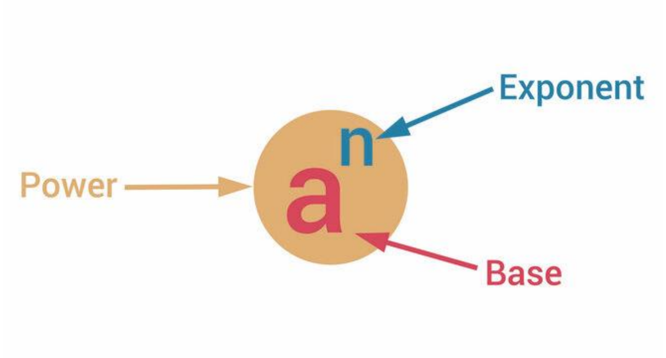
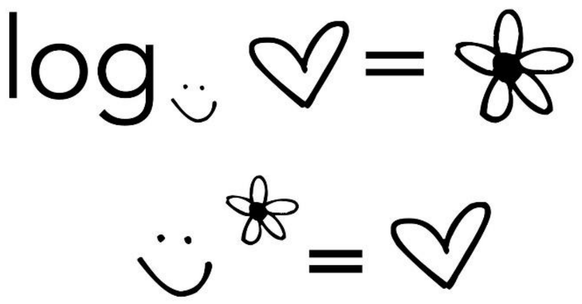


Lecture 5:

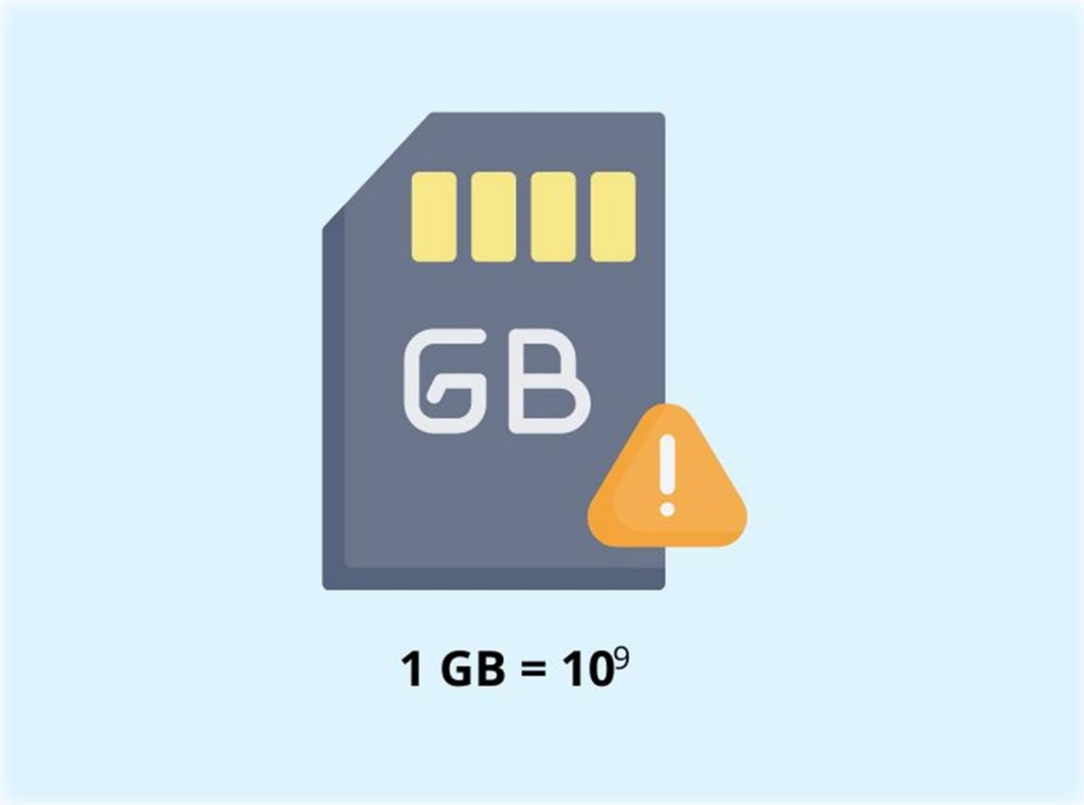
- Powers
- Logarithms



Ms. Togzhan Nurtayeva
Course Code: IT 161/A
Semester 1
Week 9-11
Date: 07.02.2024

What will we learn?

- Power and *n*th root functions
- Fractional powers and *n*th roots
- Number System Conversion
- Logarithmic Functions



Powers / Exponents

Exponents and Viral Marketing

If One Person , tells another 10 people, and then each of these 10 people tell another 10 people, and so on, we get rapid spreading of a message, video, photo, news item, or product across the Internet.

Level	0	1	2	3	4	etc
Spread	1 +	10 +	100 +	1000 +	10 000	
Powers	10^0	10^1	10^2	10^3	10^4	

Spread = 10^{Level}

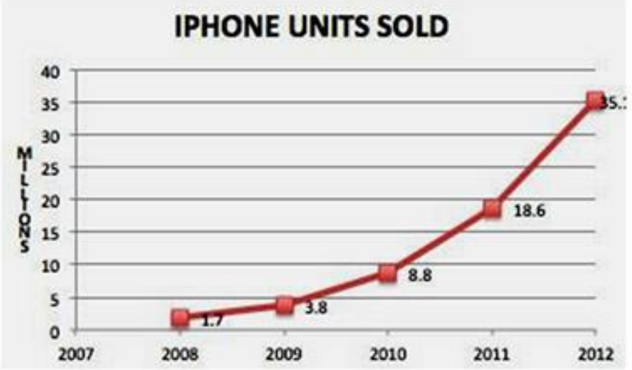
Image Source: http://m5.paperblog.com

EARTHQUAKES

Exponents are used to measure the strength of earth-quakes. A level 1 earthquake is 1×10^1, a level 2 earthquake is 1×10^2, a level 3 is 1×10^3, etc.

Smart Phone Uptake and Sales

At first only a few people had smart phones, then within only a few years, it seems that everybody has an iPhone or similar. Eg. The Growth in Smart Phone usage has been Exponential.



Exponents in Computer Games

Computer Games use "Game Physics Engines" which are low level programs inside the game to calculate the movement, interactions, and the geometry involved with the game.

These programs use lots of Algebra formulas in their Algorithms, and many of these formulas involve multiplying powers terms containing exponents.

If the mathematics isn't correct in the game engine, then the game is not going to play at all like we would expect it to.

Exponents / Powers

$$\underbrace{5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5}_{8\ times} = 5^8$$

$$b^n$$

Exponent

The value that specifies how many times the base will be multiplied by itself

Base

The number or variable that is being multiplied repeatedly in the expanded form

$$2 \times 2 \times 2 \times 2 \times 2 = 32$$

1 2 3 4 5

$$2^5$$

$$7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 = 7^9$$

Exponents/Powers Properties

Law	Example
$a^m a^n = a^{m+n}$	$2^3 2^4 = 2^{3+4} = 2^7 = 128$
$(a^m)^n = a^{mn}$	$(2^3)^4 = 2^{3.4} = 2^{12} = 4096$
$(ab)^n = a^n b^n$	$(20)^3 = (2.10)^3 = 2^3.10^3 = 8.1000 = 8000$
$(\frac{a}{b})^n = \frac{a^n}{b^n}$	$(\frac{2}{5})^3 = \frac{2^3}{5^3} = \frac{8}{125}$
$\frac{a^m}{a^n} = a^{m-n}$	$\frac{2^5}{2^3} = 2^{5-3} = 2^2 = 4$
$\frac{a^m}{a^n} = \frac{1}{a^{n-m}}$	$\frac{2^3}{2^5} = \frac{1}{2^{5-3}} = \frac{1}{2^2} = \frac{1}{4}$

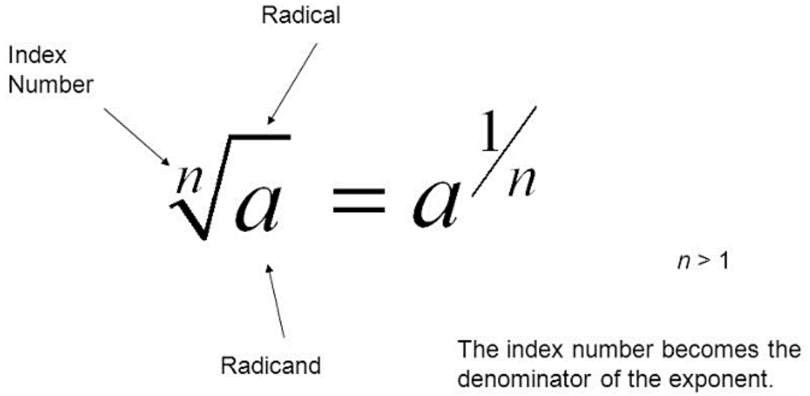
1. $3 \cdot 4^3$
2. $4x^3 \cdot 2x^3$
3. $x^5 \cdot x^3$
4. $2x^3 \cdot 2x^2$
5. $\frac{6^5}{6^3}$
6. $\frac{x^4}{x^7}$
7. 8^0
8. $-(9x)^0$
9. $(y^4)^3$
10. $(x^2y)^4$
11. $\frac{6x^7}{2x^4}$
12. $\frac{8x^5}{4x^2}$
13. $(2cd^4)^2(cd)^5$
14. $(2fg^4)^4(fg)^6$
15. $\frac{x^5y^6}{xy^2}$
16. $\frac{x^2y^5}{xy^4}$
17. $\left(\frac{4x^5y}{16xy^4}\right)^3$
18. $\left(\frac{5x^3y}{20xy^5}\right)^4$
19. y^{-7}
20. 7^{-2}
21. $\frac{1}{x^{-5}}$
22. $\frac{1}{2^{-4}}$
23. $x^5 \cdot x^{-1}$
24. x^{-6}
25. $x^9 \cdot x^{-7}$
26. $(j^{-13})(j^4)(j^6)$
27. $\frac{x^{-1}}{x^{-8}}$
28. $\frac{52x^6}{13x^{-7}}$
29. $f^{-3}(f^2)(f^{-3})$
30. $\frac{x^{-4}}{x^{-9}}$
31. $\frac{24x^6}{12x^{-8}}$
32. $\frac{3x^2y^{-3}}{12x^6y^3}$
33. $(2x^3y^{-3})^{-2}$
34. $\frac{2x^4y^{-4}}{8x^7y^3}$
35. $(4x^4y^{-4})^3$
36. $5x^2y(2x^4y^{-3})$
37. $\left(\frac{-7a^2b^3c^0}{3a^3b^4c^3}\right)^{-4}$
38. $\left(\frac{-2a^3b^2c^0}{3a^2b^3c^7}\right)^{-2}$

ANSWERS

1. 192
2. $8x^6$
3. x^8
4. $4x^5$
5. 36
6. $\frac{1}{x^3}$
7. 1
8. -1
9. y^{12}
10. x^8y^4
11. $3x^3$
12. $2x^3$
13. $4c^7d^{13}$
14. $16f^{10}g^{22}$
15. x^4y^4
16. xy
17. $\frac{x^{12}}{64y^9}$
18. $\frac{x^8}{256y^{16}}$
19. $\frac{1}{y^7}$
20. $\frac{1}{49}$
21. x^5
22. 16
23. x^4
24. $\frac{1}{x^6}$
25. x^2
26. $\frac{1}{j^3}$
27. x^7
28. $4x^{13}$
29. $\frac{1}{f^4}$
30. x^5
31. $2x^{14}$
32. $\frac{1}{4x^4y^6}$
33. $\frac{y^6}{4x^6}$
34. $\frac{1}{4x^3y^7}$
35. $\frac{64x^{12}}{y^{12}}$
36. $\frac{10x^6}{y^2}$
37. $\frac{81a^4b^4c^{12}}{2401}$
38. $\frac{9b^2c^{14}}{4a^2}$

Exponents/Powers with Roots

RULES



nth root function or fractional power:

$$\sqrt{2} = 2^{\frac{1}{2}}$$

$$\sqrt[3]{7} = 7^{\frac{1}{3}}$$

$$\sqrt[4]{5^3} = 5^{\frac{3}{4}}$$

…

Negative Exponents

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

For $a \neq 0$

a^{-n} is a reciprocal of a^n

Example:

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

$$\left(\frac{2}{5}\right)^{-6} = \left(\frac{5}{2}\right)^{6}$$

- ★ $3^{1/4} \cdot 3^{3/4}$
- ★ $\left(64^{1/3} \cdot 8^{1/3}\right)^2$
- ★ $\sqrt[3]{25} \cdot \sqrt[3]{5}$
- ★ $\sqrt[4]{27} \cdot \sqrt[4]{3}$
- ★ $6^{1/2} \cdot 6^{1/3}$
- ★ $\left(27^{1/3} \cdot 6^{1/4}\right)^2$
- ★ $(3^3 \cdot 6^3)^{-1/3}$
- ★ $\dfrac{4}{4^{1/2}}$
- ★ $\dfrac{\sqrt[3]{32}}{\sqrt[3]{4}}$
- ★ $\dfrac{\sqrt[3]{625}}{\sqrt[3]{5}}$
- ★ $(4^3 \cdot 2^3)^{-1/3}$
- ★ $\dfrac{6}{6^{3/4}}$
- ★ $\left(\dfrac{54^{1/4}}{27^{1/4}}\right)^2$

(a) $x^{\frac{2}{3}} \cdot x^{\frac{4}{3}}$

(b) $a^{\frac{3}{5}} \cdot a^{\frac{12}{5}}$

(c) $(9x)^{\frac{1}{2}} \cdot (4x^{\frac{1}{4}})$

(d) $((2b)^{\frac{2}{9}})^{3} \cdot (2b)^{\frac{1}{3}}$

(e) $\dfrac{x^{\frac{3}{2}}x^{\frac{1}{2}}}{x^{\frac{5}{2}}}$

(f) $(27z^{3})^{-\frac{2}{3}}$

(g) $(x^{5}y^{4})^{-\frac{1}{2}}$

(h) $(-8x^{6}y^{-18})^{-\frac{1}{3}}$

$y^{-1}(yx^{\frac{1}{2}})^{\frac{2}{3}}$

(i) $\left(\dfrac{a^{\frac{3}{2}}}{b^{-\frac{1}{2}}}\right)^{4}\left(\dfrac{a^{-2}}{b^{3}}\right)$

(j) $\left(\dfrac{x^{6}y^{-3}}{27y^{\frac{3}{5}}}\right)^{-\frac{1}{3}}$

(a) x^{2} (b) a^{3} (c) $12x^{\frac{3}{4}}$ (d) $2b$ (e) $\dfrac{1}{x^{\frac{1}{2}}}$ (f) $\dfrac{1}{9z^{2}}$ (g) $\dfrac{1}{x^{\frac{5}{2}}y^{2}}$ (h) $\dfrac{-y^{6}}{2x^{2}}$

(i) $\dfrac{x^{\frac{1}{3}}}{y^{\frac{1}{3}}}$ (j) $\dfrac{a^{4}}{b}$ (k) $\dfrac{3y^{\frac{6}{5}}}{x^{2}}$

Express the following in the form x^r.

(a) $(\sqrt[5]{x})^6$ (b) $\sqrt[8]{x^3}$ (c) $\dfrac{1}{(\sqrt{x})^5}$ (d) $\dfrac{1}{\sqrt[3]{x^4}}$ (e) $\sqrt[4]{\sqrt[3]{x}}$ (f) $\sqrt{\dfrac{1}{\sqrt[5]{x}}}$

Express the following in the form x^r.

(a) $x^{\frac{5}{2}}x^3$ (b) $\dfrac{x^{\frac{6}{7}}}{x^4}$ (c) $(x^3)^{-\frac{4}{5}}$ (d) $x^{\frac{7}{5}}x^{-\frac{8}{3}}$ (e) $(x^{\frac{2}{3}})^{\frac{4}{9}}$ (f) $\dfrac{1}{x^{\frac{5}{2}}}$

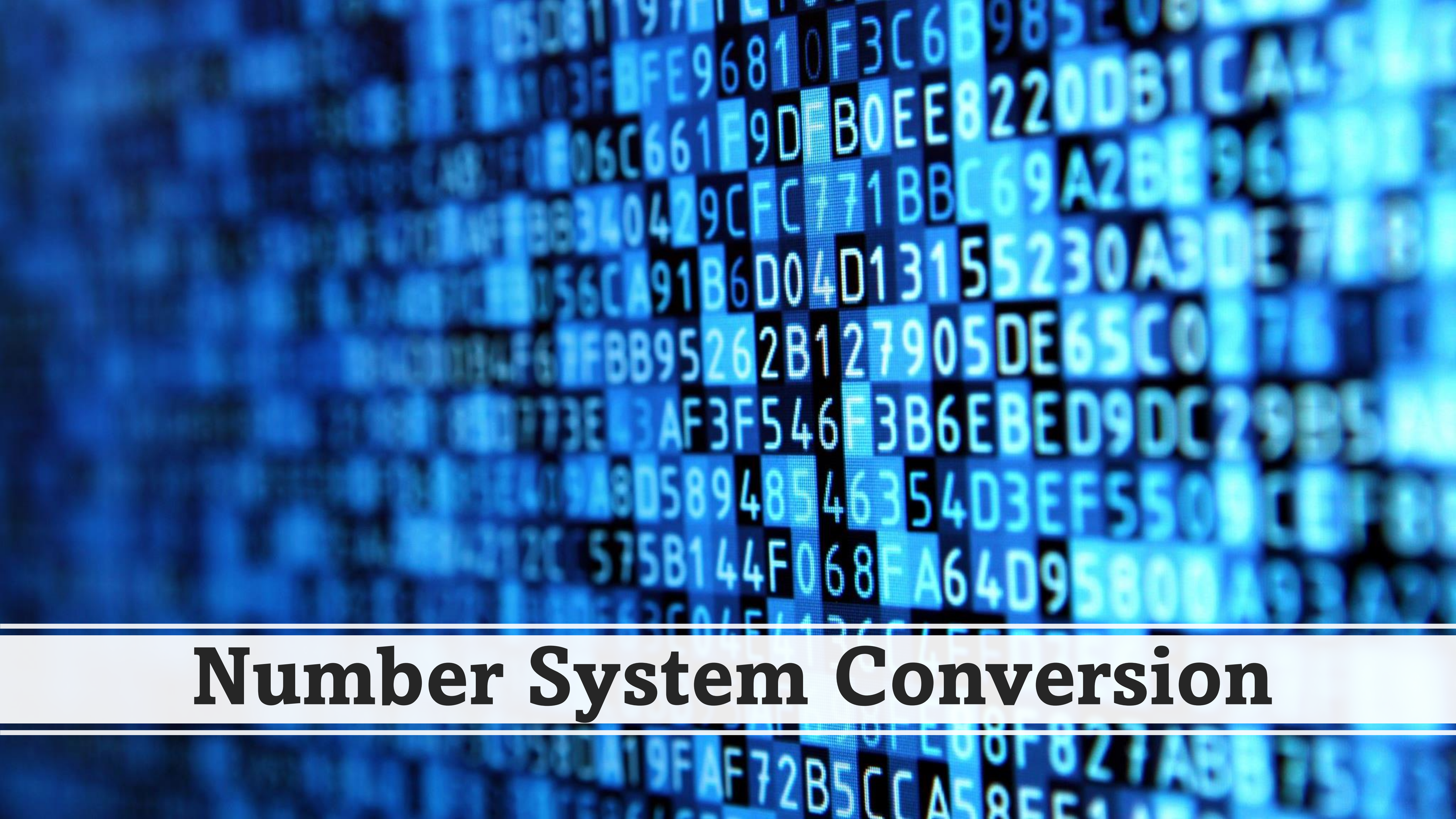
(g) $\left(\dfrac{1}{x^3}\right)^{-\frac{2}{3}}$ (h) $\dfrac{1}{x\sqrt{x}}$ (i) $x^2(\sqrt[3]{x})$ (j) $\dfrac{x}{x^{\frac{2}{5}}}$ (k) $\dfrac{x^{\frac{1}{3}}}{x}$ (l) $\dfrac{1}{x^{-\frac{5}{4}}}$

(a) $x^{\frac{6}{5}}$ (b) $x^{\frac{3}{8}}$ (c) $x^{-\frac{5}{2}}$ (d) $x^{-\frac{4}{3}}$ (e) $x^{\frac{1}{12}}$ (f) $x^{-\frac{1}{10}}$

(a) $x^{\frac{11}{2}}$ (b) $x^{-\frac{22}{7}}$ (c) $x^{-\frac{12}{5}}$ (d) $x^{-\frac{19}{15}}$ (e) $x^{\frac{8}{27}}$ (f) $x^{-\frac{5}{2}}$ (g) x^2 (h) $x^{-\frac{3}{2}}$

(i) $x^{\frac{7}{3}}$ (j) $x^{\frac{3}{5}}$ (k) $x^{-\frac{2}{3}}$ (l) $x^{\frac{5}{4}}$

Number System Conversion

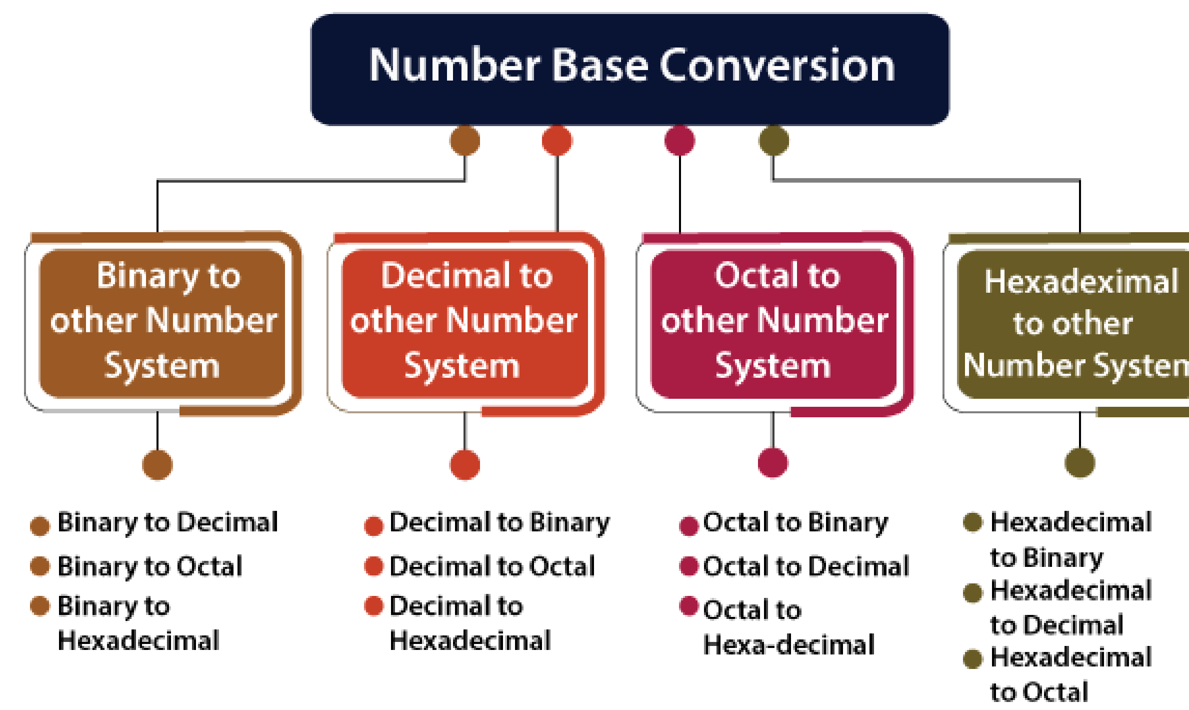


Numeral Systems in Computer Science refer to the numeric base systems used for **performing computation, storing and representing data.** They include the binary (base-2), decimal (base-10), octal (base-8), and hexadecimal (base-16) systems.

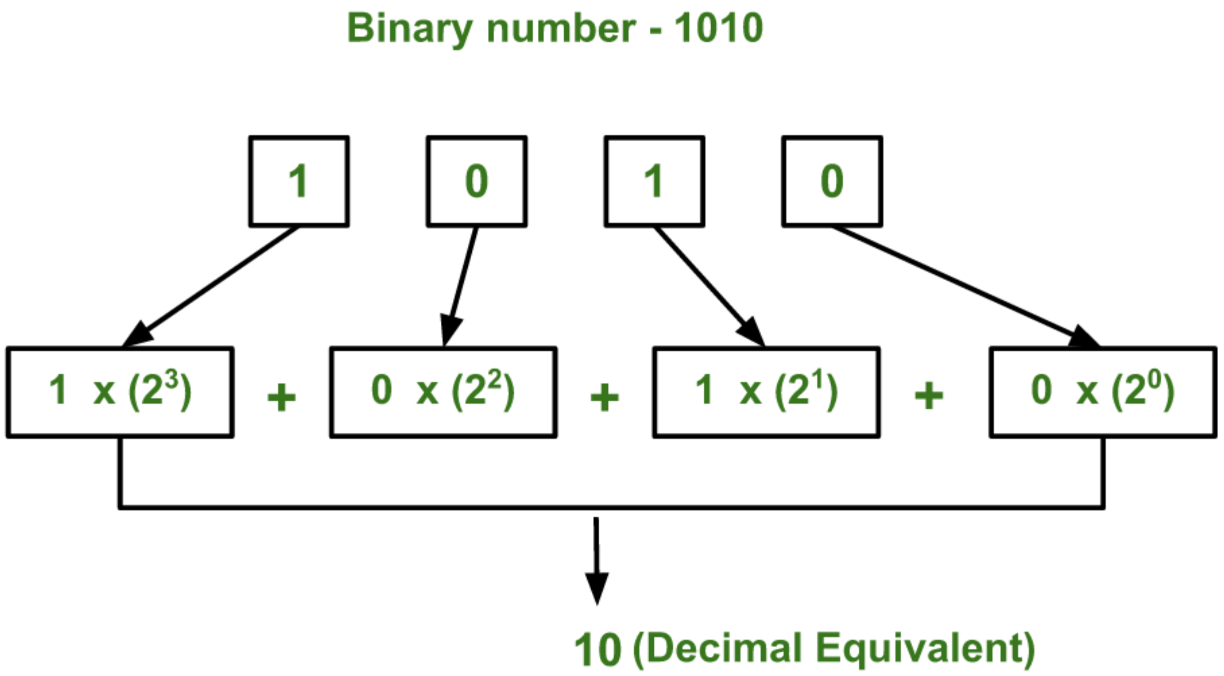
- Database systems use **decimal numbers** for all financial data, dates, and time. In fact, for any numeral data that is input or output in interaction with a user, the decimal system is ordinarily used.
- In scientific computing, **decimal numbers** are essential for complex calculations and computations involving real numbers, representing them more naturally.
- For error-correcting codes, the decimal system is used to represent parity bits. In cryptography, **decimal numbers** are used in key generation operations.

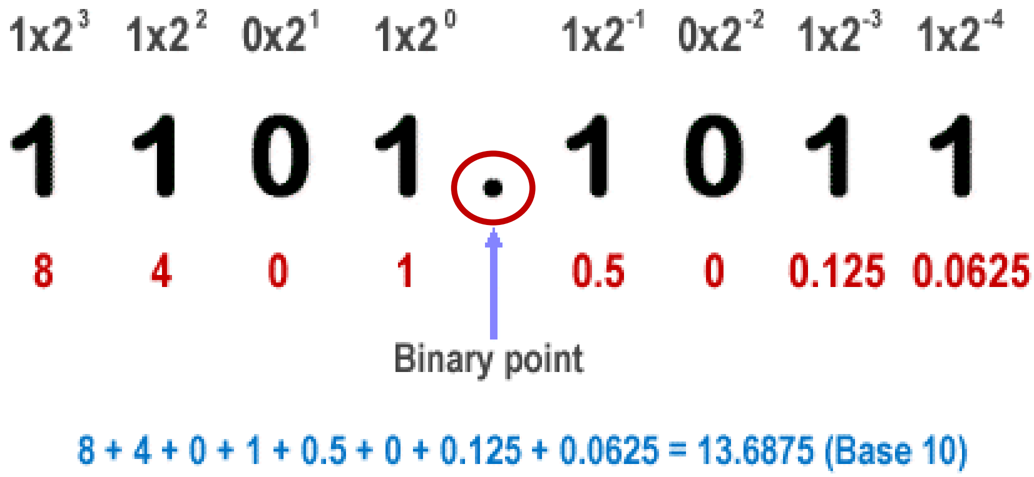
- **Binary code** governs the realm of machine language, the lowest level of programming languages. Each assembly instruction corresponds to a unique binary code, instruction set architecture being processor-specific.
- Bit manipulation tasks often utilise **binary operations**, which can prove more efficient and swift.

• Although machines operate using binary, human-interface devices primarily use the decimal system. It forms the backbone of numeric data in user-centric applications. When processing numeric data, computers convert decimal values into binary and perform computations. The resulting binary data is then transformed back into decimal form for user-friendly output.



Binary to Decimal





Convert the following binary numbers to equivalent decimal numbers.

- *(a)* $(1101)_2$
- *(b)* $(11101)_2$
- *(c)* $(0101\ 1101)_2$
- *(d)* $(1101\ 1101)_2$
- *(e)* $(1111\ 1111)_2$
- *(f)* $(0101\ 1001)_2$
- *(g)* $(1101\ 1101\ 0101)_2$
- *(h)* $(11100.101)_2$

Successive Division Method

Decimal Number:

75

$75 \div 2 = 37\ (R = 1)$ ← LSB (Least significant bit)

$37 \div 2 = 18\ (R = 1)$

$18 \div 2 = 9\ (R = 0)$

$9 \div 2 = 4\ (R = 1)$

$4 \div 2 = 2\ (R = 0)$

$2 \div 2 = 1\ (R = 0)$

$1 \div 2 = 0\ (R = 1)$ ← MSB (Most significant bit)

1001011

Decimal Number:

142 $= 10001110$

339 $= 101010011$

MSB	Binary Digit							LSB
2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256	128	64	32	16	8	4	2	1

Decimal Number:

$$\mathbf{75} = 64 + 8 + 2 + 1$$

Highest base 2 number, that is less than 75 is 64:

$75 - 64 = 11$

Highest base 2 number, that is less than 11 is 8:

$11 - 8 = 3$

$3 - 2 = 1$

1

1 0 0 1 0 1 1

Decimal Number:

$$\mathbf{142} = 10001110$$

$$\mathbf{339} = 101010011$$

Convert the following decimal numbers to equivalent binary numbers.

- *(a)* $(57)_{10}$
- *(b)* $(45)_{10}$
- *(c)* $(255)_{10}$
- *(d)* $(256)_{10}$
- *(e)* $(2416)_{10}$
- *(f)* $(4195)_{10}$

PRACTICE

DECIMAL TO BINARY

41	
30	
5	
10	
99	
123	
244	
13	
78	
143	
94	
58	
190	
202	
6	

BINARY TO DECIMAL

1111	
1101	
100101	
10	
00111100	
100	
110	
11111101	
1000100	
100001	
11010	
10101011	
10011001	
1110111	
11111	

Logarithms

Logarithms play a crucial role in various aspects of computer science, from algorithms and data structures to cryptography and information theory.

Logarithms

- In computer science, we almost always work with logarithms base 2, because we work with bits
- $\log_2 n$ (or we can just write $\log n$) tells us how many bits we need to represent n possibilities
  - Example: To represent 10 digits, we need log 10 = 3.322 bits
  - Since we can't have fractional bits, we need 4 bits, with some bit patterns not used: 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, and not 1010, 1011, 1100, 1101, 1110, 1111
- Logarithms also tell us how many times we can cut a positive integer in half before reaching 1
  - Example: 16/2=8, 8/2=4, 4/2=2, 2/2=1, and log 16 = 4
  - Example: 10/2=5, 5/2=2.5, 2.5/2=1.25, and log 10 = 3.322

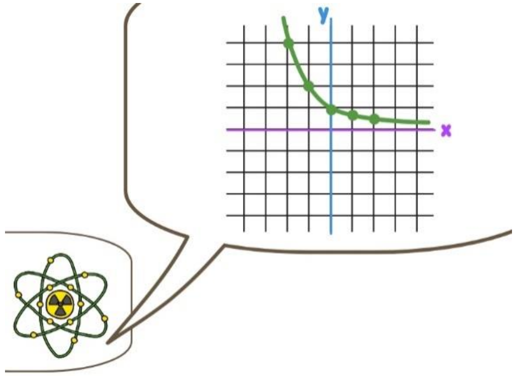
Data compression

- Ever wondered how such large data obtained from various organizations and governments is stored and used? Storing such large data requires various storage devices, which will still be insufficient. In that case, the data compression technique is used, which uses logarithms to simplify and compress the data.

- The data is compressed using different coding processes, such as arithmetic, transform, Huffman, Delta, entropy, Shannon-Fano, run-length encoding, etc., based on logarithm and its application.

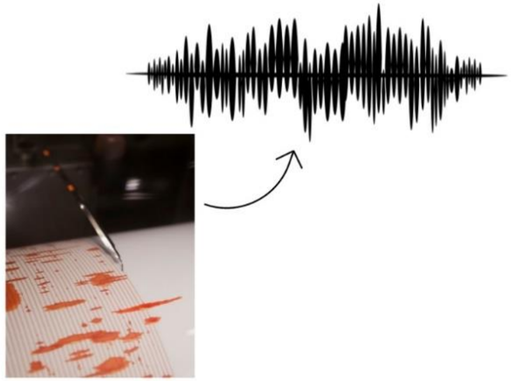
Measuring the sound intensity

Stock market analysis



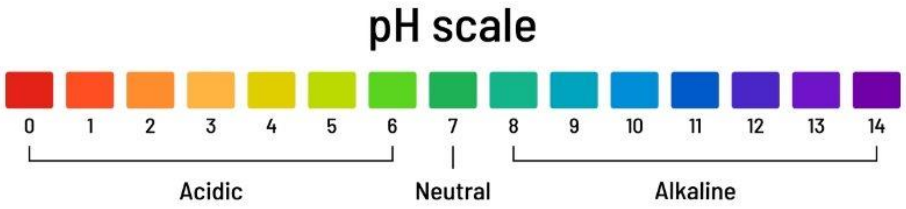
Studying the process of decay of radioactive elements

Analyzing drug concentrations in medicines



Assessing the magnitude of earthquakes using the Richter scale

Calculating the growth of the human species or other living species



Measuring pH levels of chemicals

Logarithmic Function

exponent

$\log_a x = y$ means $a^y = x$

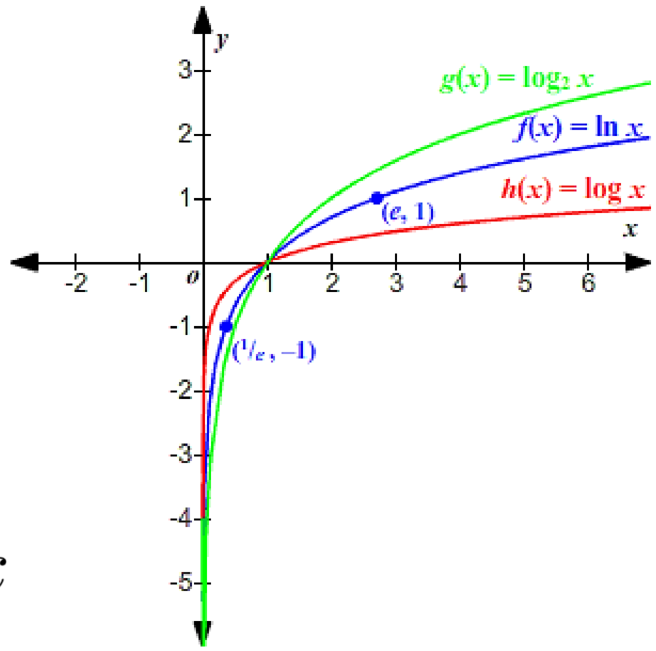
base

$a > 0,\ a \neq 1, y \neq 0$

Example:

$\log_2 8 = 3$ means $2^3 = 8$

Graph of logarithmic functions



List of logarithm rules

$$\log_a(bc) = \log_a(b) + \log_a(c)$$
$$\log_a(b^c) = c\log_a(b)$$
$$\log_a(1/b) = -\log_a(b)$$
$$\log_a(1) = 0$$
$$\log_a(a) = 1$$
$$\log_a(a^r) = r$$
$$\log_{1/a}(b) = -\log_a(b)$$
$$\log_a(b)\log_b(c) = \log_a(c)$$
$$\log_b(a) = \frac{1}{\log_a(b)}$$
$$\log_{a^m}(a^n) = \frac{n}{m}, \quad m \neq 0$$

Natural Logarithm

$$\log_e x = \ln x$$

A special form of logarithms in which **the base is mathematical constant e**

$e \approx 2.718281828459045$

Write the following equalities in exponential form.

(1) $\log_3 81 = 4$ (2) $\log_7 7 = 1$ (3) $\log_{\frac{1}{2}} \frac{1}{8} = 3$ (4) $\log_3 1 = 0$

(5) $\log_4 \frac{1}{64} = -3$ (6) $\log_6 \frac{1}{36} = -2$ (7) $\log_x y = z$ (8) $\log_m n = \frac{1}{2}$

(1) $3^4 = 81$

(2) $7^1 = 7$

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

(4) $3^0 = 1$

(5) $4^{-3} = \frac{1}{64}$

(6) $6^{-2} = \frac{1}{36}$

(7) $x^z = y$

(8) $m^{\frac{1}{2}} = n$

Write the following equalities in logarithmic form.

(1) $8^2 = 64$ (2) $10^3 = 10000$ (3) $4^{-2} = \frac{1}{16}$ (4) $3^{-4} = \frac{1}{81}$

(5) $\left(\frac{1}{2}\right)^{-5} = 32$ (6) $\left(\frac{1}{3}\right)^{-3} = 27$ (7) $x^{2z} = y$ (8) $\sqrt{x} = y$

(1) $\log_8 64 = 2$

(2) $\log_{10} 10000 = 3$

(3) $\log_4 \frac{1}{16} = -2$

(4) $\log_3 \frac{1}{81} = -4$

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

(6) $\log_{\frac{1}{3}} 27 = -3$

(7) $\log_x y = 2z$

(8) $\log_x y = \frac{1}{2}$

1. Find the value of y.

(1) $\log_5 25 = y$ (2) $\log_3 1 = y$ (3) $\log_{16} 4 = y$ (4) $\log_2 \frac{1}{8} = y$

(5) $\log_5 1 = y$ (6) $\log_2 8 = y$ (7) $\log_7 \frac{1}{7} = y$ (8) $\log_3 \frac{1}{9} = y$

(9) $\log_y 32 = 5$ (10) $\log_9 y = -\frac{1}{2}$ (11) $\log_4 \frac{1}{8} = y$ (12) $\log_9 \frac{1}{81} = y$

2. Evaluate.

(1) $\log_3 1$ (2) $\log_4 4$ (3) $\log_7 7^3$ (4) $b^{\log_b 3}$ (5) $\log_{25} 5^3$ (6) $16^{\log_4 8}$

1. (1) 2

(2) 0

(3) $\frac{1}{2}$

(4) -3

(5) 0

(6) 3

(7) -1

(8) -2

(9) 2

(10) $\frac{1}{3}$

(11) $-\frac{3}{2}$

(12) -2

2. (1) 0

(2) 1

(3) 3

(4) 3

(5) $\frac{3}{2}$

(6) 64

True or False?

(1) $\log\left(\frac{x}{y^3}\right) = \log x - 3\log y$ (2) $\log(a-b) = \log a - \log b$ (3) $\log x^k = k \cdot \log x$

(4) $(\log a)(\log b) = \log(a+b)$ (5) $\frac{\log a}{\log b} = \log(a-b)$ (6) $(\ln a)^k = k \cdot \ln a$

(7) $\log_a a^a = a$ (8) $-\ln\left(\frac{1}{x}\right) = \ln x$ (9) $\ln_{\sqrt{x}} x^k = 2k$

(1) True
(2) False
(3) True
(4) False
(5) False
(6) False
(7) True
(8) True

Solve the following logarithmic equations.

(1) $\ln x = -3$ (2) $\log(3x-2) = 2$

(3) $2\log x = \log 2 + \log(3x-4)$ (4) $\log x + \log(x-1) = \log(4x)$

(5) $\log_3(x+25) - \log_3(x-1) = 3$ (6) $\log_9(x-5) + \log_9(x+3) = 1$

(7) $\log x + \log(x-3) = 1$ (8) $\log_2(x-2) + \log_2(x+1) = 2$

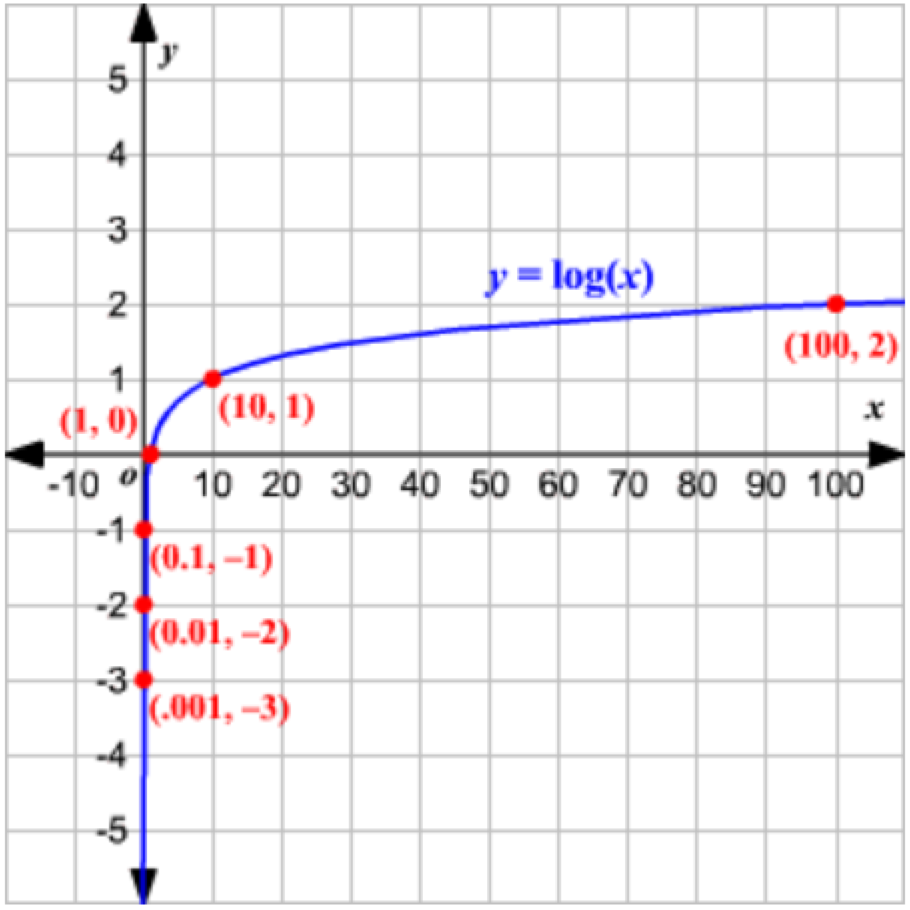
(1) $S = \{e^{-3}\}$
(2) $S = \{34\}$
(3) $S = \{2, 4\}$
(4) $S = \{5\}$
(5) $S = \{2\}$
(6) $S = \{6\}$
(7) $S = \{5\}$
(8) $S = \{3\}$

Graphing Logarithmic Functions

➢ When no base is written, assume that the log is *base* 10.

$$y = log x$$

x	$\frac{1}{1000}$	$\frac{1}{100}$	$\frac{1}{10}$	1	10	100	1000
$y = \log x$	-3	-2	-1	0	1	2	3



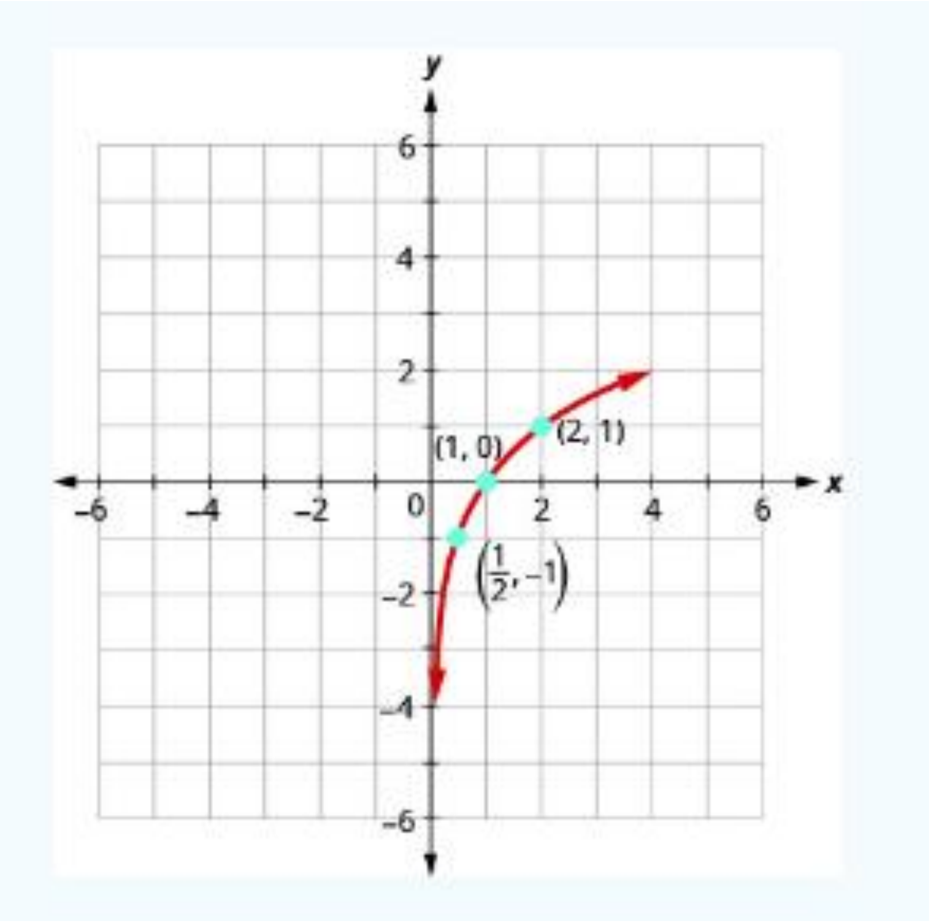
➢ The **domain** of log function $y = \log x$ is $x > 0$ (or) $(0, \infty)$.

➢ The **range** of any log function is the set of all real numbers (R)

The graph of the function $y = \log_2 x$.

$$x = 2^y$$

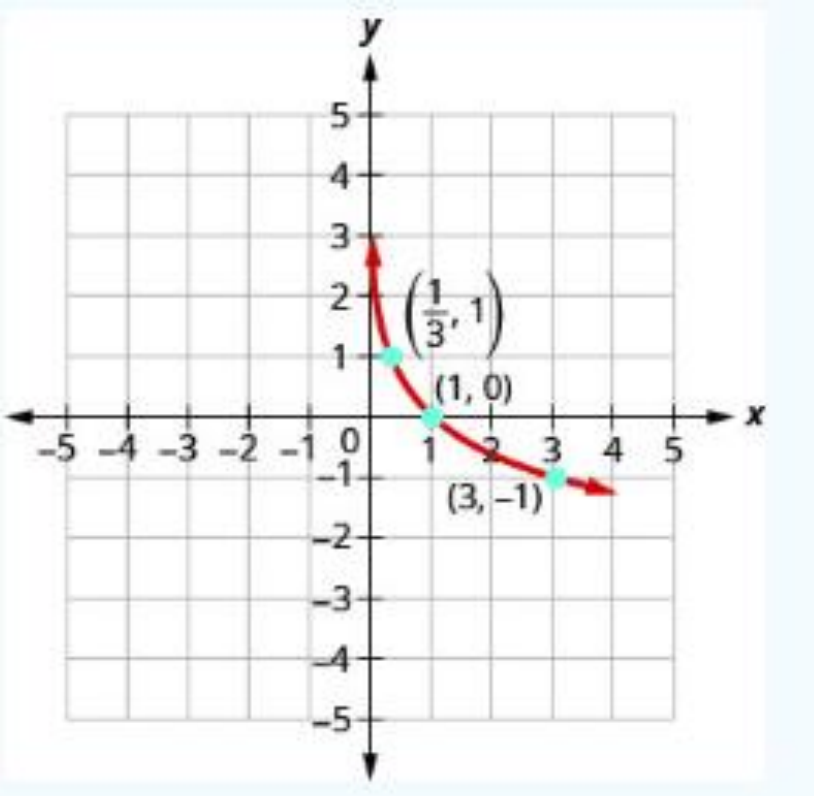
y	$2^y = x$	(x, y)
-2	$2^{-2} = \frac{1}{2^2} = \frac{1}{4}$	$(\frac{1}{4}, 2)$
-1	$2^{-1} = \frac{1}{2^1} = \frac{1}{2}$	$(\frac{1}{2}, -1)$
0	$2^0 = 1$	$(1, 0)$
1	$2^1 = 2$	$(2, 1)$
2	$2^2 = 4$	$(4, 2)$
3	$2^3 = 8$	$(8, 3)$



The graph of the function $y = \log_{\frac{1}{3}} x$.

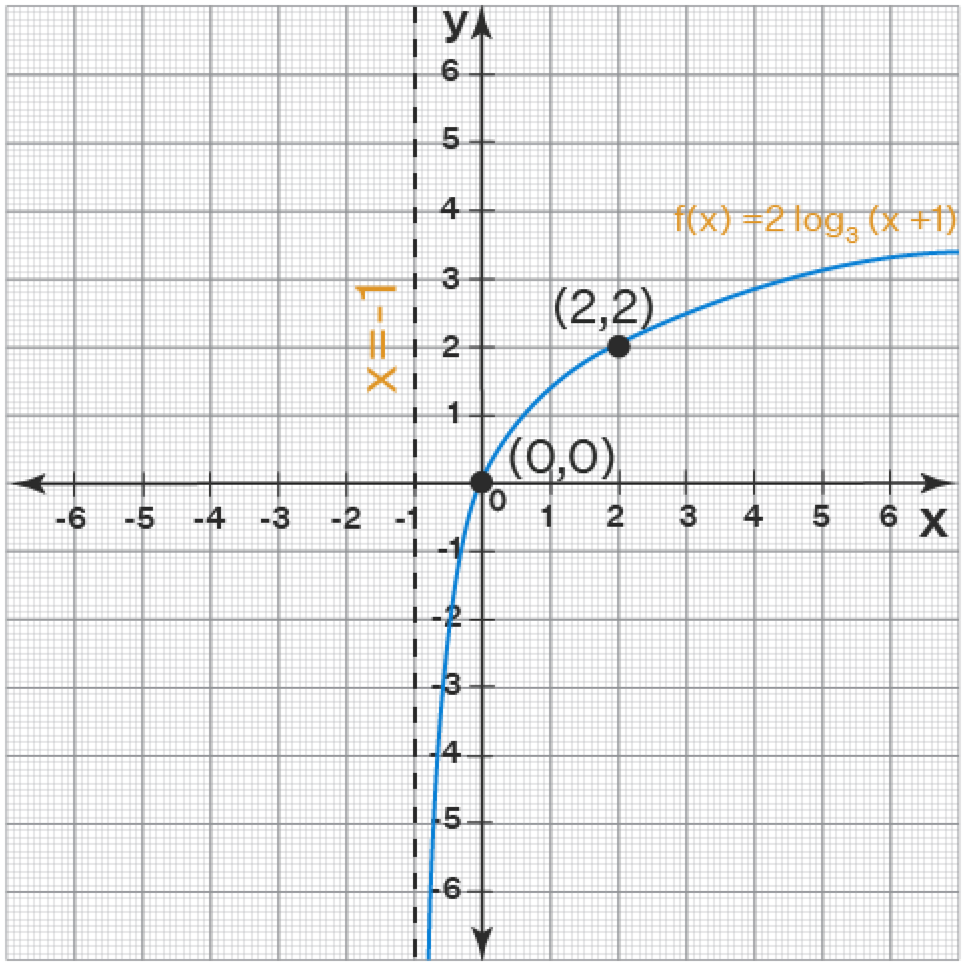
$$x = \frac{1}{3}^{y}$$

y	$\left(\frac{1}{3}\right)^y = x$	(x, y)
-2	$\left(\frac{1}{3}\right)^{-2} = 3^2 = 9$	$(9, -2)$
-1	$\left(\frac{1}{3}\right)^{-1} = 3^1 = 3$	$(3, -1)$
0	$\left(\frac{1}{3}\right)^0 = 1$	$(1, 0)$
1	$\left(\frac{1}{3}\right)^1 = \frac{1}{3}$	$\left(\frac{1}{3}, 1\right)$
2	$\left(\frac{1}{3}\right)^2 = \frac{1}{9}$	$\left(\frac{1}{9}, 2\right)$
3	$\left(\frac{1}{3}\right)^3 = \frac{1}{27}$	$\left(\frac{1}{27}, 3\right)$

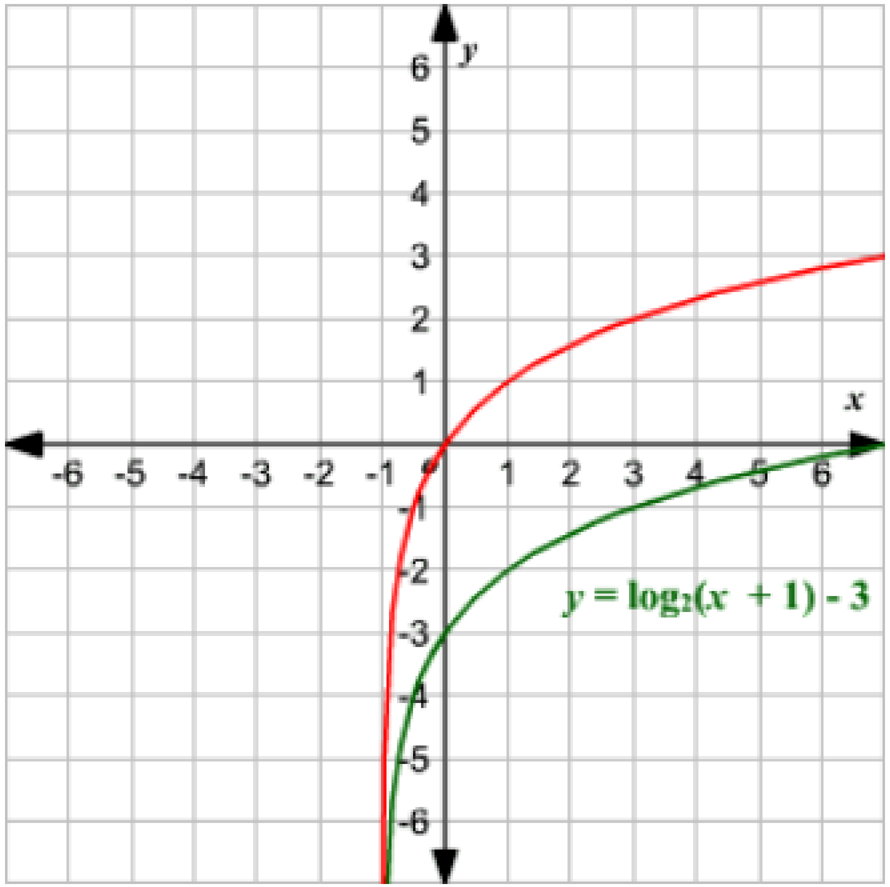


Graph the logarithmic function $f(x) = 2\log_3(x+1)$.

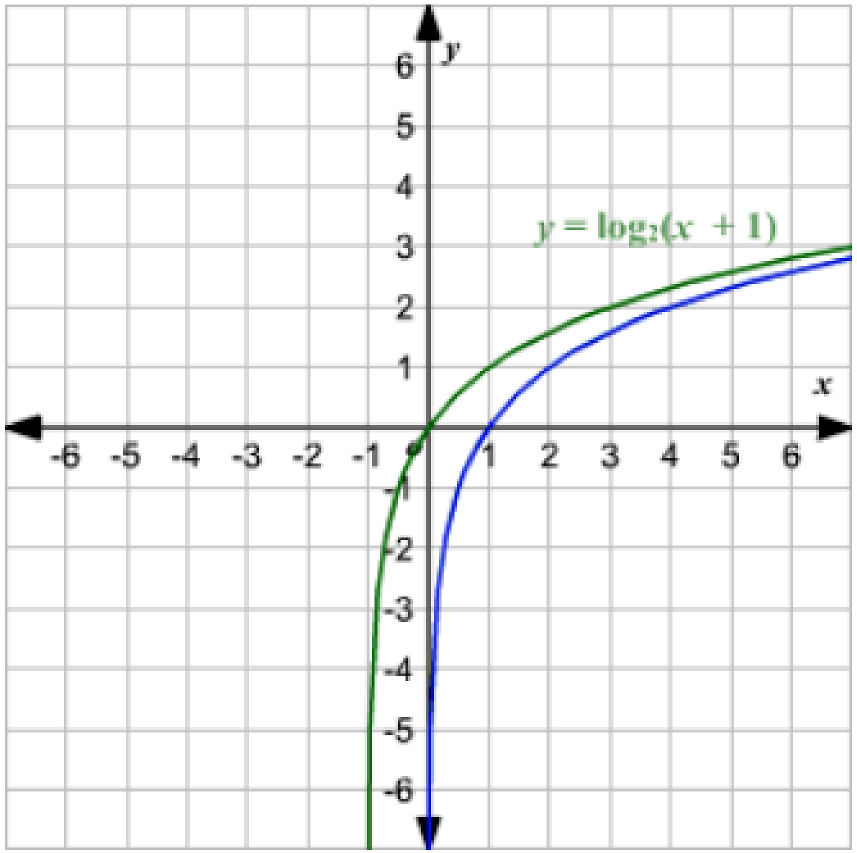
For domain: $x + 1 > 0 \Rightarrow x > -1$. So domain $= (-1, \infty)$.
Range $= R$.
Vertical asymptote is $x = -1$.
•At $x = 0, y = 2\log_3(0+1) = 2\log_3 1 = 2(0) = 0$
•At $x = 2, y = 2\log_3(2+1) = 2\log_3 3 = 2(1) = 2$



The graph of the function
$y = \log_2(x + 1) - 3.$

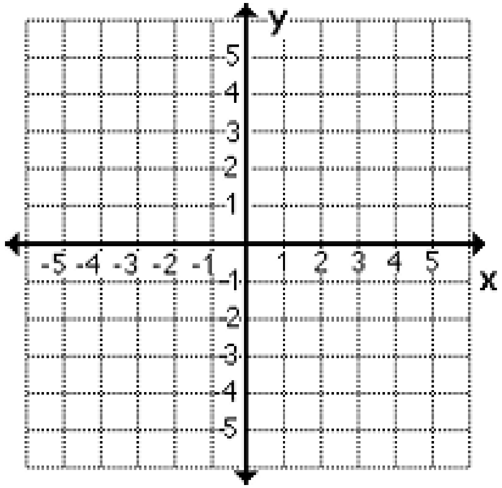


The graph of the function
$y = \log_2(x + 1).$

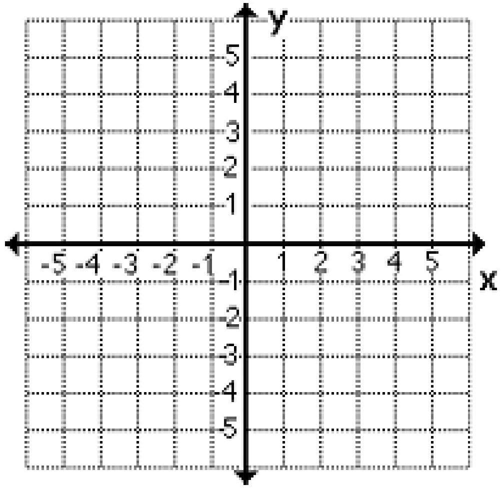


Graph each of the following logarithmic functions. Label the key point for each.

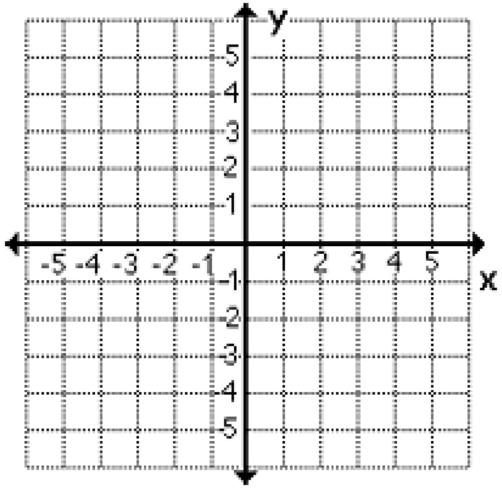
13 $f(x)=\log_2 x$



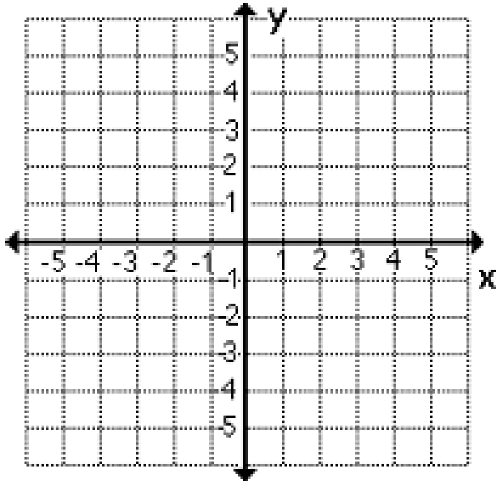
14 $f(x)=\log_4 x$



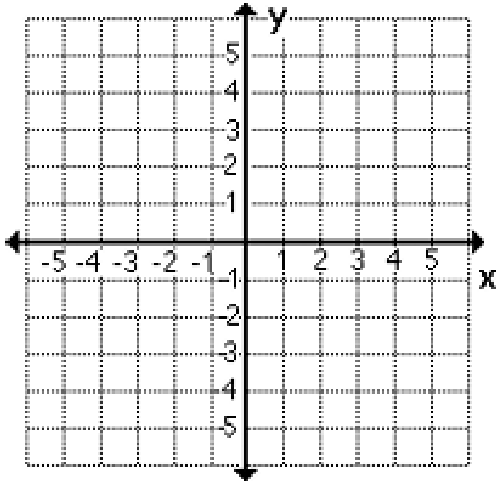
15 $f(x)=\log_4(x-3)$



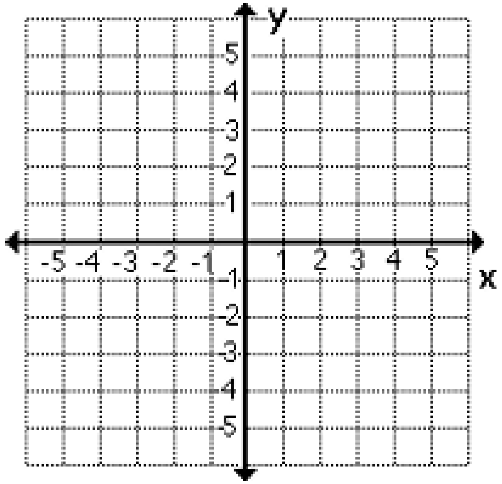
16 $f(x)=\log_2(x+2)$



17 $f(x)=\log_3 x+2$

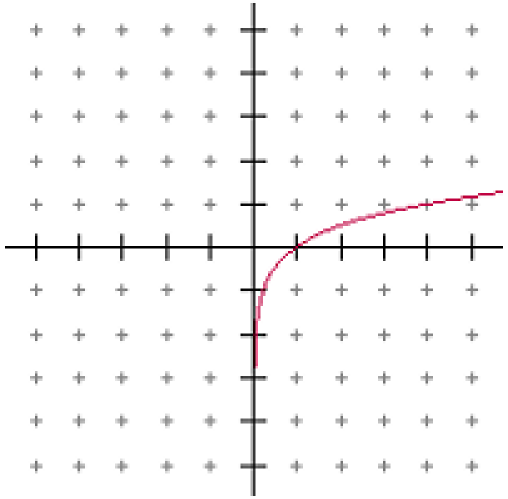


18 $f(x)=\log_5(x-3)+2$



Match the graphs with their appropriate equation below.

7



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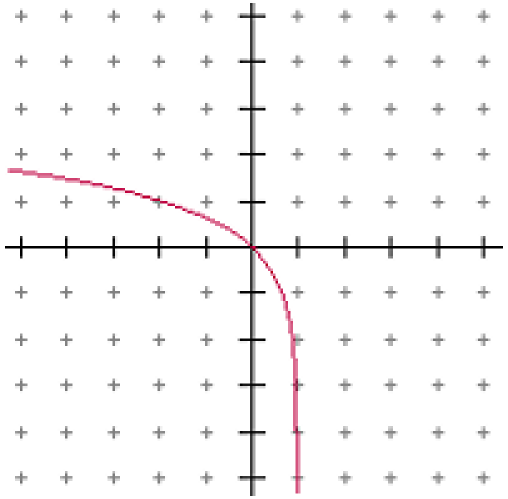

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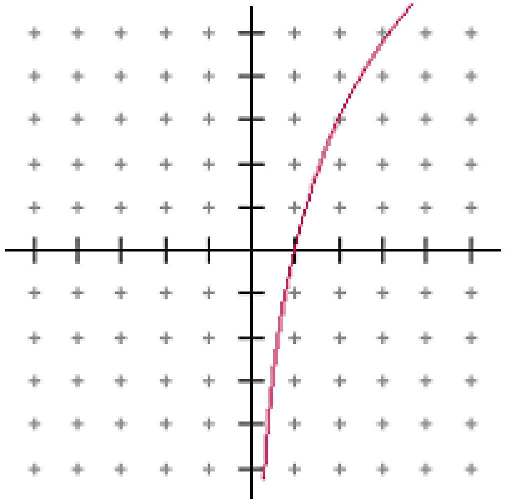
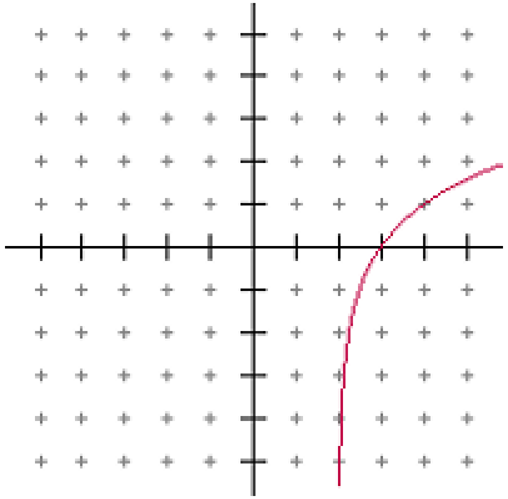
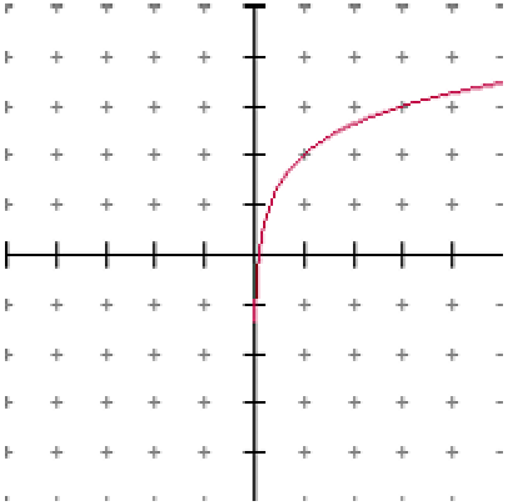


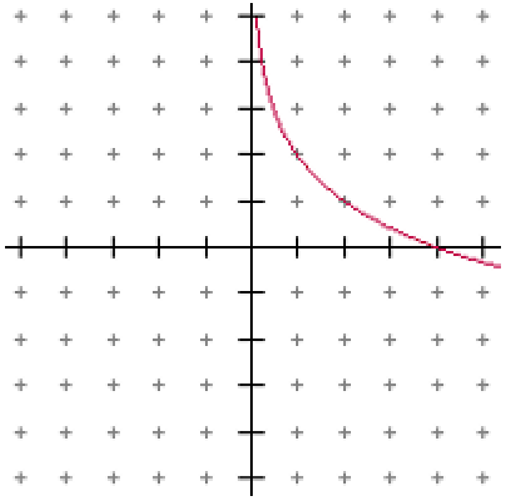
10



11



12



A) $f(x)=\log_2(x-2)$

B) $f(x)=\log_3(1-x)$

C) $f(x)=-\log_2 x+2$

D) $f(x)=\log_3 x+2$

E) $f(x)=\frac{1}{2}\log_2 x$

F) $f(x)=3\log_2 x$

1. $f(x)=\log_2(x+5)-3$

2. $f(x)=\log_5(x-3)+1$

3. $f(x)=\log_3(x-4)+2$

4. $f(x)=3\log_2(x-1)+2$

5. $f(x)=\frac{1}{2}\log_4(x-6)-5$

6. $f(x)=-4\log_2(x-2)$