

MATH 250a

Fall Semester 2007

Section 2 (J. M. Cushing)

Tuesday, August 21

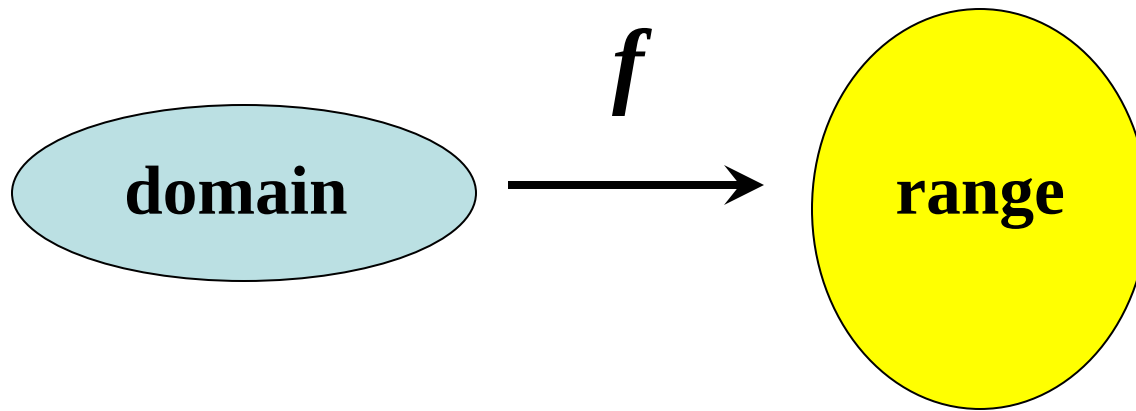
<http://math.arizona.edu/~cushing/250a.html>

TENTATIVE SCHEDULE FOR MATH 250A, Section 2, FALL 2007

Chapters 1 - 6	August	21 Introduction; Linear Functions and Linear Approximations 23 Exponential Functions 28 Power, Polynomial, and Rational Functions 30 Trigonometric Functions
	September	4 Review: Fundamental Theorem of Calculus 6 Integration Techniques I: Substitution, Integration by Parts 11 Integration Techniques II: Partial Fractions, Trigonometric Substitution 13 Integration Techniques III: Tables and Numerical Approximation 18 Error Estimates for Numerical Approximation 20 EXAM 1
		25 Improper Integrals 27 Comparison of Improper Integrals; Numerical Approximation
	October	2 Applications of Integration: Area and Volume 4 Applications of Integration: Arc Length and Surface Area 9 Integration in Polar Coordinates 11 Review of Geometric Applications of Integration 16 Applications of Integration: Mass, Density, and Center of Mass 18 EXAM 2
Chapter 7.1 – 7.6		23 Discrete Dynamical Systems and Introduction to Sequences; Convergence 25 Introduction to Series; Geometric Series and the Ratio Test 30 Convergence of Series; Improper Integrals and the Integral Test
Chapter 7.7 – 7.8	November	1 Power Series and Radius of Convergence 6 Finding and Using Taylor Series; Taylor Series for Well-Known Functions 8 Error Estimates for Taylor Series 13 Introduction to Fourier Series 15 EXAM 3
Chapter 8		20 Linear Algebra: Vectors and Matrices, Matrix Algebra, Inverses 22 Thanksgiving Day – No class 27 Linear Algebra: Linear Systems of Equations, Determinants, 29 Linear Algebra: Eigenvalues and Eigenvectors
Chapter 9	December	4 Review
Chapter 10		
Supplemental Material		

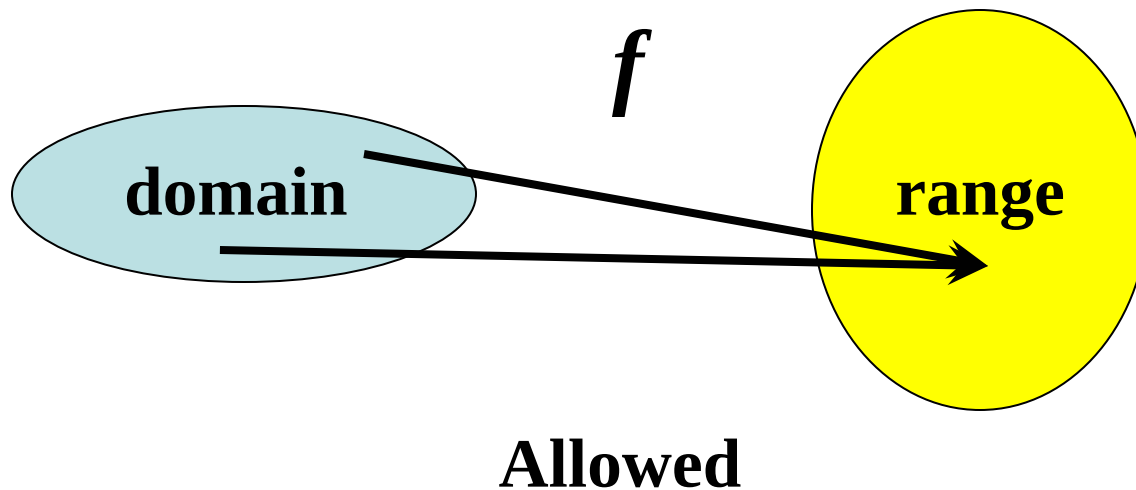
Chapter 1.1

Mathematical Functions



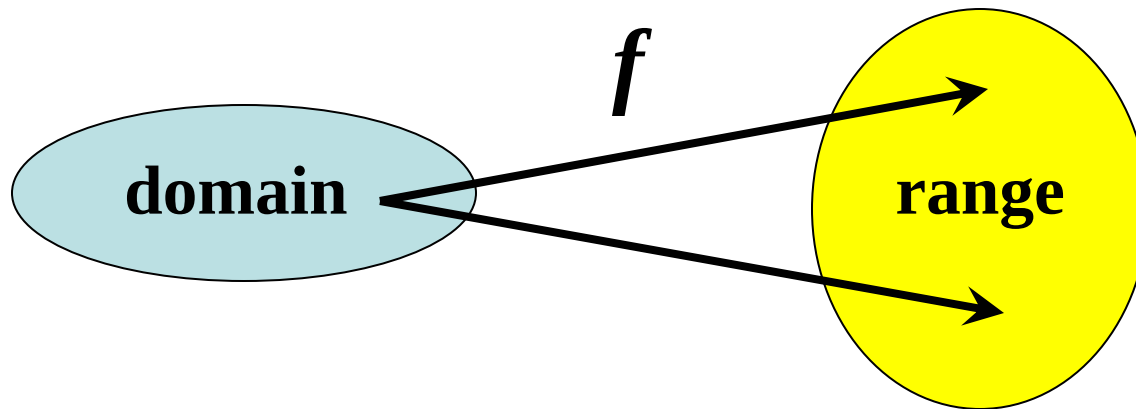
Chapter 1.1

Mathematical Functions



Chapter 1.1

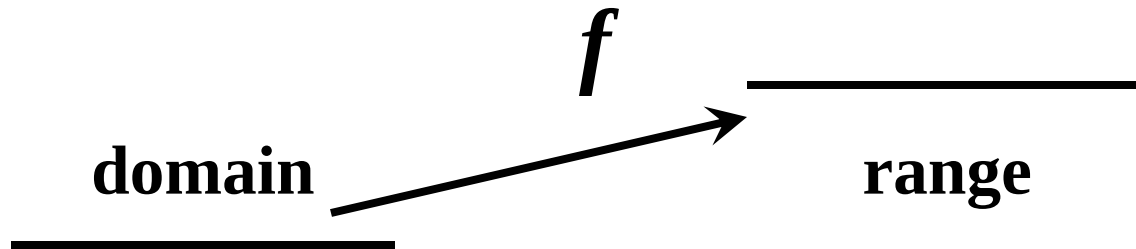
Mathematical Functions



Not Allowed

Chapter 1.1

Mathematical Functions



Intervals of real numbers

Chapter 1.1

Mathematical Functions

Define by means of algebraic formula :

Chapter 1.1

Mathematical Functions

Define by means of algebraic formula :

$$f(x) = 2x$$

$$f(x) = 2 + x - 2x^2$$

$$f(x) = 2^x$$

$$f(x) = \sqrt{x}$$

$$f(x) = \frac{1+x}{1-x^2}$$

$$f(x) = \sin x$$

$$f(x) = \tan x$$

Chapter 1.1

Mathematical Functions

Define by means of graph :

Chapter 1.1

Mathematical Functions

Define by means of graph :

domain

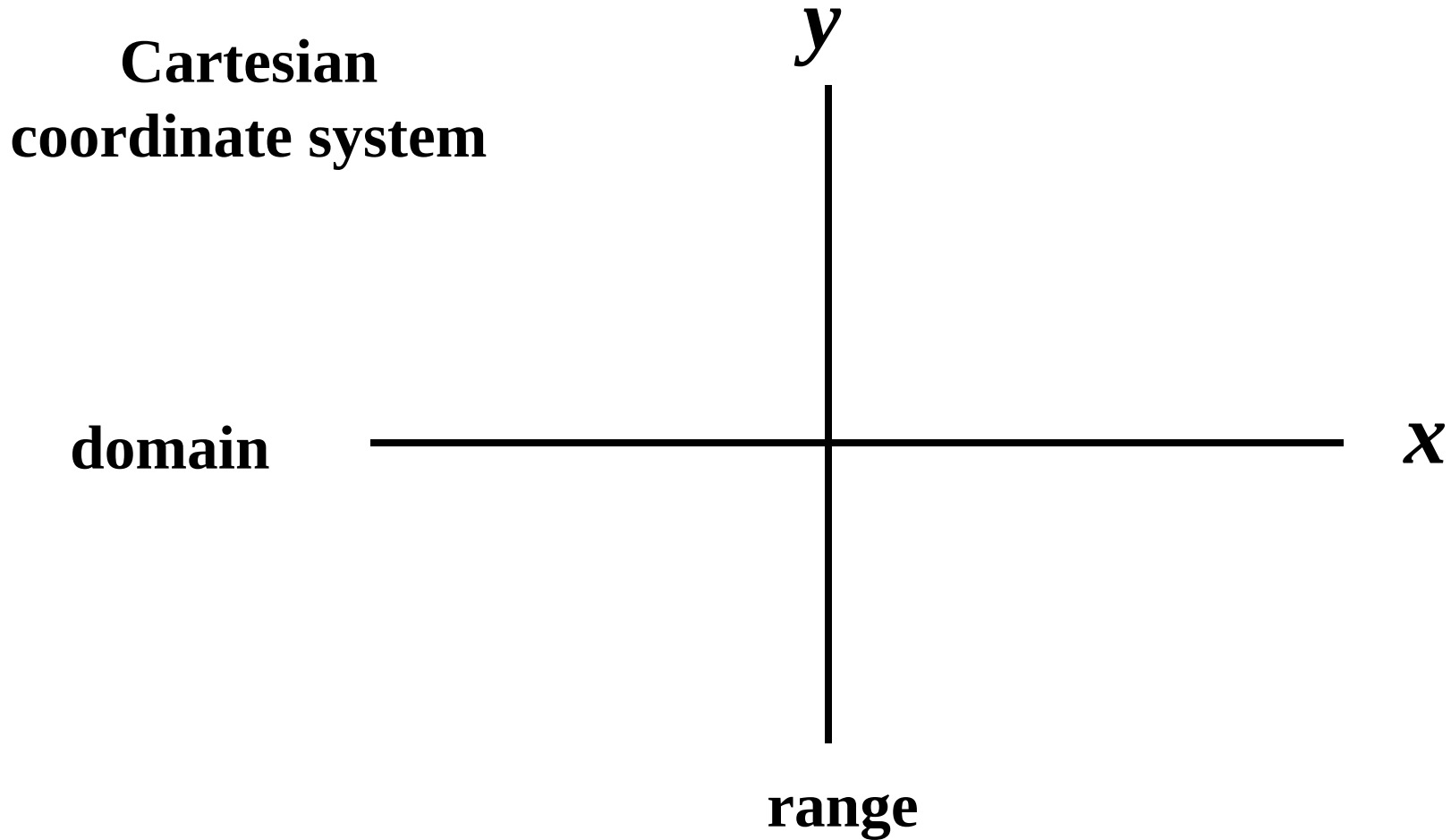


x

Chapter 1.1

Mathematical Functions

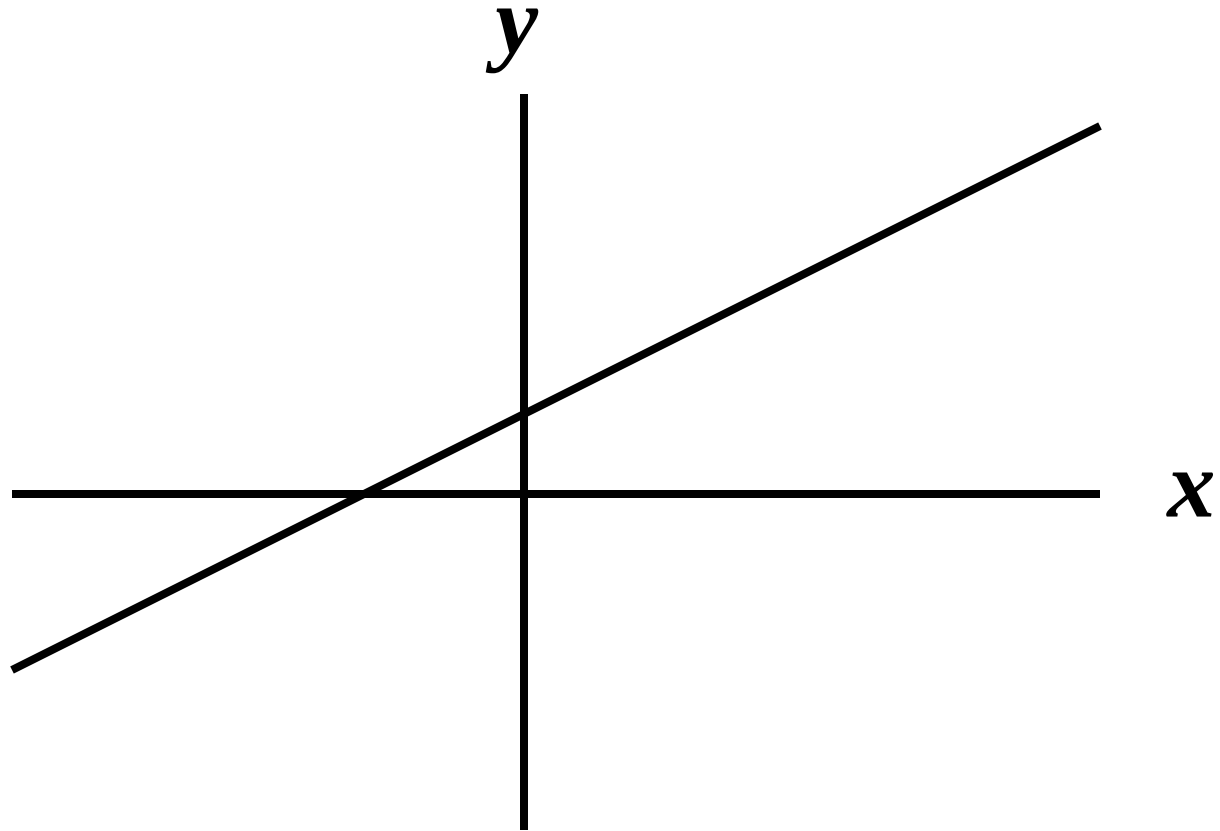
Define by means of graph :



Chapter 1.1

Mathematical Functions

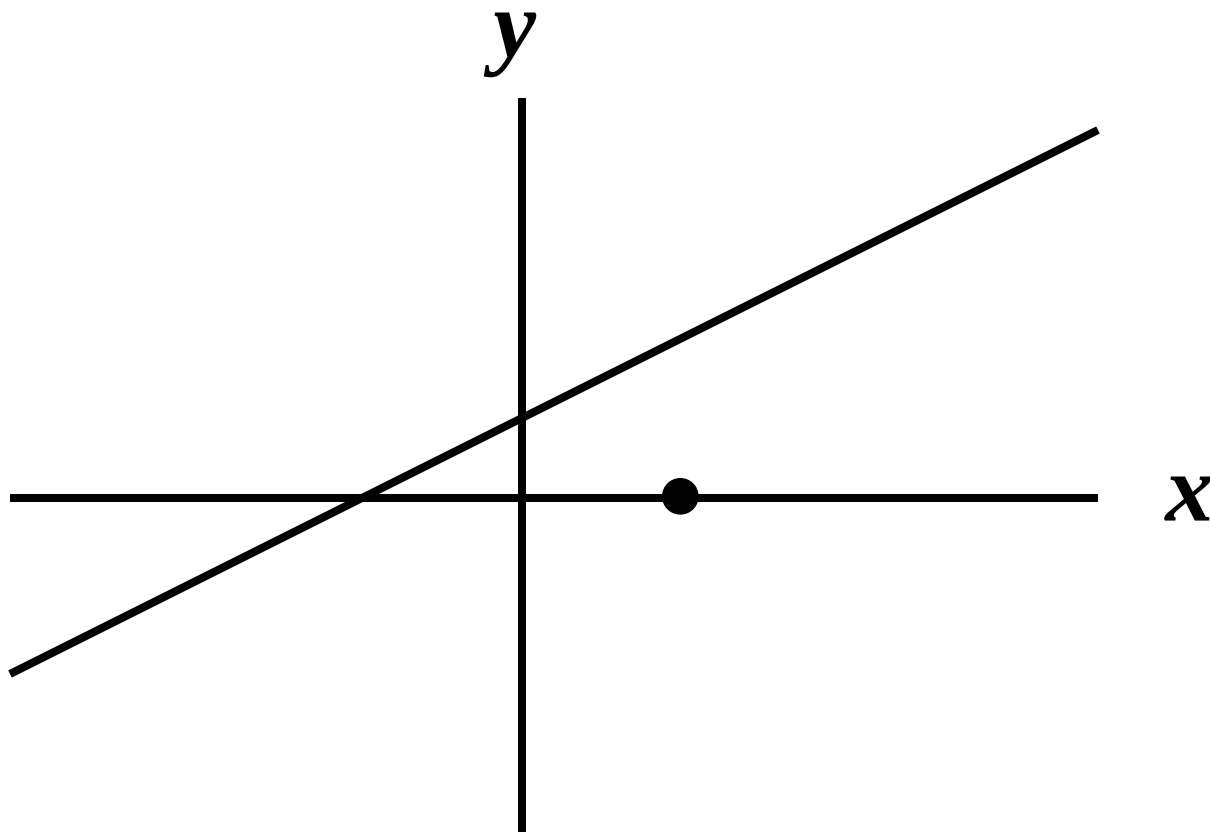
Define by means of graph :



Chapter 1.1

Mathematical Functions

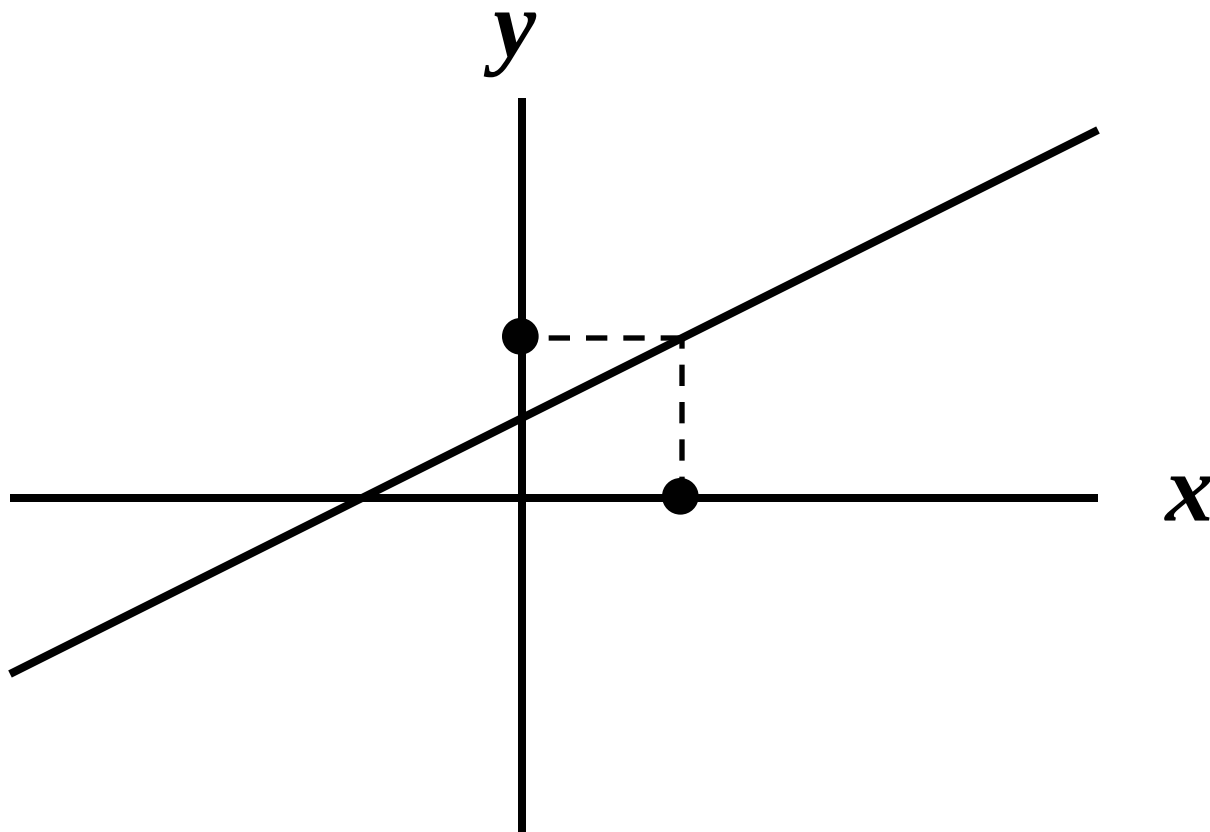
Define by means of graph :



Chapter 1.1

Mathematical Functions

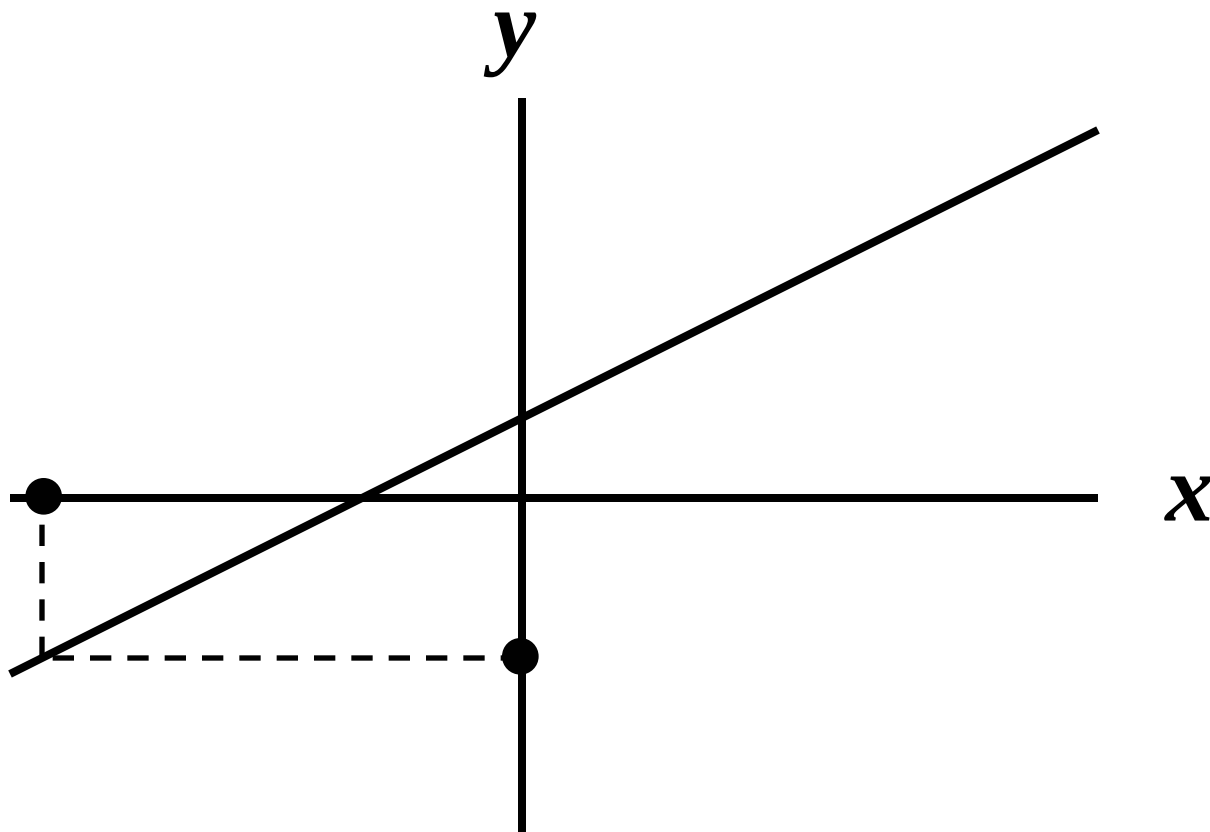
Define by means of graph :



Chapter 1.1

Mathematical Functions

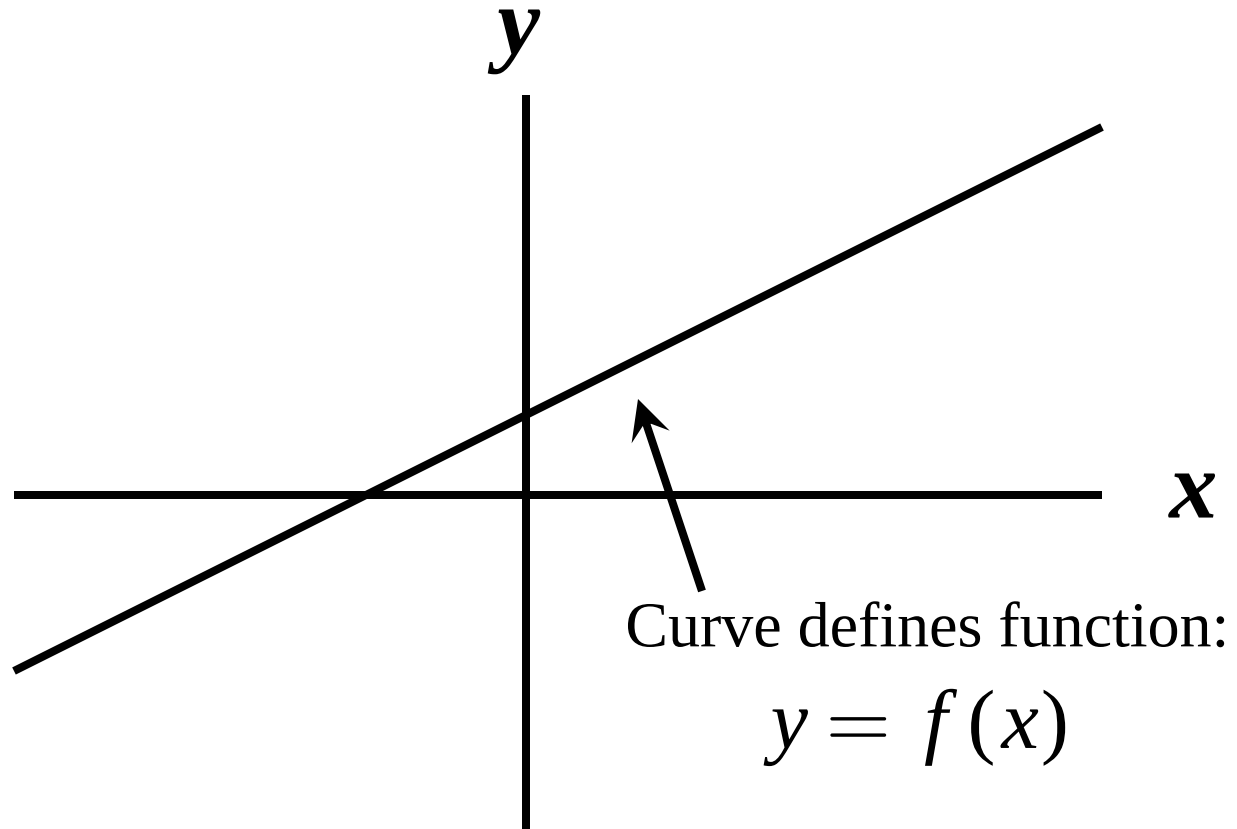
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Chapter 1.1

Mathematical Functions

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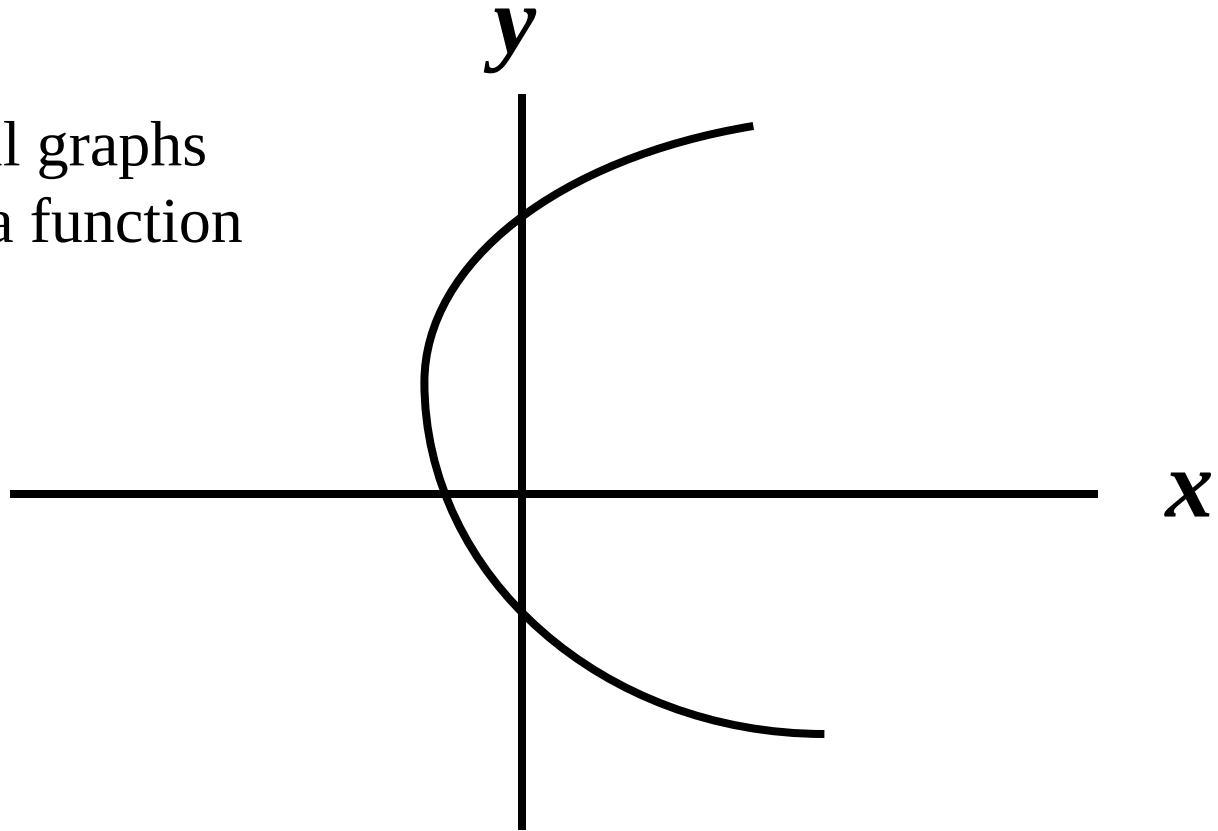


Chapter 1.1

Mathematical Functions

Define by means of graph :

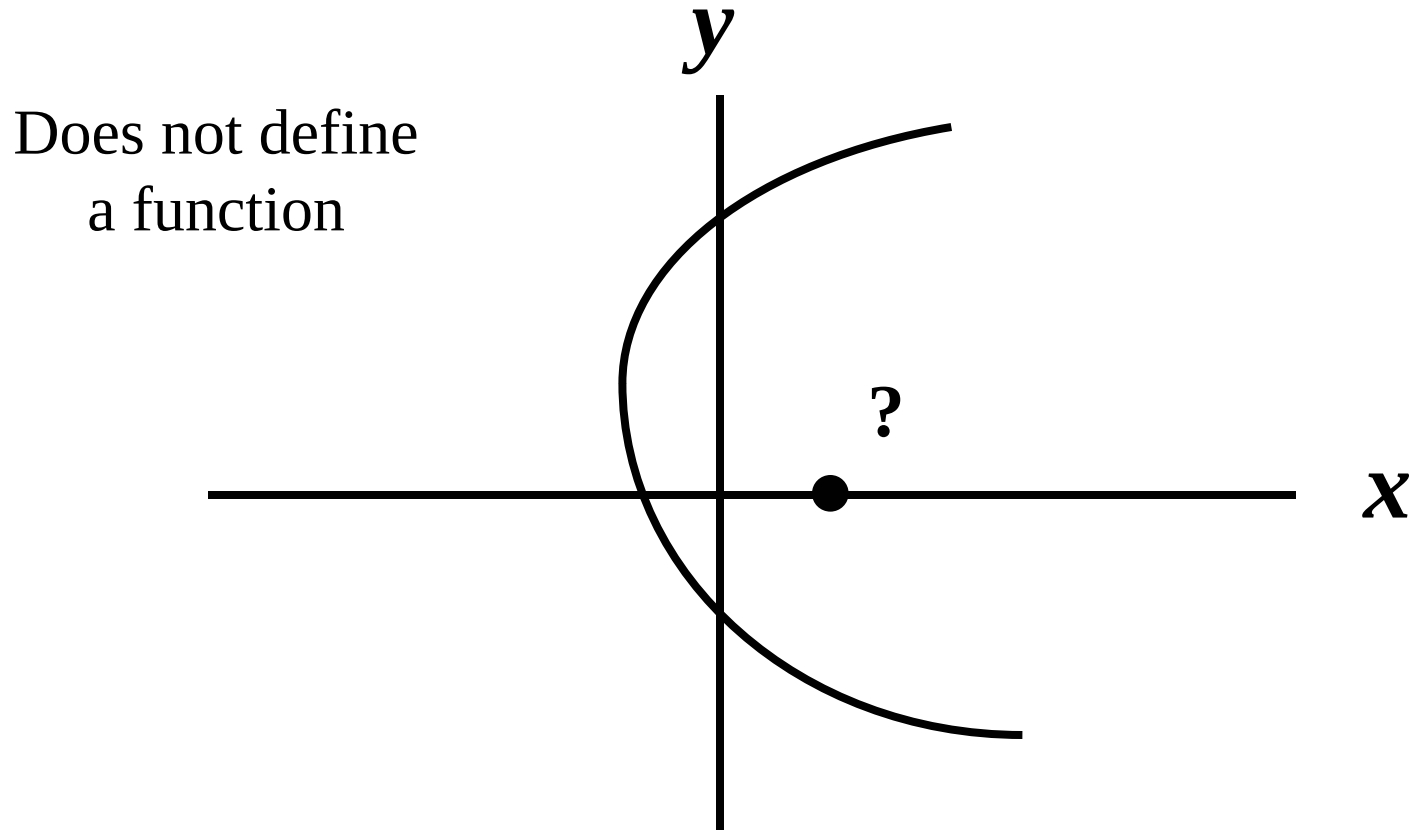
Not all graphs
define a function



Chapter 1.1

Mathematical Functions

Define by means of graph :



Two general problems in analytic geometry :

- (1) Given an algebraic formula for a function, draw its graph
- (2) Given a graph, find an algebraic formula for the function defined by the graph.

Two general problems in analytic geometry :

- (1) Given an algebraic formula for a function, draw its graph
- (2) Given a graph, find an algebraic formula for the function defined by the graph.

Each problem has its difficulties (especially (2)).

One goal is to develop a repertoire of special functions for which one can do both tasks.

Linear functions

Power functions (& polynomials)

Rational functions

Exponential/Logarithm functions

Trigonometric functions

Chapter 1.1

LINEAR FUNCTIONS

Definition

Chapter 1.1

LINEAR FUNCTIONS

Definition

Graphical: functions defined by non-vertical straight lines.

Chapter 1.1

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Algebraic: functions defined by first degree polynomials

Chapter 1.1

LINEAR FUNCTIONS

Definition

Graphical: functions defined by non-vertical straight lines.

Algebraic: functions defined by first degree polynomials

$$y = c_1x + c_0$$

Chapter 1.1

LINEAR FUNCTIONS

Definition

Graphical: functions defined by non-vertical straight lines.

Algebraic: functions defined by first degree polynomials

$$y = mx + b$$

... the more traditional notation
in analytic geometry

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

A straightforward method

A straight line graph is completely determined by two points

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

A straightforward method

A straight line graph is completely determined by two points

Calculate two y 's from *your choice* of two x 's
and plot the resulting two pairs .

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

EXAMPLE

$$y = 2x$$

Chapter 1.1

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EXAMPLE

$$y = 2x$$

$x = 0 \Rightarrow y = 0 \Rightarrow (0, 0)$ lies on graph

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

EXAMPLE

$$y = 2x$$

$x = 0 \Rightarrow y = 0 \Rightarrow (0, 0)$ lies on graph

$x = 1 \Rightarrow y = 2 \Rightarrow (1, 2)$ lies on graph

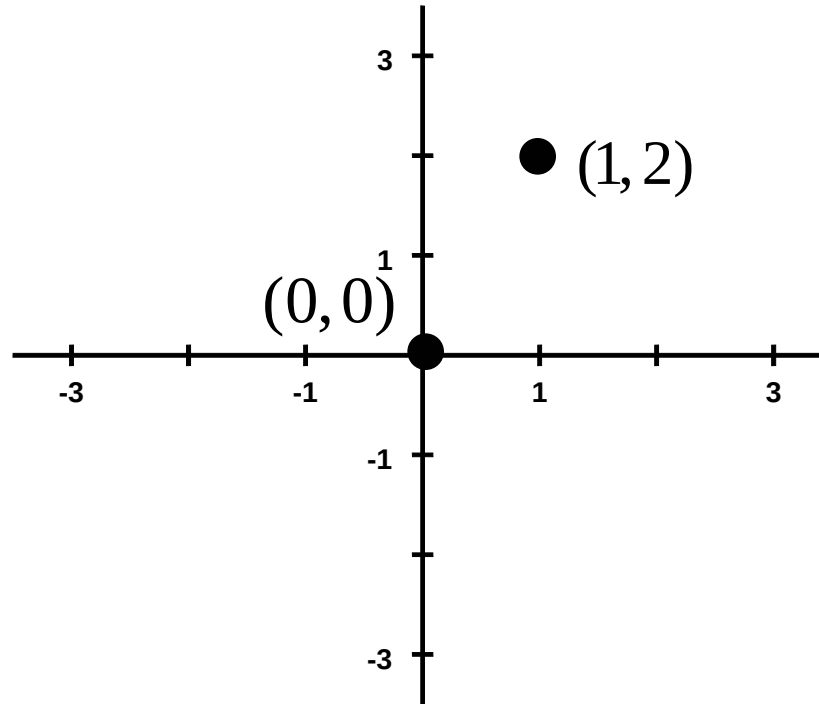
Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

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EXAMPLE



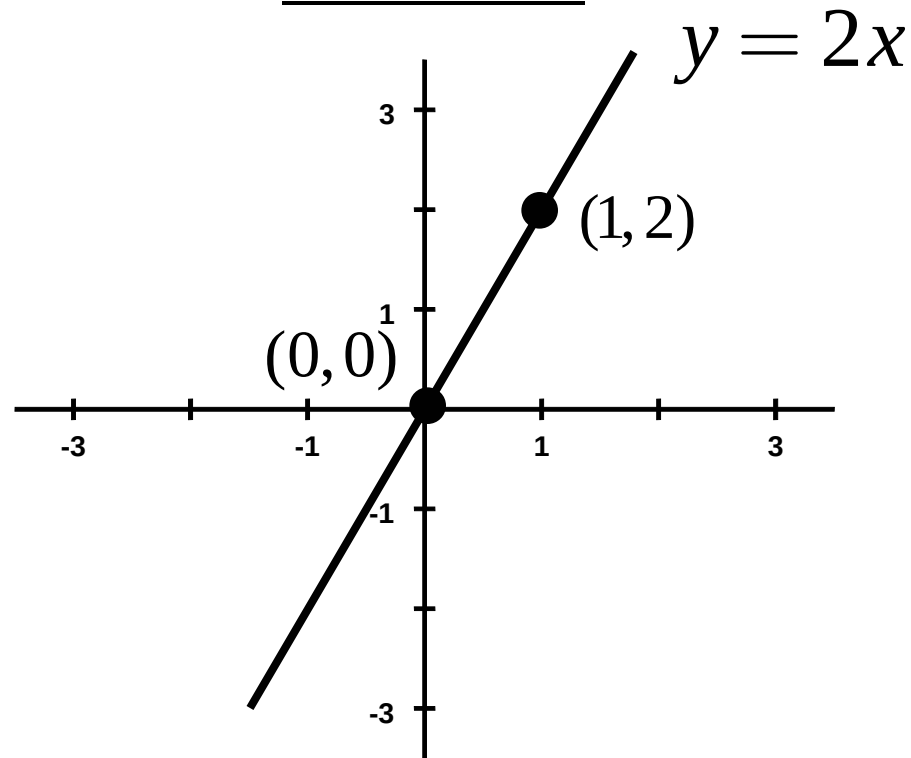
Chapter 1.1

LINEAR FUNCTIONS

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EXAMPLE



Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

EXAMPLE

$$y = -x + 2$$

Chapter 1.1

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EXAMPLE

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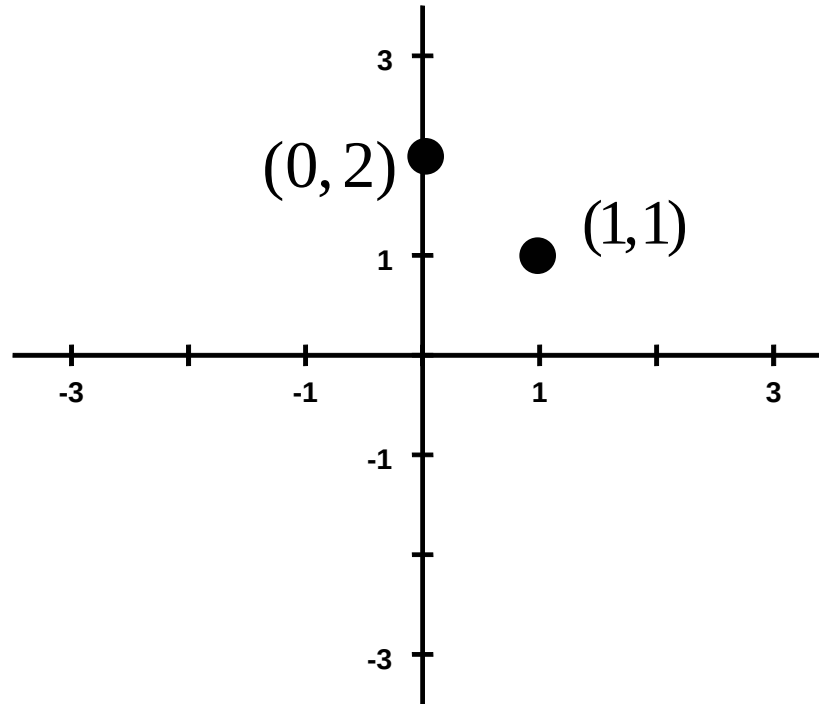
Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

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EXAMPLE



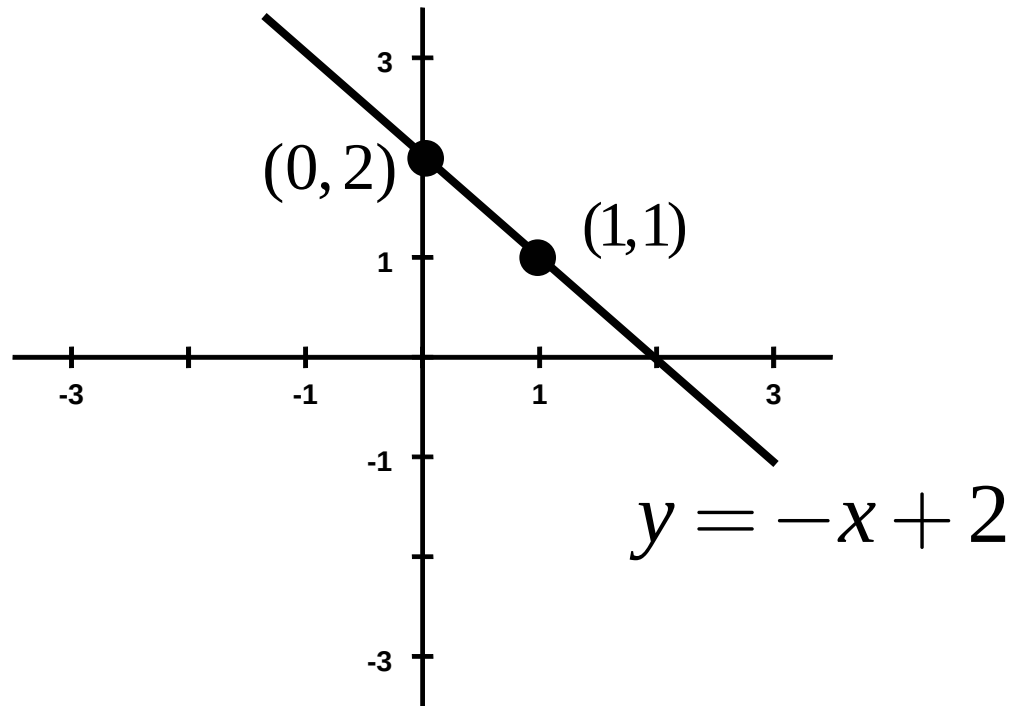
Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

EXAMPLE



Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

Geometrically, what to b and m represent ?

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

Geometrically, what do b and m represent ?

b = intercept (with the y -axis)

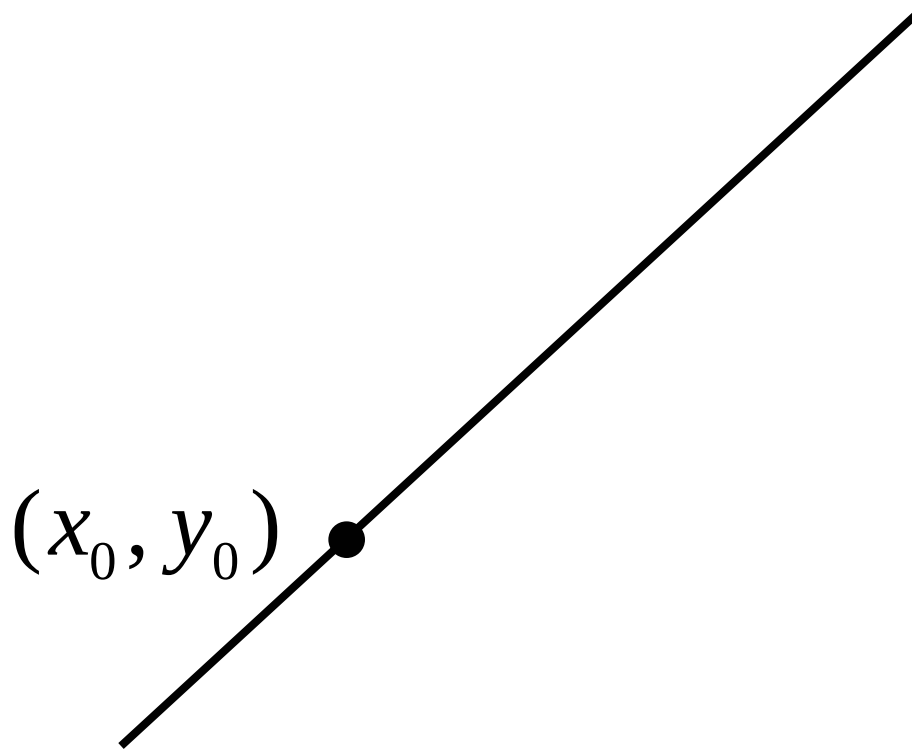
m = slope

Chapter 1.1

LINEAR FUNCTIONS

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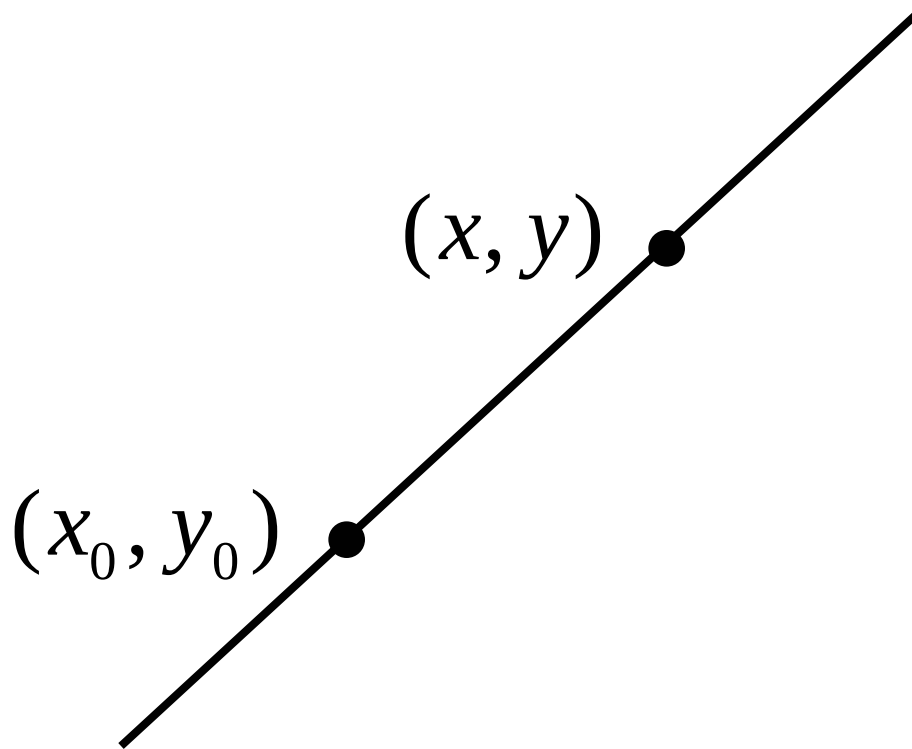


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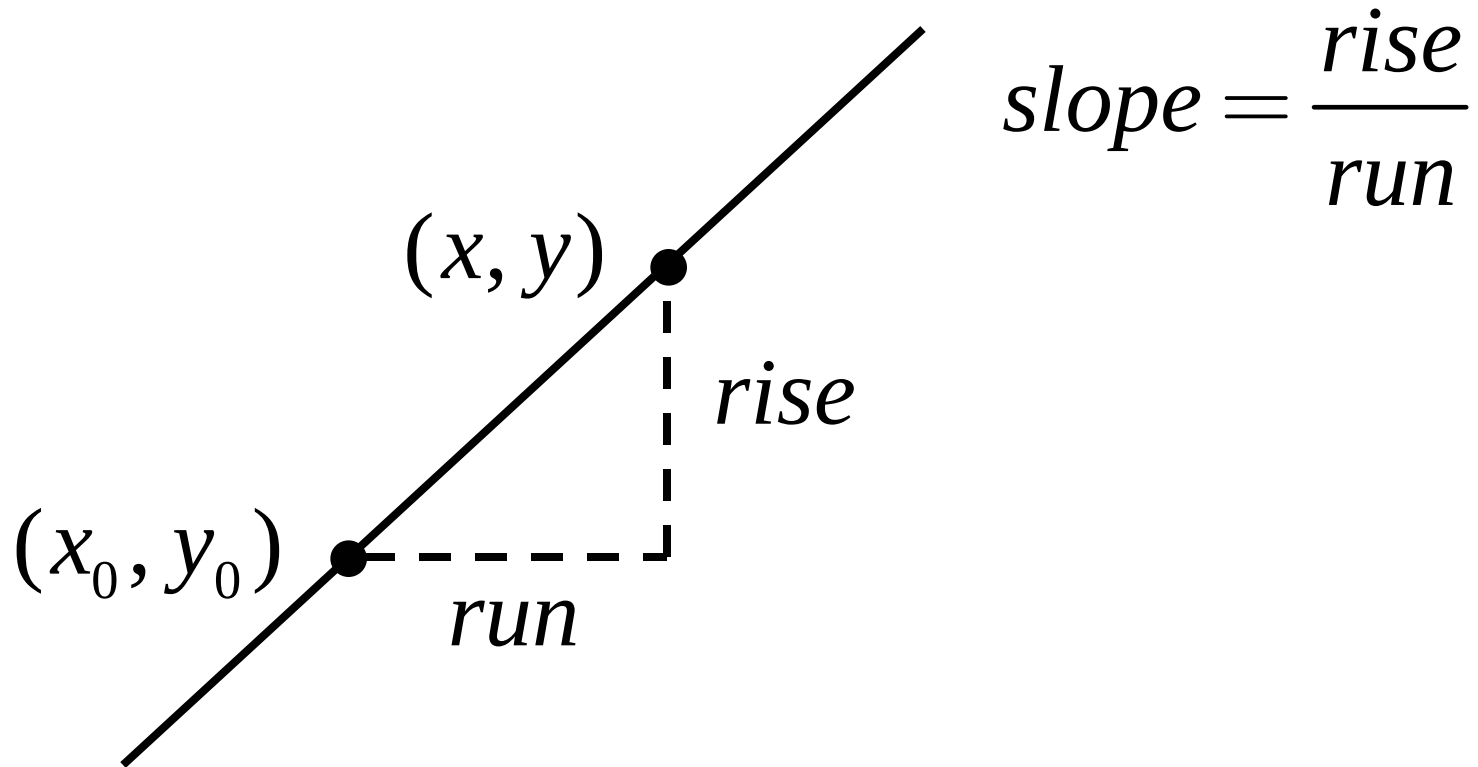


Chapter 1.1

LINEAR FUNCTIONS

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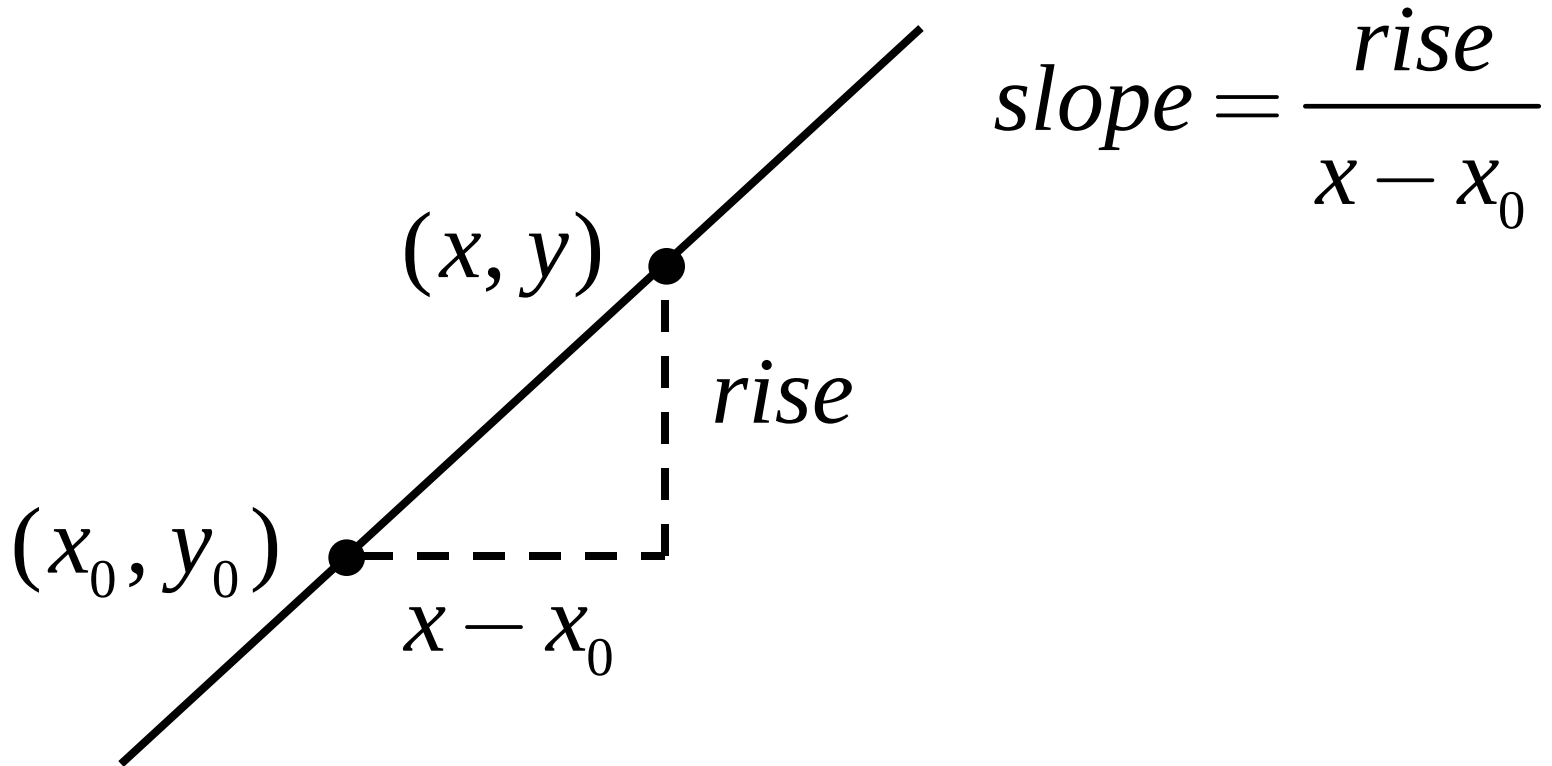


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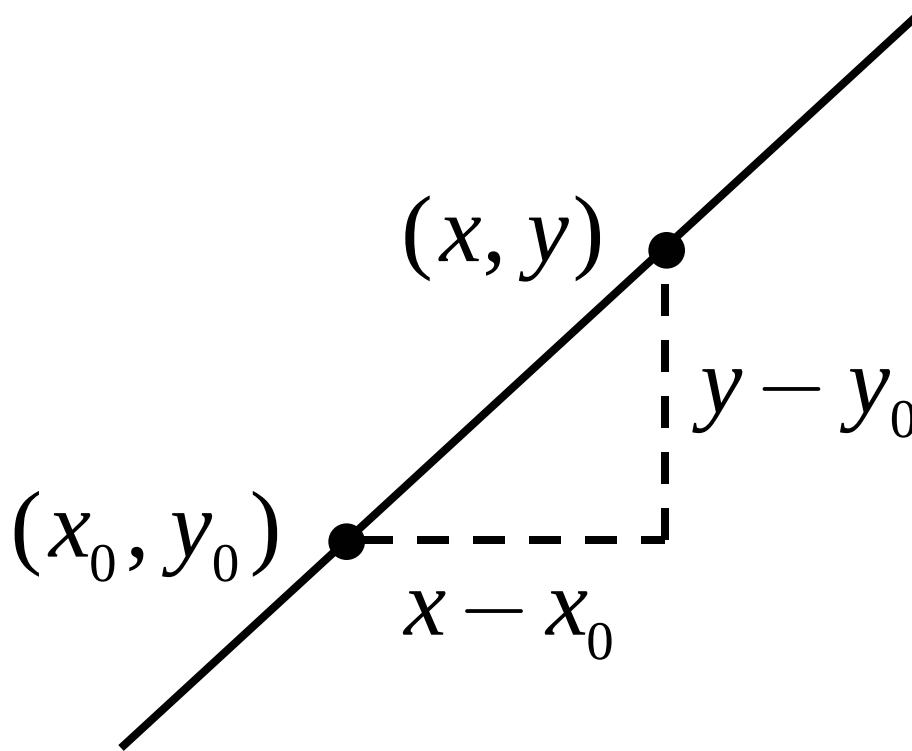


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LINEAR FUNCTIONS

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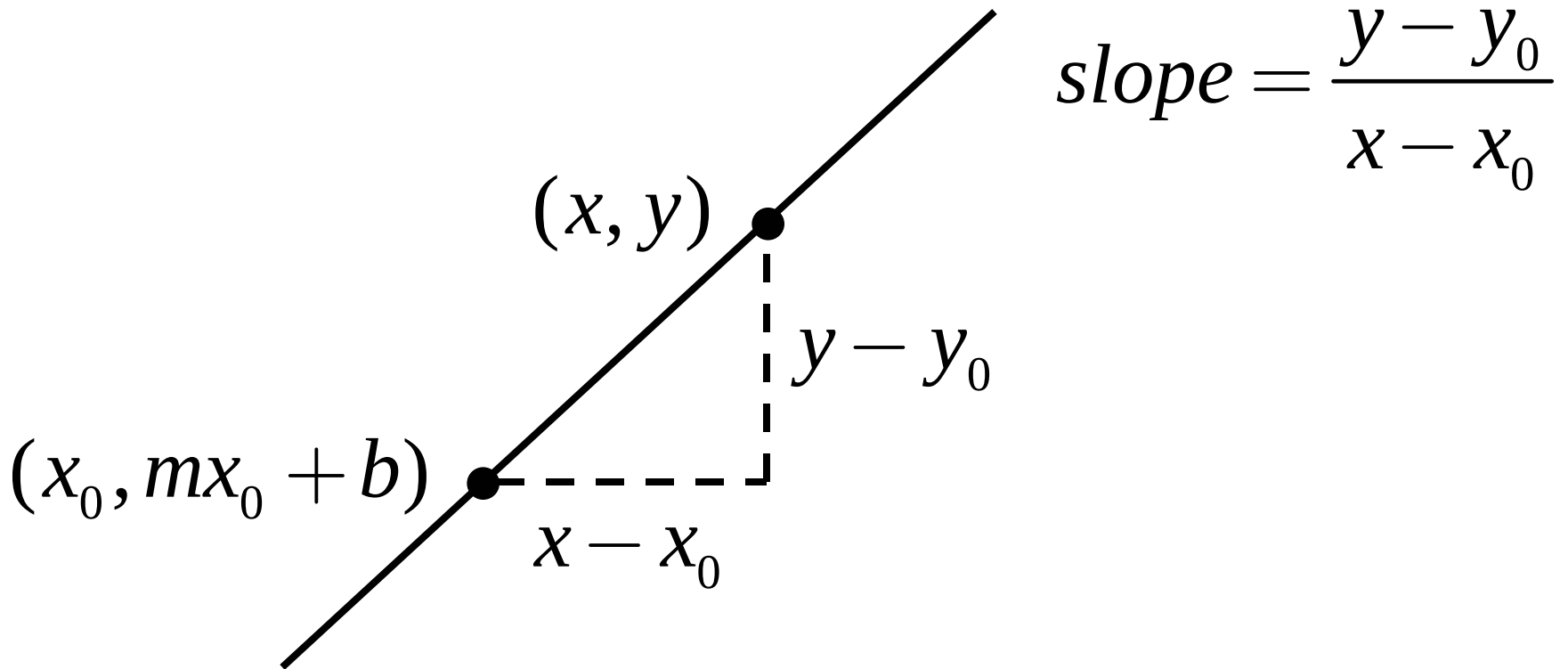
$$m = \frac{y - y_0}{x - x_0}$$

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

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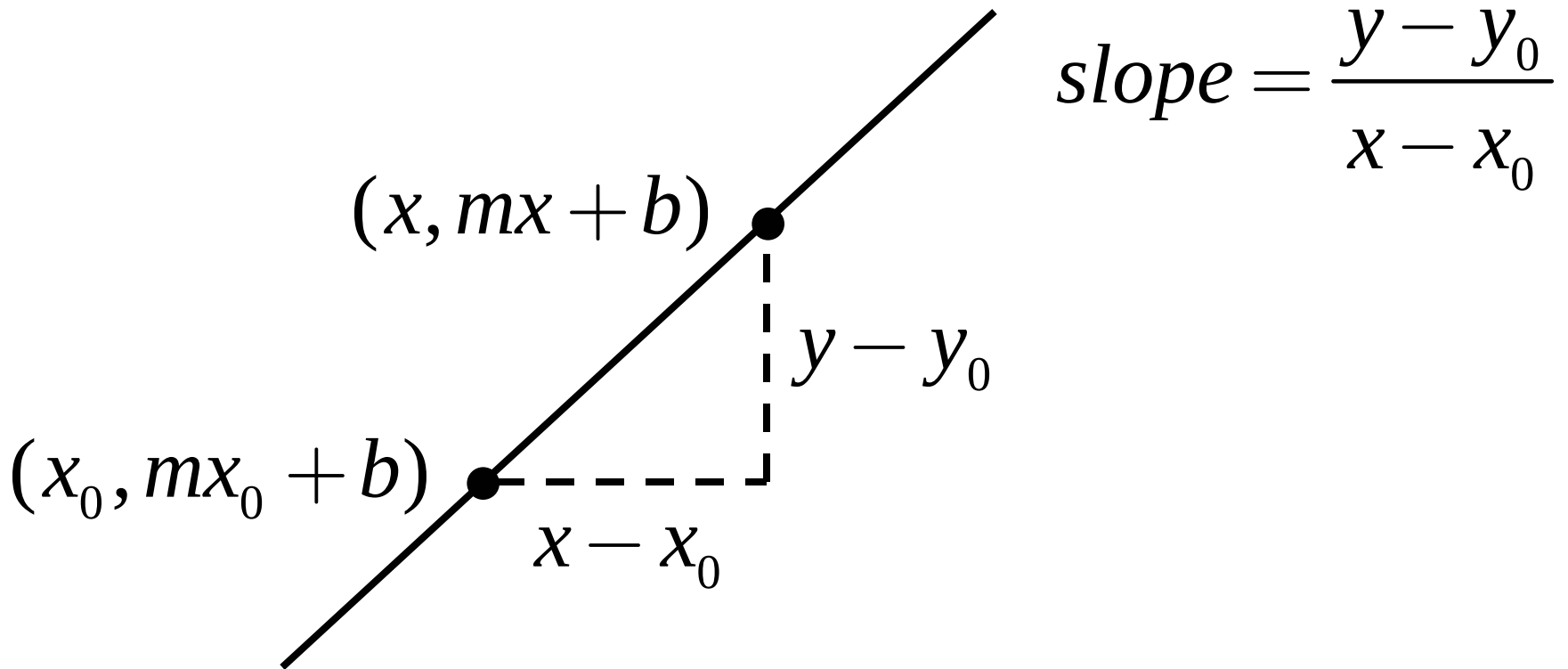


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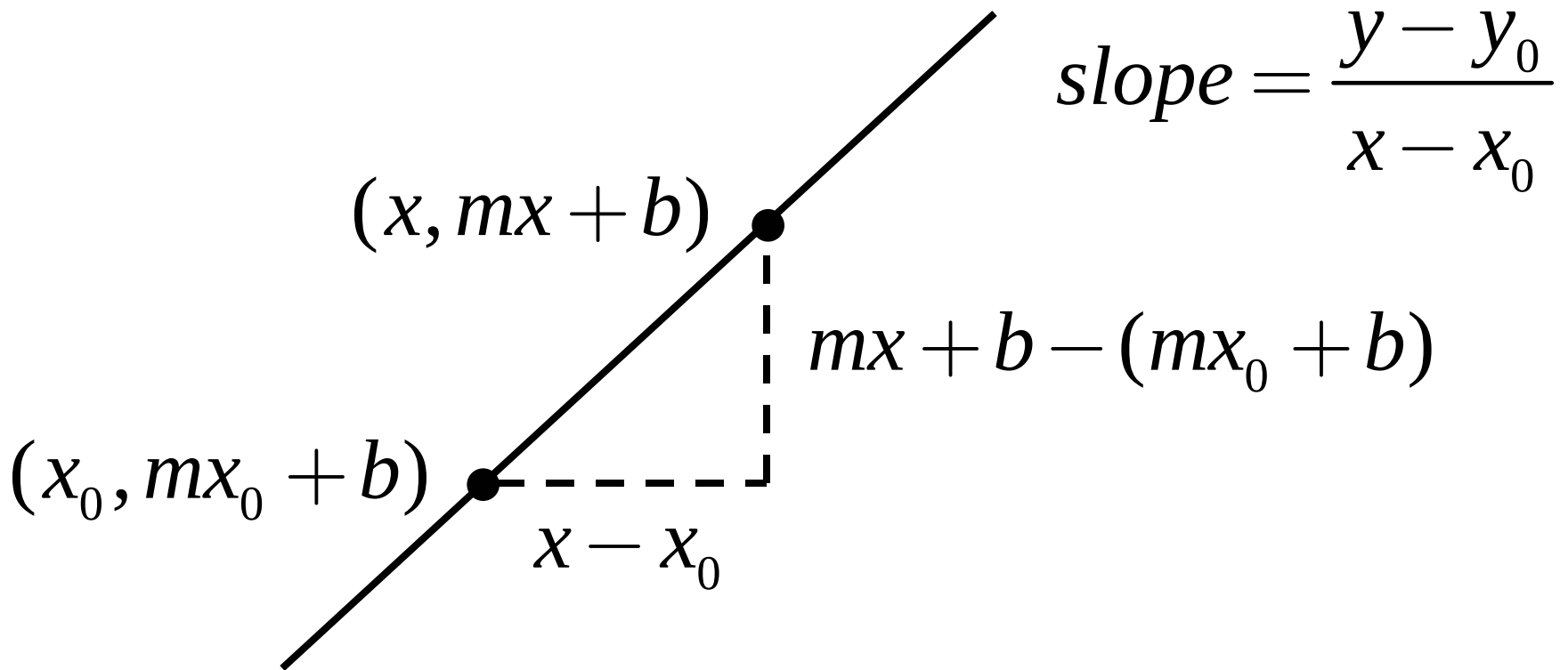


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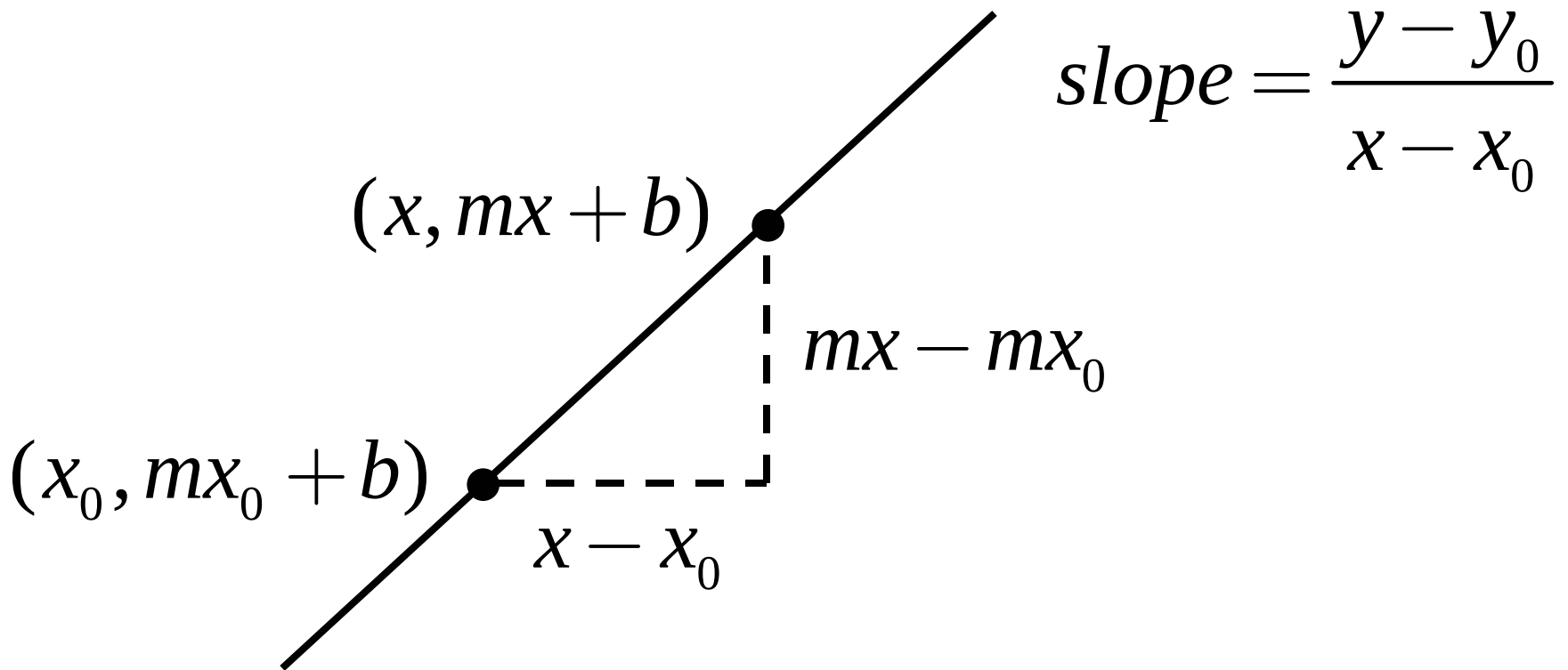


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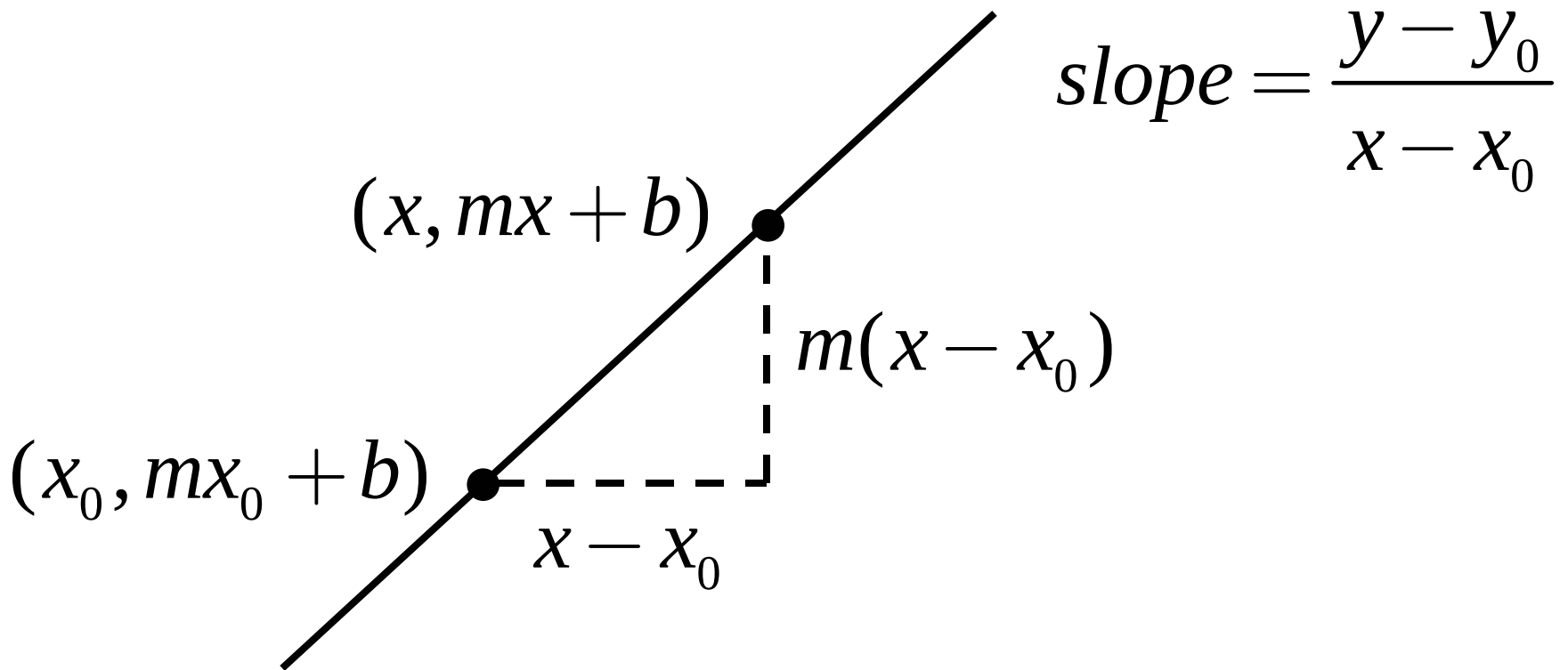


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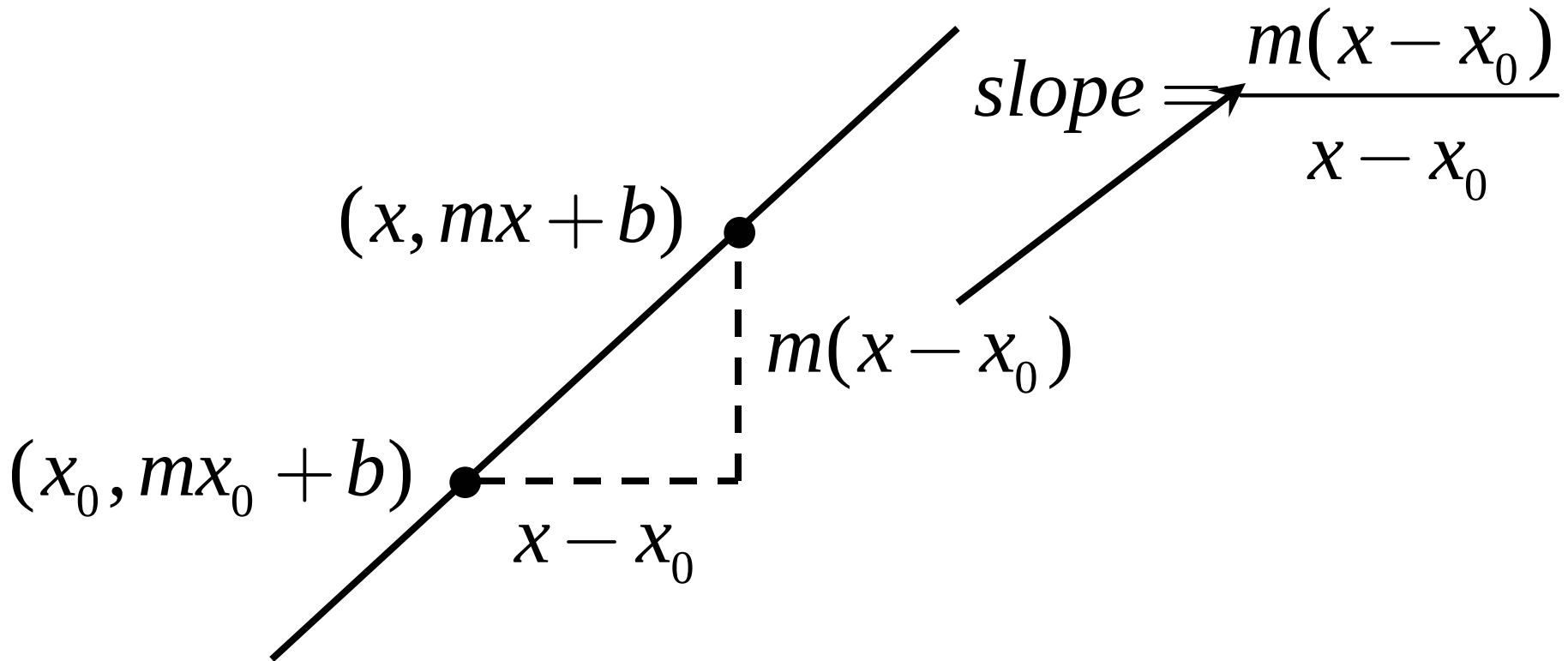


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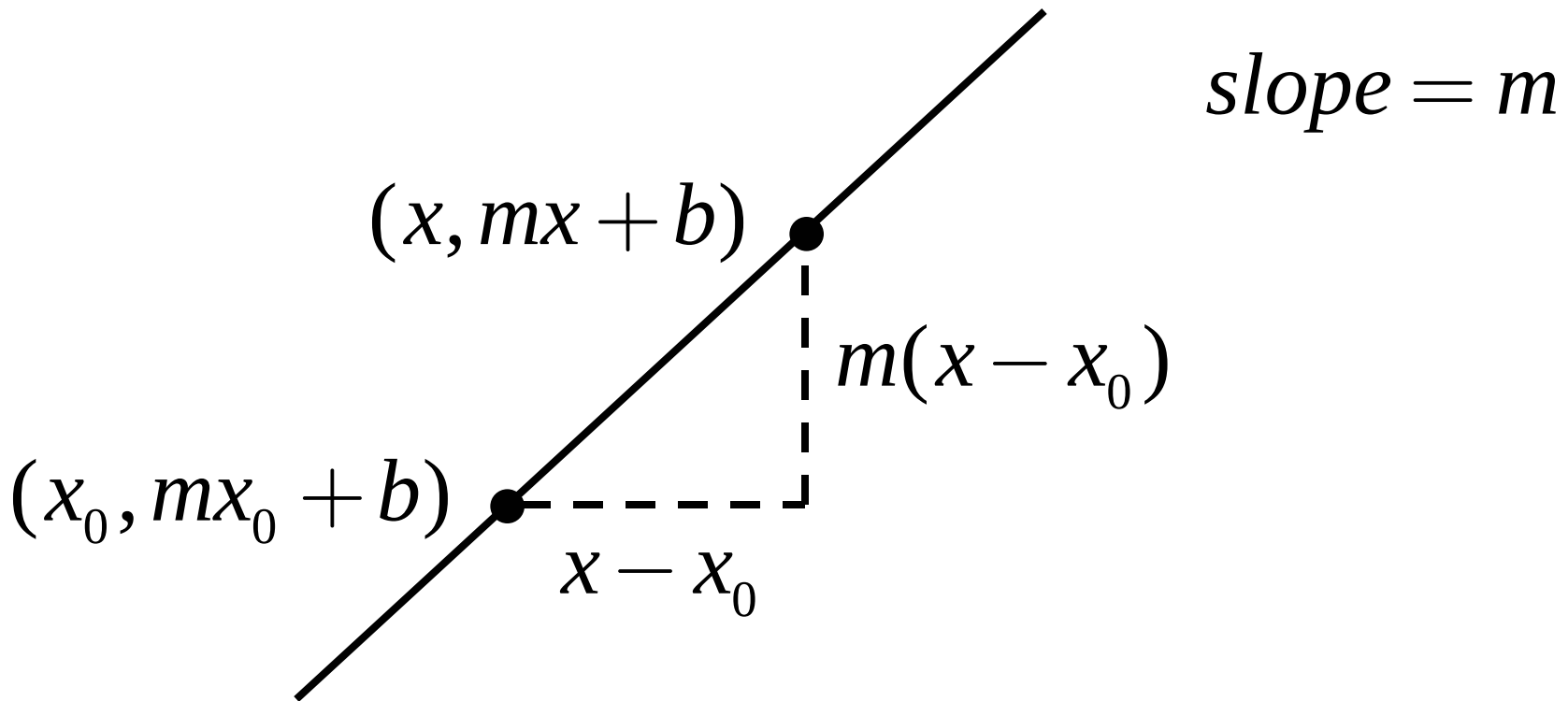


Chapter 1.1

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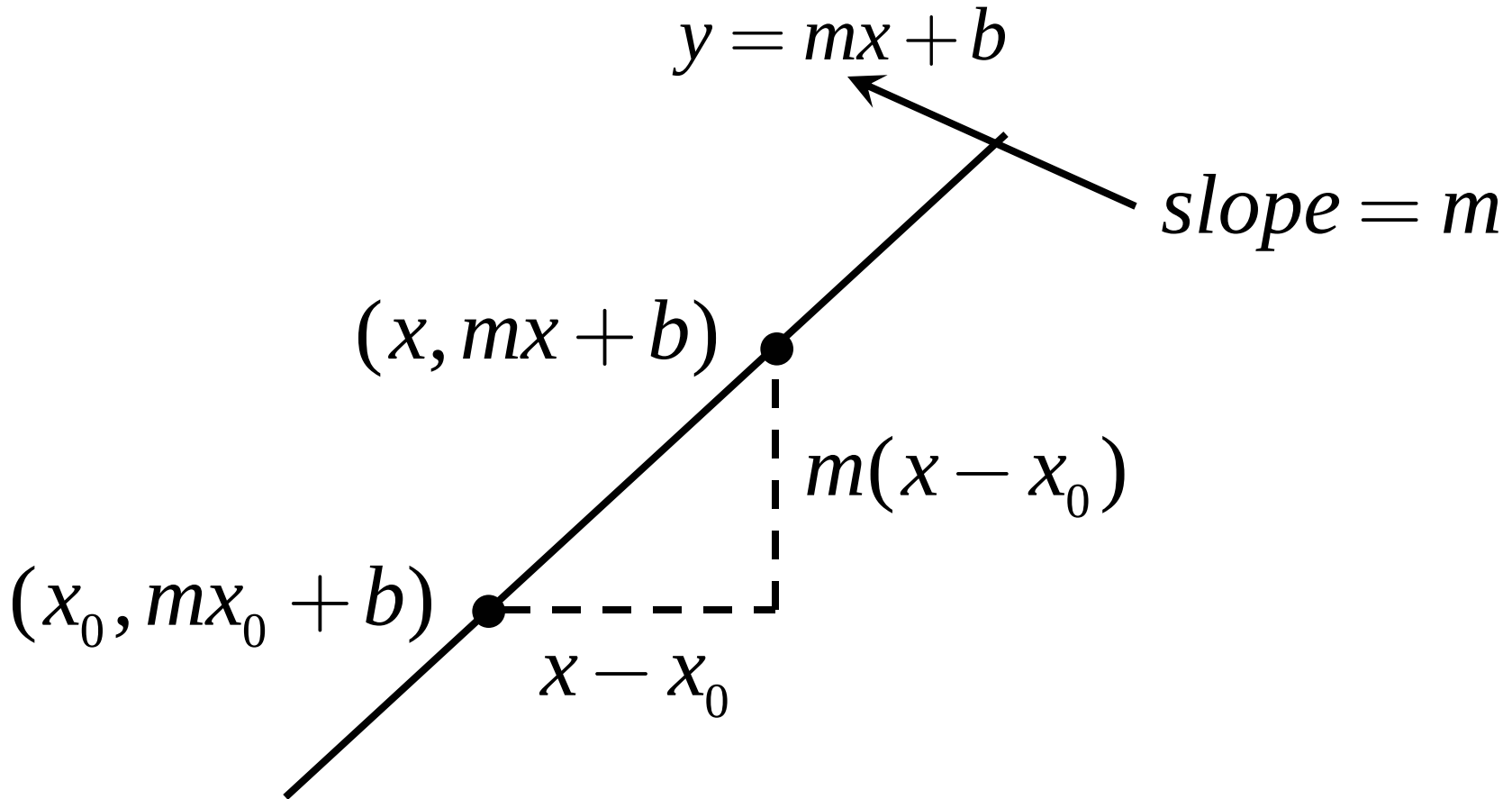
$$y = mx + b$$



Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph



Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

$x = 0 \Rightarrow y = b \Rightarrow (0, b)$ lies on graph

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

$x = 0 \Rightarrow y = b \Rightarrow (0, b)$ lies on graph

also lies on y -axis

b is the "y-intercept".

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

$$y = mx + b$$

EXAMPLE

$$y = -x + 2$$

Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

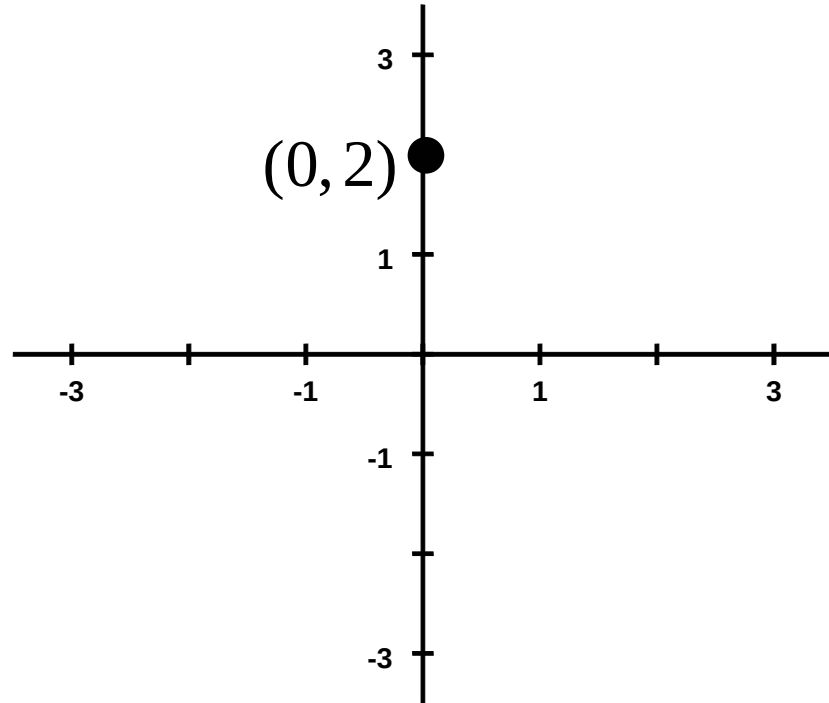
$$y = mx + b$$

EXAMPLE

$$y = -x + 2$$

$$m = -1 = \text{slope}$$

$$b = 2 = \text{y-intercept}$$



Chapter 1.1

LINEAR FUNCTIONS

(1) Given an algebraic formula for a function, draw its graph

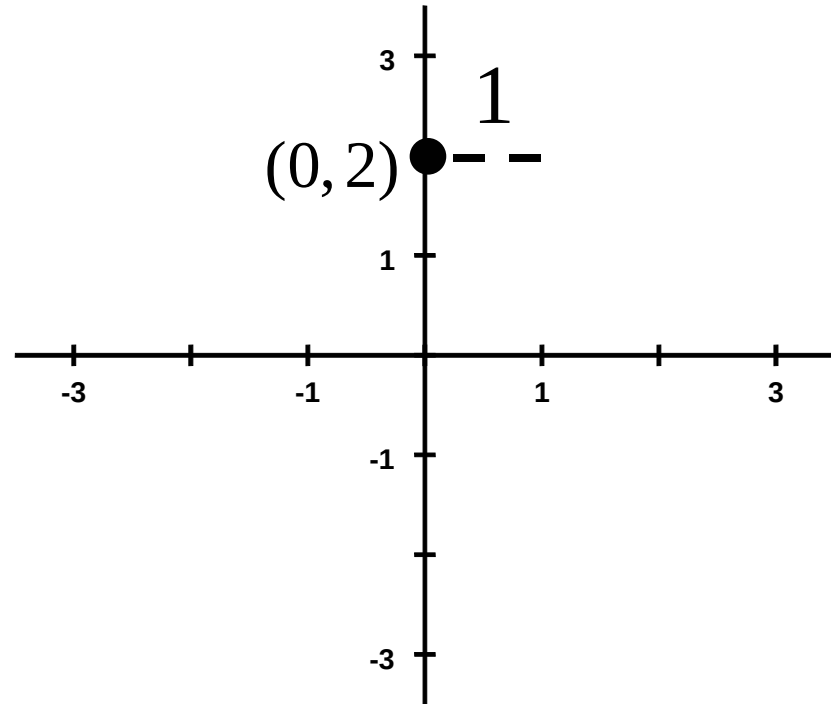
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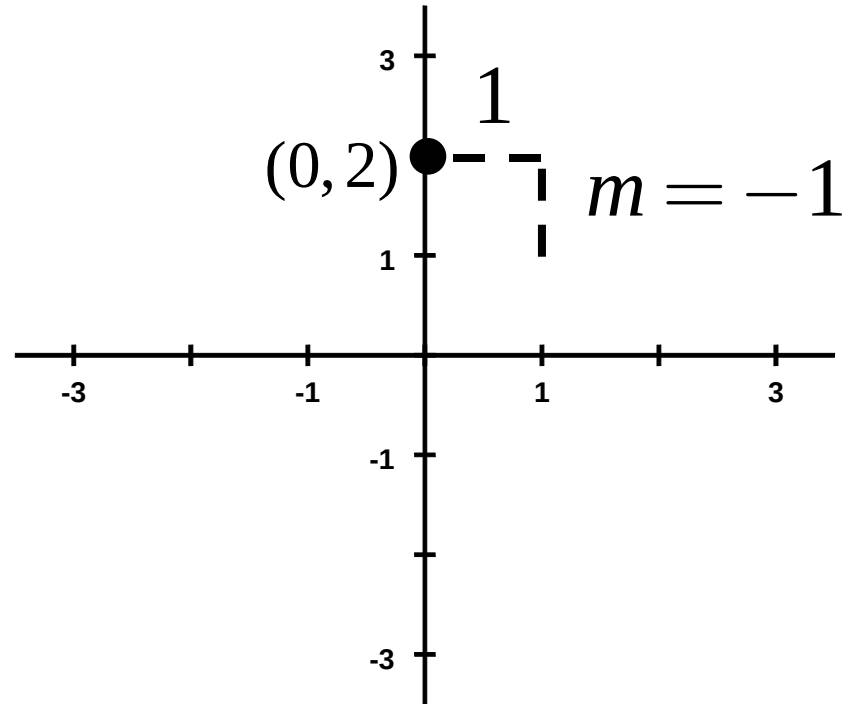
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Chapter 1.1

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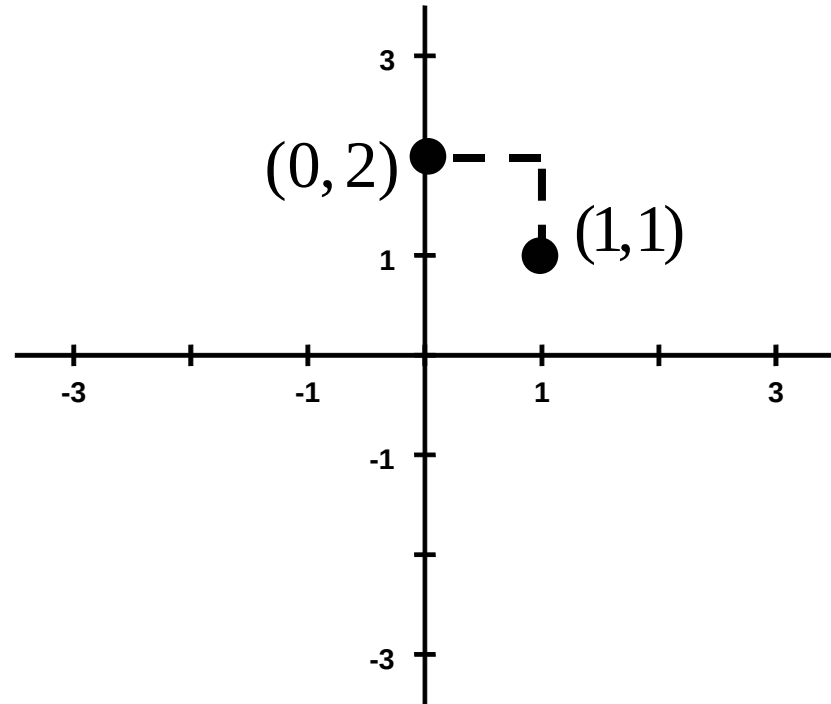
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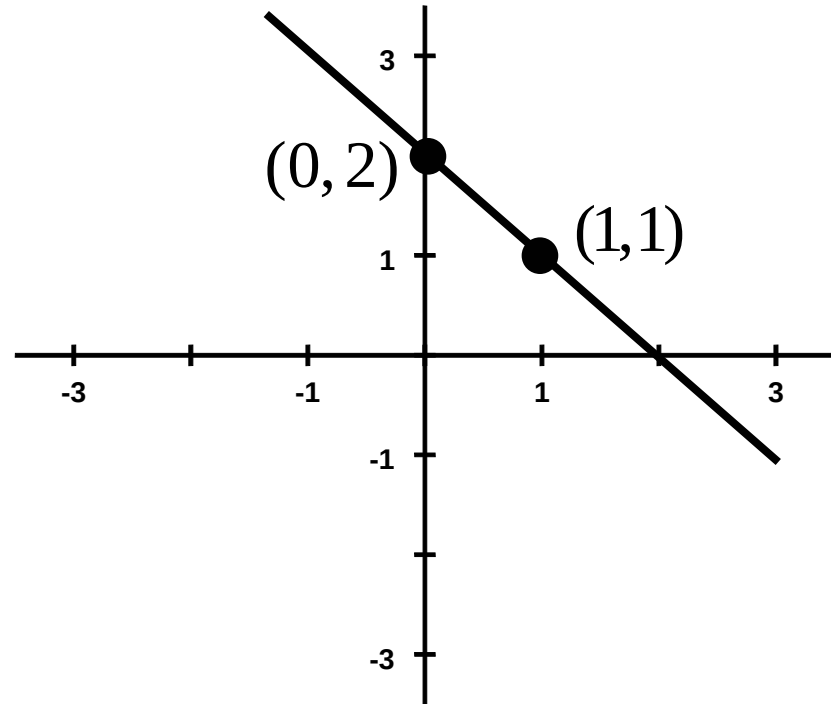
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Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

There are many ways to be “given a graph” of a straight line

Here are a few ...

Given the slope and the y -intercept

Given the slope and a point not on the y -axis

Given two points

Given indirect characterization of slope
and/or points on the line

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope $\frac{1}{3}$
and y-intercept -2

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope $1/3$
and y-intercept -2

$$m = 1/3 \text{ and } b = -2$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope $1/3$
and y-intercept -2

$$m = 1/2 \text{ and } b = -2$$

$$y = mx + b$$

$$y = \frac{1}{2}x - 2$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope -5
and passing through the point $(-1, 3)$.

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope -5
and passing through the point $(-1, 3)$.

$$m = \frac{y - y_0}{x - x_0}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope -5
and passing through the point $(-1, 3)$.

$$m = \frac{y - y_0}{x - x_0}$$

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

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line with slope -5 and passing through the point $(-1, 3)$.

$$m = \frac{y - y_0}{x - x_0}$$

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

Solve for

$$y = -5x - 2$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line passing through
the two points $(1, 2)$ and $(-3, 4)$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line passing through the two points $(1, 2)$ and $(-3, 4)$

$$m = \frac{y - y_0}{x - x_0}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line passing through the two points $(1, 2)$ and $(-3, 4)$

$$m = \frac{y - y_0}{x - x_0}$$

$$m = \frac{2 - 4}{1 - (-3)}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line passing through the two points $(1, 2)$ and $(-3, 4)$

$$m = \frac{y - y_0}{x - x_0}$$

$$m = \frac{2 - 4}{1 - (-3)}$$

$$m = -\frac{1}{2}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

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$$m = \frac{y - y_0}{x - x_0}$$

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Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line passing through the two points $(1, 2)$ and $(-3, 4)$

$$m = \frac{y - y_0}{x - x_0}$$

$$m = -\frac{1}{2}$$

$$-\frac{1}{2} = \frac{y - 2}{x - 1}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line passing through the two points (1, 2) and (−3, 4)

$$m = \frac{y - y_0}{x - x_0}$$

$$m = -\frac{1}{2} \qquad -\frac{1}{2} = \frac{y - 2}{x - 1}$$

Solve for

$$y = -\frac{1}{2}x + \frac{5}{2}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *parallel to* the line $y = 3x + 10$ and passing through the point $(1, -1)$

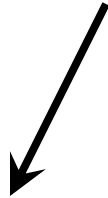
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LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

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Find the equation of the straight line *parallel to* the line $y = 3x + 10$ and passing through the point $(1, -1)$



$$m = 3$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *parallel to* the line $y = 3x + 10$ and passing through the point $(1, -1)$

$$m = \frac{y - y_0}{x - x_0}$$

$$m = 3$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *parallel to* the line $y = 3x + 10$ and passing through the point $(1, -1)$

$$m = \frac{y - y_0}{x - x_0}$$

$$m = 3$$

$$3 = \frac{y - (-1)}{x - 1}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *parallel to* the line $y = 3x + 10$ and passing through the point $(1, -1)$

$$m = \frac{y - y_0}{x - x_0}$$

$$m = 3 \qquad 3 = \frac{y - (-1)}{x - 1}$$

Solve for

$$y = 3x - 4$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *perpendicular* to the line $y = 3x + 10$ and passing through the point $(1, -1)$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *perpendicular* to the line $y = 3x + 10$ and passing through the point $(1, -1)$

A General Fact

Two lines are perpendicular if and only if
their slopes are negative reciprocals,

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *perpendicular* to the line $y = 3x + 10$ and passing through the point $(1, -1)$

A General Fact

Two lines are perpendicular if and only if
their slopes are negative reciprocals,
that is to say, if and only if

$$m_2 = -\frac{1}{m_1}$$

Chapter 1.1

LINEAR FUNCTIONS

(2) Given a graph, find an algebraic formula for the function

EXAMPLES

Find the equation of the straight line *perpendicular* to the line $y = 3x + 10$ and passing through the point $(1, -1)$

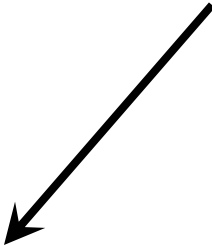
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$$m = \frac{y - y_0}{x - x_0}$$

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$$m = -\frac{1}{3}$$

$$-\frac{1}{3} = \frac{y - (-1)}{x - 1}$$

Solve for

$$y = -\frac{1}{3}x - \frac{2}{3}$$

APPLICATIONS OF LINEAR FUNCTIONS

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Proportionality relationships are linear relationships:

“*y is proportional to x*” means

$$y = m x$$

m = constant of proportionality

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EXAMPLES

Many unit conversions are proportionality relationships:

$$x = \text{yards}, y = \text{feet} \Rightarrow y = 3x$$

$$x = \text{years}, y = \text{days} \Rightarrow y = 365x$$

$$x = \text{kilograms}, y = \text{lbs} \Rightarrow y = 2.2x$$

APPLICATIONS OF LINEAR FUNCTIONS

EXAMPLES

Not all unit conversions are proportionality relationships

Temperature: Fahrenheit to Celsius

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EXAMPLES

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Temperature: Fahrenheit to Celsius

Boiling point of water is $212^{\circ}F$ and $100^{\circ}C$

Freezing point of water is $32^{\circ}F$ and $0^{\circ}C$

x = degrees Fahrenheit

Two points determine a line:

y = degrees Celsius

$(x, y) = (212, 100)$ and $(32, 0)$

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$$m = \frac{y - y_0}{x - x_0} \Rightarrow \frac{5}{9} = \frac{y - 0}{x - 32} \Rightarrow y = \frac{5}{9}(x - 32)$$

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linear relationships hold by definition.

In other applications, linear relationships are
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Problems :

Given data, under the assumption of a linear relationship

- calculate (estimate) m and b
- accept or reject the hypothesized linear relationship

EXAMPLE 1

An experimental observation:
rate of *mRNA* production (r) depends on
length of time it takes a cell to divide (μ)

μ	r
0.0	0.0
0.6	4.3
1.0	9.1
1.5	13
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