Welcome to math MHF4U

Product of Powers

$$a^n \cdot a^m = a^{n+m}$$

Negative Powers

$$a^{-n} = \frac{1}{a^n}$$

Quotient of Powers

$$\frac{a^n}{a^m} = a^{n-m}$$

Fractional Powers

$$a^{\frac{n}{m}} = \sqrt[m]{a^n}$$

Power of powers

Zero Exponent

Tuesday, February 20, 2024

Introduction

- My name is Ms.Jaksic
- My email is gradimirka.jaksic@publicboard.ca
- The class will be every Tuesday and Thursday at 6:30 pm to 10:00pm
- These office hours (6:30pm to 10:00pm) are for lessons, questions, quizzes, testing ,exams, homework help, assistance and any other concerns you may have regarding this math program
- This course is very fast paced so prepare yourself!

Exponent Laws

- (First lesson)

The following summary shows the exponent laws for integral exponents.

Exponent Law for Multiplication

$$
\begin{aligned}
3^2 \times 3^4 &= (3 \times 3)(3 \times 3 \times 3 \times 3) \\
&= 3 \times 3 \times 3 \times 3 \times 3 \times 3 \\
&= 3^6
\end{aligned}
$$

$$
\begin{aligned}
a^m \times a^n &= \underbrace{(a \times a \times \ldots \times a)}_{m\text{ factors}}\underbrace{(a \times a \times \ldots \times a)}_{n\text{ factors}} \\
&= \underbrace{a \times a \times a \times \ldots \times a}_{m + n\text{ factors}} \\
&= a^{m+n}
\end{aligned}
$$

Exponent Law for Division

$$\frac{6^5}{6^2} = \frac{6 \times 6 \times 6 \times 6 \times 6}{6 \times 6}$$
$$= 6 \times 6 \times 6$$
$$= 6^3$$

$$\frac{a^m}{a^n} = \frac{\overbrace{a \times a \times a \times \ldots \times a}^{m \text{ factors}}}{\underbrace{a \times a \times \ldots \times a}_{n \text{ factors}}},\ a \neq 0$$
$$= \underbrace{a \times a \times a \times \ldots \times a}_{m - n \text{ factors}}$$
$$= a^{m-n}$$

Power Law

$$(a^m)^n = (a \times a \times \ldots \times a)^n$$

Power Law

$$(5^2)^3 = (5 \times 5)^3$$
$$= (5 \times 5)(5 \times 5)(5 \times 5)$$
$$= 5 \times 5 \times 5 \times 5 \times 5 \times 5$$
$$= 5^6$$

$$(a^m)^n = (\underbrace{a \times a \times \ldots \times a}_{m \text{ factors}})^n$$
$$= \underbrace{(\underbrace{a \times a \times \ldots \times a}_{m \text{ factors}}) \times (\underbrace{a \times a \times \ldots \times a}_{m \text{ factors}}) \times \ldots \times (\underbrace{a \times a \times \ldots \times a}_{m \text{ factors}})}_{n \text{ times}}$$
$$= \underbrace{a \times a \times a \times \ldots \times a}_{mn \text{ factors}}$$
$$= a^{mn}$$

Power of a Product

$$(5 \times 2)^3 = (5 \times 2) \times (5 \times 2) \times (5 \times 2)$$
$$= 5 \times 5 \times 5 \times 2 \times 2 \times 2$$
$$= 5^3 \times 2^3$$

$$(ab)^m = \underbrace{(ab) \times (ab) \times \ldots \times (ab)}_{m \text{ factors}}$$
$$= (\underbrace{a \times a \times \ldots \times a}_{m \text{ factors}}) \times (\underbrace{b \times b \times \ldots \times b}_{m \text{ factors}})$$
$$= a^m b^m$$

Power of a Quotient

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

$$= \frac{2 \times 2 \times 2}{5 \times 5 \times 5}$$

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

$$\left(\frac{a}{b}\right)^m = \underbrace{\left(\frac{a}{b}\right) \times \left(\frac{a}{b}\right) \times \ldots \times \left(\frac{a}{b}\right)}_{m \text{ factors}}$$

$$= \frac{\overbrace{a \times a \times \ldots \times a}^{m \text{ factors}}}{\underbrace{b \times b \times \ldots \times b}_{m \text{ factors}}}$$

$$= \frac{a^m}{b^m},\ b \neq 0$$

A power is an expression in the form a^m. The exponent laws can be used to simplify expressions with powers.

EXAMPLE 1 Simplifying Expressions With Powers

Simplify.

a) $(3a^2b)(-2a^3b^2)$ **b)** $(m^3)^4$ **c)** $(-4p^3q^2)^3$

Example 1 Simplifying Expressions With Powers

Simplify.

a) $(3a^2b)(-2a^3b^2)$ b) $(m^3)^4$ c) $(-4p^3q^2)^3$

Solution

a) $(3a^2b)(-2a^3b^2) = 3 \times (-2) \times a^2 \times a^3 \times b \times b^2$
$= -6a^5b^3$

b) $(m^3)^4 = m^{3 \times 4}$
$= m^{12}$

c) $(-4p^3q^2)^3 = (-4)^3 \times (p^3)^3 \times (q^2)^3$
$= -64p^9q^6$

Example 2 Simplifying a Power of a Quotient

Simplify $\left(\dfrac{6x^5y^3}{8y^4}\right)^2$.

Solution 1

Use the power of a quotient law first.

$$\begin{aligned}\left(\frac{6x^5y^3}{8y^4}\right)^2 &= \frac{(6)^2(x^5)^2(y^3)^2}{(8)^2(y^4)^2}\\ &= \frac{36x^{10}y^6}{64y^8}\\ &= \frac{9x^{10}}{16y^2}\end{aligned}$$

Solution 2

Simplify the quotient first.

$$\begin{aligned}\left(\frac{6x^5y^3}{8y^4}\right)^2 &= \left(\frac{3x^5}{4y}\right)^2\\ &= \frac{(3)^2(x^5)^2}{(4)^2(y)^2}\\ &= \frac{9x^{10}}{16y^2}\end{aligned}$$

The following summarizes the rules for zero and negative exponents.

Zero Exponent

$$\frac{2^3}{2^3} = 2^{3-3}$$
$$= 2^0$$
but $\frac{2^3}{2^3} = 1$

so $2^0 = 1$

$$\frac{a^m}{a^m} = a^{m-m}$$
$$= a^0$$
but $\frac{a^m}{a^m} = 1$

so, if $a \neq 0$, $a^0 = 1$

Note that 0^0 is not defined.

Negative Exponents

$$2^3 \times 2^{-3} = 2^{3+(-3)}$$
$$= 2^0$$
so $2^3 \times 2^{-3} = 1$

$$\frac{2^3 \times 2^{-3}}{2^3} = \frac{1}{2^3}$$ Divide both sides by 2^3.

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

$$a^m \times a^{-m} = a^{m+(-m)}$$
$$= \mathrm{a}^0$$
so $a^m \times a^{-m} = 1$

$$\frac{a^m \times a^{-m}}{a^m} = \frac{1}{a^m}$$ Divide both sides by a^m.

so, if $a \neq 0$, $a^{-m} = \frac{1}{a^m}$

Similarly, if $a \neq 0$, $\frac{1}{a^{-m}} = a^m$

Practise

A

1. Express as a power of 2.

a) $2^4 \times 2^3$ b) $2^6 \div 2^2$ c) $(2^4)^3$
d) 2×2^7 e) $2^3 \times 2^m$ f) $2^7 \div 2^y$
g) $2^x \div 2^4$ h) $(2^x)^y$ i) $2^{-3} \times 2^4$
j) $2^{-2} \div 2^{-5}$ k) $(2^3)^{-1}$ l) $2^{-4} \times 2^0$

2. Evaluate.

a) 3^{-2} b) 5^0 c) $(-2)^{-4}$
d) $(2^{-1})^2$ e) $-(-3)^0$ f) $\dfrac{1}{5^{-2}}$
g) $\dfrac{1}{(-4)^{-1}}$ h) $-(2^3)^{-2}$

3. Simplify. Express each answer with positive exponents.

a) $a^4 \times a^3$ b) $(m^6)(m^2)$
c) $b^5 \times b^6 \times b$ d) $a \times b^2 \times a^4$
e) $(x^3)(y)(y^4)(x^5)$ f) $(x^3)(x^{-5})$
g) $m^{-4} \times m^{-5}$ h) $y^{-1} \times y^{-3} \times y^2$
i) $a^5 \times a^0$ j) $(a^{-3})(b^{-2})(a^2)$

4. Simplify. Express each answer with positive exponents.

a) $x^6 \div x^3$ b) $m^7 \div m$ c) $t^4 \div t^{-2}$
d) $y^{-5} \div y^{-3}$ e) $m^4 \div m^0$ f) $t^0 \div t^{-5}$

5. Simplify. Express each answer with positive exponents.

a) $(x^3)^2$ b) $(a^2b^3)^4$ c) $(x^2)^{-1}$
d) $(t^4)^0$ e) $(a^{-1}b^2)^{-2}$ f) $(x^2y^3)^{-3}$

Key Concepts

- Exponent law for multiplication: $a^m \times a^n = a^{m+n}$
- Exponent law for division: $a^m \div a^n = a^{m-n}$
- Power law: $(a^m)^n = a^{mn}$
- Power of a product law: $(ab)^m = a^m b^m$
- Power of a quotient law: $\left(\dfrac{a}{b}\right)^m = \dfrac{a^m}{b^m}$
- Zero exponent property: if $a \neq 0$, $a^0 = 1$
- Negative exponent property: if $a \neq 0$, $a^{-m} = \dfrac{1}{a^m}$ and $\dfrac{1}{a^{-m}} = a^m$

Homework:
Each question do c),d) and e).

Due this Saturday by 11pm.

6. Simplify. Express each answer with positive exponents.

a) $\left(\frac{x}{2}\right)^3$ **b)** $\left(\frac{a}{b}\right)^4$ **c)** $\left(\frac{x^2}{y^3}\right)^5$

d) $\left(\frac{x}{3}\right)^{-1}$ **e)** $\left(\frac{a^{-2}}{b^{-3}}\right)^{-2}$

7. Simplify. Express each answer with positive exponents.

a) $5m^4 \times 3m^2$ **b)** $(4ab^4)(-5a^3b^2)$

c) $5a(-2ab^2)(-3b^3)$ **d)** $(-6m^3n^2)(-4mn^5)$

e) $(7x^2)(6x^{-2})$ **f)** $(3x^{-2}y^2)(-2x^2y^{-3})$

g) $(-6a^{-1}b^2)(-a^{-3}b^{-4})$ **h)** $(-10x^4) \div (-2x)$

i) $\frac{45a^2b^4}{9ab^2}$ **j)** $\frac{(4m^2n^4)(7m^3n)}{14mn^5}$

k) $\frac{3ab^3 \times 10a^4b^2}{15a^2b^6}$ **l)** $\frac{4a^4b^3}{a^5b^6} \times \frac{-a^3}{-(b^2)}$

m) $(35x^5) \div (5x^{-3})$ **n)** $\frac{-54a^5b^{-7}}{-6a^{-2}b^{-3}}$

o) $(-6m^{-4}n^2) \div (2m^{-1}n^{-6})$

p) $\frac{(-2x^{-3}y)(-12x^{-4}y^{-2})}{6xy^{-3}}$

8. Simplify. Express each answer with positive exponents.

a) $(2m^3)^2$ **b)** $(-4x^2)^3$

c) $(-3m^3n^2)^2$ **d)** $(5c^{-3}d^3)^{-2}$

e) $(2a^{-3}b^{-2})^{-3}$ **f)** $(-3x^3y^{-2})^{-4}$

Key Concepts

- Exponent law for multiplication: $a^m \times a^n = a^{m+n}$
- Exponent law for division: $a^m \div a^n = a^{m-n}$
- Power law: $(a^m)^n = a^{mn}$
- Power of a product law: $(ab)^m = a^m b^m$
- Power of a quotient law: $\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$
- Zero exponent property: if $a \neq 0$, $a^0 = 1$
- Negative exponent property: if $a \neq 0$, $a^{-m} = \frac{1}{a^m}$ and $\frac{1}{a^{-m}} = a^m$

Rational Exponent

Second lesson

In the power law for exponents, $(a^m)^n = a^{mn}$, substituting $m = \frac{1}{n}$ gives

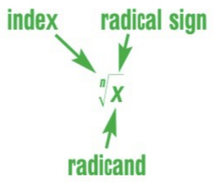
$$\left(a^{\frac{1}{n}}\right)^n = a^{\frac{1}{n} \times n}$$
$$= a^1 \text{ or } a$$

If $a \geq 0$, we can take the nth root of both sides of the equation $\left(a^{\frac{1}{n}}\right)^n = a$, which gives $a^{\frac{1}{n}} = \sqrt[n]{a}$.

This result suggests the following definition.

$a^{\frac{1}{n}} = \sqrt[n]{a}$, where n is a natural number.

The symbol $\sqrt[n]{}$ indicates an nth root, and $\sqrt[n]{x}$ represents the principal nth root of x. For example, $64^{\frac{1}{3}} = \sqrt[3]{64}$. The expression $\sqrt[3]{64}$ is read as "the cube root of 64."



Finding the cube root of a number is the inverse operation of cubing. To find the cube root of 64, find the number whose cube is 64.

Since $4^3 = 64$, $\sqrt[3]{64} = 4$.

- If n is an even number, then we must have $a \geq 0$ for the nth root to be real. Suppose that n is even and a is negative. For example, if $n = 2$ and $a = -4$, then $(-4)^{\frac{1}{2}}$ becomes $\sqrt{-4}$. There is no real square root of -4.
- If n is an odd number, then a can be any real number. For example, if $n = 3$ and $a = -8$, then $(-8)^{\frac{1}{3}}$ becomes $\sqrt[3]{-8}$, which is -2. In this case, the principal root is negative.

Note how brackets are used with fractional exponents. The expression $\sqrt{-4}$ has no meaning in the real number system, but $-\sqrt{4} = -2$. Similarly, $(-4)^{\frac{1}{2}}$ becomes $\sqrt{-4}$, which has no meaning in the real number system. But $-4^{\frac{1}{2}}$ becomes $-\left(4^{\frac{1}{2}}\right) = -\sqrt{4} = -2$.

EXAMPLE 1 Exponents in the Form $\frac{1}{n}$

Evaluate.

a) $49^{\frac{1}{2}}$ **b)** $(-27)^{\frac{1}{3}}$ **c)** $(-8)^{-\frac{1}{3}}$

Example 1 Exponents in the Form $\frac{1}{n}$

Evaluate.

a) $49^{\frac{1}{2}}$ b) $(-27)^{\frac{1}{3}}$ c) $(-8)^{-\frac{1}{3}}$

Solution

a)
$$49^{\frac{1}{2}} = \sqrt{49} = 7$$

b)
$$(-27)^{\frac{1}{3}} = \sqrt[3]{-27} = -3$$

c)
$$(-8)^{-\frac{1}{3}} = \frac{1}{(-8)^{\frac{1}{3}}} = \frac{1}{\sqrt[3]{-8}} = -\frac{1}{2}$$

The following suggests how to evaluate an expression with a fractional exponent in which the numerator is not 1, such as $4^{\frac{3}{2}}$.

The power law $(a^m)^n = a^{mn}$ is used.

Method 1

$$4^{\frac{3}{2}} = \left(4^{\frac{1}{2}}\right)^3$$
$$= \left(\sqrt{4}\right)^3$$
$$= 2^3$$
$$= 8$$

Method 2

$$4^{\frac{3}{2}} = (4^3)^{\frac{1}{2}}$$
$$= \sqrt{4^3}$$
$$= \sqrt{64}$$
$$= 8$$

Notice that $\left(\sqrt{4}\right)^3$ and $\sqrt{4^3}$ have the same value.

This result suggests the following definition for rational exponents.

$a^{\frac{m}{n}} = \sqrt[n]{a^m} = \left(\sqrt[n]{a}\right)^m$, where m and n are natural numbers.

If n is an even number, then $a \geq 0$.

If n is an odd number, then a can be any real number.

To calculate $a^{\frac{m}{n}}$

- take the nth root of a, then raise the result to the mth power

$$9^{\frac{3}{2}} = \left(\sqrt{9}\right)^3$$
$$= 3^3$$
$$= 27$$

or

- raise a to the mth power, then take the nth root

$$9^{\frac{3}{2}} = \sqrt{9^3}$$
$$= \sqrt{729}$$
$$= 27$$

It is common practice to take the nth root first.

Example 2 Exponents in the Form $\frac{m}{n}$

Evaluate.

a) $(-8)^{\frac{4}{3}}$ b) $9^{-2.5}$ c) $\left(\frac{25}{4}\right)^{-\frac{3}{2}}$

Solution 1 Paper-and-Pencil Method

a)
$$\begin{aligned}(-8)^{\frac{4}{3}} &= \left(\sqrt[3]{-8}\right)^4\\ &= (-2)^4\\ &= 16\end{aligned}$$

b)
$$\begin{aligned}9^{-2.5} &= 9^{-\frac{5}{2}}\\ &= \frac{1}{9^{\frac{5}{2}}}\\ &= \frac{1}{\left(\sqrt{9}\right)^5}\\ &= \frac{1}{3^5}\\ &= \frac{1}{243}\end{aligned}$$

c)
$$\begin{aligned}\left(\frac{25}{4}\right)^{-\frac{3}{2}} &= \frac{1}{\left(\frac{25}{4}\right)^{\frac{3}{2}}}\\ &= \frac{1}{\frac{\left(\sqrt{25}\right)^3}{\left(\sqrt{4}\right)^3}}\\ &= \frac{1}{\frac{5^3}{2^3}}\\ &= \frac{1}{\frac{125}{8}}\\ &= \frac{8}{125}\end{aligned}$$

Practise

A

1. Write in radical form.

a) $2^{\frac{1}{3}}$ b) $37^{\frac{1}{2}}$ c) $x^{\frac{1}{2}}$
d) $a^{\frac{3}{5}}$ e) $6^{\frac{4}{3}}$ f) $6^{\frac{3}{4}}$
g) $7^{-\frac{1}{2}}$ h) $9^{-\frac{1}{5}}$ i) $x^{-\frac{3}{7}}$
j) $b^{-\frac{6}{5}}$ k) $(3x)^{\frac{1}{2}}$ l) $3x^{\frac{1}{2}}$

2. Write using exponents.

a) $\sqrt{7}$ b) $\sqrt{34}$ c) $\sqrt[3]{-11}$
d) $\sqrt[5]{a^2}$ e) $\sqrt[3]{6^4}$ f) $(\sqrt[3]{b})^4$
g) $\dfrac{1}{\sqrt{x}}$ h) $\dfrac{1}{\sqrt[3]{a}}$ i) $\dfrac{1}{\sqrt[5]{x^4}}$
j) $\sqrt[3]{2b^3}$ k) $\sqrt{3x^5}$ l) $\sqrt[4]{5t^3}$

3. Evaluate.

a) $4^{\frac{1}{2}}$ b) $125^{\frac{1}{3}}$ c) $16^{-\frac{1}{4}}$
d) $(-32)^{\frac{1}{5}}$ e) $25^{0.5}$ f) $(-27)^{-\frac{1}{3}}$
g) $64^{-\frac{1}{6}}$ h) $0.04^{\frac{1}{2}}$ i) $81^{0.25}$
j) $0.001^{\frac{1}{3}}$ k) $\left(\dfrac{4}{9}\right)^{\frac{1}{2}}$ l) $\left(\dfrac{-27}{-8}\right)^{\frac{1}{3}}$

Key Concepts

- Exponent law for multiplication: $a^m \times a^n = a^{m+n}$
- Exponent law for division: $a^m \div a^n = a^{m-n}$
- Power law: $(a^m)^n = a^{mn}$
- Power of a product law: $(ab)^m = a^m b^m$
- Power of a quotient law: $\left(\dfrac{a}{b}\right)^m = \dfrac{a^m}{b^m}$
- Zero exponent property: if $a \neq 0$, $a^0 = 1$
- Negative exponent property: if $a \neq 0$, $a^{-m} = \dfrac{1}{a^m}$ and $\dfrac{1}{a^{-m}} = a^m$

Homework question 4.

Due Saturday 11pm.

4. Evaluate.

a) $8^{\frac{2}{3}}$ b) $4^{\frac{3}{2}}$ c) $9^{2.5}$
d) $81^{\frac{3}{4}}$ e) $16^{-\frac{3}{4}}$ f) $(-32)^{\frac{2}{5}}$
g) $(-8)^{-\frac{5}{3}}$ h) $(-27)^{-\frac{2}{3}}$ i) $1^{\frac{5}{3}}$
j) $(-1)^{-\frac{8}{5}}$ k) $\left(\dfrac{100}{9}\right)^{\frac{3}{2}}$ l) $\left(\dfrac{27}{8}\right)^{-\frac{2}{3}}$

Solving Exponential Equations

Third lesson

One method for solving an exponential equation is to rewrite the powers with the same base, so that the exponents are equal. Equating the exponents gives a linear equation, which can be solved.

This method of solving an exponential equation is based on the property that, if $a^x = a^y$, then $x = y$, for $a \neq 1, 0, -1$.

EXAMPLE 1 Solving Using a Common Base

Solve and check $4^{x+1} = 2^{x-1}$.

SOLUTION

The base 4 on the left side is a power of 2.

	$4^{x+1} = 2^{x-1}$
Rewrite using base 2:	$(2^2)^{x+1} = 2^{x-1}$
Simplify exponents:	$2^{2x+2} = 2^{x-1}$
Equate exponents:	$2x + 2 = x - 1$
Solve for x:	$x = -3$

Check.

L.S. $= 4^{x+1}$	R.S. $= 2^{x-1}$
$= 4^{-3+1}$	$= 2^{-3-1}$
$= 4^{-2}$	$= 2^{-4}$
$= \frac{1}{4^2}$	$= \frac{1}{2^4}$
$= \frac{1}{16}$	$= \frac{1}{16}$

L.S. = R.S.

The solution is $x = -3$.

EXAMPLE 2 Rational Solutions

Solve and check $9^{3x+1} = 27^x$.

SOLUTION

Both bases are powers of 3.

$$9^{3x+1} = 27^x$$

Rewrite using base 3: $(3^2)^{3x+1} = (3^3)^x$

Simplify exponents: $3^{6x+2} = 3^{3x}$

Equate exponents: $6x + 2 = 3x$

Solve for x: $3x = -2$

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

The solution is $x = -\frac{2}{3}$.

Check.

$$\text{L.S.} = 9^{3x+1} = 9^{3\left(-\frac{2}{3}\right)+1} = 9^{-2+1} = 9^{-1} = \frac{1}{9}$$

$$\text{R.S.} = 27^x = 27^{-\frac{2}{3}} = \frac{1}{\left(\sqrt[3]{27}\right)^2} = \frac{1}{3^2} = \frac{1}{9}$$

L.S. = R.S.

EXAMPLE 3 Solving Using a Common Factor

Solve and check $3^{x+2} - 3^{x} = 216$.

SOLUTION

	$3^{x+2} - 3^{x} = 216$	Check.	
Remove a common factor:	$3^{x}(3^{2} - 1) = 216$	L.S. $= 3^{x+2} - 3^{x}$	R.S. $= 216$
Simplify:	$3^{x}(8) = 216$	$= 3^{3+2} - 3^{3}$	
Divide both sides by 8:	$3^{x} = 27$	$= 3^{5} - 27$	
Solve for x:	$3^{x} = 3^{3}$	$= 243 - 27$	
	$x = 3$	$= 216$	

The solution is $x = 3$.

L.S. = R.S.

Practise

A

1. Solve.

a) $2^x = 16$ **b)** $3^x = 27$

c) $2^x = 128$ **d)** $5^x = 125$

e) $4^y = 256$ **f)** $729 = 9^z$

g) $(-3)^x = -27$ **h)** $(-2)^x = -32$

i) $(-5)^a = 25$ **j)** $81 = (-3)^x$

k) $-2^x = -16$ **l)** $-4^y = -64$

m) $-5^x = -625$ **n)** $(-1)^x = 1$

o) $(-1)^m = -1$

2. Solve.

a) $7^{w-2} = 49$ **b)** $3^{x+4} = 27$

c) $2^{1-x} = 128$ **d)** $4^{3k} = 64$

e) $5^{3x-1} = 25$ **f)** $-81 = -3^{2x+8}$

g) $4^{x-1} = 1$ **h)** $3^{2-2x} = 1$

i) $(-1)^{2x} = 1$

3. Solve and check.

a) $6^{x+3} = 6^{2x}$ **b)** $2^{x+3} = 2^{2x-1}$

c) $3^{2y+3} = 3^{y+5}$ **d)** $2^{4x-7} = 2^{2x+1}$

e) $7^{5d-1} = 7^{2d+5}$ **f)** $3^{b-5} = 3^{2b-3}$

4. Solve.

a) $16^{2x} = 8^{3x}$ **b)** $4^t = 8^{t+1}$

c) $27^{x-1} = 9^{2x}$ **d)** $25^{2-c} = 125^{2c-4}$

e) $16^{2p+1} = 8^{3p+1}$ **f)** $(-8)^{1-2x} = (-32)^{1-x}$

5. Solve and check.

a) $2^{x+5} = 4^{x+2}$ **b)** $2^x = 4^{x-1}$

c) $9^{2q-6} = 3^{q+6}$ **d)** $4^x = 8^{x+1}$

e) $27^{y-1} = 9^{2y-4}$ **f)** $8^{x+3} = 16^{2x+1}$

6. Solve and check.

a) $5^{4-x} = \frac{1}{5}$ **b)** $10^{y-2} = \frac{1}{10\,000}$

c) $6^{3x-7} = \frac{1}{6}$ **d)** $3^{3x-1} = \frac{1}{81}$

e) $5^{2n+1} = \frac{1}{125}$ **f)** $\frac{1}{256} = 2^{2-5w}$

Homework:
Each question do e) and f).

Due Saturday 11pm.