Greek characters

Name	Symbol	Typical use(s)
alpha	α	angle, constant
beta	β	angle, constant
gamma	γ	angle, constant
delta	δ	limit definition
epsilon	ϵ or ε	limit definition
theta	θ or ϑ	angle
pi	π or π	circular constant
phi	ϕ or φ	angle, constant

Named sets

empty set	$\varnothing$	integers	$\mathbf{Z}$	
real numbers	$\mathbf{R}$	positive integers	$\mathbf{Z}_{>0}$	
ordered pairs	$\mathbf{R}^2$	positive reals	$\mathbf{R}_{>0}$	

Set symbols

Meaning	Symbol	Meaning	Symbol
is a member	$\in$	union	$\cup$
subset	$\subset$	complement	superscript$^{\mathrm{C}}$
intersection	$\cap$	set minus	$\setminus$

Logic symbols

Meaning	Symbol	Meaning	Symbol
negation	$\neg$	equivalent	$\equiv$
and	$\wedge$	iff	$\Longleftrightarrow$
or	$\vee$	for all	$\forall$
implies	$\Longrightarrow$	there exists	$\exists$

Arithmetic properties of $\mathbf{R}$

$$(\forall a, b \in \mathbf{R})(a + b = b + a) \qquad \text{commutivity}$$
$$(\forall a, b, c \in \mathbf{R})(a + (b + c) = (a + b) + c) \quad \text{associative}$$
$$(\forall a, b \in \mathbf{R})(ab = ba) \qquad \text{commutivity}$$
$$(\forall a, b, c \in \mathbf{R})(a(bc) = (ab)c) \qquad \text{associative}$$
$$(\forall a, b, c \in \mathbf{R})(a(b + c) = ab + ac) \qquad \text{distributive}$$

Intervals

For numbers a and b, we define the intervals

$$(a, b) = \{x \in \mathbf{R} \mid a < x < b\}$$
$$[a, b) = \{x \in \mathbf{R} \mid a \leq x < b\}$$
$$(a, b] = \{x \in \mathbf{R} \mid a < x \leq b\}$$
$$[a, b] = \{x \in \mathbf{R} \mid a \leq x \leq b\}$$

Distance & Midpoint

The distance between the points (x_1, y_1) and (x_2, y_2) is

$$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}.$$

The midpoint is the point

$$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2} \right).$$

Exponents

For $a, b > 0$ and m, n real:

$$a^0 = 1, \qquad 0^a = 0$$
$$1^a = 1, \qquad a^n a^m = a^{n+m}$$
$$a^n / a^m = a^{n-m}, \qquad (a^n)^m = a^{n \cdot m}$$
$$a^{-m} = 1/a^m, \qquad (a/b)^m = a^m / b^m$$

Radicals

$$\sqrt[n]{a} = a^{1/n}$$
$$\sqrt[n]{ab} = \sqrt[n]{a}\,\sqrt[n]{b} \quad \text{(provided } a, b \geq 0)$$
$$\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a}$$
$$\sqrt[n]{\frac{a}{b}} = \frac{\sqrt[n]{a}}{\sqrt[n]{b}}$$
$$\sqrt[n]{a^n} = \begin{cases} a & n \text{ odd} \\ |a| & n \text{ even} \end{cases}$$

Identities

$$a(b + c) = ab + ac$$
$$((a + b)(c + d)) = ac + ad + bc + bd$$
$$\frac{ab + ac}{a} = b + c \quad \text{(provided } a \neq 0)$$
$$\frac{\frac{a}{b}}{\frac{c}{d}} = \frac{ad}{bc} \quad \text{(provided } b, d \neq 0)$$
$$\sqrt{ab} = \sqrt{a}\sqrt{b} \quad \text{(provided } a \geq 0, b \geq 0)$$
$$\ln(ab) = \ln(a) + \ln(b) \quad \text{(provided } a \geq 0, b \geq 0)$$

Solution of Equations

Algebraic

Suppose X, Y, P, and Q possibly depend on the unknown x; and suppose a, b, and c do not depend on the unknown.

$$\big[XY = 0\big] \equiv \big[X = 0 \text{ or } Y = 0\big]$$
$$\big[X^2 = Y^2\big] \equiv \big[X = Y \text{ or } X = -Y\big]$$
$$\left[\frac{X}{Y} = 0\right] \equiv \big[X = 0 \text{ and } Y \neq 0\big]$$
$$\left[\frac{X}{Y} = \frac{P}{Q}\right] \equiv \big[XQ = YP \text{ and } Y \neq 0 \text{ and } Q \neq 0\big]$$
$$\big[|X| = |Y|\big] \equiv \big[X = Y \text{ or } X = -Y\big]$$
$$\big[\sqrt{X} = Y\big] \equiv \big[X = Y^2 \text{ and } Y \geq 0\big]$$

For $a \neq 0$,

$$\big[ax^2 + bx + c = 0\big] \equiv \left[x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}\right]$$

Logarithmic and Exponential

$$\big[\ln(X) = 0\big] \equiv \big[X = 1\big]$$
$$\big[e^X = 1\big] \equiv \big[X = 0\big]$$
$$\big[\log_a(X) = b\big] \equiv \big[X = a^b\big]$$
$$\big[a^X = a^Y\big] \equiv \big[X = Y\big]$$
$$\big[\log_a(X) = \log_a(Y)\big] \equiv \big[X = Y \text{ and } X > 0\big]$$

Logarithms

For $x > 0$ and $y > 0$

$$\log_a(x) = \frac{\ln(x)}{\ln(a)}$$

$$\log_a(y) + \log_a(y) = \log_a(xy)$$

$$\log(x^z) = z \log(x)$$

Graph Translations

For the graph of $F(x, y) = 0$

- The graph of $F(x - h, y) = 0$ is the graph of $F(x, y) = 0$ translated h units to the right.

- The graph of $F(x, y - k) = 0$ is the graph of $F(x, y) = 0$ translated k units up.

- The graph of $F(x/c, y) = 0$ is the graph of $F(x, y) = 0$ stretched a factor of c horizontally.

- The graph of $F(x, y/c) = 0$ is the graph of $F(x, y) = 0$ stretched a factor of c vertically.

Circles

Equation of circle centered at (h, k) with radius r is

$$(x - h)^2 + (y - k)^2 = r^2.$$

Expanded the equation is

$$x^2 - 2hx + y^2 - 2ky = r^2 - h^2 - k^2.$$

Parabolas & Lines

The vertex of the parabola $ax^2 + bx + c = y$ is

$$\left(x = -\frac{b}{2a}, y = c - \frac{b^2}{4a} \right).$$

An equation of the line that contains the points (x_1, y_1) and (x_2, y_2) is

$$y - y_1 = \left(\frac{y_2 - y_1}{x_2 - x_1} \right)(x - x_1).$$

The number $\dfrac{y_2 - y_1}{x_2 - x_1}$ is the slope.

Function notation

dom(F)	domain of function F
range(F)	range of function F

Domains, Ranges, and Zeros

Function	Domain	Range	Zeros
ln, log	$(0, \infty)$	$(-\infty, \infty)$	1
exp	$(-\infty, \infty)$	$(0, \infty)$	$\varnothing$
abs	$(-\infty, \infty)$	$(0, \infty)$	0
$\sqrt{}$	$(0, \infty)$	$(0, \infty)$	0
$\sqrt[3]{}$	$(-\infty, \infty)$	$(-\infty, \infty)$	0
floor	$(-\infty, \infty)$	$\mathbf{Z}$	$[0, 1)$
ceiling	$(-\infty, \infty)$	$\mathbf{Z}$	$(-1, 0]$

Compound Interest

Interest rate r compounded n times per year

$$A = P(1 + r/n)^{nt}$$

Continuous compounding:

$$A = P e^{rt}$$

Exponential Growth

The exponential function that contains the points $(t = t_o, y = y_o)$ and $(t = t_1, y = y_1)$ is
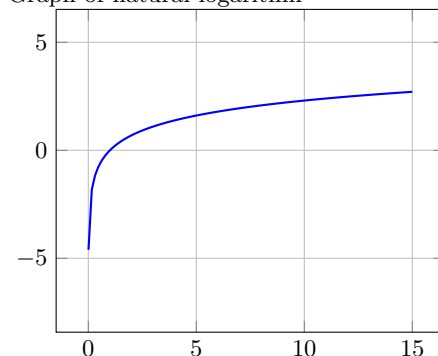
$$y = y_o \left(\frac{y_1}{y_o} \right)^{\frac{t - t_o}{t_1 - t_o}}.$$

Common Errors

Error	Correct or Example
$x/0 = 0$ or x	$x/0$ is undefined
$-x^2 = x^2$	$-x^2 = -(x^2)$
$a/(b+c) = a/b + a/c$	$1/(1+1) \neq 1/1 + 1/1$
$a+bx/a = 1 + bx$	$a+bx/a = 1 + bx/a$
$(a + b)^2 = a^2 + b^2$	$(a + b)^2 = a^2 + 2ab + b^2$
$\sqrt{a + b} = \sqrt{a} + \sqrt{b}$	$\sqrt{1 + 1} \neq \sqrt{1} + \sqrt{1}$

Graphs

Graph of natural logarithm

Graph of natural exponential