

# 10. [Exponents]

## Skill 10.1 Evaluating whole numbers in exponential form.

MMMaive 1 1 2 2 3 3 4 4  
MMLime 1 1 2 2 3 3 4 4

- 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

$5^4 = 5 \cdot 5 \cdot 5 \cdot 5$  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

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

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

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

a)  $3^4 =$   
 $= 3 \cdot 3 \cdot 3 \cdot 3 =$

b)  $2^3 =$   
 $= 2 \cdot 2 \cdot 2 =$

c)  $2^6 =$   
 $= \dots =$

d)  $5^2 =$   
 $= \dots =$

e)  $1^7 =$   
 $= \dots =$

f)  $4^2 =$   
 $= \dots =$

g)  $7^2 =$   
 $= \dots =$

h)  $6^3 =$   
 $= \dots =$

i)  $10^3 =$   
 $= \dots =$

j)  $3^5 =$   
 $= \dots =$

k)  $7^3 =$   
 $= \dots =$

l)  $9^2 =$   
 $= \dots =$

m)  $8^1 =$   
 $= \dots =$

n)  $9^0 =$   
 $= \dots =$

o)  $0^7 =$   
 $= \dots =$

- 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

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

Q.  $\left(\frac{3}{7}\right)^2 =$       A.  $\left(\frac{3}{7}\right)^2 =$   
 $= \frac{3 \cdot 3}{7 \cdot 7} = \frac{9}{49}$   
 3 multiplied by itself 2 times  
 7 multiplied by itself 2 times

a)  $\left(\frac{3}{10}\right)^3 =$   
 $= \frac{3 \cdot 3 \cdot 3}{10 \cdot 10 \cdot 10} = \frac{27}{1000}$

b)  $\left(\frac{1}{5}\right)^3 =$   
 $= \frac{1 \cdot 1 \cdot 1}{5 \cdot 5 \cdot 5} = \frac{1}{125}$

c)  $\left(\frac{2}{7}\right)^2 =$   
 $= \frac{2 \cdot 2}{7 \cdot 7} = \frac{4}{49}$

d)  $\left(\frac{1}{10}\right)^2 =$   
 $= \frac{1 \cdot 1}{10 \cdot 10} = \frac{1}{100}$

e)  $\left(\frac{2}{3}\right)^3 =$   
 $= \frac{2 \cdot 2 \cdot 2}{3 \cdot 3 \cdot 3} = \frac{8}{27}$

f)  $\left(\frac{3}{8}\right)^2 =$   
 $= \frac{3 \cdot 3}{8 \cdot 8} = \frac{9}{64}$

g)  $\left(\frac{6}{11}\right)^2 =$   
 $= \frac{6 \cdot 6}{11 \cdot 11} = \frac{36}{121}$

h)  $\left(\frac{4}{9}\right)^2 =$   
 $= \frac{4 \cdot 4}{9 \cdot 9} = \frac{16}{81}$

i)  $\left(\frac{1}{4}\right)^4 =$   
 $= \frac{1 \cdot 1 \cdot 1 \cdot 1}{4 \cdot 4 \cdot 4 \cdot 4} = \frac{1}{256}$

j)  $\left(\frac{2}{3}\right)^5 =$   
 $= \frac{2 \cdot 2 \cdot 2 \cdot 2 \cdot 2}{3 \cdot 3 \cdot 3 \cdot 3 \cdot 3} = \frac{32}{243}$

k)  $\left(\frac{4}{5}\right)^3 =$   
 $= \frac{4 \cdot 4 \cdot 4}{5 \cdot 5 \cdot 5} = \frac{64}{125}$

l)  $\left(\frac{7}{10}\right)^3 =$   
 $= \frac{7 \cdot 7 \cdot 7}{10 \cdot 10 \cdot 10} = \frac{343}{1000}$

- Observe the exponent.

$$\begin{aligned} &\text{even exponent} \\ (-5)^2 &= -5 \cdot (-5) \\ &= +25 \\ &\text{positive result} \end{aligned}$$

$$\begin{aligned} &\text{odd exponent} \\ (-5)^3 &= -5 \cdot (-5) \cdot (-5) \\ &= +25 \cdot (-5) \\ &= -125 \\ &\text{negative result} \end{aligned}$$

**Q.** Evaluate  $(-4)^3$

$$\begin{aligned} \mathbf{A.} \quad &(-4^3) \quad \text{odd exponent} \\ &= -4 \cdot (-4) \cdot (-4) \\ &= -64 \quad \text{negative result} \end{aligned}$$

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

$$= -9 \cdot (-9) = \boxed{81}$$

*positive result*

**b)** Evaluate  $(-2)^2$

$$= \dots = \boxed{\phantom{00}}$$

**c)** Evaluate  $(-1)^5$

$$= \dots = \boxed{\phantom{00}}$$

**d)** Evaluate  $(-4)^3$

$$= \dots = \boxed{\phantom{00}}$$

**e)** Evaluate  $(-8)^2$

$$= \dots = \boxed{\phantom{00}}$$

**f)** Evaluate  $(-2)^4$

$$= \dots = \boxed{\phantom{00}}$$

**g)** Evaluate  $(-1)^7$

$$= \dots = \boxed{\phantom{00}}$$

**h)** Evaluate  $(-2)^6$

$$= \dots = \boxed{\phantom{00}}$$

**i)** Evaluate  $(-3)^3$

$$= \dots = \boxed{\phantom{00}}$$

**j)** Evaluate  $(-6)^3$

$$= \dots = \boxed{\phantom{00}}$$

**k)** Evaluate  $(-7)^2$

$$= \dots = \boxed{\phantom{00}}$$

**l)** Evaluate  $(-5)^4$

$$= \dots = \boxed{\phantom{00}}$$

**m)** Evaluate  $(-10)^3$

$$= \dots = \boxed{\phantom{00}}$$

**n)** Evaluate  $(-12)^2$

$$= \dots = \boxed{\phantom{00}}$$

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

$$= \dots = \boxed{\phantom{00}}$$

- Add the exponents of like numbers or like variables (letters).

Example:  $8^3 \cdot 8^4 = \underbrace{8 \cdot 8 \cdot 8}_8 \cdot \underbrace{8 \cdot 8 \cdot 8 \cdot 8}_8$   
 $= 8^{3+4}$   
 $= 8^7$

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

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

**Q.** Simplify and evaluate  $6 \cdot 6^2$      **A.**  $6 \cdot 6^2$   
 $= 6^{1+2}$  *add the exponents*  
 $= 6^3$   
 $= 6 \cdot 6 \cdot 6$   
 $= 216$

**a)** Simplify  $b^2 \cdot b^2$

$= b^{2+2} = \boxed{b^4}$

**b)** Simplify  $z \cdot z^3$

$= \dots = \boxed{\phantom{z^4}}$

**c)** Simplify  $y^3 \cdot y^2$

$= \dots = \boxed{\phantom{y^5}}$

**d)** Simplify  $x^3 \cdot x^6$

$= \dots = \boxed{\phantom{x^9}}$

**e)** Simplify  $f \cdot f^4$

$= \dots = \boxed{\phantom{f^5}}$

**f)** Simplify  $m^3 \cdot m^4$

$= \dots = \boxed{\phantom{m^7}}$

**g)** Simplify and evaluate  $2^3 \cdot 2$

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

**h)** Simplify and evaluate  $3^2 \cdot 3^3$

$= \dots = \dots$   
 $= \dots = \boxed{\phantom{3^5}}$

**i)** Simplify and evaluate  $5 \cdot 5^2$

$= \dots = \dots$   
 $= \dots = \boxed{\phantom{5^3}}$

**j)** Simplify and evaluate  $5^3 \cdot 5$

$= \dots = \dots$   
 $= \dots = \boxed{\phantom{5^4}}$

**k)** Simplify and evaluate  $4 \cdot 4^2$

$= \dots = \dots$   
 $= \dots = \boxed{\phantom{4^3}}$

**l)** Simplify and evaluate  $3^2 \cdot 3^2$

$= \dots = \dots$   
 $= \dots = \boxed{\phantom{3^4}}$

**m)** Simplify  $ab^2 \cdot a^4b^2$

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

**n)** Simplify  $l^2m^3 \cdot lm^4$

$= \dots = \boxed{\phantom{l^3m^7}}$

**o)** Simplify  $g^5h^3 \cdot gh^2$

$= \dots = \boxed{\phantom{g^6h^5}}$

- Subtract the exponents of like numbers or like variables.

$$\begin{aligned} \text{Example: } 8^5 \div 8^3 &= \frac{8^5}{8^3} = \frac{8 \cdot 8 \cdot \cancel{8} \cdot \cancel{8} \cdot \cancel{8}}{\cancel{8} \cdot \cancel{8} \cdot \cancel{8}} \\ &= 8^{5-3} = 8^2 = 64 \end{aligned}$$

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 variable without an exponent actually is to the power of 1.*

**Q.** Simplify and evaluate  $2^9 \div 2^3$     **A.**  $2^9 \div 2^3$   
 $= 2^{9-3}$  *subtract the exponents*  
 $= 2^6$   
 $= 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$   
 $= 64$

**a)** Simplify  $t^4 \div t^3$

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

**b)** Simplify  $p^8 \div p^2$

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

**c)** Simplify  $r^9 \div r^2$

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

**d)** Simplify  $\frac{j^8}{j^3}$

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

**e)** Simplify  $\frac{q^9}{q^4}$

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

**f)** Simplify  $\frac{y^7}{y^5}$

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

**g)** Simplify and evaluate  $4^3 \div 4$

$$\begin{aligned} &= 4^{3-1} = 4^2 \\ &= 4 \cdot 4 = \boxed{16} \end{aligned}$$

**h)** Simplify and evaluate  $9^6 \div 9^4$

$$\begin{aligned} &= \dots = \dots \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

**i)** Simplify and evaluate  $5^8 \div 5^5$

$$\begin{aligned} &= \dots = \dots \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

**j)** Simplify and evaluate  $\frac{8^8}{8^5}$

$$\begin{aligned} &= 8^{8-5} = 8^3 \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

**k)** Simplify and evaluate  $\frac{7^4}{7^2}$

$$\begin{aligned} &= \dots = \dots \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

**l)** Simplify and evaluate  $\frac{10^9}{10^6}$

$$\begin{aligned} &= \dots = \dots \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

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

$$\begin{aligned} &= (p^6 \div p^3) \cdot (q^4 \div q^2) \\ &= p^{6-3} \cdot q^{4-2} = \boxed{p^3 q^2} \end{aligned}$$

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

$$\begin{aligned} &= \dots \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

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

$$\begin{aligned} &= \dots \\ &= \dots = \boxed{\phantom{t}} \end{aligned}$$

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

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

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

Q. Simplify  $7a^7b \cdot a^3b^6$

A.  $7a^7b \cdot a^3b^6$

$= (7 \cdot 1)(a^7 \cdot a^3)(b \cdot b^6)$   
 $= 7 \cdot a^{7+3} \cdot b^{1+6}$   
 $= 7a^{10}b^7$

*(multiply the coefficients)*      *(add the exponents)*

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

$= (3 \cdot 3)(t^4 \cdot t^1)$   
 $= 9 \cdot t^{4+1} = 9t^5$

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

$=$   
 $=$    $=$

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

$=$   
 $=$    $=$

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

$=$   
 $=$

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

$=$   
 $=$

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

$=$   
 $=$

g) Simplify  $4s^2t \cdot 6st^3$

$=$   
 $=$

h) Simplify  $5a^4b \cdot 2ab^6$

$=$   
 $=$

i) Simplify  $7j^2k^2 \cdot jk^7$

$=$   
 $=$

j) Simplify  $6c^6d \cdot 3c^5d$

$=$   
 $=$

k) Simplify  $2xy \cdot 9x^3y^7$

$=$   
 $=$

l) Simplify  $4uv^4 \cdot u^3v^2$

$=$   
 $=$

m) Simplify  $2j^2k \cdot 4j^3k^4$

$=$   
 $=$

n) Simplify  $y^2z^3 \cdot 7y^3z^4$

$=$   
 $=$

o) Simplify  $3v^3w \cdot 2v^2w^5$

$=$   
 $=$

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

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

OR

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

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

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

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

**A.**  $(10j^6) \div (5j^3) =$   
 $= (10 \div 5)(j^6 \div j^3)$   
 $= 2 \cdot j^{6-3}$   
 $= 2j^3$

subtract the exponents

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

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

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

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

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

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

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

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

$$=$$

$$= \boxed{\phantom{000}}$$

**m)** Simplify  $\frac{15j^3k^2}{45j^2k^2}$

$$=$$

$$= \boxed{\phantom{000}}$$

**n)** Simplify  $\frac{6c^3d^4}{60c^5d}$

$$=$$

$$= \boxed{\phantom{000}}$$

**o)** Simplify  $\frac{32g^2h^3}{8g^3h}$

$$=$$

$$= \boxed{\phantom{000}}$$

- Raise each number or variable in the product or the quotient to the exponent.

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

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

- Multiply from left to right.

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

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

**A.**  $(2x)^3$   
 $= 2^3 \cdot x^3$   
 $= 8 \cdot x^3$   
 $= 8x^3$

**a)** Simplify  $(-2x)^4$  *even exponent*

$= -2^4 \cdot x^4$   
 $= 16 \cdot x^4 = 16x^4$  *positive result*

**b)** Simplify  $(fg)^2$

$= \dots = \boxed{\phantom{00}}$

**c)** Simplify  $(de)^f$

$= \dots = \boxed{\phantom{00}}$

**d)** Simplify  $(6m)^3$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**e)** Simplify  $(7r)^2$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**f)** Simplify  $(3p)^4$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**g)** Simplify  $(-5t)^3$

$= -5^3 \cdot t^3$   
 $= -125 \cdot t^3 = -125t^3$

**h)** Simplify  $(-4j)^4$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**i)** Simplify  $(-2m)^6$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**j)** Simplify  $6(2y)^3$

$= 6 \cdot 2^3 \cdot y^3$   
 $= \dots = \boxed{\phantom{00}}$

**k)** Simplify  $2(2q)^2$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**m)** Simplify  $\left(\frac{4u}{3}\right)^2$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**n)** Simplify  $\left(\frac{lm}{5n}\right)^2$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

**o)** Simplify  $\left(\frac{cd}{3e}\right)^4$

$= \dots$   
 $= \dots = \boxed{\phantom{00}}$

- Multiply the exponents of the number or variable.

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

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

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

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

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

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

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

**b)** Simplify  $(p^q)^r$

$= \dots = \boxed{\phantom{000}}$

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

$= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= 2 \cdot b^3 \cdot b^3 = 2 \cdot b^{3+3}$   
 $= 2 \cdot b^{3 \cdot 2} = \boxed{2b^6}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

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

$= \dots$   
 $= \dots = \boxed{\phantom{000}}$

- Use the appropriate operations to simplify the exponential expressions:
  - Multiplying powers (see skills 10.4, page 110 and 10.6, page 112)
  - Dividing powers (see skills 10.5, page 111 and 10.7, page 113)
  - Raising a product to a power (see skill 10.8, page 114)
  - Raising a quotient to a power (see skill 10.8, page 114)
  - Raising a power to a power (see skill 10.9, page 115)

**Q.** Simplify  $(6w^5)^2 \cdot w^4$

**A.**  $(6w^5)^2 \cdot w^4$   
 $= 6^2 \cdot w^{5 \times 2} \cdot w^4$   
 $= 36 \cdot w^{10} \cdot w^4$   
 $= 36 \cdot w^{10+4}$   
 $= 36w^{14}$

**a)** Simplify  $(4s^3)^2 \cdot s^5$

$= 4^2 \cdot s^{3 \cdot 2} \cdot s^5$   
 $= 16 \cdot s^6 \cdot s^5$   
 $= 16 \cdot s^{6+5} = \boxed{16s^{11}}$

**b)** Simplify  $(5x^6)^3 \cdot x^5$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**c)** Simplify  $(3x^2)^4 \cdot x^3$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**d)** Simplify  $mn^6 \cdot (m^2n^3)^3$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**e)** Simplify  $l^5m \cdot (l^3m^3)^3$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**f)** Simplify  $(g^2h^6)^2 \cdot (h^4)^3$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**g)** Simplify  $\left(\frac{d^2}{5}\right)^4$

$= \frac{(d^2)^4}{5^4}$   
 $= \frac{d^{2 \cdot 4}}{5 \cdot 5 \cdot 5 \cdot 5} = \boxed{\frac{d^8}{625}}$

**h)** Simplify  $\left(\frac{a^3}{2}\right)^5$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**i)** Simplify  $\left(\frac{h^3}{4}\right)^3$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**j)** Simplify  $\frac{6m \cdot 8m^4}{12m^2}$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**k)** Simplify  $\frac{8r^7 \cdot 3r^6}{6r^3}$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

**l)** Simplify  $\frac{15x^3 \cdot 3x^6}{9x^5}$

$=$   
 $=$   
 $=$   $= \boxed{\phantom{000}}$

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

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

Negative exponent (pointing to  $a^{-2}$ )  
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)  
 $= \frac{1}{4 \cdot 4}$  (Multiply 4 by itself 2 times)  
 $= \frac{1}{16}$

a) Simplify  $f^{-3}$

$$\frac{1}{f^3}$$

b) Evaluate  $v^{-5}$

$$\frac{1}{v^5}$$

c) Evaluate  $b^{-8}$

$$\frac{1}{b^8}$$

d) Evaluate  $r^{-6}$

$$\frac{1}{r^6}$$

e) Evaluate  $w^{-9}$

$$\frac{1}{w^9}$$

f) Evaluate  $z^{-7}$

$$\frac{1}{z^7}$$

g) Evaluate  $10^{-3}$

$$= \frac{1}{10 \cdot 10 \cdot 10} = \frac{1}{1000}$$

h) Evaluate  $3^{-3}$

$$= \frac{1}{3 \cdot 3 \cdot 3} = \frac{1}{27}$$

i) Evaluate  $2^{-2}$

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

j) Evaluate  $4^{-3}$

$$= \frac{1}{4 \cdot 4 \cdot 4} = \frac{1}{64}$$

k) Evaluate  $7^{-1}$

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

l) Evaluate  $8^{-2}$

$$= \frac{1}{8 \cdot 8} = \frac{1}{64}$$

m) Evaluate  $9^{-2}$

$$= \frac{1}{9 \cdot 9} = \frac{1}{81}$$

n) Evaluate  $2^{-4}$

$$= \frac{1}{2 \cdot 2 \cdot 2 \cdot 2} = \frac{1}{16}$$

o) Evaluate  $5^{-4}$

$$= \frac{1}{5 \cdot 5 \cdot 5 \cdot 5} = \frac{1}{625}$$

p) Evaluate  $6^{-3}$

$$= \frac{1}{6 \cdot 6 \cdot 6} = \frac{1}{216}$$

q) Evaluate  $10^{-4}$

$$= \frac{1}{10 \cdot 10 \cdot 10 \cdot 10} = \frac{1}{10000}$$

r) Evaluate  $3^{-5}$

$$= \frac{1}{3 \cdot 3 \cdot 3 \cdot 3 \cdot 3} = \frac{1}{243}$$

**Skill 10.12** Simplifying expressions involving negative exponents.

- Simplify the coefficients first.
- Simplify the powers. (see skill 10.6, page 112, skill 10.7, page 113 and skill 10.9, page 115)
- Express the answer using positive exponents.

**Q.** Simplify  $(12a^{-8}) \div (3a^{-2})$  and express the answer using positive exponents.

**A.**  $(12a^{-8}) \div (3a^{-2})$  — Simplify:  $\div 4$   
 $= 4(a^{-8} \div a^{-2})$   
 $= 4 \cdot a^{-8 - (-2)}$  — subtract powers  
 $= 4a^{-6}$   
 $= \frac{4}{a^6}$

**a)** Simplify  $3x^{-3} \cdot 5x^{-2}$  and express the answer using positive exponents.

$15x^{-3 + (-2)}$   
 $= 15x^{-5}$  =

**b)** Simplify  $m^{-8} \cdot m^4$  and express the answer using positive exponents.

$=$

**c)** Simplify  $7z^3 \cdot 2z^{-5}$  and express the answer using positive exponents.

$=$

**d)** Simplify  $4g^{-1} \cdot 7g^{-2}$  and express the answer using positive exponents.

$=$

**e)** Simplify  $(63c^3) \div (7c^{-7})$  and express the answer using positive exponents.

$=$

**f)** Simplify  $(27w^{-9}) \div (3w^3)$  and express the answer using positive exponents.

$=$

**g)** Simplify  $(2t^{-2})^5$  and express the answer using positive exponents.

$=$

**h)** Simplify  $(4t^{-1})^3$  and express the answer using positive exponents.

$=$