Properties of Exponents:

$a^r \bullet a^s = a^{(r+s)}$	$(a^r)^s = a^{(r \bullet s)}$
$(ab)^r = (a^r)(b^r)$	$a^{-r} = \frac{1}{a^r}$ or $a^r = \frac{1}{a^{-r}}$
$\left(\frac{a}{b}\right)^{-r} = \left(\frac{b}{a}\right)^r$	$\left(\frac{a}{b}\right)^r = \frac{a^r}{b^r}$
$\frac{a^r}{a^s} = a^{(r-s)}$	$a^1 = a$ and $a^0 = 1$ if $a \neq 0$

Definition: A number is written in **scientific notation** if it is written as the product of a number between 1 and 10 and an integer power of 10. A number written in scientific notation has the form

$a \times 10^n$ where $1 \le a < 10$ and n is an integer.

Additional examples:

18) $\left(-\frac{3}{5}x^4\right)^3$

$$\left(-\frac{3}{5}x^4\right)^3 = \left(-\frac{3}{5}x^4\right)\left(-\frac{3}{5}x^4\right)\left(-\frac{3}{5}x^4\right) = -\frac{(3)(3)(3)}{(5)(5)(5)}(x^4)(x^4)(x^4) = -\frac{27}{125}x^{12}$$

20) $5a^7(-4a^6)$

$$5a^7(-4a^6) = (5)(-4)(a^7)(a^6) = -20a^{13}$$

22) $(-5)^{-2}$

$$(-5)^{-2} = \frac{1}{(-5)^2} = \frac{1}{(-5)(-5)} = \frac{1}{25}$$

24) 2^{-5}

$$2^{-5} = \frac{1}{2^5} = \frac{1}{(2)(2)(2)(2)(2)} = \frac{1}{32}$$

26) $\left(\frac{3}{5}\right)^{-2}$

$$\left(\frac{3}{5}\right)^{-2} = \left(\frac{5}{3}\right)^2 = \left(\frac{5}{3}\right)\left(\frac{5}{3}\right) = \frac{25}{9}$$

28) $\left(\frac{1}{2}\right)^{-2} + \left(\frac{1}{3}\right)^{-3}$

$$\left(\frac{1}{2}\right)^{-2} + \left(\frac{1}{3}\right)^{-3} = \left(\frac{2}{1}\right)^2 + \left(\frac{3}{1}\right)^3 = (2)^2 + (3)^3 = (2)(2) + (3)(3)(3) = 4 + 27 = 31$$

30) $x^{-3}x^{8}$

$$x^{-3}x^{8}=\frac{x^{8}}{x^{3}}=\frac{x^{5}}{1}=x^{5}$$

32) $(a^{4}b^{-3})^{3}$

$$(a^{4}b^{-3})^{3}=\left(\frac{a^{4}}{b^{3}}\right)^{3}=\left(\frac{a^{4}}{b^{3}}\right)\left(\frac{a^{4}}{b^{3}}\right)\left(\frac{a^{4}}{b^{3}}\right)=\frac{a^{12}}{b^{9}}$$

34) $(3y^{5})^{-2}(2y^{-4})^{3}$

$$(3y^{5})^{-2}(2y^{-4})^{3}=\left(\frac{1}{(3y^{5})^{2}}\right)\left(\frac{2}{y^{4}}\right)^{3}=\left(\frac{1}{(3y^{5})(3y^{5})}\right)\left(\frac{2}{y^{4}}\right)\left(\frac{2}{y^{4}}\right)\left(\frac{2}{y^{4}}\right)=\frac{8}{9y^{22}}$$

36) $\left(\frac{1}{7}x^{-3}\right)\left(\frac{7}{8}x^{-5}\right)\left(\frac{8}{9}x^{8}\right)$

$$\left(\frac{1}{7}x^{-3}\right)\left(\frac{7}{8}x^{-5}\right)\left(\frac{8}{9}x^{8}\right)=\left(\frac{1}{7}\bullet\frac{1}{x^{3}}\right)\left(\frac{7}{8}\bullet\frac{1}{x^{5}}\right)\left(\frac{8}{9}\bullet\frac{x^{8}}{1}\right)=\left(\frac{1}{7x^{3}}\right)\left(\frac{7}{8x^{5}}\right)\left(\frac{8x^{8}}{9}\right)=\left(\frac{1}{1x^{3}}\right)\left(\frac{1}{1x^{5}}\right)\left(\frac{1x^{8}}{9}\right)=\frac{x^{8}}{9x^{8}}=\frac{1}{9}$$

38) $(3a^{-2}c^{3})(5b^{-6}c^{5})(4a^{6}b^{-2})$

$$(3a^{-2}c^{3})(5b^{-6}c^{5})(4a^{6}b^{-2})=\left(\frac{3c^{3}}{a^{2}}\right)\left(\frac{5c^{5}}{b^{6}}\right)\left(\frac{4a^{6}}{b^{2}}\right)=\frac{60a^{6}c^{8}}{a^{2}b^{8}}=\frac{60a^{4}c^{8}}{b^{8}}$$

40) $(4x^{-4}y^{9})^{-2}(5x^{4}y^{-3})^{2}$

$$(4x^{-4}y^{9})^{-2}(5x^{4}y^{-3})^{2}=\left(\frac{4y^{9}}{x^{4}}\right)^{-2}\left(\frac{5x^{4}}{y^{3}}\right)^{2}=\left(\frac{x^{4}}{4y^{9}}\right)^{2}\left(\frac{5x^{4}}{y^{3}}\right)^{2}=\left(\frac{x^{4}}{4y^{9}}\right)\left(\frac{x^{4}}{4y^{9}}\right)\left(\frac{5x^{4}}{y^{3}}\right)\left(\frac{5x^{4}}{y^{3}}\right)=\frac{25x^{16}}{16y^{24}}$$

42) $\frac{x^{-3}}{x^{5}}$

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

44) $\frac{a^{5}}{a^{-2}}$

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

46) $\frac{t^{-8}}{t^{-5}}$

$$\frac{t^{-8}}{t^{-5}}=\frac{t^{5}}{t^{8}}=\frac{1}{t^{3}}$$

48) $\left(\dfrac{x^7}{x^4}\right)^5$

$$\left(\frac{x^7}{x^4}\right)^5 = (x^3)^5 = (x^3)(x^3)(x^3)(x^3)(x^3) = x^{15}$$

50) $\dfrac{(x^7)^3}{(x^4)^5}$

$$\frac{(x^7)^3}{(x^4)^5} = \frac{(x^7)(x^7)(x^7)}{(x^4)(x^4)(x^4)(x^4)(x^4)} = \frac{x^{21}}{x^{20}} = \frac{x^1}{1} = x$$

52) $\dfrac{(x^{-4})^3(x^3)^{-4}}{x^{10}}$

$$\frac{(x^{-4})^3(x^3)^{-4}}{x^{10}} = \frac{(x^{-4})^3}{x^{10}(x^3)^4} = \frac{(x^{-4})(x^{-4})(x^{-4})}{x^{10}(x^3)(x^3)(x^3)(x^3)} = \frac{x^{-12}}{x^{22}} = \frac{1}{x^{22}(x^{12})} = \frac{1}{x^{34}}$$

54) $\dfrac{7a^6b^{-2}}{21a^2b^{-5}}$

$$\frac{7a^6b^{-2}}{21a^2b^{-5}} = \frac{7a^6b^5}{21a^2b^2} = \frac{1a^4b^3}{3(1)(1)} = \frac{a^4b^3}{3}$$

56) $\dfrac{(6x^{-3}y^{-5})^2}{(3x^{-4}y^{-3})^4}$

$$\frac{(6x^{-3}y^{-5})^2}{(3x^{-4}y^{-3})^4} = \frac{(6x^{-3}y^{-5})(6x^{-3}y^{-5})}{(3x^{-4}y^{-3})(3x^{-4}y^{-3})(3x^{-4}y^{-3})(3x^{-4}y^{-3})} = \frac{(2x^{-3}y^{-5})(2x^{-3}y^{-5})}{(1x^{-4}y^{-3})(1x^{-4}y^{-3})(3x^{-4}y^{-3})(3x^{-4}y^{-3})}$$

$$= \frac{4x^{-6}y^{-10}}{9x^{-16}y^{-12}} = \frac{4x^{16}y^{12}}{9x^6y^{10}} = \frac{4x^{10}y^2}{9}$$

58) $\left(\dfrac{5x^4y^5}{10xy^{-2}}\right)^3$

$$\left(\frac{5x^4y^5}{10xy^{-2}}\right)^3 = \left(\frac{1x^3y^5(y^2)}{2}\right)^3 = \left(\frac{x^3y^7}{2}\right)^3 = \left(\frac{x^3y^7}{2}\right)\left(\frac{x^3y^7}{2}\right)\left(\frac{x^3y^7}{2}\right) = \frac{x^9y^{21}}{8}$$

60) $\left(\dfrac{x^{-8}y^{-3}}{x^{-5}y^6}\right)^{-1}$

$$\left(\frac{x^{-8}y^{-3}}{x^{-5}y^6}\right)^{-1} = \left(\frac{x^{-5}y^6}{x^{-8}y^{-3}}\right)^1 = \frac{x^8y^6(y^3)}{x^5} = \frac{x^3y^9}{1} = x^3y^9$$

62) $\left(\dfrac{a^3b^2c^1}{a^{-1}b^{-2}c^{-3}}\right)^2$

$$\left(\frac{a^3b^2c^1}{a^{-1}b^{-2}c^{-3}}\right)^2 = \left(\frac{a^3(a^1)b^2(b^2)c^1(c^3)}{1}\right)^2 = (a^4b^4c^4)^2 = (a^4b^4c^4)(a^4b^4c^4) = a^8b^8c^8$$

64) $3,780,000 = 3.78\times10^6$

66) $490 = 4.9\times10^2$

68) $0.000037 = 3.7\times10^{-5}$

70) $0.0495 = 4.95\times10^{-2}$

72) $5.34\times10^2 = 534$

74) $7.8\times10^4 = 78000 = 78,000$

76) $3.44\times10^{-5} = 0.0000344$

78) $4.9\times10^{-2} = 0.049$

80) $(3\times10^{-12})(3\times10^4)$

$$(3\times10^{-12})(3\times10^4) = (3)(3)\times10^{(-12+4)} = 9\times10^{-8}$$

82) $\dfrac{6\times10^8}{3\times10^3}$

$$\frac{6\times10^8}{3\times10^3} = \frac{6}{3}\times\frac{10^8}{10^3} = 2\times10^5$$

84) $\dfrac{(6\times10^{-7})(3\times10^9)}{5\times10^6}$

$$\frac{(6\times10^{-7})(3\times10^9)}{5\times10^6} = \frac{(6)(3)}{5}\times\frac{(10^{-7})(10^9)}{10^6} = \frac{18}{5}\times10^{(-7+9-6)} = 3.6\times10^{-4}$$

86) $\dfrac{(7.5\times10^{-6})(1.5\times10^9)}{(1.8\times10^4)(2.5\times10^{-2})}$

$$\frac{(7.5\times10^{-6})(1.5\times10^9)}{(1.8\times10^4)(2.5\times10^{-2})} = \frac{(7.5)(1.5)}{(1.8)(2.5)}\times\frac{(10^{-6})(10^9)}{(10^4)(10^{-2})} = \frac{(3)(0.5)}{(0.6)(1)}\times\frac{(10^9)(10^2)}{(10^6)(10^4)} = \frac{(1)(0.5)}{(0.2)(1)}\times\frac{10^7}{10^2} = \frac{0.5}{0.2}\times10^{(7-2)}$$

$$= \frac{5}{2}\times10^5 = 2.5\times10^5$$