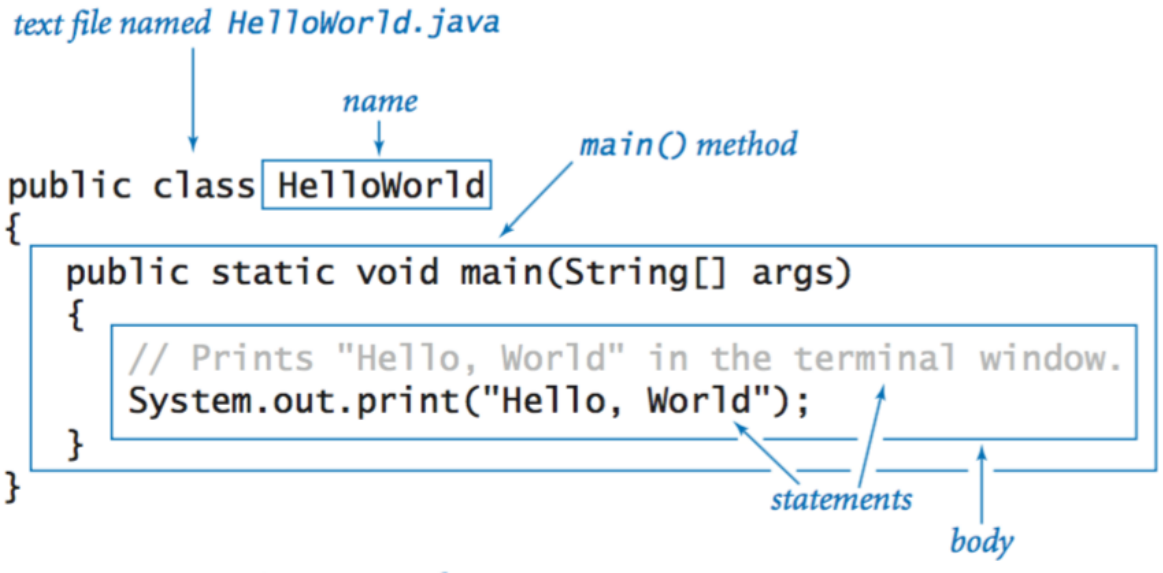
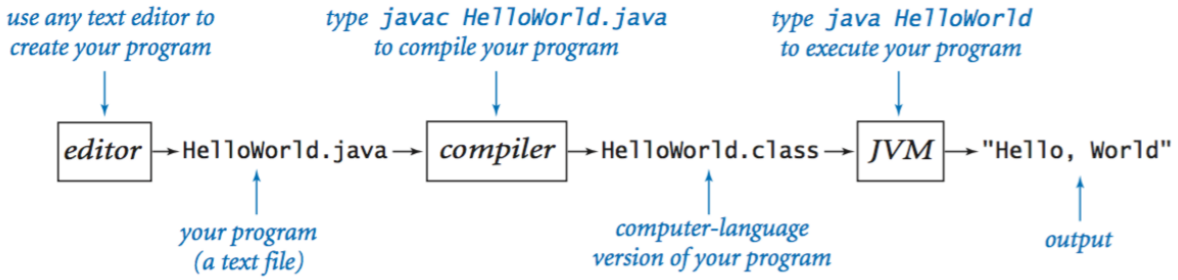
We summarize the most commonly used Java language features and APIs in the textbook.

Hello, World.



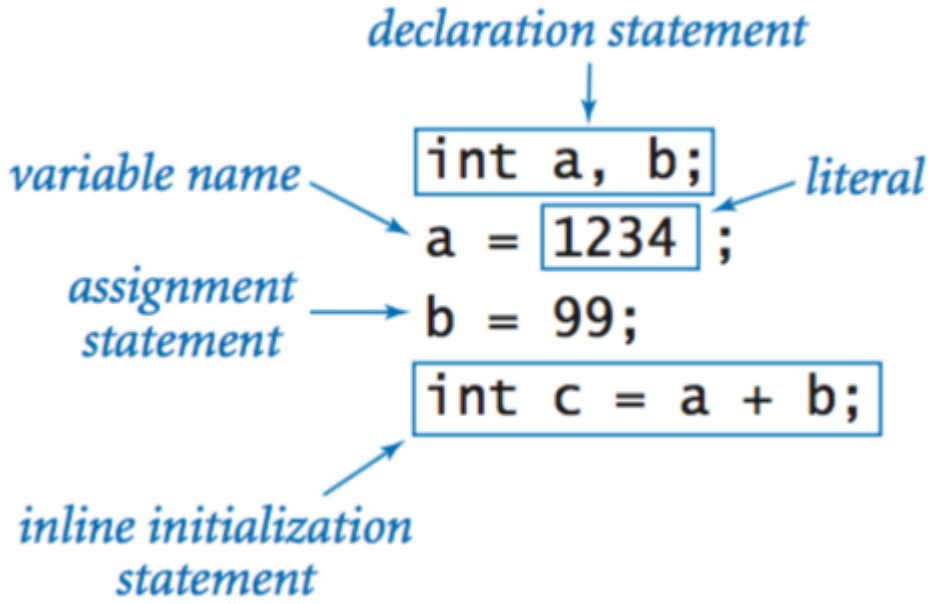
Editing, compiling, and executing.



Built-in data types.

type	set of values	common operators	sample literal values
int	integers	+ - * / %	99 12 2147483647
double	floating-point numbers	+ - * /	3.14 2.5 6.022e23
boolean	boolean values	&& || !	true false
char	characters		'A' '1' '%' '\n'
String	sequences of characters	+	"AB" "Hello" "2.5"

Declaration and assignment statements.



Integers.

values	integers between -2^{31} and $+2^{31}-1$					
typical literals	1234 99 0 1000000					
operations	*sign*	*add*	*subtract*	*multiply*	*divide*	*remainder*
operators	+ -	+	-	*	/	%

expression	*value*	*comment*
`99`	99	*integer literal*
`+99`	99	*positive sign*
`-99`	-99	*negative sign*
`5 + 3`	8	*addition*
`5 - 3`	2	*subtraction*
`5 * 3`	15	*multiplication*
`5 / 3`	1	*no fractional part*
`5 % 3`	2	*remainder*
`1 / 0`		*run-time error*
`3 * 5 - 2`	13	** has precedence*
`3 + 5 / 2`	5	*/ has precedence*
`3 - 5 - 2`	-4	*left associative*
`( 3 - 5 ) - 2`	-4	*better style*
`3 - ( 5 - 2 )`	0	*unambiguous*

Floating-point numbers.

values	real numbers (specified by IEEE 754 standard)			
typical literals	`3.14159`	`6.022e23`	`2.0`	`1.4142135623730951`
operations	*add*	*subtract*	*multiply*	*divide*
operators	`+`	`-`	`*`	`/`

expression	*value*
`3.141 + 2.0`	`5.141`
`3.141 - 2.0`	`1.111`
`3.141 / 2.0`	`1.5705`
`5.0 / 3.0`	`1.6666666666666667`
`10.0 % 3.141`	`0.577`
`1.0 / 0.0`	`Infinity`
`Math.sqrt(2.0)`	`1.4142135623730951`
`Math.sqrt(-1.0)`	`NaN`

Booleans.

values	*true or false*		
literals	`true`	`false`	
operations	and	or	not
operators	&&	||	!

a	*!a*
`true`	`false`
`false`	`true`

a	*b*	*a && b*	*a || b*
`false`	`false`	`false`	`false`
`false`	`true`	`false`	`true`
`true`	`false`	`false`	`true`
`true`	`true`	`true`	`true`

Comparison operators.

op	*meaning*	*true*	*false*
==	*equal*	2 == 2	2 == 3
!=	*not equal*	3 != 2	2 != 2
<	*less than*	2 < 13	2 < 2
<=	*less than or equal*	2 <= 2	3 <= 2
>	*greater than*	13 > 2	2 > 13
>=	*greater than or equal*	3 >= 2	2 >= 3

non-negative discriminant?	(b*b - 4.0*a*c) >= 0.0
beginning of a century?	(year % 100) == 0
legal month?	(month >= 1) && (month <= 12)

Printing.

void System.out.print(String s)	*print s*
void System.out.println(String s)	*print s, followed by a newline*
void System.out.println()	*print a newline*

Parsing command-line arguments.

int Integer.parseInt(String s)	*convert s to an `int` value*
double Double.parseDouble(String s)	*convert s to a `double` value*
long Long.parseLong(String s)	*convert s to a `long` value*

Math library.

public class Math	
double abs(double a)	*absolute value of a*
double max(double a, double b)	*maximum of a and b*
double min(double a, double b)	*minimum of a and b*
double sin(double theta)	*sine of theta*
double cos(double theta)	*cosine of theta*
double tan(double theta)	*tangent of theta*
double toRadians(double degrees)	*convert angle from degrees to radians*
double toDegrees(double radians)	*convert angle from radians to degrees*
double exp(double a)	*exponential* (e^a)
double log(double a)	*natural log* ($\log_e a$, *or* $\ln a$)
double pow(double a, double b)	*raise a to the bth power* (a^b)
long round(double a)	*round a to the nearest integer*
double random()	*random number in* [0, 1)
double sqrt(double a)	*square root of a*
double E	*value of e (constant)*
double PI	*value of π (constant)*

The full java.lang.Math API.

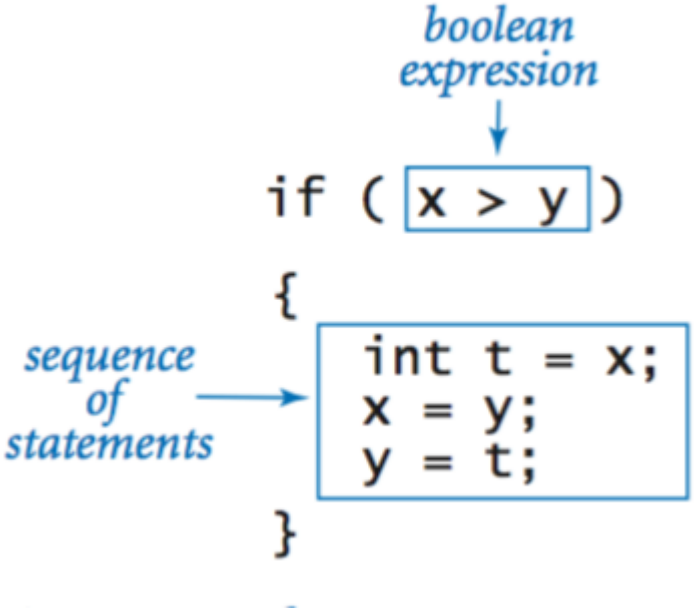
Java library calls.

method call	*library*	*return type*	*value*
Integer.parseInt("123")	Integer	int	123
Double.parseDouble("1.5")	Double	double	1.5
Math.sqrt(5.0*5.0 - 4.0*4.0)	Math	double	3.0
Math.log(Math.E)	Math	double	1.0
Math.random()	Math	double	*random in* [0, 1)
Math.round(3.14159)	Math	long	3
Math.max(1.0, 9.0)	Math	double	9.0

Type conversion.

expression	*expression type*	*expression value*
`(1 + 2 + 3 + 4) / 4.0`	`double`	`2.5`
`Math.sqrt(4)`	`double`	`2.0`
`"1234" + 99`	`String`	`"123499"`
`11 * 0.25`	`double`	`2.75`
`(int) 11 * 0.25`	`double`	`2.75`
`11 * (int) 0.25`	`int`	`0`
`(int) (11 * 0.25)`	`int`	`2`
`(int) 2.71828`	`int`	`2`
`Math.round(2.71828)`	`long`	`3`
`(int) Math.round(2.71828)`	`int`	`3`
`Integer.parseInt("1234")`	`int`	`1234`

Anatomy of an if statement.



If and if-else statements.

absolute value	`if (x < 0) x = -x;`

put the smaller value in x and the larger value in y	`if (x > y)`
	`{`
	`  int t = x;`
	`  x = y;`
	`  y = t;`
	`}`

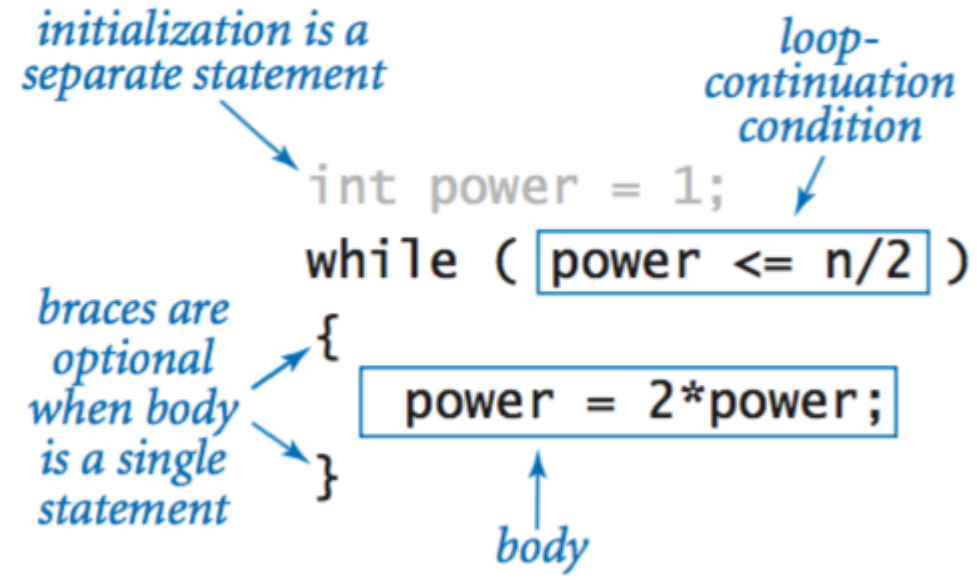
maximum of x and y	`if (x > y) max = x;` `else  max = y;`
error check for division operation	`if (den == 0) System.out.println("Division by zero");` `else  System.out.println("Quotient = " + num/den);`

error check for quadratic formula	`double discriminant = b*b - 4.0*c;`
	`if (discriminant < 0.0)`
	`{`
	`  System.out.println("No real roots");`
	`}`
	`else`
	`{`
	`  System.out.println((-b + Math.sqrt(discriminant))/2.0);`
	`  System.out.println((-b - Math.sqrt(discriminant))/2.0);`
	`}`

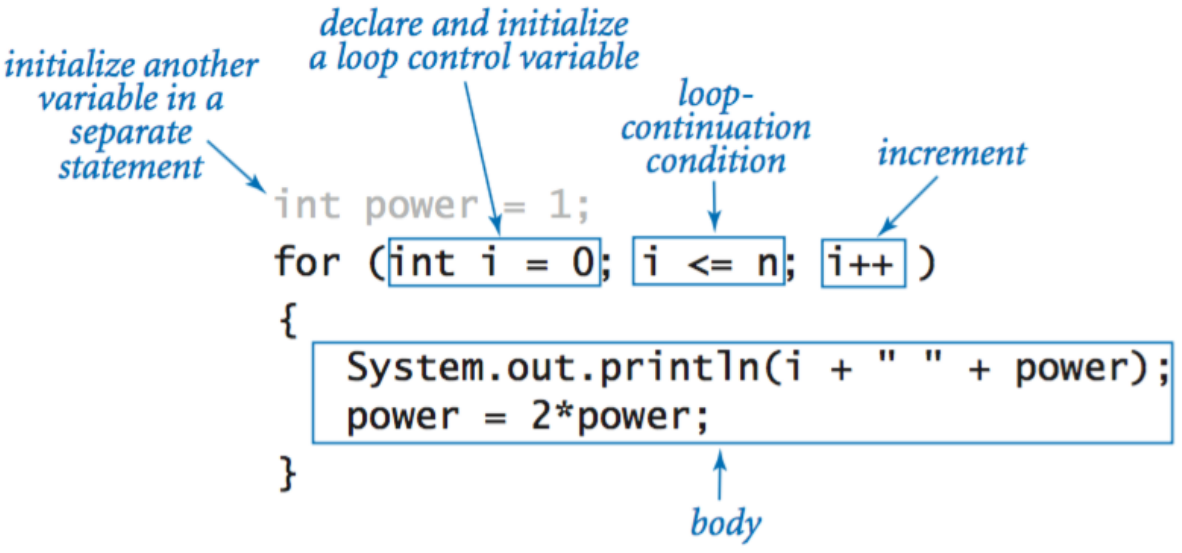
Nested if-else statement.

```
if      (income <      0) rate = 0.00;
else if (income <   8925) rate = 0.10;
else if (income <  36250) rate = 0.15;
else if (income <  87850) rate = 0.23;
else if (income < 183250) rate = 0.28;
else if (income < 398350) rate = 0.33;
else if (income < 400000) rate = 0.35;
else                      rate = 0.396;
```

Anatomy of a while loop.



Anatomy of a for loop.



Loops.

compute the largest power of 2 less than or equal to n	`int power = 1;`
	`while (power <= n/2)`
	`  power = 2*power;`
	`System.out.println(power);`

compute a finite sum $(1 + 2 + \ldots + n)$	`int sum = 0;`
	`for (int i = 1; i <= n; i++)`
	`  sum += i;`
	`System.out.println(sum);`

compute a finite product $(n! = 1 \times 2 \times \ldots \times n)$	`int product = 1;`
	`for (int i = 1; i <= n; i++)`
	`  product *= i;`
	`System.out.println(product);`

print a table of function values	`for (int i = 0; i <= n; i++)` `  System.out.println(i + " " + 2*Math.PI*i/n);`

compute the ruler function (see PROGRAM 1.2.1)	`String ruler = "1";`
	`for (int i = 2; i <= n; i++)`
	`  ruler = ruler + " " + i + " " + ruler;`
	`System.out.println(ruler);`

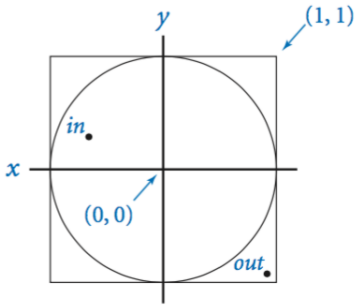
Break statement.

```
int factor;
for (factor = 2; factor <= n/factor; factor++)
   if (n % factor == 0) break;

if (factor > n/factor)
   System.out.println(n + " is prime");
```

Do-while loop.

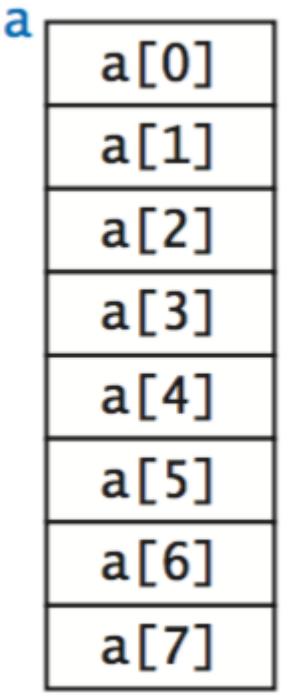
```
do
{  // Scale x and y to be random in (-1, 1).
   x = 2.0*Math.random() - 1.0;
   y = 2.0*Math.random() - 1.0;
} while (Math.sqrt(x*x + y*y) > 1.0);
```



Switch statement.

```
switch (day) {
   case 0: System.out.println("Sun"); break;
   case 1: System.out.println("Mon"); break;
   case 2: System.out.println("Tue"); break;
   case 3: System.out.println("Wed"); break;
   case 4: System.out.println("Thu"); break;
   case 5: System.out.println("Fri"); break;
   case 6: System.out.println("Sat"); break;
}
```

Arrays.



Inline array initialization.

```
String[] SUITS = { "Clubs", "Diamonds", "Hearts", "Spades" };

String[] RANKS = {
   "2", "3", "4", "5", "6", "7", "8", "9", "10",
   "Jack", "Queen", "King", "Ace"
};
```

Typical array-processing code.

create an array with random values	`double[] a = new double[n];`
	`for (int i = 0; i < n; i++)`
	`  a[i] = Math.random();`

print the array values, one per line	`for (int i = 0; i < n; i++)` `  System.out.println(a[i]);`

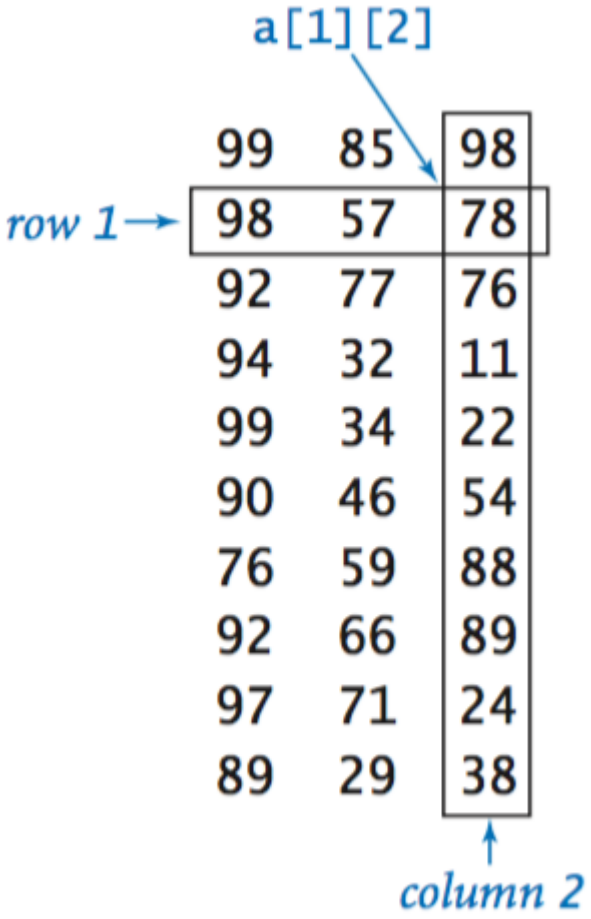
find the maximum of the array values	`double max = Double.NEGATIVE_INFINITY;`
	`for (int i = 0; i < n; i++)`
	`  if (a[i] > max) max = a[i];`

compute the average of the array values	`double sum = 0.0;`
	`for (int i = 0; i < n; i++)`
	`  sum += a[i];`
	`double average = sum / n;`

reverse the values within an array	`for (int i = 0; i < n/2; i++)`
	`{`
	`  double temp = a[i];`
	`  a[i] = a[n-1-i];`
	`  a[n-i-1] = temp;`
	`}`

copy sequence of values to another array	`double[] b = new double[n];`
	`for (int i = 0; i < n; i++)`
	`  b[i] = a[i];`

Two-dimensional arrays.



Inline initialization.

```
double [][] a =
{
   { 99.0, 85.0, 98.0,  0.0 },
   { 98.0, 57.0, 79.0,  0.0 },
   { 92.0, 77.0, 74.0,  0.0 },
   { 94.0, 62.0, 81.0,  0.0 },
   { 99.0, 94.0, 92.0,  0.0 },
   { 80.0, 76.5, 67.0,  0.0 },
   { 76.0, 58.5, 90.5,  0.0 },
   { 92.0, 66.0, 91.0,  0.0 },
   { 97.0, 70.5, 66.5,  0.0 },
   { 89.0, 89.5, 81.0,  0.0 },
   {  0.0,  0.0,  0.0,  0.0 }
};
```

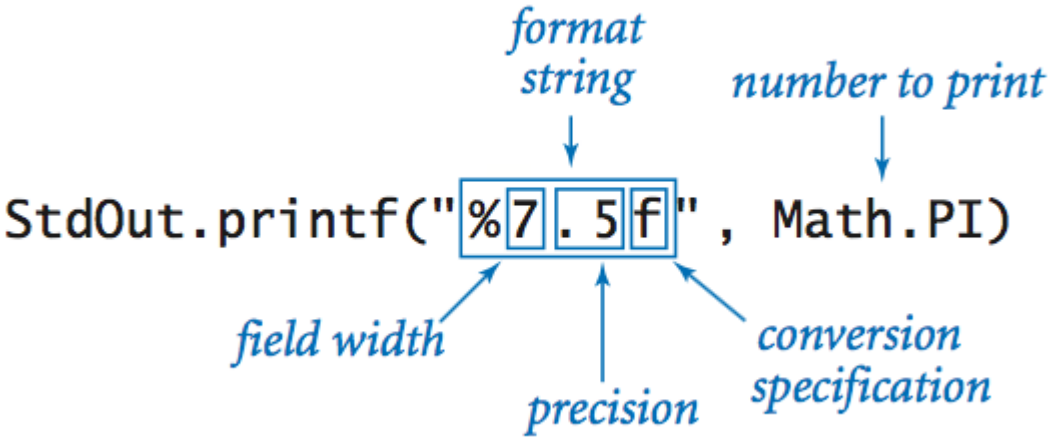
Our standard output library.

public class StdOut

void print(String s)	*print* `s` *to standard output*
void println(String s)	*print* `s` *and a newline to standard output*
void println()	*print a newline to standard output*
void printf(String format, ...)	*print the arguments to standard output, as specified by the format string* `format`

The full StdOut API.

Formatted printing.



type	code	typical literal	sample format strings	converted string values for output
int	d	512	"%14d" "%-14d"	" 512" "512 "
double	f e	1595.1680010754388	"%14.2f" "%.7f" "%14.4e"	" 1595.17" "1595.1680011" "1.5952e+03"
String	s	"Hello, World"	"%14s" "%-14s" "%-14.5s"	" Hello, World" "Hello, World " "Hello "
boolean	b	true	"%b"	"true"

Our standard input library.

The full StdIn API.

Our standard drawing library.

The full StdDraw API.

Our standard audio library.

public class StdAudio	
void play(String filename)	*play the given .wav file*
void play(double[] a)	*play the given sound wave*
void play(double x)	*play sample for 1/44100 second*
void save(String filename, double[] a)	*save to a .wav file*
double[] read(String filename)	*read from a .wav file*

The full StdAudio API.

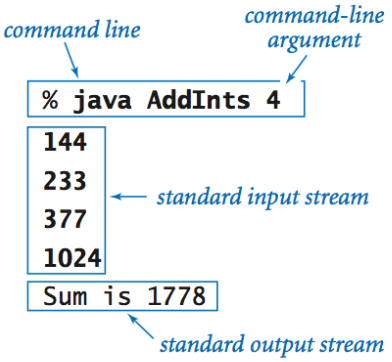
Command line.

```
public class AddInts
{
   public static void main(String[] args)
   {
      int n = Integer.parseInt(args[0]);
      int sum = 0;
      for (int i = 0; i < n; i++)
      {
         int value = StdIn.readInt();
         sum += value;
      }
      StdOut.println("Sum is " + sum);
   }
}
```

parse command-line argument

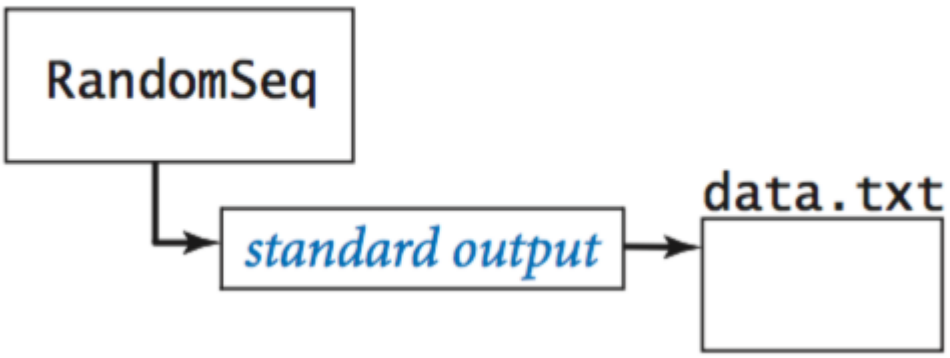
read from standard input stream

print to standard output stream



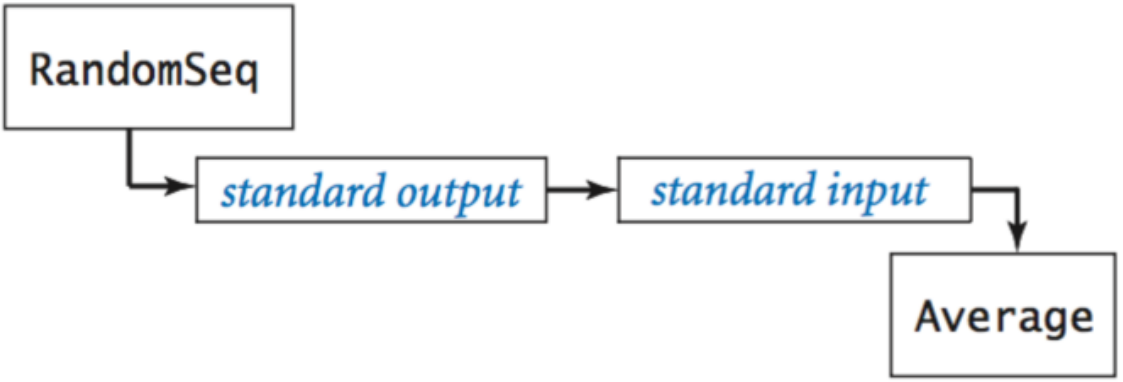
Redirection and piping.

```
% java RandomSeq 1000 > data.txt
```

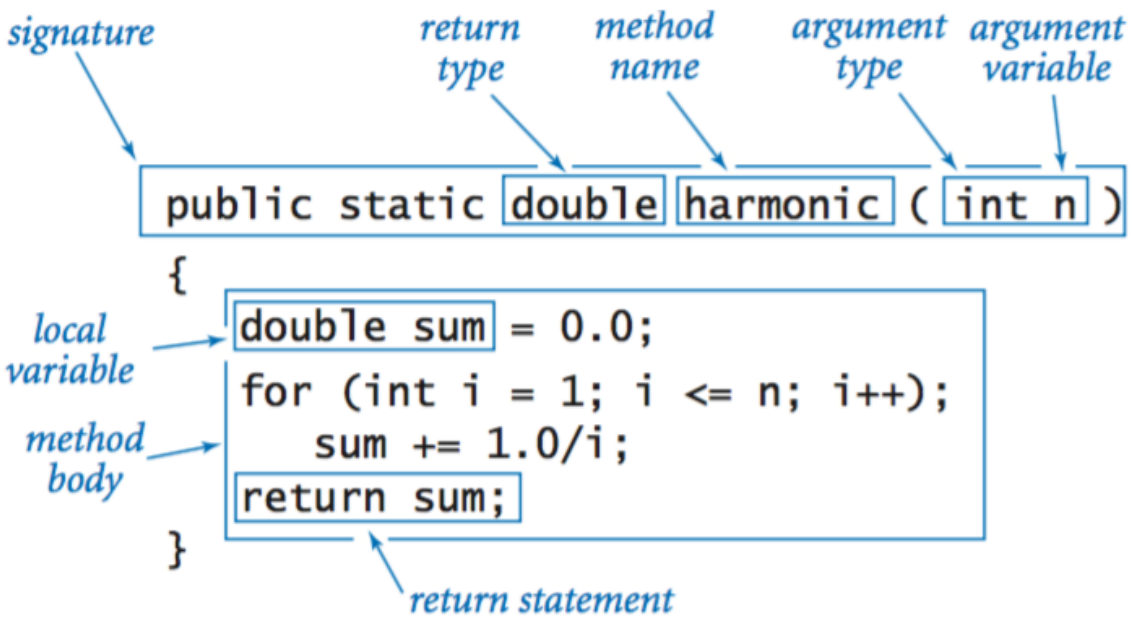



```
% java Average < data.txt
```


```
% java RandomSeq 1000 | java Average
```



Functions.


signature
return type
method name
argument type
argument variable
public static double harmonic (int n)
{
local variable
double sum = 0.0;
for (int i = 1; i <= n; i++);
method body
sum += 1.0/i;
return sum;
}
return statement

absolute value of an `int` value

```
public static int abs(int x)
{
   if (x < 0) return -x;
   else       return  x;
}
```

absolute value of a `double` value

```
public static double abs(double x)
{
   if (x < 0.0) return -x;
   else         return  x;
}
```

primality test

```
public static boolean isPrime(int n)
{
   if (n < 2) return false;
   for (int i = 2; i <= n/i; i++)
      if (n % i == 0) return false;
   return true;
}
```

hypotenuse of a right triangle

```
public static double hypotenuse(double a, double b)
{  return Math.sqrt(a*a + b*b);  }
```

harmonic number

```
public static double harmonic(int n)
{
   double sum = 0.0;
   for (int i = 1; i <= n; i++)
      sum += 1.0 / i;
   return sum;
}
```

uniform random integer in [0, n)

```
public static int uniform(int n)
{  return (int) (Math.random() * n);  }
```

draw a triangle

```
public static void drawTriangle(double x0, double y0,
                                double x1, double y1,
                                double x2, double y2 )
{
   StdDraw.line(x0, y0, x1, y1);
   StdDraw.line(x1, y1, x2, y2);
   StdDraw.line(x2, y2, x0, y0);
}
```

Libraries of functions.

client

```
Gaussian.pdf(x)

Gaussian.cdf(z)
```

calls library methods

API

```
public class Gaussian

   double pdf(double x)     φ(x)
   double cdf(double z)     Φ(z)
```

defines signatures and describes library methods

implementation

```
public class Gaussian
{  ...

   public static double pdf(double x)
   {  ...  }

   public static double cdf(double z)
   { ...  }

}
```

Java code that implements library methods

Our standard random library.

public class StdRandom	
void setSeed(long seed)	*set the seed for reproducible results*
int uniform(int n)	*integer between 0 and n-1*
double uniform(double lo, double hi)	*real between lo and hi*
boolean bernoulli(double p)	*true with probability p*
double gaussian()	*normal, mean 0, standard deviation 1*
double gaussian(double mu, double sigma)	*normal, mean mu, standard deviation sigma*
int discrete(double[] probabilities)	*i with probability probabilities[i]*
void shuffle(double[] a)	*randomly shuffle the array a[]*

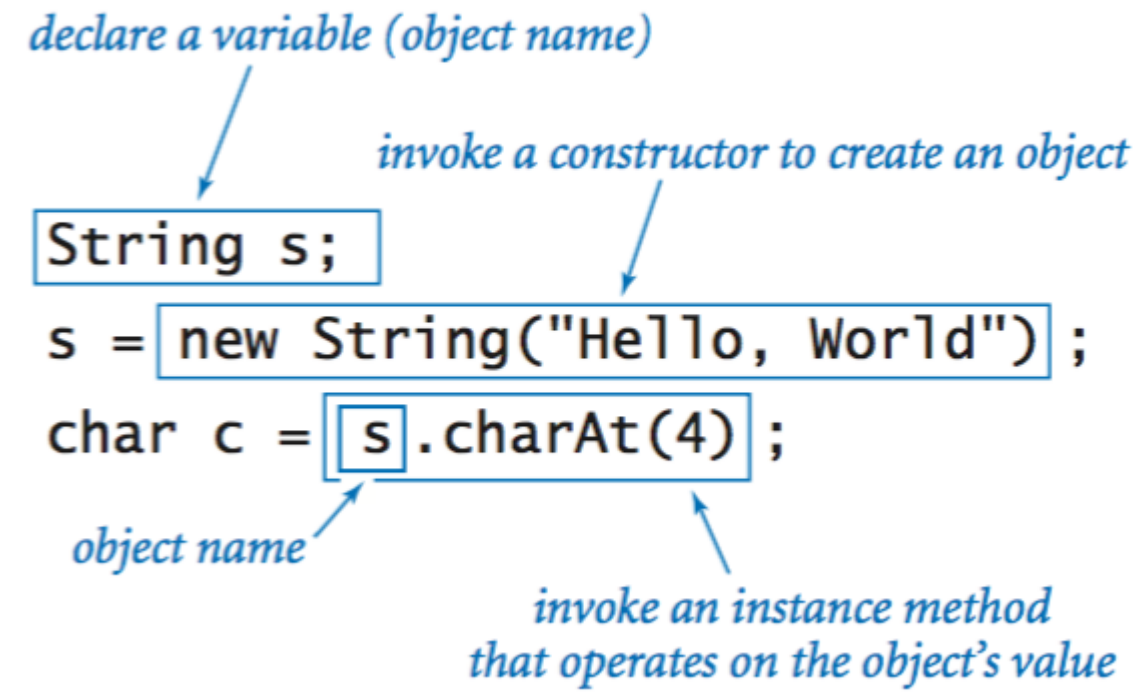
The full StdRandom API.

Our standard statistics library.

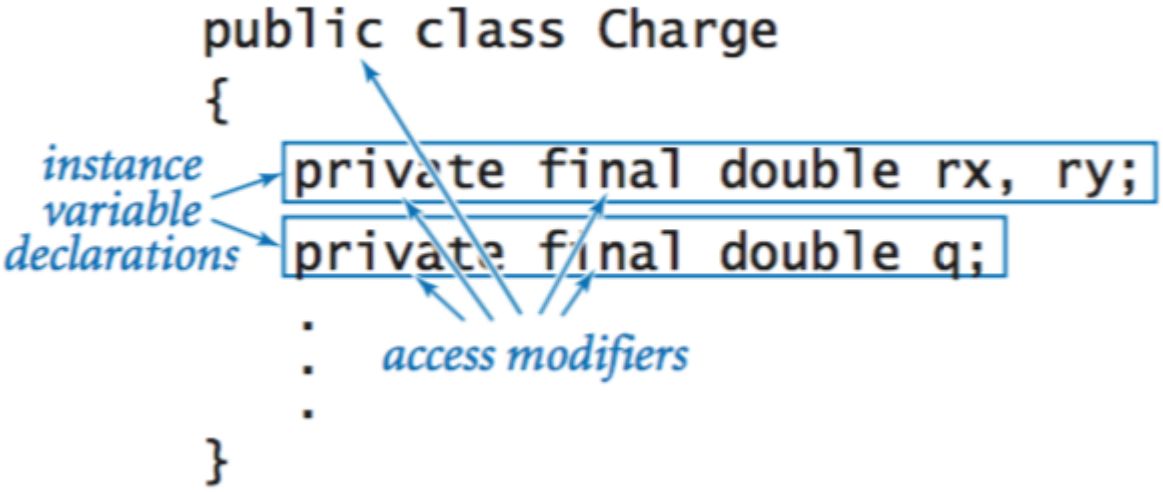
public class StdStats	
double max(double[] a)	*largest value*
double min(double[] a)	*smallest value*
double mean(double[] a)	*average*
double var(double[] a)	*sample variance*
double stddev(double[] a)	*sample standard deviation*
double median(double[] a)	*median*
void plotPoints(double[] a)	*plot points at (i, a[i])*
void plotLines(double[] a)	*plot lines connecting (i, a[i])*
void plotBars(double[] a)	*plot bars to points at (i, a[i])*

The full StdStats API.

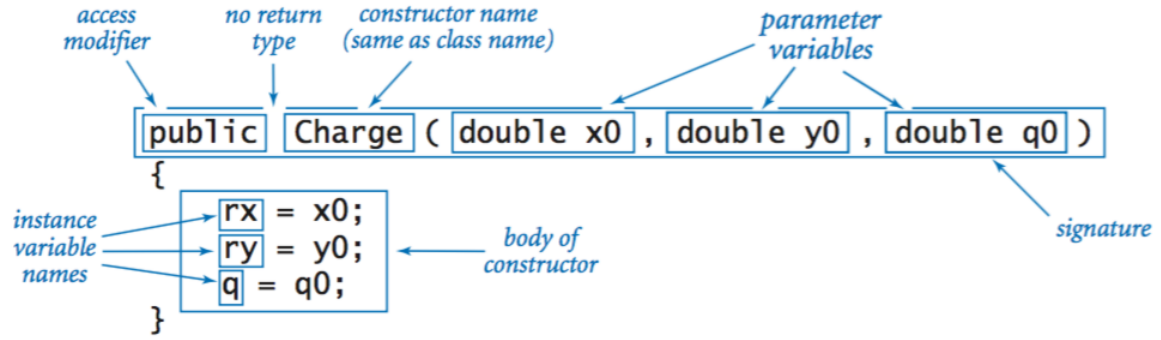
Using an object.



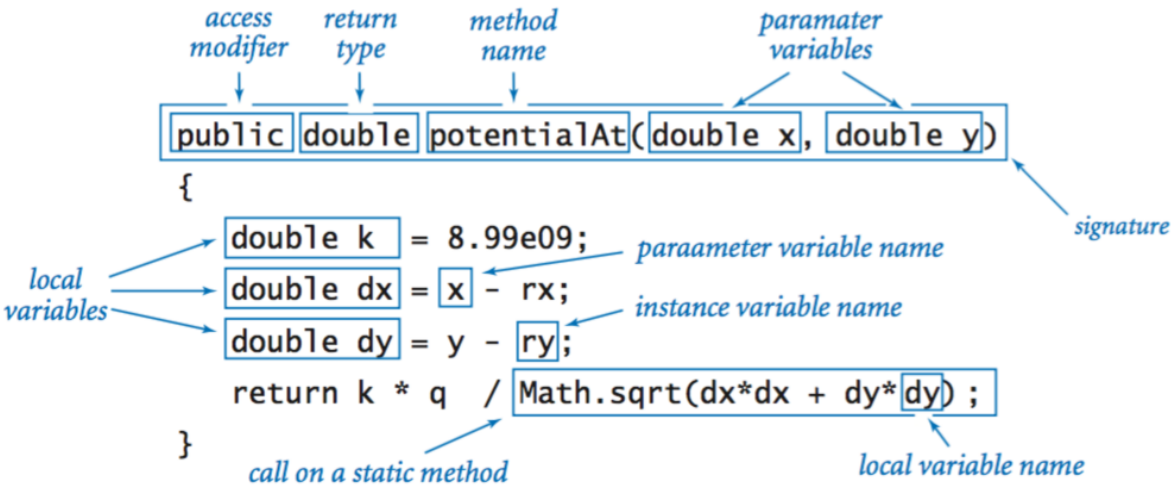
Instance variables.



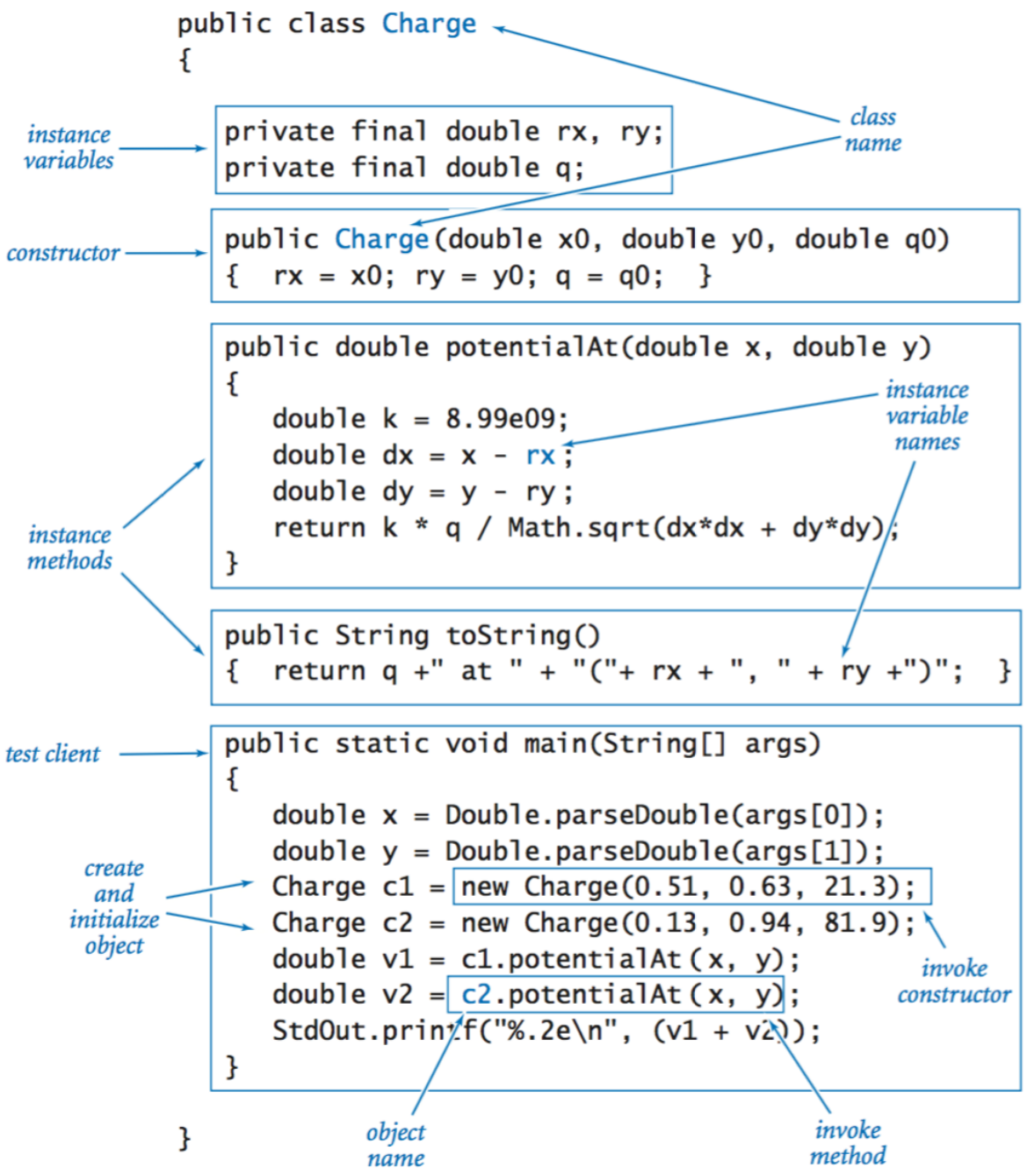
Constructors.



Instance methods.



Classes.



Object-oriented libraries.

client

```
Charge c1 = new Charge(0.51, 0.63, 21.3);

c1.potentialAt(x, y)
```

creates objects and invokes methods

API

```
public class Charge
-----------------------------------------------------------
        Charge(double x0, double y0, double q0)

double  potentialAt(double x, double y)   potential at (x, y) due to charge

String  toString()                        string representation
```

defines signatures and describes methods

implementation

```
public class Charge
{
   private final double rx, ry;
   private final double q;

   public Charge(double x0, double y0, double q0)
   {  ...  }

   public double potentialAt(double x, double y)
   {  ...  }

   public String toString()
   {  ...  }
}
```

defines instance variables and implements methods

Java's String data type.

public class String		
	String(String s)	*create a string with the same value as* `s`
	String(char[] a)	*create a string that represents the same sequence of characters as in* `a[]`
int	length()	*number of characters*
char	charAt(int i)	*the character at index* `i`
String	substring(int i, int j)	*characters at indices* `i` *through* `(j-1)`
boolean	contains(String substring)	*does this string contain* `substring`*?*
boolean	startsWith(String prefix)	*does this string start with* `prefix`*?*
boolean	endsWith(String postfix)	*does this string end with* `postfix`*?*
int	indexOf(String pattern)	*index of first occurrence of* `pattern`
int	indexOf(String pattern, int i)	*index of first occurrence of* `pattern` *after* `i`
String	concat(String t)	*this string, with* `t` *appended*
int	compareTo(String t)	*string comparison*
String	toLowerCase()	*this string, with lowercase letters*
String	toUpperCase()	*this string, with uppercase letters*
String	replace(String a, String b)	*this string, with* `a`*s replaced by* `b`*s*
String	trim()	*this string, with leading and trailing whitespace removed*
boolean	matches(String regexp)	*is this string matched by the regular expression?*
String[]	split(String delimiter)	*strings between occurrences of* `delimiter`
boolean	equals(Object t)	*is this string's value the same as* `t`*'s?*
int	hashCode()	*an integer hash code*

The full java.lang.String API.

```
String a = new String("now is");
String b = new String("the time");
String c = new String(" the");
```

instance method call	*return type*	*return value*
`a.length()`	`int`	`6`
`a.charAt(4)`	`char`	`'i'`
`a.substring(2, 5)`	`String`	`"w i"`
`b.startsWith("the")`	`boolean`	`true`
`a.indexOf("is")`	`int`	`4`
`a.concat(c)`	`String`	`"now is the"`
`b.replace("t", "T")`	`String`	`"The Time"`
`a.split(" ")`	`String[]`	`{ "now", "is" }`
`b.equals(c)`	`boolean`	`false`

Java's Color data type.

The full java.awt.Color API.

Our input library.

public class In	
In()	*create an input stream from standard input*
In(String name)	*create an input stream from a file or website*
instance methods that read individual tokens from the input stream	
boolean isEmpty()	*is standard input empty (or only whitespace)?*
int readInt()	*read a token, convert it to an `int`, and return it*
double readDouble()	*read a token, convert it to a `double`, and return it*
...	
instance methods that read characters from the input stream	
boolean hasNextChar()	*does standard input have any remaining characters?*
char readChar()	*read a character from standard input and return it*
instance methods that read lines from the input stream	
boolean hasNextLine()	*does standard input have a next line?*
String readLine()	*read the rest of the line and return it as a `String`*
instance methods that read the rest of the input stream	
int[] readAllInts()	*read all remaining tokens; return as array of integers*
double[] readAllDoubles()	*read all remaining tokens; return as array of doubles*
...	

The full In API.

Our output library.

public class Out	
Out()	*create an output stream to standard output*
Out(String name)	*create an output stream to a file*
void print(String s)	*print `s` to the output stream*
void println(String s)	*print `s` and a newline to the output stream*
void println()	*print a newline to the output stream*
void printf(String format, ...)	*print the arguments to the output stream, as specified by the format string `format`*

The full Out API.

Our picture library.

public class Picture	
Picture(String filename)	*create a picture from a file*
Picture(int w, int h)	*create a blank w-by-h picture*
int width()	*return the width of the picture*
int height()	*return the height of the picture*
Color get(int col, int row)	*return the color of pixel (col, row)*
void set(int col, int row, Color color)	*set the color of pixel (col, row) to color*
void show()	*display the picture in a window*
void save(String filename)	*save the picture to a file*

The full Picture API.

Our stack data type.

public class Stack<Item> implements Iterable<Item>	
Stack()	*create an empty stack*
boolean isEmpty()	*is the stack empty?*
void push(Item item)	*push an item onto the stack*
Item pop()	*return and remove the item that was inserted most recently*
int size()	*number of items on stack*

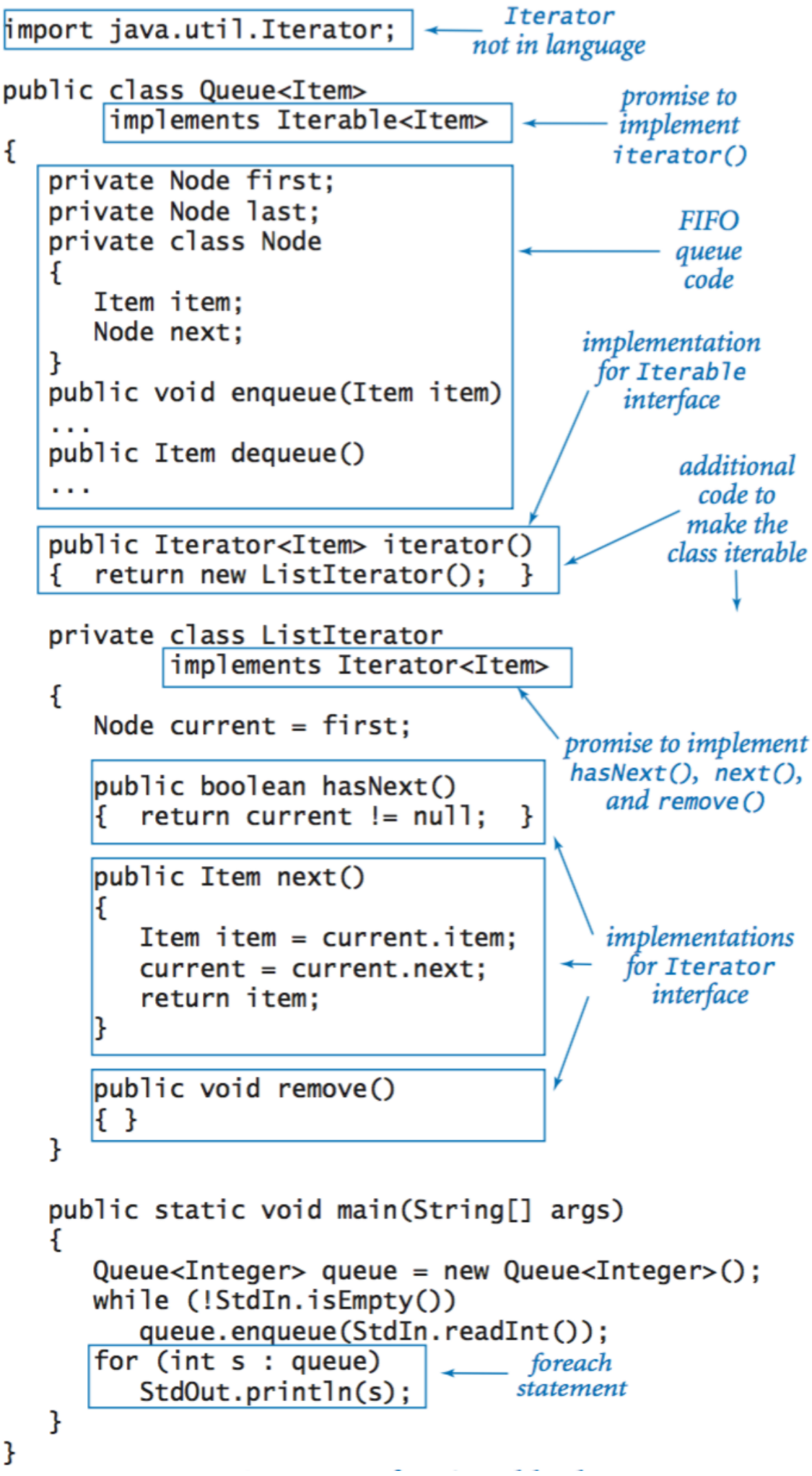
The full Stack API.

Our queue data type.

public class Queue<Item> implements Iterable<Item>	
Queue()	*create an empty queue*
boolean isEmpty()	*is the queue empty?*
void enqueue(Item item)	*insert an item onto queue*
Item dequeue()	*return and remove the item that was inserted least recently*
int size()	*number of items on queue*

The full Queue API.

Iterable.


import java.util.Iterator;
Iterator not in language
public class Queue<Item>
implements Iterable<Item>
promise to implement iterator()
{
private Node first;
private Node last;
private class Node
{
Item item;
Node next;
}
public void enqueue(Item item)
...
public Item dequeue()
...
FIFO queue code
implementation for Iterable interface
public Iterator<Item> iterator()
{ return new ListIterator(); }
additional code to make the class iterable
private class ListIterator
implements Iterator<Item>
{
Node current = first;
promise to implement hasNext(), next(), and remove()
public boolean hasNext()
{ return current != null; }
public Item next()
{
Item item = current.item;
current = current.next;
return item;
}
implementations for Iterator interface
public void remove()
{ }
}
public static void main(String[] args)
{
Queue<Integer> queue = new Queue<Integer>();
while (!StdIn.isEmpty())
queue.enqueue(StdIn.readInt());
for (int s : queue)
StdOut.println(s);
foreach statement
}
}

Our symbol table data type.

public class ST<Key extends Comparable<Key>, Value>		
	ST()	*create an empty symbol table*
void	put(Key key, Value val)	*associate* `val` *with* `key`
Value	get(Key key)	*value associated with* `key`
void	remove(Key key)	*remove* `key` *(and its associated value)*
boolean	contains(Key key)	*is there a value associated with* `key`*?*
int	size()	*number of key–value pairs*
Iterable<Key>	keys()	*all keys in the symbol table*

The full ST API.

Our set data type.

public class SET<Key extends Comparable<Key>> implements Iterable<Key>		
	SET()	*create an empty set*
boolean	isEmpty()	*is the set empty?*
void	add(Key key)	*add* `key` *to the set*
void	remove(Key key)	*remove* `key` *from set*
boolean	contains(Key key)	*is* `key` *in the set?*
int	size()	*number of elements in set*

The full SET API.

Our graph data type.

public class Graph		
	Graph()	*create an empty graph*
	Graph(String filename, String delimiter)	*create graph from a file*
void	addEdge(String v, String w)	*add edge* `v-w`
int	V()	*number of vertices*
int	E()	*number of edges*
Iterable<String>	vertices()	*vertices in the graph*
Iterable<String>	adjacentTo(String v)	*neighbors of* `v`
int	degree(String v)	*number of neighbors of* `v`
boolean	hasVertex(String v)	*is* `v` *a vertex in the graph?*
boolean	hasEdge(String v, String w)	*is* `v-w` *an edge in the graph?*