Learning Goal 2.2	I can apply exponent laws to expressions.

1. Simplify the following expressions to a single power (if possible). Show all your work.

Developing			
a. $5^2 \times 5^9$	b. $7^{10} \times 7^{12}$	c. $4^8 \times 3^9$	d. $a^{14} \times a^{18}$
e. $\frac{4^{14}}{4^8}$	f. $\frac{8^8}{5^3}$	g. $\frac{2^{23}}{2^6}$	h. $\frac{f^{19}}{f^{13}}$
i. $(3^6)^{10}$	j. $(6^{14})^3$	k. $(t^5)^{12}$	l. $(8^9)^4$
Proficient			
a. $(5^6 \times 5^2)^4$	b. $(7^0 \times 7^{15})^2$	c. $(3^8 \times 3^9)^0$	d. $(a^4 \times a^8)^{12}$
e. $\frac{4^8}{4^{14}}$	f. $\frac{8^8}{8^{17}}$	g. $\frac{2^2}{2^{16}}$	h. $\frac{f^{11}}{f^{24}}$
i. $\left(\frac{3^6}{3^3}\right)^{12}$	j. $\left(\frac{6^{14}}{6^{21}}\right)^3$	k. $\left(\frac{t^5}{t^{11}}\right)^8$	l. $\frac{a^4}{a^5} \times a^{-6}$
m. $\left(\frac{x^5 \times x^8}{x^3}\right)^9$	n. $\left(\frac{x^5}{x^3} \times x^8\right)^9$	o. $\left(\frac{x^5}{x^3}\right)^9 \times x^8$	p. $\frac{(x^5 \times x^8)^9}{x^3}$

b. $7^{10} \times 7^{12} = 7^{10+12}$
$= 7^{22}$

g. $\frac{2^{23}}{2^6} = 2^{23-6}$
$= 2^{17}$

l. $(8^9)^4 = 8^{9\times4}$
$= 8^{36}$

B E D M A S

d. $(a^4 \times a^8)^{12}$
$= (a^{4+8})^{12}$
$= (a^{12})^{12}$
$= a^{12\times12}$
$= a^{24}$

g. $\frac{2^2}{2^{16}} = 2^{2-16}$
$= 2^{-14}$
$= \frac{1}{2^{14}}$
$= \frac{1}{2^{16-2}}$
$= \frac{1}{2^{14}}$

j. $\left(\frac{6^{14}}{6^{21}}\right)^3 = (6^{14-21})^3$
$= (6^{-7})^3$
$= 6^{-7\times3}$
$= 6^{-21}$
$= \frac{1}{6^{21}}$
$= \left(\frac{1}{6^{21-14}}\right)^3$
$= \left(\frac{1}{6^7}\right)^3$
$= \frac{1^3}{6^{7\times3}}$
$= \frac{1}{6^{21}}$

m. $\left(\frac{x^5 \times x^8}{x^3}\right)^9$
$= \left(\frac{x^{5+8}}{x^3}\right)^9$
$= \left(\frac{x^{13}}{x^3}\right)^9$
$= (x^{13-3})^9$
$= (x^{10})^9$
$= x^{10\times9}$
$= x^{19}$

2. Simplify the following expressions. Show all your work.

Proficient			
a. $\left(\frac{6}{12a}\right)^3$	b. $(2b^2c^5)^3$	c. $(4m^4n^{-3})^{-3}$	d. $(-3a^{-4}b^{-5})^{-3}$
e. $\frac{4q^2r^5}{12q^7r^2}$	f. $\left(\frac{f^5}{fg^3}\right)^{-4}$	g. $\frac{2xy^2z^3}{x^3y^2z}$	h. $\left(\frac{14f^{11}}{7f^{24}}\right)^4$
i. $\frac{x^9y^5}{x^6y^{-2}}$	j. $\left(\frac{c^5d^{-3}}{c^{-2}d^3}\right)^{-4}$	k. $\left(\frac{-r^5s^3}{2t^{-11}}\right)^8$	l. $\left(\frac{16g^7}{8g^5h^{-4}}\right)^{15}$
m. $\left(-\frac{x^5y^8}{6y^3}\right)^3$	n. $\left(\frac{j^5}{k^3}\times j^8k^{-4}\right)^9$	o. $\left(\frac{c^{-2}d}{a^{-3}b^{-4}}\right)^{-9}$	p. $(-3p^{-4}q^3)^{-3}$

Extending	
a. $(3p^4q^5)^{-2}\times(2p^{-3})^4$	b. $(15r^6s^2t^{-4})^3\times(3r^3s^{-6}t^{-8})^{-4}$
c. $\left(\frac{-12a^7b^{-6}}{20a^{-3}c^4}\right)^{-3}$	d. $\left(\frac{60x^9y^{-12}}{12x^{-3}y^4z^{-2}}\right)^{-2}$

c. $(4m^4n^{-3})^{-3}$

$= \left(\frac{4m^4}{n^3}\right)^{-3}$

$= \left(\frac{n^3}{4m^4}\right)^3$

$= \frac{n^{3\times3}}{4^3m^{4\times3}}$

$= \frac{n^9}{4^3m^{12}}$

$= \boxed{\frac{n^9}{64m^{12}}}$

e. $\frac{\cancel{4}q^2r^5}{\cancel{12}_3q^7r^2}$

$= \frac{q^2r^5}{3q^7r^2q}$

$= \frac{r^5}{3q^{7-2}r^2}$

$= \frac{r^5}{3q^5r^2}$

$= \frac{r^{5-2}}{3q^5}$

$= \frac{r^3}{3q^5}$

j. $\left(\frac{c^5d^{-3}}{c^{-2}d^3}\right)^{-4}$

$= \left(\frac{c^5}{c^{-2}d^3d^3}\right)^{-4}$

$= \left(\frac{c^5c^2}{d^3d^3}\right)^{-4}$

$= \left(\frac{c^{5+2}}{d^{3+3}}\right)^{-4}$

$= \left(\frac{c^7}{d^6}\right)^{-4}$

$= \left(\frac{d^6}{c^7}\right)^4$

$= \frac{d^{6\times4}}{}$

p. $(-3p^{-4}q^3)^{-3}$

$= \left(\frac{-3q^3}{p^4}\right)^{-3}$ $\quad -3\times\frac{1}{3}$

$= \left(\frac{p^4}{-3q^3}\right)^3$

$= \frac{p^{4\times3}}{(-3)^3q^{3\times3}}$

$= \frac{p^{12}}{-27q^9}$

$= -\frac{p^{12}}{27q^9}$

$c^{7\times4}$

$= \frac{d^{24}}{c^{28}}$

Extending
3. The tallest tree in the world, Hyperion in California, is about 10^2 m tall. The highest mountain, Mount Everest, is about 10^4 m high. About how many times as high as the tree is the mountain?
4. Scientists grow bacteria. This table shows how the number of bacteria doubles every hour. How many bacteria are there at noon? At 3:00 PM? If the pattern continues, how many bacteria would you expect by midnight?

Time	Elapsed Time After Noon (h)	Number of Bacteria
noon	0	1000×2^0
1:00 P.M.	1	1000×2^1
2:00 P.M.	2	1000×2^2
3:00 P.M.	3	1000×2^3

At noon : 1000×2^0
$= 1000 \times 1$
$= 1000$ bacteria

At 3PM : 1000×2^3
$= 1000 \times 8$
$= 8000$ bacteria

At midnight
12:00 AM : 1000×2^{12}
$= 1000 \times 4096$
$= 4\,096\,000$ bacteria