

**Order of Operations**

Date: \_\_\_\_\_

The mathematical operations (addition, subtraction, multiplication, division, and exponentiation) are done in a specific order. The rules for this order are:

1. Do the calculations within the brackets.
2. Then, calculate powers first.
3. Then, do multiplications/divisions in the order they appear from left to right.
4. Then, do additions/subtractions in the order they appear from left to right.

The acronym for this is BEDMAS

Examples:

a)  $3(8^2 - 2 \times 3)$

b)  $\frac{3^2 - 2^3}{8 \div (24 \div 3)}$

c)  $\left[ \left( -1\frac{2}{3} \right) + \left( -1\frac{1}{3} \right)^2 \right] \cdot \left( -\frac{3}{11} \right)$

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

e)  $42 \div 3 + 8^2 \div 4$

f)  $\frac{-5 + (-3)(-6)}{(-2)^2 + (-3)^2}$

Order of Operations

Date:

1. Evaluate.

- (a)  $\frac{1}{2} - \frac{-2}{3}$
- (b)  $\frac{3}{5} - \frac{2}{3}$
- (c)  $\frac{-7}{11} + \frac{1}{3}$
- (d)  $\frac{5}{-6} + \frac{2}{-4}$
- (e)  $\frac{2}{-3} - 2\frac{5}{6}$
- (f)  $\frac{-3}{4} + 3\frac{2}{5}$
- (g)  $-8\frac{1}{4} + 3\frac{1}{2}$
- (h)  $\frac{7}{10} - \frac{-3}{4} + \frac{3}{5}$
- (i)  $1\frac{3}{4} + 2\frac{1}{5} - 4\frac{2}{3}$
- (j)  $\frac{-5}{7} + \frac{2}{3} - \frac{-1}{2}$

2. Evaluate.

- (a)  $\left(\frac{-2}{-3}\right)\left(\frac{9}{-10}\right)$
- (b)  $\left(\frac{1}{-2}\right)\left(\frac{2}{-5}\right)$
- (c)  $\left(\frac{-5}{12}\right)\left(\frac{-4}{-15}\right)$
- (d)  $\left(2\frac{1}{2}\right)\left(-5\frac{2}{3}\right)$
- (e)  $\left(\frac{9}{4}\right)\left(\frac{-8}{27}\right)$
- (f)  $\left(-3\frac{1}{11}\right)\left(1\frac{1}{10}\right)$
- (g)  $\left(5\frac{3}{7}\right)\left(\frac{-7}{19}\right)$
- (h)  $\left(\frac{-2}{-9}\right)\left(-3\frac{1}{4}\right)$
- (i)  $\left(-4\frac{1}{3}\right)\left(-2\frac{3}{4}\right)$
- (j)  $\left(\frac{-2}{3}\right)\left(\frac{15}{-18}\right)\left(\frac{9}{5}\right)\left(\frac{-7}{8}\right)$

3. Evaluate.

- (a)  $\frac{2}{-3} \div \frac{-4}{3}$
- (b)  $\frac{-3}{8} \div \frac{-2}{3}$
- (c)  $-1\frac{1}{2} \div \frac{9}{4}$
- (d)  $2\frac{5}{7} \div \frac{-38}{21}$
- (e)  $-6\frac{1}{8} \div \frac{7}{-16}$
- (f)  $\frac{-2}{\frac{3}{4}}$
- (g)  $\frac{\frac{3}{-5}}{\frac{21}{-20}}$
- (h)  $\frac{\frac{5}{9}}{\frac{-10}{27}}$
- (i)  $\frac{\frac{-4}{5}}{\frac{8}{-15}}$
- (j)  $\left(2\frac{1}{3}\right) \div \left(-3\frac{2}{3}\right)$

4. Evaluate.

- (a)  $\frac{2}{-5} - \left(\frac{-1}{10} + \frac{-1}{2}\right)$
- (b)  $\frac{3}{5} - \left(2\frac{1}{2} - \frac{2}{3}\right)$
- (c)  $-3\frac{4}{7} - \left(\frac{2}{5} - 2\frac{2}{3}\right)$
- (d)  $\frac{-4}{9} \left(\frac{3}{8} - \frac{1}{12}\right)$
- (e)  $-2\frac{5}{8} \left(-1\frac{2}{3} + 4\frac{3}{4}\right)$
- (f)  $3\frac{4}{5} \div \left(2\frac{1}{4} - \frac{2}{3}\right)$
- (g)  $\left(2\frac{1}{8}\right)\left(-1\frac{3}{4}\right)\left(3\frac{2}{3}\right)$
- (h)  $\left(-1\frac{1}{8}\right)\left(2\frac{3}{4}\right) \div \left(3\frac{2}{3}\right)$
- (i)  $\left(\frac{5}{12}\right) \div \left(-1\frac{3}{4}\right)\left(3\frac{2}{3}\right)$
- (j)  $\left(1\frac{3}{8}\right)\left(-1\frac{3}{4}\right) \div \left(-3\frac{2}{3}\right)\left(2\frac{3}{4}\right)$

5. Evaluate the expression.

- (a)  $\frac{\frac{-4}{5} - \frac{3}{5}}{\frac{1}{5} - \frac{-1}{3}}$
- (b)  $\frac{\frac{1}{4} - \frac{-1}{3}}{\frac{-5}{12} - \frac{-3}{-4}}$
- (c)  $\frac{1\frac{2}{3} - 2\frac{3}{4}}{-2\frac{3}{5} - 1\frac{1}{4}}$
- (d)  $\frac{6\frac{2}{5} - 8\frac{2}{3}}{-3\frac{5}{7} - 2\frac{3}{14}}$

- 1. (a)  $1\frac{1}{6}$  (b)  $-\frac{1}{15}$  (c)  $-\frac{10}{33}$  (d)  $-1\frac{1}{3}$  (e)  $-3\frac{1}{2}$
- (f)  $2\frac{13}{20}$  (g)  $-4\frac{3}{4}$  (h)  $2\frac{1}{20}$  (i)  $-\frac{43}{60}$  (j)  $\frac{19}{42}$
- 2. (a)  $-\frac{3}{5}$  (b)  $\frac{1}{5}$  (c)  $\frac{1}{9}$  (d)  $-14\frac{1}{6}$  (e)  $-\frac{2}{3}$
- (f)  $-3\frac{2}{5}$  (g)  $-2$  (h)  $-\frac{13}{18}$  (i)  $11\frac{11}{12}$  (j)  $-\frac{7}{8}$
- 3. (a)  $\frac{1}{2}$  (b)  $\frac{9}{16}$  (c)  $-\frac{2}{3}$  (d)  $-1\frac{1}{2}$  (e) 14
- (f)  $-1\frac{1}{2}$  (g)  $\frac{4}{7}$  (h)  $-1\frac{1}{2}$  (i)  $1\frac{1}{2}$  (j)  $-\frac{7}{11}$
- 4. (a)  $\frac{1}{5}$  (b)  $-1\frac{7}{30}$  (c)  $-1\frac{32}{105}$  (d)  $-\frac{7}{54}$  (e)  $-\frac{83}{32}$
- (f)  $2\frac{2}{5}$  (g)  $-13\frac{61}{96}$  (h)  $-\frac{27}{32}$  (i)  $-\frac{5}{77}$  (j)  $\frac{21}{88}$
- 5. (a)  $-2\frac{5}{8}$  (b)  $\frac{3}{4}$  (c)  $\frac{65}{231}$  (d)  $\frac{476}{1245}$

-259  
32

## Exponent Laws (Notes)

### Review of the exponent laws

If  $m$  and  $n$  are any real numbers, then

1)  $a^m \times a^n = a^{m+n}$

2)  $\frac{a^m}{a^n} = a^{m-n}$  ( $a \neq 0$ )

3)  $(a^m)^n = a^{mn}$

4)  $(abc)^n = a^n b^n c^n$

5)  $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$  ( $b \neq 0$ )

### Negative Exponents

6)  $a^{-m} = \frac{1}{a^m}$  ( $a \neq 0$ ) ( $m \in N$ )

7)  $\left(\frac{a}{b}\right)^{-m} = \left(\frac{b}{a}\right)^m$

### Zero Exponents

8)  $a^0 = 1$  ( $a \neq 0$ )

### Example 1: Evaluate

a)  $4^{-2}$

b)  $-4^2$

c)  $(-4)^2$

d)  $(-4)^{-2}$

e)  $-4^{-2}$

### Example 2: Express answers in positive exponent

a)  $a^5 \cdot a^7$

b)  $a^7 \cdot a^{-4}$

c)  $a^{-5} \times a^{-2}$

d)  $a^0$

### Example 3: Express answers in positive exponent

a)  $(a^2)^4$

b)  $(a^{-2})^4$

c)  $(ab^3)^2$

d)  $\left(\frac{a^2}{b^3}\right)^2$

e)  $(2a^{-2}b^3)^5$

### Example 4: Simplify

$$\frac{10a^5b^3c^2}{2a^7bc^2}$$

Simplify each of the following:

1.  $5^{-2} =$

2.  $-5^2 =$

3.  $(-5)^2 =$

4.  $(-5)^{-2} =$

5.  $\frac{1}{5^{-2}} =$

6.  $\frac{1}{(-5)^2} =$

7.  $\frac{1}{(-5)^{-2}} =$

8.  $\frac{1}{(-5)^{-3}} =$

9.  $\left(\frac{2}{5}\right)^{-2} =$

10.  $\left(\frac{2}{5}\right)^{-2} =$

11.  $\left(-\frac{2}{5}\right)^2 =$

12.  $\left(-\frac{2}{5}\right)^{-2} =$

13.  $\frac{(9^{-1})(3^3)}{(5^{-2})(20)} =$

14.  $4^0 =$

15.  $\frac{2^0}{8^0} =$

16.  $(-126)^0 =$

Express as a single power:

1. a)  $a^2 \cdot a^3 =$

b)  $y^{-5} \cdot y^{-3} =$

c)  $m^{-3} \cdot m^4 =$

d)  $s^3 \cdot s^{-3} =$

e)  $t^2 \cdot t^{-3} =$

f)  $r^{-2} \cdot r^{-12} =$

g)  $x^{-2} \cdot x^{-4} =$

h)  $a^{-3} \cdot a^{-2} =$

2. a)  $x^7 \div x^9 =$

b)  $5^3 \div 5^5 =$

c)  $7^{-4} \div 7^{-8} =$

d)  $m^2 \div m^5 =$

e)  $m^{-3} \div m^2 =$

f)  $a^{-3} \div a^{-4} =$

g)  $15^{-7} \div 15^{-9} =$

h)  $3^7 \div 3^{-4} =$

Simplify:

1. a)  $3y^2 \cdot 2y^3 =$

b)  $4x^3 \cdot 3x^2 =$

c)  $5a^5 \cdot 3a^2 =$

d)  $7t^3 \cdot 3t^7 =$

e)  $12c^5 \cdot 4c^7 =$

f)  $-3m^3 \cdot 2m^2 =$

g)  $6m^5 \cdot 3m^7 =$

h)  $-4r^{14} \cdot 2r^8 =$

2. a)  $\frac{18t^9}{9t^3} =$

b)  $\frac{4r^5s^7}{2r^2s^3} =$

c)  $\frac{27m^3n^5}{9m^2n^2} =$

d)  $\frac{-15x^3}{3x^2} =$

e)  $2r^9 \div 2r^7 =$

f)  $12a^{12} \div 4a^3 =$

g)  $5y^4 \div 10y^2 =$

h)  $22m^9 \div 11m^8 =$

Simplify:

1. a)  $(a^2)^3 =$

b)  $(y^4)^3 =$

c)  $(m^3)^4 =$

d)  $(x^9)^2 =$

2. a)  $(m^{-4})^2 =$

b)  $(t^{-3})^3 =$

c)  $(c^{-2})^{-2} =$

d)  $(x^{-3})^{-5} =$

e)  $(u^7)^{-4} =$

f)  $(x^{-1})^{-1} =$

g)  $(ab)^5 =$

h)  $(x^2y^{-7})^3 =$

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

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

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

l)  $\left(\frac{ab^2}{c^3}\right)^5 =$

3. a)  $(a^2b^2)(a^3b^4) =$                       b)  $(ab^{-4})(a^4b^{-1}) =$                       c)  $(x^{-6}yz^2)(x^6y^{-1}z^{-5}) =$   
d)  $(3xy)(4x^3y) =$                       e)  $(m^4n^3)^4(mn) =$                       f)  $(mn)^2(mn)^3 =$
4. a)  $\frac{a^5b^8}{a^2b^2} =$                       b)  $\frac{x^8y^{-4}}{xy} =$                       c)  $\frac{a^5b^{-2}}{a^5b^{-2}} =$   
d)  $\frac{m^3n^4}{m^7n^9} =$                       e)  $\frac{x^{-3}y^{-1}}{x^8y} =$                       f)  $\frac{a^{-2}b^{-3}}{a^{-6}b^{-5}} =$
5. a)  $(3x^3y^2)^2 =$                       b)  $(7xy^3)^2 =$                       c)  $(2m^5n)^4 =$   
d)  $(abc^2)^3 =$                       e)  $(3x^3y^3)^3 =$                       f)  $(4x^8y^6z^4)^2 =$

**Rewrite using positive exponents:**

1. a)  $a^{-3} =$                       b)  $x^{-5} =$                       c)  $m^{-2} =$                       d)  $r^{-2} =$   
e)  $m^{-1} =$                       f)  $a^{-3}b^{-4} =$                       g)  $a^{-5}b^{-1} =$                       h)  $a^{-1}b^{-1} =$   
i)  $\frac{1}{m^{-3}} =$                       j)  $\frac{1}{r^{-4}} =$                       k)  $\frac{1}{a^{-4}b^{-6}} =$                       l)  $\frac{1}{a^{-1}b^{-3}} =$

**Rewrite using positive exponents, then evaluate:** (Show one middle step.)

1. a)  $6^{-3} =$                       b)  $5^{-2} =$                       c)  $9^{-1} =$   
d)  $1^{-1} =$                       e)  $\frac{1}{7^{-4}} =$                       f)  $\frac{1}{10^{-3}} =$   
g)  $\frac{1}{5^{-1}} =$                       h)  $\frac{1}{2^{-3} \cdot 3^{-2}} =$                       i)  $\frac{2^{-3}}{3^{-2}} =$

**Simplify. Give all answers with positive exponents only:** (Show at least one middle step.)

1. a)  $\frac{10a^5b^3}{2a^3b^5} =$                       b)  $\frac{18m^4n^3q^5}{36m^7n^4q^5} =$   
c)  $\frac{30m^6n^3}{6m^{-3}n^2} =$                       d)  $\frac{27a^5b^3c^4}{9a^8b^4c^3} =$   
e)  $\frac{m^{-2}n^6p^3}{m^4n^{-5}p^{-2}} =$                       f)  $\frac{18a^2b^{-2}}{3a^{-3}b^5} =$

1. Simplify the following, positive exponents only in the answer.

- |                    |                                    |                          |                          |                    |
|--------------------|------------------------------------|--------------------------|--------------------------|--------------------|
| a) $4^2 \cdot 4^5$ | b) $2^{-4} \cdot 2^{-5} \cdot 2^5$ | c) $3^{-5} \cdot 3^{-1}$ | d) $2^{-14} \div 2^{-8}$ | e) $5^{-3} \div 5$ |
| f) $m^5 \div m^9$  | g) $x^4 \div x^{-5}$               | h) $y^{-2} \div y^{-3}$  | i) $(g^2)^4$             | j) $(m^3)^2$       |
| k) $(2x^2)^3$      | l) $(6a^2)^4$                      | m) $(7^{-2})^2$          | n) $(2^4)^{-2}$          | o) $(3^{-3})^{-2}$ |

2. Rewrite using positive exponents.

- |                                    |                                 |                                       |  |
|------------------------------------|---------------------------------|---------------------------------------|--|
| a) $a^{-3} =$                      | b) $x^{-5} =$                   | c) $m^{-2} =$                         | d) $r^{-2} =$                            |
| e) $m^{-1} =$                      | f) $a^{-3}b^{-4} =$             | g) $a^{-5}b^{-1} =$                   | h) $a^{-1}b^{-1} =$                      |
| i) $\frac{1}{m^{-3}} =$            | j) $\frac{1}{r^{-4}} =$         | k) $\frac{1}{a^{-4}b^{-6}} =$         | l) $\frac{1}{a^{-1}b^{-3}} =$            |
| m) $\frac{1}{a^4b^{-7}} =$         | n) $\frac{1}{ab^{-4}} =$        | o) $\frac{1}{a^{-1}b} =$              | p) $\frac{x^{-3}}{y^{-2}} =$             |
| q) $\frac{b^2}{a^{-1}} =$          | r) $\frac{x^{-9}}{y^4} =$       | s) $\frac{a^{-1}}{b^{-1}} =$          | t) $\frac{x^{-3}}{y^2z^5} =$             |
| u) $\frac{a^2b^{-2}}{c^{-1}d^4} =$ | v) $\frac{s^4t^5}{x^{-6}y^7} =$ | w) $\frac{x^{-2}y^{-3}}{w^{-4}z^5} =$ | x) $\frac{m^{-2}n^{-2}}{a^{-3}b^{-3}} =$ |

3. Rewrite using positive exponents, then evaluate. (*Show one middle step.*)

- |                           |                                      |                                   |
|---------------------------|--------------------------------------|-----------------------------------|
| a) $6^{-3} =$             | b) $5^{-2} =$                        | c) $9^{-1} =$                     |
| d) $1^{-1} =$             | e) $\frac{1}{7^{-4}} =$              | f) $\frac{1}{10^{-3}} =$          |
| g) $\frac{1}{5^{-1}} =$   | h) $\frac{1}{2^{-3} \cdot 3^{-2}} =$ | i) $\frac{2^{-3}}{3^{-2}} =$      |
| j) $\frac{2^3}{3^{-2}} =$ | k) $\frac{2^{-3}}{3^2} =$            | l) $2^{-2} \cdot 3^{-3} =$        |
| m) $2^{-3} \cdot 4^2 =$   | n) $\frac{1}{2^{-3} \cdot 2^7} =$    | o) $\frac{1}{2^3 \cdot 2^{-7}} =$ |

4. Simplify. Give all answers with positive exponents only. (*Show at least one middle step.*)

- |                                       |   |                                       |
|---------------------------------------|---|---------------------------------------|
| a) $\frac{10a^5b^3}{2a^3b^5} =$       | b) $\frac{18m^4n^3q^5}{36m^7n^4q^5} =$      | c) $\frac{30m^6n^3}{6m^{-3}n^2} =$    |
| d) $\frac{27a^5b^3c^4}{9a^8b^4c^3} =$ | e) $\frac{m^{-2}n^6p^3}{m^4n^{-5}p^{-2}} =$ | f) $\frac{18a^2b^{-2}}{3a^{-3}b^5} =$ |

$$g) \frac{36x^6y^{-1}}{3x^{-3}y^2} =$$

$$h) \frac{x^{-2}y^{-5}z^4}{x^{-3}y^2z^{-2}} =$$

$$i) \frac{9a^{-5}b^2c^3}{a^{-6}b^3c} =$$

$$j) \frac{4a^{-3}b^{-4}c^6}{2a^2b^{-3}c^8} =$$

$$k) \frac{x^{-1}yz^{-1}}{x^{-1}y^{-1}z} =$$

$$l) \frac{x^{-2}y^{-3}z^{-4}}{x^{-5}y^{-6}z^{-3}} =$$

5. Simplify. Give all answers with positive exponents only. (Show at least one middle step.)

$$a) \frac{12(mn)^2}{3m^2n^3} =$$

$$b) \frac{25x^2y^4}{5x^4(y^2)^2} =$$

$$c) \frac{42x^{-1}(y^3)^2}{7x^3y^{-1}} =$$

$$d) \frac{16(s^2t)^2}{4s^{-3}t^2} =$$

$$e) \frac{16(mn^{-1})^3}{12m^4n^{-3}} =$$

$$f) \frac{6(ab^{-1})^2}{42a^{-3}b^4} =$$

$$g) \frac{14s^3t^3}{6s^4(t^{-1})^3} =$$

$$h) \frac{20(a^2)^{-3}b^2}{5a^2b^3} =$$

$$i) \frac{(x^{-2}y^5)^2z^{-4}}{x^7(y^{-1}z)^{-2}} =$$

$$j) \frac{(2m^4n^2q^6)^7}{(2m^4n^5q^2)^4} =$$

$$k) \frac{12(xy)^{-1}z}{8(x^{-1}y)^{-1}z^{-1}} =$$

$$l) \frac{(4xy)^{-1}}{(2x^{-1}y^2)^{-3}} =$$

**Answers:**

1. a)  $4^7$     b)  $\frac{1}{16}$     c)  $\frac{1}{3^6}$     d)  $\frac{1}{64}$     e)  $\frac{1}{625}$     f)  $\frac{1}{m^4}$     g)  $x^9$     h)  $y$
- i)  $g^8$     j)  $m^6$     k)  $8x^6$     l)  $1296a^8$     m)  $\frac{1}{2401}$     n)  $\frac{1}{256}$     o)  $729$
2. a)  $\frac{1}{a^3}$     b)  $\frac{1}{x^5}$     c)  $\frac{1}{m^2}$     d)  $\frac{1}{r^2}$     e)  $\frac{1}{m}$     f)  $\frac{1}{a^3b^4}$     g)  $\frac{1}{a^5b}$     h)  $\frac{1}{ab}$
- i)  $m^3$     j)  $r^4$     k)  $a^4b^6$     l)  $ab^3$     m)  $\frac{b^7}{a^4}$     n)  $\frac{b^4}{a}$     o)  $\frac{a}{b}$     p)  $\frac{y^2}{x^3}$
- q)  $ab^2$     r)  $\frac{1}{x^9y^4}$     s)  $\frac{b}{a}$     t)  $\frac{1}{x^3y^2z^5}$     u)  $\frac{a^2c}{b^2d^4}$     v)  $\frac{s^4t^5x^6}{y^7}$     w)  $\frac{w^4}{x^2y^3z^5}$     x)  $\frac{a^3b^3}{m^2n^2}$
3. a)  $\frac{1}{216}$     b)  $\frac{1}{25}$     c)  $\frac{1}{9}$     d)  $1$     e)  $2401$     f)  $1000$     g)  $5$     h)  $72$
- i)  $\frac{9}{8}$     j)  $72$     k)  $\frac{1}{72}$     l)  $\frac{1}{108}$     m)  $2$     n)  $\frac{1}{16}$     o)  $16$
4. a)  $\frac{5a^2}{b^2}$     b)  $\frac{1}{2m^3n}$     c)  $5m^9n$     d)  $\frac{3c}{a^3b}$     e)  $\frac{n^{11}p^5}{m^6}$     f)  $\frac{6a^5}{b^7}$
- g)  $\frac{12x^9}{y^3}$     h)  $\frac{xz^6}{y^7}$     i)  $\frac{9ac^2}{b}$     j)  $\frac{2}{a^5bc^2}$     k)  $\frac{y^2}{z^2}$     l)  $\frac{x^3y^3}{z}$
5. a)  $\frac{4}{n}$     b)  $\frac{5}{x^2}$     c)  $\frac{6y^7}{x^4}$     d)  $4s^7$     e)  $\frac{4}{3m}$     f)  $\frac{a^5}{7b^6}$
- g)  $\frac{7t^6}{3s}$     h)  $\frac{4}{a^8b}$     i)  $\frac{y^8}{x^{11}z^2}$     j)  $\frac{8m^{12}q^{34}}{n^6}$     k)  $\frac{3z^2}{2x^2}$     l)  $\frac{2y^5}{x^4}$