Lecture 5

Methods

Intermezzo

- loops and unlimited number of variables are enough to express every conceivable calculation
- how to program if with while?

```
if (b) { S1 } else { S2 }
```

Solution

Solution

```
boolean c = b;

while ( c ) {
  S1
  c = !c;
}

while ( c ) {
  S2
  c = !c;
}
```

Lecture 3

Methods

Control structuring - methods

- A method is a sequence of statements with a name
- Calling (aka invoking) the name leads to execution of the sequence of statements
- After execution, control returns to the place after the call

Defining and using a method

Define a class

define the name of the method

define the body

call the method again and again

```
class Publiek {

   void scheld() {

      System.out.println("Hij is een hondelul");

   }

   void spreekkoor() {
      scheld();
      scheld();
      scheld();
   }

   public static void main(String..
      new Publiek().spreekkoor();
   }
}
```

output

```
Hij is een hondelul
Hij is een hondelul
Hij is een hondelul
```

method – syntax

1. definition (declaration):

```
void <name> () {
        <statements>                    "method body"
}
```

2. use (call):

```
<name>();
```

- "void" is only used at the definition
- will be explained later

Why use methods?

- saves time with recurring tasks
- makes your program more readable
- gives a better organization of your program:
  - subdivision of larger tasks
  - group tasks that belong together
- makes your program more flexible and reusable

Recurring tasks

Recurring tasks

```
class Emoticon {
   void smile() {
     System.out.println( ":-)" );
   }

   void sad() {
     System.out.println( ":-(" );
   }

   void angry() {
     System.out.println( ">:-|" );
   }

   void message() {
      System.out.println("Hi, Plien");
      smile();
      System.out.println("Gisteren zag ik Annechien");
      angry();
      angry();
      angry();
   }
}
```

Recurring tasks

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Output:

Recurring tasks

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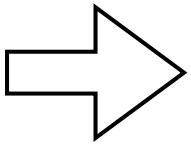
}
```



Output:

Recurring tasks

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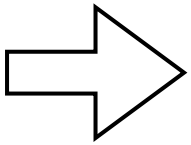

Output:

```
Hi, Plien
```

Recurring tasks

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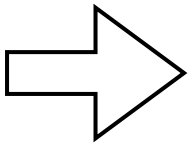
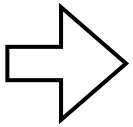


Output:

```
Hi, Plien
```

Recurring tasks



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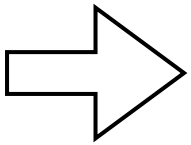
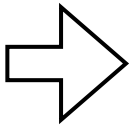


Output:

```
Hi, Plien
```

Recurring tasks



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}
```

Output:

```
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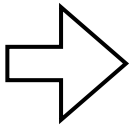
```

Recurring tasks



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Output:

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Recurring tasks

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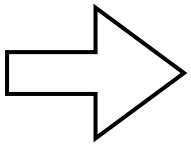

Output:

```
Hi, Plien
:-)
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Recurring tasks

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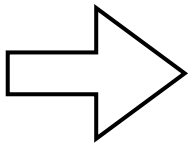

Output:

```
Hi, Plien
:-)
```

Recurring tasks

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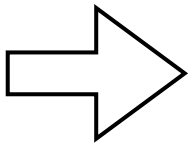

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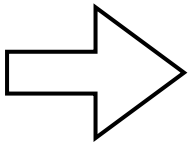

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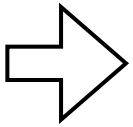

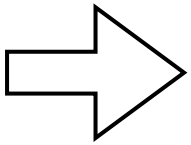

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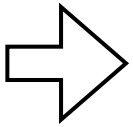

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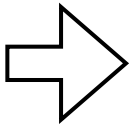

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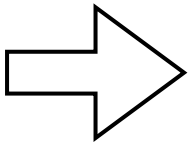

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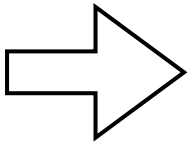

Output:

```
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:-)
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>:-|
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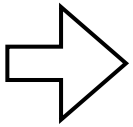

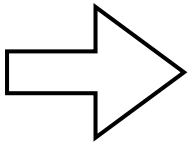

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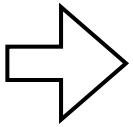

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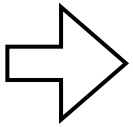

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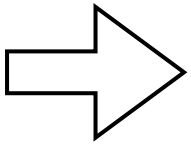

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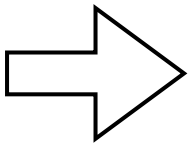
}
```



Output:

```
Hi, Plien
:-)
Gisteren zag ik Annechien
>:-|
>:-|
```

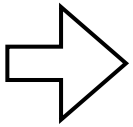
Recurring tasks

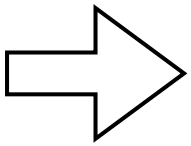
```
class Emoticon {
   void smile() {
     System.out.println( ":-)" );
   }

   void sad() {
     System.out.println( ":-(" );
   }

   void angry() {
     System.out.println( ">:-|" );
   }

   void message() {
      System.out.println("Hi, Plien");
      smile();
      System.out.println("Gisteren zag ik Annechien");
      angry();
      angry();
      angry();
   }
}
```





Output:

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:-)
Gisteren zag ik Annechien
>:-|
>:-|
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     System.out.println( ":-(" );
   }

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     System.out.println( ">:-|" );
   }

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      System.out.println("Hi, Plien");
      smile();
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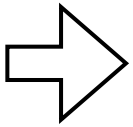
      angry();
      angry();
      angry();
   }
}
```



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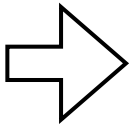

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>:-|
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Recurring tasks

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      angry();
      angry();
      angry();
   }
}
```

Output:

```
Hi, Plien
:-)
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>:-|
>:-|
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```

Recurring tasks

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   void smile() {
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   }

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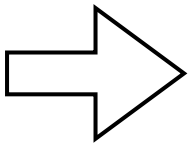

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Recurring tasks

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   void smile() {
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      angry();
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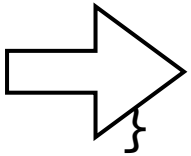
```



Output:

```
Hi, Plien
:-)
Gisteren zag ik Annechien
>:-|
>:-|
>:-|
```

Recurring tasks

```
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   void smile() {
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      angry();
      angry();
      angry();
   }
}
```

Output:

```
Hi, Plien
:-)
Gisteren zag ik Annechien
>:-|
>:-|
>:-|
```

Reusability: parameters

```
class Emoticon {
   void smile() {
     System.out.println( ":-)" );
   }

   void angry(int n) {
     for (int i=0; i<n; i++) {
        System.out.println( ">:-|" );
     }
   }



   void demoticon {
      System.out.println("Hi, Plien");
      smile();
      System.out.println("Gisteren zag ik Annechien");
      angry(3);
   }
}
```

Reusability: parameters

```
class Emoticon {
   void smile() {
     System.out.println( ":-)" );
   }

   void angry(int n) {
     for (int i=0; i<n; i++) {
        System.out.println( ">:-|" );
     }
   }



   void demoticon {
      System.out.println("Hi, Plien");
      smile();
      System.out.println("Gisteren zag ik Annechien");
      angry(3);
   }
}
```

Output:

```
Hi, Plien
:-)
Gisteren zag ik Annech
>:-|
>:-|
>:-|
```

Reusability: parameters

```
class Blah {
   void angry( int n ) {

     for (int i=0; i<n; i++) {
        System.out.println( ">:-|" );
     }
   }


  void happy( int hl ) {
      System.out.println("Happiness level "+hl);
  }

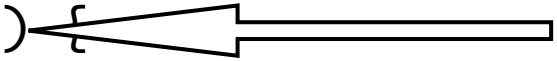




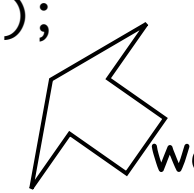




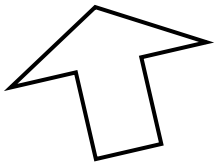
}
```



parameter declaration works as a variable in the body



working area (scope) of n



scope of hl

Reusability: parameters

```
class Blah {
   void angry( int n ) {

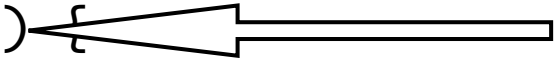
     for (int i=0; i<n; i++) {
        System.out.println( ">:-|" );
     }
   }


  void happy( int hl ) {
      System.out.println("Happiness level "+hl);
  }




   void printSquare( int n ) {
     System.out.println( n*n );
   }

}
```



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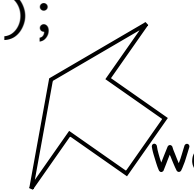

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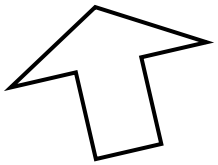
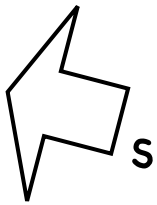


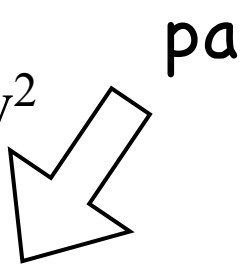
scope of hl



scope of another n

special methods - functions

- known from mathematics: square root, formulas, functions
- math: $\text{squareIt}(w) = w^2$




```
class Example {
   double squareIt(double w) {
      return w*w;
   }
}
```

- examples of use:

```
a = squareIt(10);

b = squareIt(5) + squareIt(q/2);

System.out.println("kwadraat: "+squareIt(x));
```

special methods - functions

- known from mathematics: square root, formulas, functions
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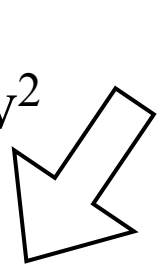


```
class Example {
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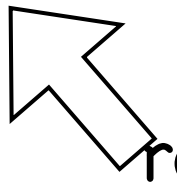
}
```



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System.out.println("kwadraat: "+squareIt(x));
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special methods - functions

- known from mathematics: square root, formulas, functions
- math: $\text{squareIt}(w) = w^2$

parameter

```
class Example {
   double squareIt(double w) {
      return w*w;
   }
}
```

return type

return value

- examples of use:

```
a = squareIt(10);

b = squareIt(5) + squareIt(q/2);

System.out.println("kwadraat: "+squareIt(x));
```

Local variables

- a variable that is only relevant for a single method execution can be declared inside the method body:

```
void elections() {
     String answer;
     System.out.println("Who won?");
     answer = Scanner.next();
     if (answer.equals("AZ") {
        System.out.println("pheww");
     }
  }
```

- variable answer is only needed for elections
- answer is not available outside elections
- value is discarded when call to elections terminates (returns)

Variables

```
class Blah {
   String madsmile ;

   void angry( int n ) {
     for (int i = 0; i<n; i++) {
        System.out.println( madsmile );
     }
   }

   void doIt() {
      madsmile = ">:-|";
      angry( 3 );
   }
```

Variables

```
class Blah {
   String madsmile;

   void angry( int n ) {
     for (int i = 0; i<n; i++) {
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Variables

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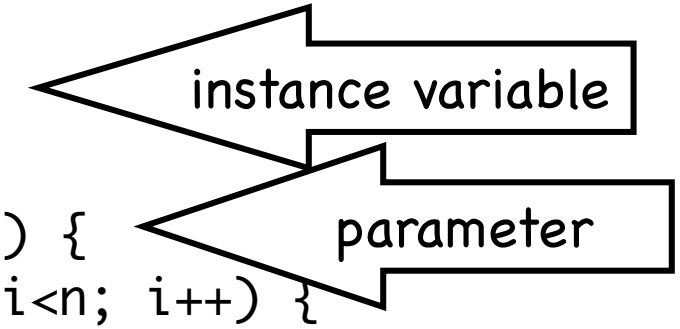
```



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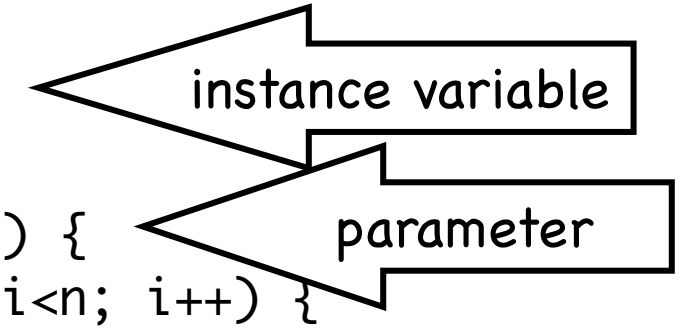

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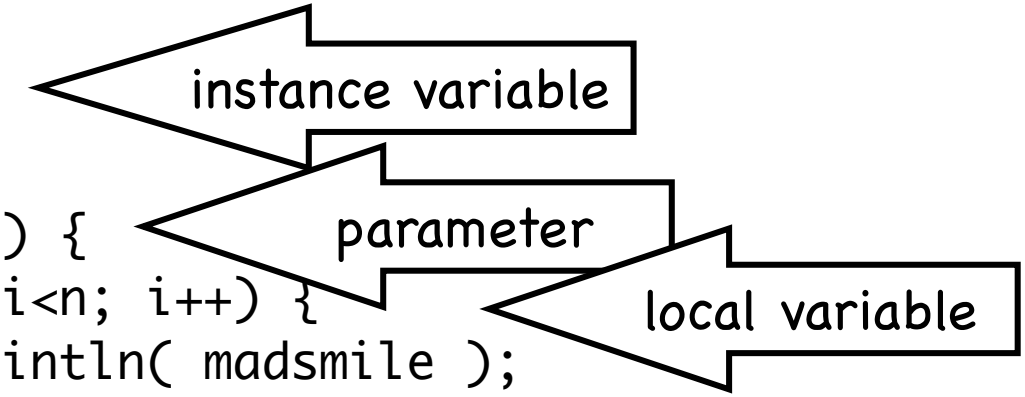
   }
```



three kinds of variables

- instance variable:
  - scope is all methods in class
  - automatic initialization with 0 or false (booleans)
- parameter:
  - scope is one method only
  - initialization by call
- local variable:
  - scope is one method or less
  - initialization required

What does the box do?

```
class Printer {
  void hek(int n) {
    String s = "";
    for (int i=0; i<n; i++) {
      s = s+"#";
    }
    System.out.println(s);
  }

  void box() {
    hek(1);
    hek(2);
    hek(3);
    hek(4);
  }

  public static void main(String[] a) {  new Printer().box(); }
}
```

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```

```
#
##
###
####
```

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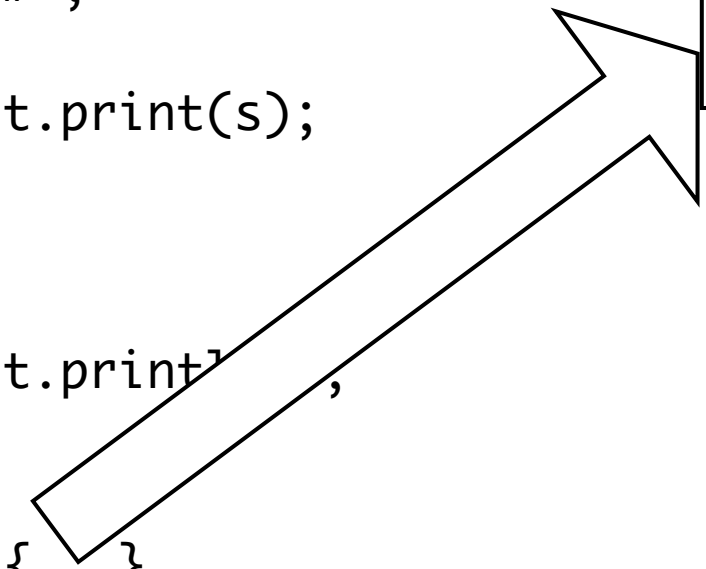
class Printer {
  void hek(int n) {
    String s = "";
    for (int i=0; i<n; i++) {
      s = s+"#";
    }
    System.out.print(s);
  }

  void nl() {
    System.out.print("\n");
  }

  void box() {   }
}
```

```
hek(8); nl();
hek(2); nl();
hek(6); nl();
hek(2); nl();
hek(2); nl();
hek(2); nl();
```



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```
class Printer {
  void hek(int n) {
    String s = "";
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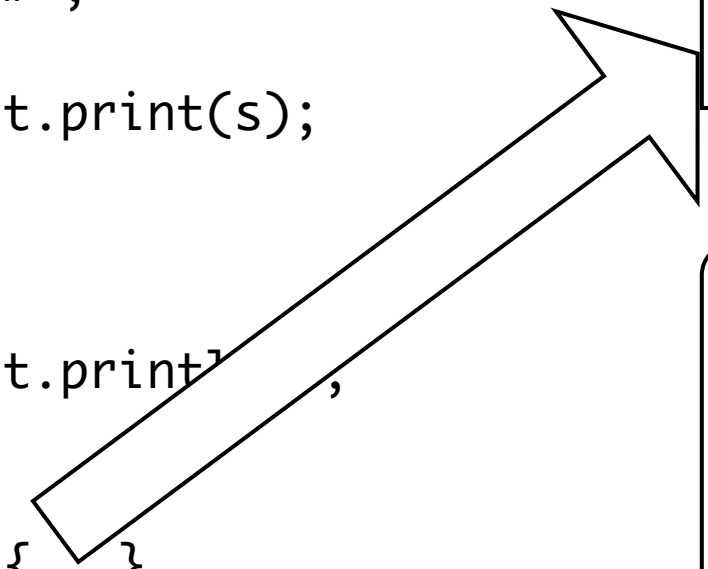
      s = s+"#";
    }
    System.out.print(s);
  }

  void nl() {
    System.out.println();
  }

  void box() {   }
}
```



```
hek(8); nl();
hek(2); nl();
hek(6); nl();
hek(2); nl();
hek(2); nl();
hek(2); nl();
```

```
########
##
######
##
##
##
```

What does the box do?

```
class Printer {
  void hek(int n) {
    String s = "";
    for (int i=0; i<n; i++) {
      s = s+"#";
    }
    System.out.print(s);
  }

  void nl() {
    System.out.print("\n");
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  void box() {   }
}
```

```
hek(8); nl();
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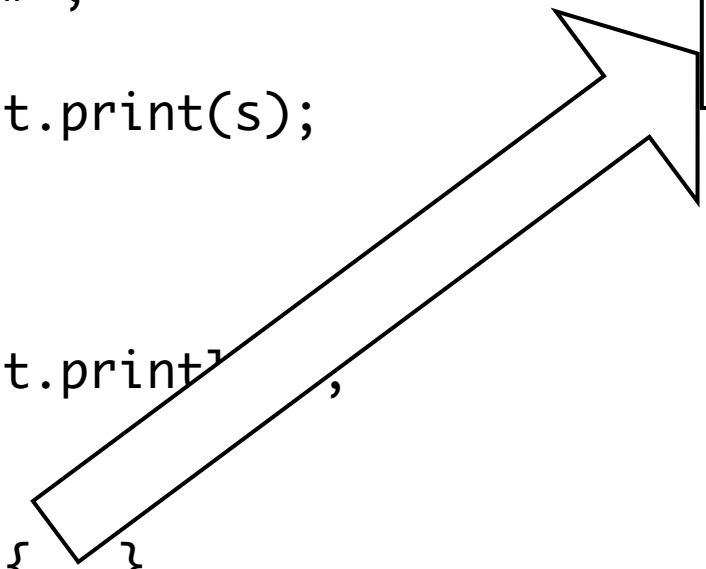

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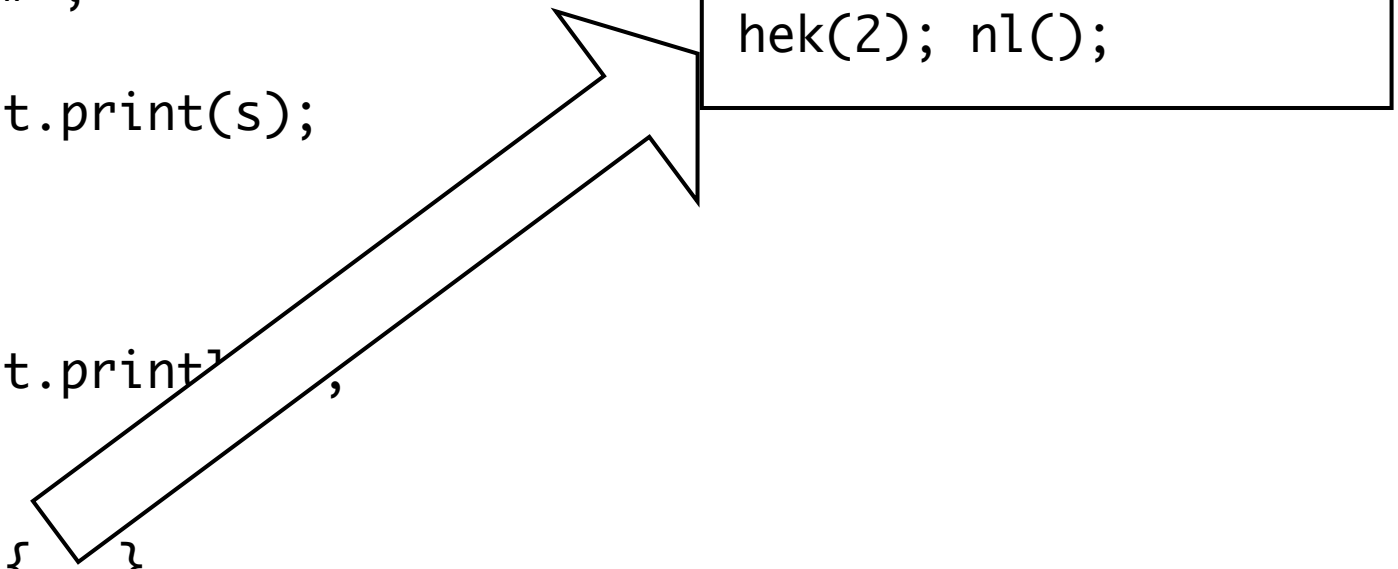
      s = s+"#";
    }
    System.out.print(s);
  }

  void nl() {
    System.out.println();
  }

  void box() {   }
}
```



Method types

I. simple

```
void <name>() {
  <body>
}
```

II. parameters

```
void <name>(<type> <var>,..., <type> <var>) {
  <body>
}
```

III. return

```
<type> <name>() {
  <body>
  return <val>;
}
```

IV. combination of II and III

Method examples

I. simple

```
void hello() {
  System.out.println("Hellooooo!");
}
```

II. parameters

```
void repeat(String s, int n) {
  for (int i=0;i<n;i++){ System.out.println(s); }
}
```

III. return

```
double pi() {
  return 3.14159265359;
}
```

IV. combination of II and III

```
int max (int a, int b) {
  if (a>b){return a;}else{return b;}
}
```

Scope

- scope is the working area of a variable or parameter
- it begins at the declaration and ends at the closing brace
- outside its scope, a variable cannot be referred to
- Example:

```
class Zuip {
  void drunk() {
     if (n > 10) {    // error!
        ...
     ;
  }

  void drink(int n) { ...}
  }
```

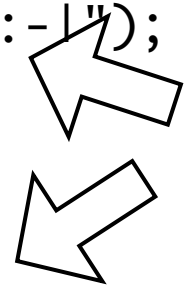
- scope of an instance variable is the whole class
(except the static methods)

Scope 2a

- many variables and parameters with the same name may occur in different parts of your program, without conflict

- Example:

```
void angry(int n) {
  for (int i=0; i<n; i++) {
    System.out.println(">:-|");
  }
}
...
void halve(int n) {
  double i = n/2.0;
  System.out.println("helft is "+i);
}
```



different variables i

Scope 2b

- many variables and parameters with the same name may occur, without conflict

- Example:

```
void angry(int n) {
  for (int i=0; i<n; i++) {
    System.out.println(">:-|");
  }
}
...
void halve(int n) {
  double i = n/2.0;
  System.out.println("helft is "+i);
}
```

different variables n

Scope 3

```
class ScopeExample {
     int n;

     void blah( int p ) {
        System.out.println( p );
        int q = 5;
        n = q * p;
        // etc.
     }

     void rhubarb( ) {
        int n = 2;

        System.out.println( n + n );
        // etc.
     }

     void plauder() {
        System.out.println( n*n );
     }
}
```

Scope 3

```
class ScopeExample {
    int n;

    void blah( int p ) {
       System.out.println( p );
       int q = 5;
       n = q * p;
       // etc.
    }

    void rhubarb( ) {
       int n = 2;

       System.out.println( n + n );
       // etc.
    }

    void plauder() {
       System.out.println( n*n );
    }
}
```

n

Scope 3

```
class ScopeExample {
    int n;

    void blah( int p ) {
        System.out.println( p );
        int q = 5;
        n = q * p;
        // etc.
    }

    void rhubarb( ) {
        int n = 2;

        System.out.println( n + n );
        // etc.
    }

    void plauder() {
        System.out.println( n*n );
    }
}
```

n

p

Scope 3

```
class ScopeExample {
    int n;

    void blah( int p ) {
        System.out.println( p );
        int q = 5;
        n = q * p;
        // etc.
    }

    void rhubarb( ) {
        int n = 2;

        System.out.println( n + n );
        // etc.
    }

    void plauder() {
        System.out.println( n*n );
    }
}
```

n

p

q

Scope 3

```
class ScopeExample {
    int n;

    void blah( int p ) {
        System.out.println( p );
        int q = 5;
        n = q * p;
        // etc.
    }

    void rhubarb( ) {
        int n = 2;

        System.out.println( n + n );
        // etc.
    }

    void plauder() {
        System.out.println( n*n );
    }
}
```

n

p

q

Scope 3

```
class ScopeExample {
    int n;

    void blah( int p ) {
        System.out.println( p );
        int q = 5;
        n = q * p;
        // etc.
    }

    void rhubarb( ) {
        int n = 2;

        System.out.println( n + n );
        // etc.
    }

    void plauder() {
        System.out.println( n*n );
    }
}
```

n

p

q

n

Scope 3

```
class ScopeExample {
    int n;

    void blah( int p ) {
        System.out.println( p );
        int q = 5;
        n = q * p;
        // etc.
    }

    void rhubarb( ) {
        String n = “twee”;

        System.out.println( n + n );
        // etc.
    }

    void plauder() {
        System.out.println( n*n );
    }
}
```

n

p

q

n

Notes

- changes in local variables are lost as soon as method returns
- use instance variables for "permanent" changes
- do not change parameters

More notes

- group code that belongs together in method
- break long methods up (> ±15 lines)
- try to find methods with simple interface:
  - few and clear parameters
  - few and clear uses/changes of instance variables

Specifications

- // @pre: what has to hold before the call
- // @returns: description of return value
- // @post: what holds after the call
- // @modifies: what is changed by the method

Specification example 1

```
//@pre: x >= 0

//@returns: √x

double squareroot( double x ) {

   ...

}
```

Specification example 2

```
//@pre: n >= 0 & input contains at least n ints
//@post: a contains the first n ints from input
//@modifies: a

double readinput( int n ) {
  a = new int[n];
  for (int i=0; i<n; i++) {
    a[i] = scanner.nextInt();
  }
}
```

Notes on functions

- functions are methods with return value
- reserve functions for "mathematical" calculations
- side-effects preferably not in functions:

  change of instance variables

  input or output

- pure functions: functions that do not change or consult the state