JAVA Programming Cheatsheet

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Java Programming Cheatsheet

Hello, World.

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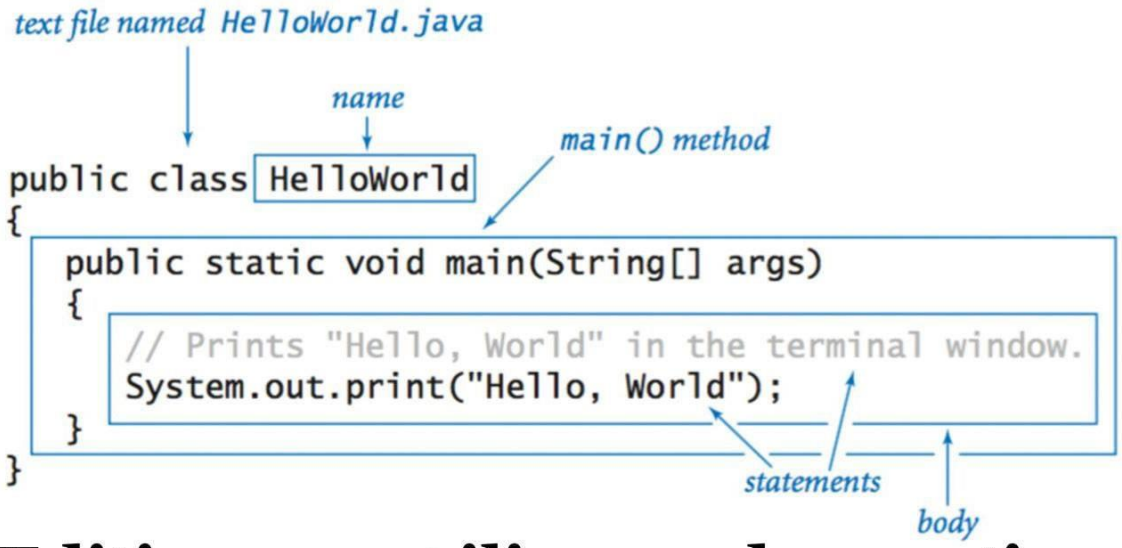
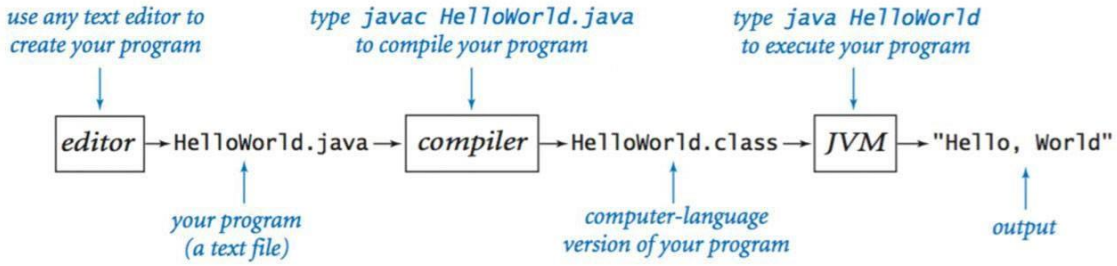


Editing, compiling, and executing.



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"`

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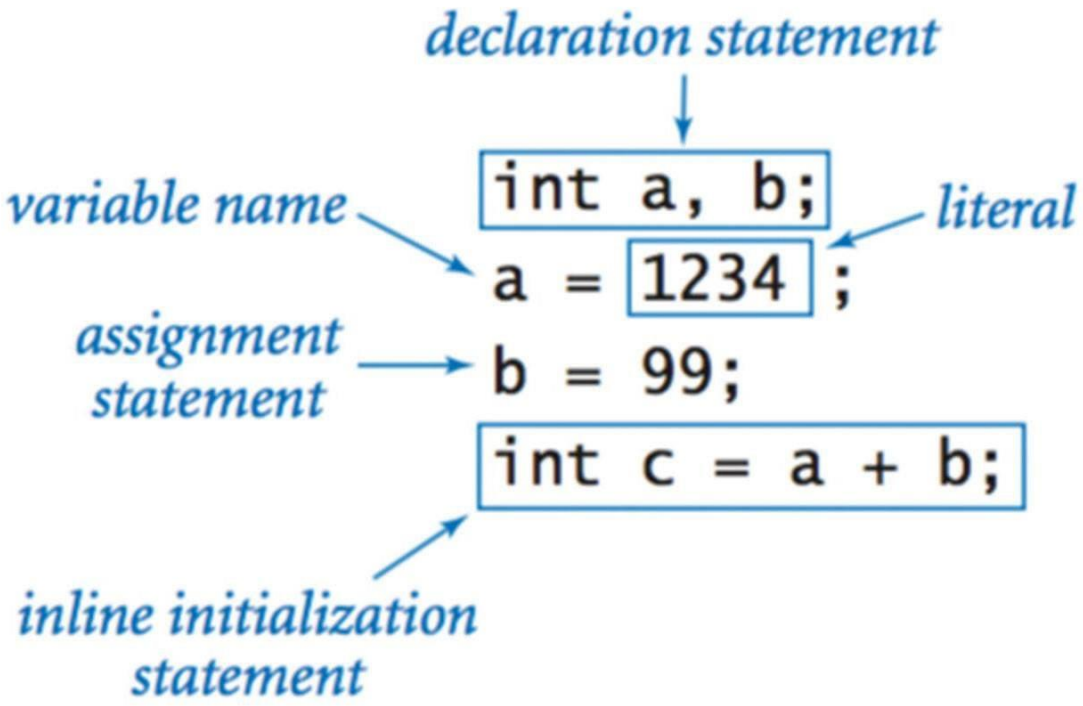
Declaration and assignment statements.



Integers.

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

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Integers.

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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*

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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`

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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`

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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)`

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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)*

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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

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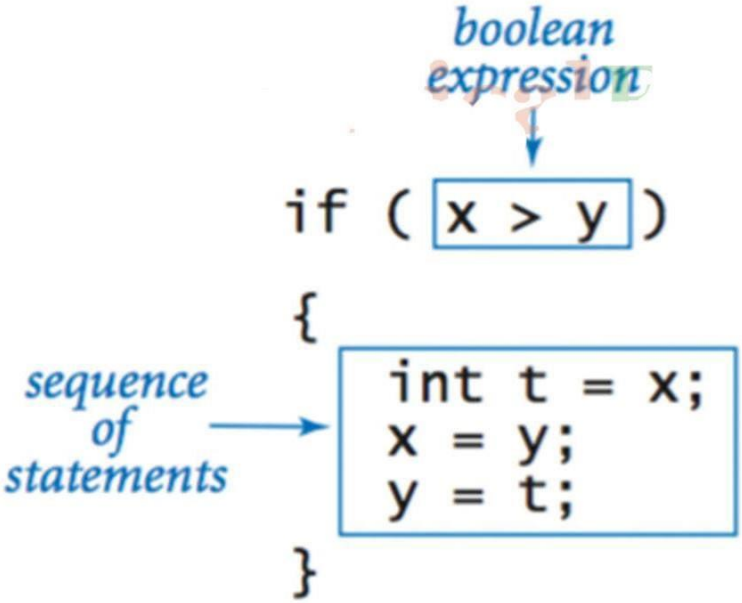
Anatomy of an if statement.



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);`
	`}`

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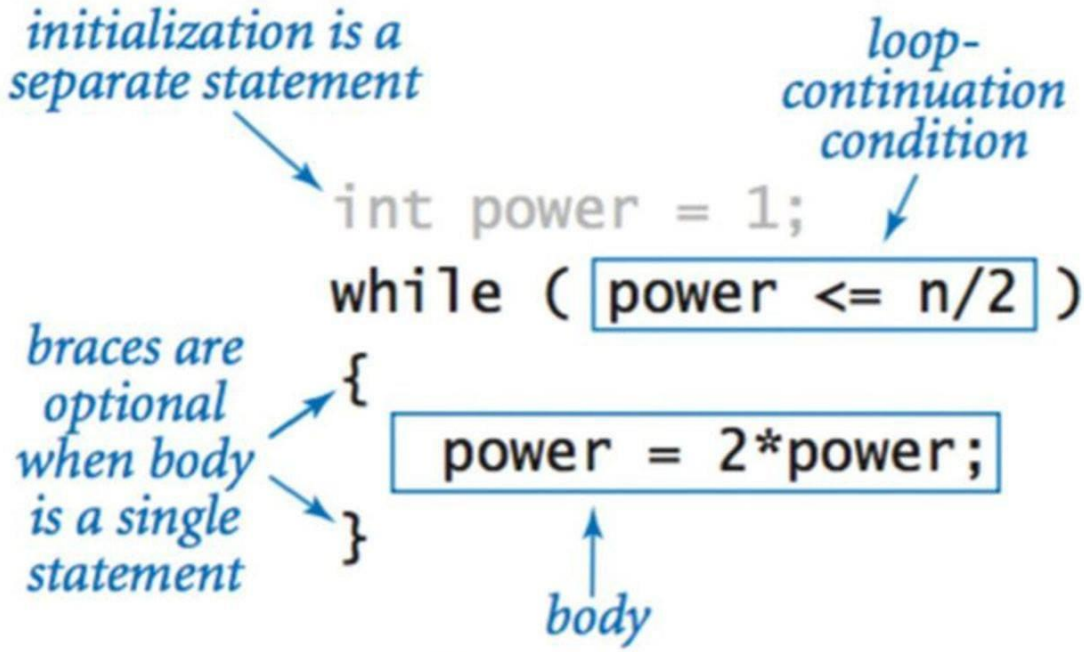
Nested if-else statement.

```
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.



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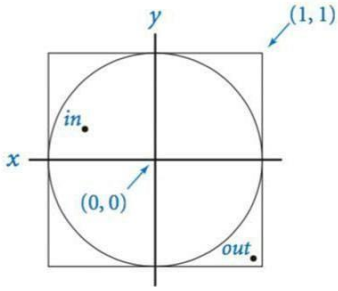
Break statement.

```
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;
}
```

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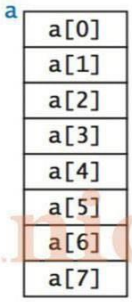
Arrays.



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];`

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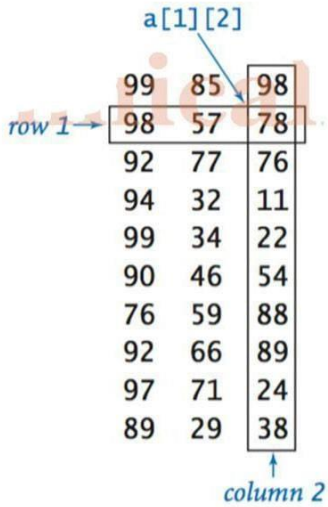
Two-dimensional arrays.



99	85	98
98	57	78
92	77	76
94	32	11
99	34	22
90	46	54
76	59	88
92	66	89
97	71	24
89	29	38

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 }
};
```

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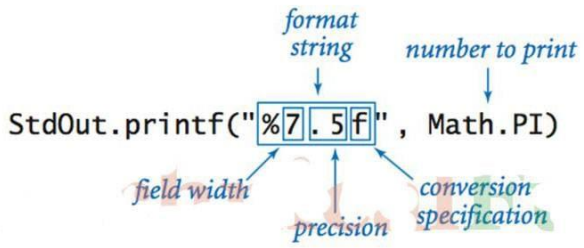
Our standard output library.

```
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.



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

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Our standard input library.

```
public class StdIn
```

methods for reading individual tokens from standard input		
`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*
`boolean`	`readBoolean()`	*read a token, convert it to a `boolean`, and return it*
`String`	`readString()`	*read a token and return it as a `String`*
methods for reading characters from standard input		
`boolean`	`hasNextChar()`	*does standard input have any remaining characters?*
`char`	`readChar()`	*read a character from standard input and return it*
methods for reading lines from standard input		
`boolean`	`hasNextLine()`	*does standard input have a next line?*
`String`	`readLine()`	*read the rest of the line and return it as a `String`*
methods for reading the rest of standard input		
`int[]`	`readAllInts()`	*read all remaining tokens and return them as an `int` array*
`double[]`	`readAllDoubles()`	*read all remaining tokens and return them as a `double` array*
`boolean[]`	`readAllBooleans()`	*read all remaining tokens and return them as a `boolean` array*
`String[]`	`readAllStrings()`	*read all remaining tokens and return them as a `String` array*
`String[]`	`readAllLines()`	*read all remaining lines and return them as a `String` array*
`String`	`readAll()`	*read the rest of the input and return it as a `String`*

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Our standard drawing library.

```
public class StdDraw
```

drawing commands

```
void line(double x0, double y0, double x1, double y1)
void point(double x, double y)
void circle(double x, double y, double radius)
void filledCircle(double x, double y, double radius)
void square(double x, double y, double radius)
void filledSquare(double x, double y, double radius)
void rectangle(double x, double y, double r1, double r2)
void filledRectangle(double x, double y, double r1, double r2)
void polygon(double[] x, double[] y)
void filledPolygon(double[] x, double[] y)
void text(double x, double y, String s)
```

control commands

`void setXscale(double x0, double x1)`	*reset x-scale to (x0, x1)*
`void setYscale(double y0, double y1)`	*reset y-scale to (y0, y1)*
`void setPenRadius(double radius)`	*set pen radius to radius*
`void setPenColor(Color color)`	*set pen color to color*
`void setFont(Font font)`	*set text font to font*
`void setCanvasSize(int w, int h)`	*set canvas size to w-by-h*
`void enableDoubleBuffering()`	*enable double buffering*
`void disableDoubleBuffering()`	*disable double buffering*
`void show()`	*copy the offscreen canvas to the onscreen canvas*
`void clear(Color color)`	*clear the canvas to color color*
`void pause(int dt)`	*pause dt milliseconds*
`void save(String filename)`	*save to a .jpg or .png file*

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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*

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

command line

command-line argument

```
% java AddInts 4
```

```
144
233
377
1024
```

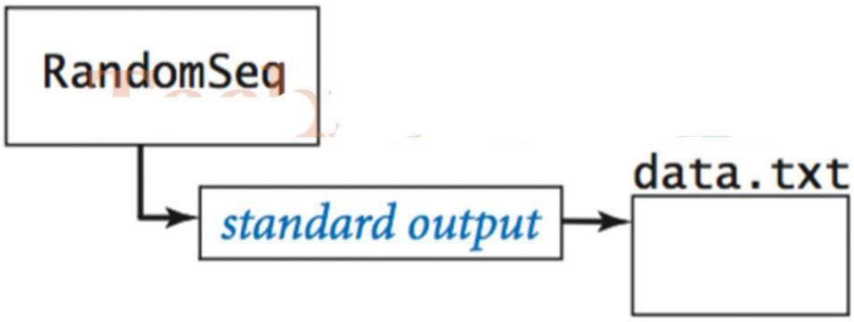
standard input stream

```
Sum is 1778
```

standard output stream

Redirection and piping.

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



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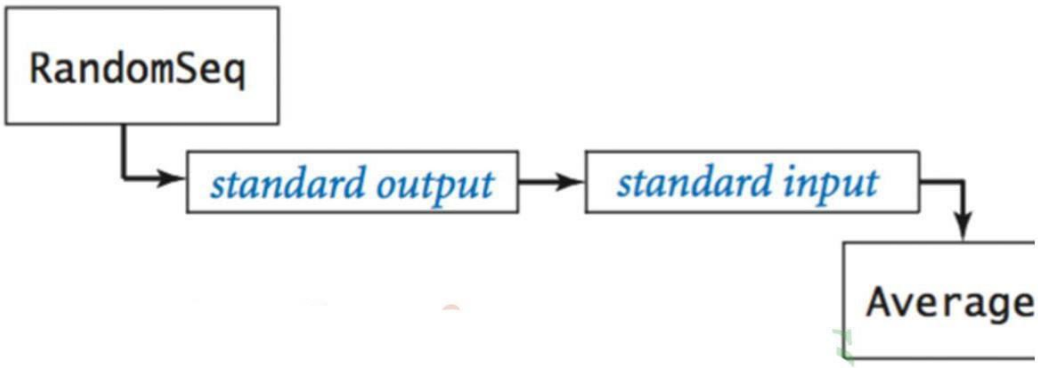
Redirection and piping.

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

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



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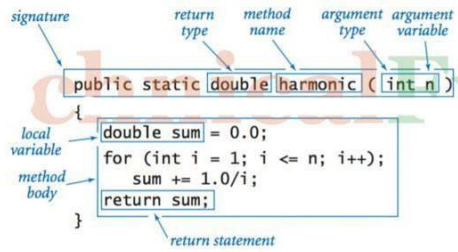
Functions.



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);`
	`}`

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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

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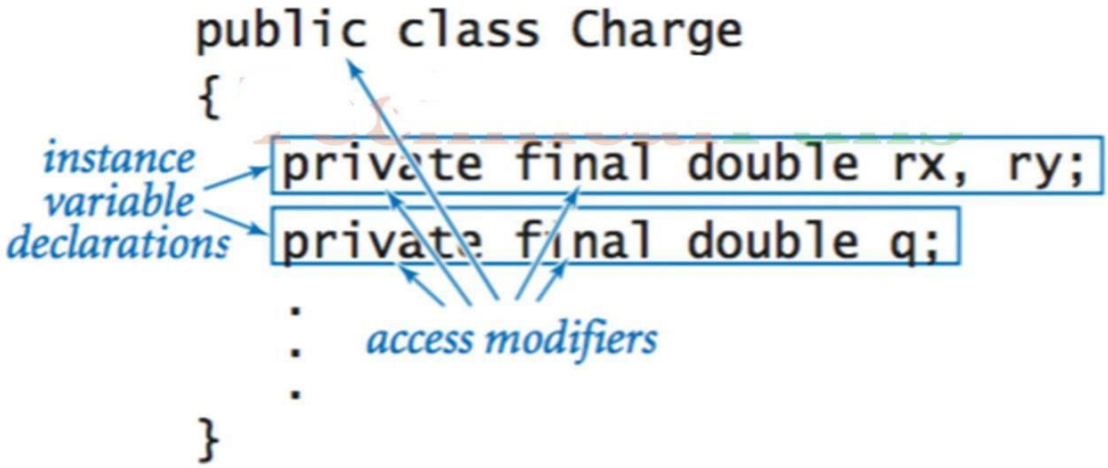
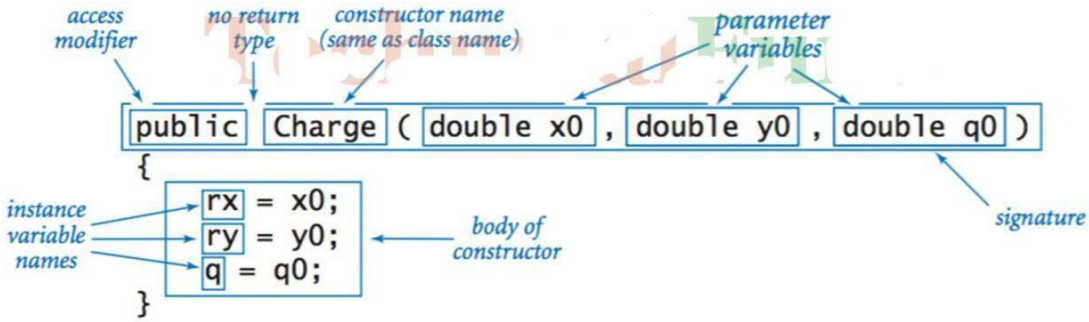
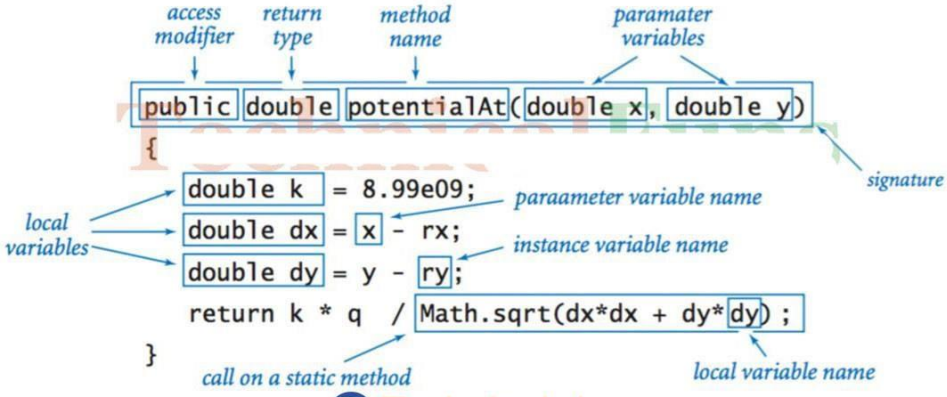
Instance variables.



Constructors.



Instance methods.



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Java Programming Cheatsheet

Classes.

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

   public Charge(double x0, double y0, double q0)
   {  rx = x0; ry = y0; q = q0;  }

   public double potentialAt(double x, double y)
   {
      double k = 8.99e09;
      double dx = x - rx;
      double dy = y - ry;
      return k * q / Math.sqrt(dx*dx + dy*dy);
   }

   public String toString()
   {  return q +" at " + "("+ rx + ", " + ry +")";  }

   public static void main(String[] args)
   {
      double x = Double.parseDouble(args[0]);
      double y = Double.parseDouble(args[1]);
      Charge c1 = new Charge(0.51, 0.63, 21.3);
      Charge c2 = new Charge(0.13, 0.94, 81.9);
      double v1 = c1.potentialAt(x, y);
      double v2 = c2.potentialAt(x, y);
      StdOut.printf("%.2e\n", (v1 + v2));
   }

}
```

class name

instance variables

constructor

instance variable names

instance methods

test client

create and initialize object

invoke constructor

object name

invoke method

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Java Programming Cheatsheet

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

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Java Programming Cheatsheet

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*

```
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 Tim"
a.split(" ")	String[]	{ "now", "is" }
b.equals(c)	boolean	false

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Java Programming Cheatsheet

Java's Color data type.

```
public class java.awt.Color
```

	`Color(int r, int g, int b)`	
`int`	`getRed()`	*red intensity*
`int`	`getGreen()`	*green intensity*
`int`	`getBlue()`	*blue intensity*
`Color`	`brighter()`	*brighter version of this color*
`Color`	`darker()`	*darker version of this color*
`String`	`toString()`	*string representation of this color*
`String`	`equals(Object c)`	*is this color's value the same as* `c` *?*

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*
	`...`	

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Java Programming Cheatsheet

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`*

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*

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*

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Java Programming Cheatsheet

Iterable.

```
import java.util.Iterator;

public class Queue<Item>
      implements Iterable<Item>
{
   private Node first;
   private Node last;
   private class Node
   {
      Item item;
      Node next;
   }
   public void enqueue(Item item)
   ...
   public Item dequeue()
   ...

   public Iterator<Item> iterator()
   {  return new ListIterator();  }

   private class ListIterator
         implements Iterator<Item>
   {
      Node current = first;

      public boolean hasNext()
      {  return current != null;  }

      public Item next()
      {
         Item item = current.item;
         current = current.next;
         return item;
      }

      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);
   }
}
```

Iterator not in language

promise to implement iterator()

FIFO queue code

implementation for Iterable interface

additional code to make the class iterable

promise to implement hasNext(), next(), and remove()

implementations for Iterator interface

foreach statement

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Java Programming Cheatsheet

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*

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*

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*

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Java Programming Cheatsheet

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?*

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