

11. [Exponents]

Skill 11.1 Evaluating whole numbers in exponential form.

MM9 11 22 33 44
MM10 11 22 33 44

- Observe the exponent. The exponent tells you how many times to multiply the base by itself.

5 to the power of 4
Base 5^4 Exponent

$5^4 = 5 \times 5 \times 5 \times 5$ 5 multiplied by itself 4 times

$6^0 = 1$
number to the power of 0 = 1

$3^1 = 3$
number to the power of 1 = itself

$4^2 = 4 \times 4 = 16$
4 squared

$2^3 = 2 \times 2 \times 2 = 8$
2 cubed

Q. $2^5 =$

A. $2^5 =$
 $= 2 \times 2 \times 2 \times 2 \times 2$
 $= 32$
2 multiplied by itself 5 times

a) $3^4 =$

$= 3 \times 3 \times 3 \times 3 =$

b) $2^3 =$

$= 2 \times 2 \times 2 =$

c) $2^6 =$

$=$ $=$

d) $5^2 =$

$=$ $=$

e) $1^7 =$

$=$ $=$

f) $4^2 =$

$=$ $=$

g) $7^2 =$

$=$ $=$

h) $6^3 =$

$=$ $=$

i) $10^3 =$

$=$ $=$

j) $3^5 =$

$=$ $=$

k) $7^3 =$

$=$ $=$

l) $9^2 =$

$=$ $=$

m) $8^1 =$

$=$ $=$

n) $9^0 =$

$=$ $=$

o) $0^7 =$

$=$ $=$

Skill 11.2 Evaluating powers with fraction bases.

- Observe the exponent. The exponent tells you how many times to multiply the numerator by itself and the denominator by itself.

numerator, 2 to the power of 3

Base $\left(\frac{2}{5}\right)^3$ Exponent

denominator, 5 to the power of 3

$\left(\frac{2}{5}\right)^3 = \frac{2 \times 2 \times 2}{5 \times 5 \times 5} = \frac{8}{125}$

2 multiplied by itself 3 times

5 multiplied by itself 3 times

Q. $\left(\frac{3}{7}\right)^2 =$

A. $\left(\frac{3}{7}\right)^2 =$

$= \frac{3 \times 3}{7 \times 7}$

$= \frac{9}{49}$

3 multiplied by itself 2 times

7 multiplied by itself 2 times

a) $\left(\frac{3}{10}\right)^3 =$

$= \frac{3 \times 3 \times 3}{10 \times 10 \times 10} = \frac{27}{1000}$

b) $\left(\frac{1}{5}\right)^3 =$

$= \frac{1 \times 1 \times 1}{5 \times 5 \times 5} = \frac{1}{125}$

c) $\left(\frac{2}{7}\right)^2 =$

$= \frac{2 \times 2}{7 \times 7} = \frac{4}{49}$

d) $\left(\frac{1}{10}\right)^2 =$

$= \frac{1 \times 1}{10 \times 10} = \frac{1}{100}$

e) $\left(\frac{2}{3}\right)^3 =$

$= \frac{2 \times 2 \times 2}{3 \times 3 \times 3} = \frac{8}{27}$

f) $\left(\frac{3}{8}\right)^2 =$

$= \frac{3 \times 3}{8 \times 8} = \frac{9}{64}$

g) $\left(\frac{6}{11}\right)^2 =$

$= \frac{6 \times 6}{11 \times 11} = \frac{36}{121}$

h) $\left(\frac{4}{9}\right)^2 =$

$= \frac{4 \times 4}{9 \times 9} = \frac{16}{81}$

i) $\left(\frac{1}{4}\right)^4 =$

$= \frac{1 \times 1 \times 1 \times 1}{4 \times 4 \times 4 \times 4} = \frac{1}{256}$

j) $\left(\frac{2}{3}\right)^5 =$

$= \frac{2 \times 2 \times 2 \times 2 \times 2}{3 \times 3 \times 3 \times 3 \times 3} = \frac{32}{243}$

k) $\left(\frac{4}{5}\right)^3 =$

$= \frac{4 \times 4 \times 4}{5 \times 5 \times 5} = \frac{64}{125}$

l) $\left(\frac{7}{10}\right)^3 =$

$= \frac{7 \times 7 \times 7}{10 \times 10 \times 10} = \frac{343}{1000}$

- Add the exponents of like numbers or like pronumerals.

Example: $8^3 \times 8^4 = \underbrace{8 \times 8 \times 8}_{8^3} \times \underbrace{8 \times 8 \times 8 \times 8}_{8^4}$
 $= 8^{3+4}$
 $= 8^7$

In general: $a^m \times a^n = a^{m+n}$

- The size of the new exponent tells you how many times to multiply the base by itself.

Q. Evaluate 6×6^2

A. 6×6^2
 $= 6^{1+2}$ (add the exponents)
 $= 6^3$
 $= 6 \times 6 \times 6$
 $= 216$

a) Evaluate $2^3 \times 2$

$= 2^{3+1} = 2^4$
 $= 2 \times 2 \times 2 \times 2 = \boxed{16}$

b) Evaluate $3^2 \times 3^3$

$= \dots = \dots$
 $= \dots = \boxed{\dots}$

c) Evaluate 2×2^2

$= \dots = \dots$
 $= \dots = \boxed{\dots}$

d) Evaluate $5^3 \times 5$

$= \dots = \dots$
 $= \dots = \boxed{\dots}$

e) Evaluate 4×4^2

$= \dots = \dots$
 $= \dots = \boxed{\dots}$

f) Evaluate $3^2 \times 3^2$

$= \dots = \dots$
 $= \dots = \boxed{\dots}$

g) Simplify $x^3 \times x^6$

$= \dots = \boxed{\dots}$

h) Simplify $z \times z^3$

$= \dots = \boxed{\dots}$

i) Simplify $y^3 \times y^2$

$= \dots = \boxed{\dots}$

j) Simplify $d \times d^6$

$= \dots = \boxed{\dots}$

k) Simplify $ab^2 \times a^4b^2$

$= a^{1+4} \times b^{2+2} = \boxed{a^5b^4}$

l) Simplify $fg^2 \times f^4g$

$= \dots = \boxed{\dots}$

m) Simplify $l^2m^3 \times lm^4$

$= \dots = \boxed{\dots}$

n) Simplify $a^3b \times ab$

$= \dots = \boxed{\dots}$

o) Simplify $g^2h^2 \times gh^2$

$= \dots = \boxed{\dots}$

- Subtract the exponents of like numbers or like pronumerals.

$$\text{Example: } 8^5 \div 8^3 = \frac{8^5}{8^3} = \frac{8 \times 8 \times 8 \times 8 \times 8}{8 \times 8 \times 8}$$

$$= 8^{5-3} = 8^2 = 64$$

In general: $a^m \div a^n = a^{m-n}$

- The size of the new exponent tells you how many times to multiply the base by itself.
Hint: A number or a pronumeral without an exponent actually is to the power of 1.

Q. Evaluate $2^9 \div 2^3$

A. $2^9 \div 2^3$
 $= 2^{9-3}$ *subtract the exponents*
 $= 2^6$
 $= 2 \times 2 \times 2 \times 2 \times 2 \times 2$
 $= 64$

a) Evaluate $4^3 \div 4$

$$= 4^{3-1} = 4^2$$

$$= 4 \times 4 = \boxed{16}$$

b) Evaluate $3^8 \div 3^4$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

c) Evaluate $2^7 \div 2^2$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

d) Evaluate $6^4 \div 6$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

e) Evaluate $9^6 \div 9^4$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

f) Evaluate $5^8 \div 5^5$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

g) Evaluate $\frac{8^8}{8^5}$

$$= 8^{8-5} = 8^3$$

$$= \dots = \boxed{}$$

h) Evaluate $\frac{7^4}{7^2}$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

i) Evaluate $\frac{10^9}{10^6}$

$$= \dots = \dots$$

$$= \dots = \boxed{}$$

j) Simplify $t^4 \div t^3$

$$= \dots = \boxed{t}$$

k) Simplify $p^8 \div p^2$

$$= \dots = \boxed{}$$

l) Simplify $r^9 \div r^2$

$$= \dots = \boxed{}$$

m) Simplify $\frac{j^8}{j^3}$

$$= \dots = \boxed{}$$

n) Simplify $\frac{q^9}{q^4}$

$$= \dots = \boxed{}$$

o) Simplify $\frac{y^7}{y^5}$

$$= \dots = \boxed{}$$

p) Simplify $\frac{p^6 q^4}{p^3 q^2}$

$$= (p^6 \div p^3) \times (q^4 \div q^2)$$

$$= p^{6-3} \times q^{4-2} = \boxed{p^3 q^2}$$

q) Simplify $\frac{a^5 b^3}{ab}$

$$= \dots = \boxed{}$$

r) Simplify $\frac{t^4 u^6}{tu^2}$

$$= \dots = \boxed{}$$

Skill 11.5 Multiplying powers with coefficients and with the same base.

- Multiply the coefficients.
- Add the exponents of like pronumerals.

Example: $2a^3 \times 3a^2 = (2 \times 3) \times (a \times a \times a) \times (a \times a)$
 $= 6a^{3+2} = 6a^5$

Hint: A number or a pronumeral without an exponent actually is to the power of 1.

Q. Simplify $7a \times a^3$

multiply the coefficients

A. $7a \times a^3$

$= (7 \times 1) \times (a^1 \times a^3)$

$= 7a^{1+3}$

$= 7a^4$

add the exponents

a) Simplify $3t^4 \times 3t$

$= (3 \times 3) \times (t^4 \times t^1)$

$= 9t^{4+1}$

$= \boxed{9t^5}$

b) Simplify $x^3 \times 2x$

$=$

$= \boxed{}$

c) Simplify $2p^2 \times 2p$

$=$

$= \boxed{}$

d) Simplify $2b \times 3b^2$

$=$

$= \boxed{}$

e) Simplify $2d^2 \times 4d^4$

$=$

$= \boxed{}$

f) Simplify $3m^3 \times 5m^5$

$=$

$= \boxed{}$

g) Simplify $4s^2 \times 6s^3$

$=$

$= \boxed{}$

h) Simplify $5a^4 \times 2a^6$

$=$

$= \boxed{}$

i) Simplify $7k^2 \times k^7$

$=$

$= \boxed{}$

j) Simplify $6c^6 \times 3c^5$

$=$

$= \boxed{}$

k) Simplify $2y \times y^7$

$=$

$= \boxed{}$

l) Simplify $7w^8 \times 4w$

$=$

$= \boxed{}$

m) Simplify $2r \times 8r$

$=$

$= \boxed{}$

n) Simplify $5g^4 \times 5g^4$

$=$

$= \boxed{}$

o) Simplify $y^8 \times 6y^5$

$=$

$= \boxed{}$

- Divide the coefficients.
- Subtract the exponents of like pronumerals.

Example: $12a^5 \div 4a^2 = (12 \div 4) \times (a^5 \div a^2)$
 $= 3 \times a^{5-2}$
 $= 3a^3$

OR

$$\frac{12a^5}{4a^2} = \frac{12 \times a \times a \times a \times a \times a}{4 \times a \times a}$$

$$= \frac{12a^3}{4} = 3a^3$$

Hint: A number or a pronumeral without an exponent actually is to the power of 1.

Q. Simplify $10j^6 \div 5j^3$

A. $10j^6 \div 5j^3 =$
 $= (10 \div 5) \times (j^6 \div j^3)$ *subtract the exponents*
 $= 2 \times j^{6-3}$
 $= 2j^3$

a) Simplify $8c^4 \div 2c^3$

$$= (8 \div 2) \times (c^4 \div c^3)$$

$$= 4 \times c = \boxed{4c}$$

b) Simplify $6a^5 \div 2a^2$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

c) Simplify $8h^7 \div 2h^3$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

d) Simplify $10m^9 \div 2m$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

e) Simplify $5z^8 \div 5z^4$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

f) Simplify $12f^7 \div 2f^2$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

g) Simplify $\frac{8u^{11}}{4u^7}$

$$= (8 \div 4) \times (u^{11} \div u^7)$$

$$= 2 \times u^{11-7} = \boxed{2u^4}$$

h) Simplify $\frac{12b^3}{6b}$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

i) Simplify $\frac{6w^5}{2w^2}$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

j) Simplify $\frac{7e^{10}}{e^6}$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

k) Simplify $\frac{14q^6}{7q^6}$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

l) Simplify $\frac{9w^6}{3w^2}$

$$= \dots$$

$$= \dots = \boxed{\dots}$$

- Raise each number or pronumeral in the product to the exponent.

Example: $(ab)^3 = a^3 \times b^3 = a^3b^3$

In general: $(ab)^m = a^m \times b^m$

- Multiply from left to right.

Hint: A number or a pronumeral without an exponent actually is to the power of 1.

Q. Simplify $5(2x)^3$

A. $5(2x)^3$
 $= 5 \times 2^3 \times x^3$
 $= 5 \times 8 \times x^3$
 $= 40x^3$

a) Simplify $(2x)^4$

$= 2^4 \times x^4$
 $= 16 \times x^4 = 16x^4$

b) Simplify $(fg)^2$

$= \dots = \boxed{}$

c) Simplify $(de)^f$

$= \dots = \boxed{}$

d) Simplify $(6m)^3$

$= \dots$
 $= \dots = \boxed{}$

e) Simplify $(7r)^2$

$= \dots$
 $= \dots = \boxed{}$

f) Simplify $(3p)^4$

$= \dots$
 $= \dots = \boxed{}$

g) Simplify $6(2y)^3$

$= 6 \times 2^3 \times y^3$
 $= 6 \times 8 \times y^3 = 48y^3$

h) Simplify $2(2q)^2$

$= \dots$
 $= \dots = \boxed{}$

i) Simplify $4(2n)^3$

$= \dots$
 $= \dots = \boxed{}$

j) Simplify $5(2v)^5$

$= \dots$
 $= \dots = \boxed{}$

k) Simplify $3(4s)^2$

$= \dots$
 $= \dots = \boxed{}$

l) Simplify $8(3h)^2$

$= \dots$
 $= \dots = \boxed{}$

- Multiply the exponents of the number or pronomeral.

Example: $(a^2)^4 = a^2 \times a^2 \times a^2 \times a^2 = a^{2+2+2+2}$
 $= a^{2 \times 4}$
 $= a^8$

In general: $(a^m)^n = a^{m \times n}$

Hint: A number or a pronomeral without an exponent actually is to the power of 1.

Q. Simplify $(m^y)^z$

A. $(m^y)^z$
 $= m^{y \times z}$ *multiply the exponents*
 $= m^{yz}$

a) Simplify $(y^4)^2$

$= y^4 \times y^4 = y^{4+4}$
 $= y^{4 \times 2} = \boxed{y^8}$

b) Simplify $(p^9)^r$

$= \dots = \boxed{}$

c) Simplify $(t^u)^v$

$= \dots = \boxed{}$

d) Simplify $(d^2)^2$

$= \dots$
 $= \dots = \boxed{}$

e) Simplify $(h^3)^2$

$= \dots$
 $= \dots = \boxed{}$

f) Simplify $(n^4)^3$

$= \dots$
 $= \dots = \boxed{}$

g) Simplify $(w^5)^0$

$= \dots$
 $= \dots = \boxed{}$

h) Simplify $(a^4)^5$

$= \dots$
 $= \dots = \boxed{}$

i) Simplify $(g^2)^5$

$= \dots$
 $= \dots = \boxed{}$

j) Simplify $(2b^3)^2$

$= (2)^2 \times (b^3)^2$
 $= 4 \times b^{3 \times 2} = \boxed{4b^6}$

k) Simplify $(4q^3)^3$

$= \dots$
 $= \dots = \boxed{}$

l) Simplify $(5z^3)^2$

$= \dots$
 $= \dots = \boxed{}$

- Observe the exponent.

$$(-5)^2 = -5 \times -5 = +25$$

Even exponent
Positive result

$$(-5)^3 = -5 \times -5 \times -5 = +25 \times -5 = -125$$

Odd exponent
Negative result

Q. Evaluate $(-4)^3$

A. (-4^3) *odd exponent*

$$= -4 \times -4 \times -4$$

$$= -64$$
 negative result

a) Evaluate $(-9)^2$ *even exponent*

$$= -9 \times -9 = \boxed{81}$$

positive result

b) Evaluate $(-2)^2$

$$= \dots = \boxed{}$$

c) Evaluate $(-1)^5$

$$= \dots = \boxed{}$$

d) Evaluate $(-4)^3$

$$= \dots = \boxed{}$$

e) Evaluate $(-8)^2$

$$= \dots = \boxed{}$$

f) Evaluate $(-2)^4$

$$= \dots = \boxed{}$$

g) Evaluate $(-1)^7$

$$= \dots = \boxed{}$$

h) Evaluate $(-2)^6$

$$= \dots = \boxed{}$$

i) Evaluate $(-3)^3$

$$= \dots = \boxed{}$$

j) Evaluate $(-6)^3$

$$= \dots = \boxed{}$$

k) Evaluate $(-7)^2$

$$= \dots = \boxed{}$$

l) Evaluate $(-5)^4$

$$= \dots = \boxed{}$$

m) Evaluate $(-10)^3$

$$= \dots = \boxed{}$$

n) Evaluate $(-12)^2$

$$= \dots = \boxed{}$$

o) Evaluate $(-1)^{123}$

$$= \dots = \boxed{}$$

Skill 11.10 Raising a number to a negative power.

- Write the reciprocal of the base number.
- Raise the reciprocal of the base number to the corresponding positive exponent.

$$a^{-2} = \left(\frac{1}{a}\right)^2 = \frac{1}{a^2}$$

Labels: Negative exponent (pointing to -2), Base (pointing to a), Positive exponent (pointing to 2), Reciprocal (pointing to $\frac{1}{a}$)

In general: $a^{-n} = \frac{1}{a^n}$

Q. Evaluate 4^{-2}

A. 4^{-2}

$$= \frac{1}{4^2}$$

Write the reciprocal of 4

$$= \frac{1}{4 \times 4}$$

Multiply 4 by itself 2 times

$$= \frac{1}{16}$$

a) Evaluate 10^{-3}

$$= \frac{1}{10 \times 10 \times 10} = \boxed{\frac{1}{1000}}$$

b) Evaluate 3^{-3}

$$= \frac{1}{3 \times 3 \times 3} = \boxed{\frac{1}{27}}$$

c) Evaluate 2^{-2}

$$= \frac{1}{2 \times 2} = \boxed{\frac{1}{4}}$$

d) Evaluate 4^{-3}

$$= \frac{1}{4 \times 4 \times 4} = \boxed{\frac{1}{64}}$$

e) Evaluate 7^{-1}

$$= \frac{1}{7} = \boxed{\frac{1}{7}}$$

f) Evaluate 8^{-2}

$$= \frac{1}{8 \times 8} = \boxed{\frac{1}{64}}$$

g) Evaluate 9^{-2}

$$= \frac{1}{9 \times 9} = \boxed{\frac{1}{81}}$$

h) Evaluate 2^{-4}

$$= \frac{1}{2 \times 2 \times 2 \times 2} = \boxed{\frac{1}{16}}$$

i) Evaluate 5^{-4}

$$= \frac{1}{5 \times 5 \times 5 \times 5} = \boxed{\frac{1}{625}}$$

j) Evaluate 6^{-3}

$$= \frac{1}{6 \times 6 \times 6} = \boxed{\frac{1}{216}}$$

k) Evaluate 10^{-4}

$$= \frac{1}{10 \times 10 \times 10 \times 10} = \boxed{\frac{1}{10000}}$$

l) Evaluate 3^{-5}

$$= \frac{1}{3 \times 3 \times 3 \times 3 \times 3} = \boxed{\frac{1}{243}}$$