \times 125$ $= 250$	2×5^4 $= 2 \times 625$ $= 1250$	2×5^5 $= 2 \times 3125$ $= 6250$
$(2 \times 5)^x$	$(2 \times 5)^2$ $= 100$	$(2 \times 5)^3$ $= 1000$	$(2 \times 5)^4$ $= 10000$	$(2 \times 5)^5$ $= 100000$
$2^x \times 5^x$	$2^2 \times 5^2$ 4×25 $= 100$	$2^3 \times 5^3$ 8×125 $= 1000$	$2^4 \times 5^4$ 16×625 $= 10000$	$2^5 \times 5^5$ 32×3125 $= 100000$

8 No

9 $2^x \times 5^x$ and $(2 \times 5)^x$

10.1 Multiplied the exponents instead of adding them.

10.2 Forgot to square the 5.

10.3 This problem was answered correctly.

6.4 Exercise 4

1.1 $\left(\frac{1}{5}\right)^6$ or 5^{-6}

1.2 $\left(\frac{1}{3}\right)^4$ or 3^{-4}

2.1 The statement is true because 10^{-3} simplifies to 0,001 in the following way:

$$\begin{aligned} 10^{-3} &= \frac{1}{10^3} \\ &= \frac{1}{1000} = 0,001 \end{aligned}$$

2.2 The statement is false. The correct statement is given by:

$$\begin{aligned} 3^{-5} \times 9^2 &= 3^{-5} \times \left(3^2\right)^2 \\ &= 3^{-5} \times 3^4 \\ &= 3^{-1} \\ &= \frac{1}{3} \\ &= 0.\dot{3} \end{aligned}$$

2.3 The statement is false The correct statement is given by:

$$\begin{aligned} 25^2 \times 10^{-6} \times 2^6 &= \left(5^2\right)^2 \times (5 \times 2)^{-6} \times 2^6 \\ &= 5^4 \times 5^{-6} \times 2^{-6} \times 2^6 \\ &= 5^{-2} \times 2^0 \\ &= \frac{1}{5^2} \\ &= 0.04 \end{aligned}$$

2.4 The statement is true:

$$\begin{aligned} \left(\frac{1}{5}\right)^{-4} &= \left(5^{-1}\right)^{-4} \\ &= 5^4 \end{aligned}$$

3.1 160

3.2 625

4.

Power	2^{-1}	5^{-1}	$(-2)^{-1}$	$(0,3)^{-1}$	0^{-1}	10^{-1}	10^{-2}
Decimal value	0,5	0,2	-0,5	3,3	undefined	0,1	0,01

5. $0,001$

6.1 $\frac{1}{729}$

6.2 1

6.3 $\frac{1}{125}$

7.1 $\frac{1}{8}$

7.2 1

7.3 $\frac{1}{25}$

7.4 $\frac{1}{72}$

7.5 $\frac{35}{216}$

7.6 $\frac{1}{1000}$

7.7 $8\frac{1}{8}$

7.8 3

7.9 $\frac{1}{64}$

8.1 False Correct statement:

$$6^{-1} = \frac{1}{6}$$

8.2 False Correct statement:

$$3x^{-2} = \frac{3}{x^2}$$

8.3 True

8.4 True

8.5 True

8.6 True

6.5 Exercise 5

1.1 $x = 5$

1.2 $x = 4$

1.3 $x = 5$

1.4 $x = 3$

1.5 $x = 4$

1.6 $x = 2$

1.7 $x = 1$

1.8 $x = 1$

1.9 $x = 4$

2.1 $x = -3$

2.2 $x = 2$

2.3 $x = -2$

2.4 $x = -8$

2.5 $x = 5$

2.6 $x = -5$

2.7 $x = -7$

2.8 $x = -2$

2.9 $x = -1$

6.6 Exercise 6

1.1 $1,3456 \times 10^2$

1.2 $5,678 \times 10^{-7}$

1.3 $8,765 \times 10^{-8}$

1.4 $3,21 \times 10^{-11}$

1.5 $6,789 \times 10^{-3}$

1.6 $8,91 \times 10^{13}$

1.7 1×10^{-3}

1.8 1×10^2

2.1 $1\ 234\ 000$

2.2 $0,5$

2.3 $450\ 000$

2.4 $0,00000000006543$

3. Because $34 \times 10^3 = 34000$. In scientific notation it would be $3,4 \times 10^4$.

4.1 No. $9,03 \times 10^{-4}$

4.2 No. 1×10^4

4.3 Yes.

4.4 Yes.

4.5 No. 1×10^1

4.6 No. 6×10^7

6.7 Exercise 7

1.1 $3,321 \times 10^{13}$

1.2 $1,21931812224 \times 10^{11}$

1.3 $1,404 \times 10^{-8}$

1.4 $3,75093 \times 10^{-11}$

2.1 $7,183 \times 10^{5}$

2.2 $6,73 \times 10^{-3}$

2.3 $4,467 \times 10^{7}$

2.4 $3,9513 \times 10^{-8}$

6.8 Exercise 8

1.1 3^4

1.2 -5^3

1.3 $5^3 \cdot 9^2$

1.4 3

1.5 $1 + 2^5$

1.6 4^2

1.7 $3^2 \cdot 7^4$

1.8 1

1.9 -1

1.10 5^3

2.1 x^4

2.2 x^6

3.1 a^4b^4

3.2 a^3b^5

3.3 $\frac{1}{x^2}$

3.4 $\frac{1}{2x^2}$

3.5 2

3.6 5

3.7 $-27x^6y^3z^9$

3.8 $16x^6$

3.9 $72x^5y^3$

3.10 $64x^6y^{18}z^6$

3.11 $108x^9y^{15}$

3.12 $\frac{3xy}{2}$

3.13 $\frac{-2}{x}$

3.14 $\frac{-3x}{z}$

3.15 $3x$

3.16 $\frac{1}{y^2z^2}$

6.9 Exercise 9

1.1 $\frac{1}{9}$

1.2 $\frac{1}{x^3}$

1.3 $\frac{4}{x^3}$

1.4 $\frac{-10}{y^2}$

1.5 $-x^6$

1.6 $\frac{-x^5}{36}$

1.7 $2x^5$

1.8 $-\frac{x^3}{3}$

1.9 $\frac{y}{x}$

1.10 $\frac{y^6}{25x^4}$

1.11 $\frac{x^{18}}{4^6y^{18}}$

1.12 $m^4n^8p^4$

1.13 $\frac{4}{x^4y^2z^3}$

1.14 $\frac{16}{x^8}$

1.15 $4t^4$

1.16 $\frac{4}{9a^2b^4}$

1.17 $4x^4y^4$

1.18 $\frac{1}{p^6q^4r^8}$

1.19 $\frac{1}{-x^6y^6}$

1.20 $-\frac{2x^4}{3^4y^1}$