Data Conversion

- Implicit
  - Assignment conversion

    ```
    int a = 5;
    double b = a;
    ```

  - Promotion

    ```
    int a = 5;
    double b = 2.0;
    c = b + a;  // a is promoted to double
    ```

- Explicit (Type casting)

  ```
  int a = 7;
  double b = (double)a;
  ```

Data Conversion

- Widening conversion

```
int a = 8;
double b = a;           // Implicit
double c = (double)a;  // Explicit
```

- Narrowing conversion

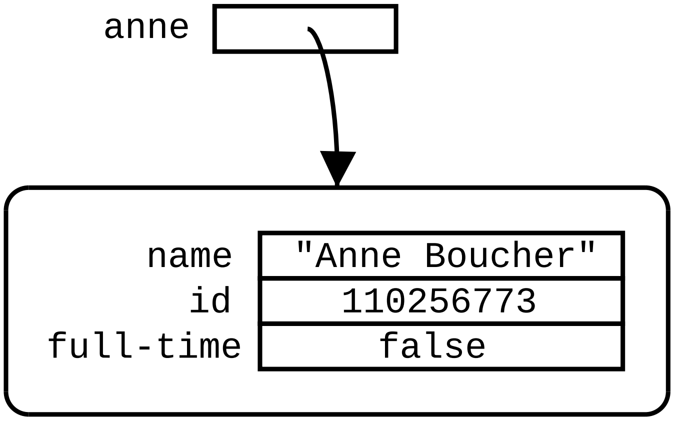
```
double a = 7.8;
int b = (int)a; // Always explicit
```

- Narrowing conversion can result in loss of information
- Sometimes widening conversions are needed to ensure a particular type of operation:

```
int a = 7;
double b = a / 2;
double c = (double)a / 2;
```

Objects and Classes

- Programs manipulate data
- Variables store data
- A variable holds either:
  - a value from a primitive data type (int, boolean, char, …)
  - or a reference to an object
- An *object* is a composite piece of data: it is a group of variables treated as a unit

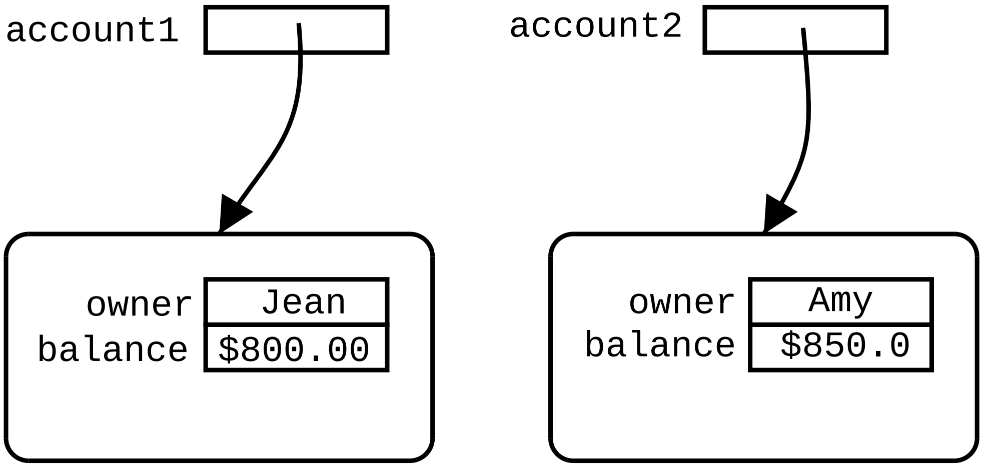


Objects and Classes

- A bank account has:
  - owner
  - balance

- Given a bank account we can:
  - deposit
  - withdraw

Objects and Classes



Objects and Classes

- Objects have a type
- The type of an object is a *class*
- A class describes:
  - the structure of its objects (attributes)
  - and its operations (methods)
- To be able to use objects we need:
  - Define some class or classes
  - A mechanism to create objects of a defined class
  - A mechanism to apply operations to these objects

Objects and Classes

- Defining a class:

```
public class BankAccount
{
    String owner;
    double balance;

    void withdraw(double amount)
    {
      // ...
    }

    void deposit(double amount)
    {
      // ...
    }
}
```

- Note: only one class in a program has a `main` method

Classes and Objects

- Declaring a variable:

  type *identifier*;

- It is the same for primitive types

$$\underbrace{\texttt{int}}_{\text{type}}\qquad\underbrace{\texttt{age}}_{\text{ident}};$$

as for non-primitive types (classes)

$$\underbrace{\texttt{BankAccount}}_{\text{type}}\qquad\underbrace{\texttt{account1}}_{\text{identifier}};$$

Classes and Objects

- Declaring a variable does not create any objects
- To *create objects* we use the `new` operator

```
account1 = new BankAccount(‘‘Jean’’);
```

- To *apply operations to objects* we use the *dot* operator:

```
account1.deposit(200.00);
```

- You cannot apply methods without first creating objects

Classes and Objects

- To *create objects* we use the `new` operator

```
objectvariable = new ClassName(parameters);
```

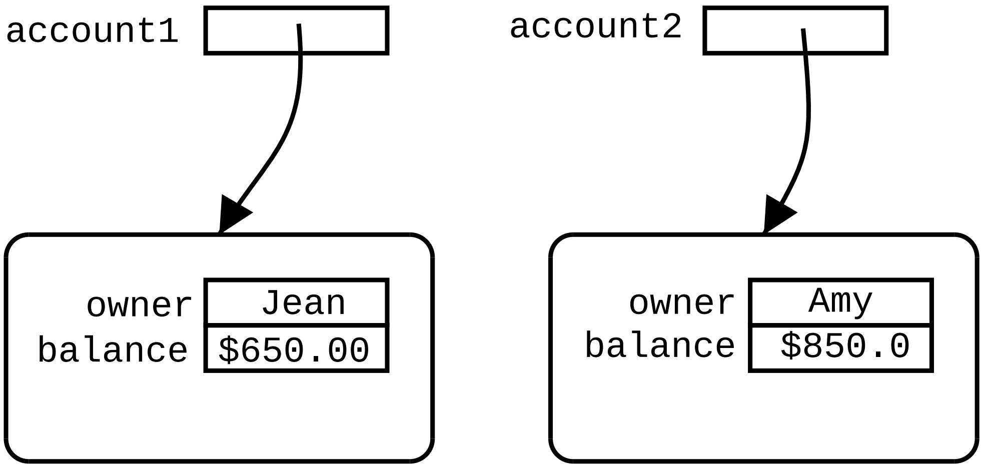
- To *apply operations to objects* we use the *dot* operator:

```
objectvariable.method(parameters);
```

Objects and Classes

$$\underbrace{\texttt{account1}}_{\text{object}} \;.\; \underbrace{\texttt{withdraw}}_{\text{method}} \; \underbrace{(150.00)}_{\text{parameters}};$$

- Applying a method to an object affects only the object it is being applied to.



Strings, Classes and Objects

- Strings are objects
- The String type is a class, predifined in the *Standard Java Library*
- A *class library* is a collection of predefined classes
- To create String objects we can use the new operator

```
title = new String(“Trainspotting”);
```

- but this can be abbreviated as

```
title = “Trainspotting”;
```

- ...only for Strings

Strings

- `String` is a class, and particular strings are objects

- Methods of the `String` class define operations on strings
  - `int length()`
  - `char charAt(int index)`
  - `String substring(int offset, int endIndex)`
  - `boolean equals(String s)`
  - `String concat(String s)`
  - `String replace(char a, char b)`

Strings

- Examples of `int length()`

```
String question;
int l;
question = “Is this course  easy?”;

l = question.length();

System.out.println(l);   // 21

String answer;
answer = “It depends...”;

l = answer.length();

System.out.println(l);   // 13

String very_short_message = “”;
System.out.println( very_short_message.length() );
```

Strings

- Examples of `char charAt(int index)`

```
String phrase;
char initial1, initial2, initial3,
     initial4, initial5;
String acronym;

phrase = ‘‘Emacs makes a computer swell’’;

initial1 = phrase.charAt(0);
initial2 = phrase.charAt(6);
initial3 = phrase.charAt(12);
initial4 = phrase.charAt(14);
initial5 = phrase.charAt(23);

acronym = ‘“’ + initial1 + initial2
               + initial3 + initial4 + initial5;
```

Strings

- The argument or parameter of `charAt` can be any integer expression

```
String phrase;
char c;
int start = 3;

phrase = “Strings do not have to make sense.”;

c = phrase.charAt( start + 2 );

// c == ‘g’

c = phrase.charAt( phrase.length() - 1 );

// c == ‘.’

c = phrase.charAt( phrase.length() );
// Runtime error
```

Strings

- Since the `charAt` method returns a character, it can be used in any character expression, and in particular it can be used within string expressions

```
String word1 = “rat”, word2 = “case”;
String word3;
word3 = word1 + word2.charAt(2);

// word3 contains “rats”
```

Strings

- charAt cannot be used to modify a string

```
String word = “clap”;
word.charAt(0) = ‘f’; // WRONG!
```

- Strings in Java are immutable: they cannot change
- But String references can change:

```
String word = “clap”;
String new_word;
new_word = “f” + word.charAt(1)
         + word.charAt(2) + word.charAt(3);
word = new_word;

// word contains “flap”;
```

Strings

- Examples of
  `String substring(int offset, int endIndex)`

```
String word = “clap”;
String end, new_word;
end = word.substring(1, 4);

// end contains “lap”;

new_word = “f” + end;

// new_word contains “flap”
```

Strings

- `s.substring(i, j)` returns the part of string `s` beginning at index `i` and ending at index `j-1`

```
String phrase, subject, verb, article, noun;

phrase = “This is a string”;
subject = phrase.substring(0, 4);
verb = phrase.substring(5, 7);
article = phrase.substring(8, 9);
noun = phrase.substring(10, phrase.length());

System.out.println(subject+article+noun+verb);

// Prints
// Thisastringis
```

Strings

- Since the `substring` method returns a `String`, it can be used within any string expression

```
String old_phrase = “This is a string”;
int size = old_phrase.length();
String new_phrase;

new_phrase = old_phrase.substring(0, 8)
             + “not ”
             + old_phrase.substring(8, size);

// new_phrase contains “This is not a string”
```

Strings

- Examples of `boolean equals(String s)`

  ```
  String pet1 = “cat”, pet2 = “rat”;
  String end1, end2;
  boolean same_pet, same_end;

  same_pet = pet1.equals(pet2);

  end1 = pet1.substring(1, pet1.length() );
  end2 = pet2.substring(1, pet2.length() );

  same_end = end1.equals(end2);
  ```

- For every pair of strings `a` and `b`, `a.equals(b)` returns the same as `b.equals(a)`

Strings

- Since the `equals` method returns a `boolean`, it can be used in any boolean expression

```
String season = ‘‘Winter’’;
float temp = -5.0f;
boolean warm;

warm = !season.equals(‘‘Winter’’) || temp >= -10.0f;
```

`season.equals(‘‘Winter’’)`	`temp>=-10.0f`	`!season.equals("Winter")`	`warm`
`true`	`true`	`false`	`true`
`true`	`false`	`false`	`false`
`false`	`true`	`true`	`true`
`false`	`false`	`true`	`true`

Strings

- Examples of `String concat(String s)`

  ```
  String sentence;
  sentence = “This sentence is ”;
  sentence = sentence.concat(“ false”);
  ```

- If `a` and `b` are strings, `a + b` is shorthand for `a.concat(b)`

Strings

- Examples of `String replace(char a, char b)`

```
String message, encoded;
message = “This message is irrelevant”;
encoded = message.replace(‘e’, ‘x’);

// encoded contains “This mxssagx is  irrxlxvant”

encoded = encoded.replace(‘a’, ‘y’);
encoded = encoded.replace(‘i’, ‘z’);
encoded = encoded.replace(‘r’, ‘w’);
encoded = encoded.replace(‘s’, ‘u’);
encoded = encoded.replace(‘ ’, ‘-’);
encoded = encoded.replace(‘t’, ‘v’);

// encoded contains “Thzu-mxuuygx-zu--zwwxlxvynv”
```

An example

- Problem: Given a four letter word, print the word in reverse.

- Analysis:
  - Information involved: a four letter word, *w*.
  - Input: *w*
  - Output: a word *v* which is the reverse of *w*
  - Definitions:
    - The *reverse* of a word *w* is a word *v* which has the the same characters as *w*, but in inverse order: the first letter of *v* is the last of *w*, the second letter of *v* is the second-to-last of *w*, etc.
  - Restrictions: *w* is assumed to have only four letters

An example

- Design

1. Obtain the word *w*
2. Create a new word *v*, initially empty
3. Add the last character of *w* to the end of *v*
4. Add the third character of *w* to the end of *v*
5. Add the second character of *w* to the end of *v*
6. Add the first character of *w* to the end of v
7. Print *v*

An example

- Implementation

```
import cs1.Keyboard;
public class Reverse {
  public static void main(String[] args)
  {
    String w, v;

    System.out.print(“Enter a four letter word: ”)
    w = Keyboard.readString();

    v = “”;
    v = v + w.charAt( 3 );
    v = v + w.charAt( 2 );
    v = v + w.charAt( 1 );
    v = v + w.charAt( 0 );

    System.out.println(v);
  }
}
```

An example

- Implementation

```
import cs1.Keyboard;
public class Reverse {
  public static void main(String[] args)
  {
    String w, v;

    System.out.print(‘‘Enter a four letter word: ’’)
    w = Keyboard.readString();

    v = ‘‘’’ + w.charAt( 3 ) + w.charAt( 2 )
        + w.charAt( 1 ) + w.charAt( 0 );

    System.out.println(v);
  }
}
```

An example

- Design (alternative)

1. Obtain the word *w*

2. Create a new word *v*, initially empty

3. Add the first character of *w* to the front of *v*

4. Add the second character of *w* to the front of *v*

5. Add the third character of *w* to the front of *v*

6. Add the last character of *w* to the front of v

7. Print *v*

An example

- Implementation

```
import cs1.Keyboard;
public class Reverse {
  public static void main(String[] args)
  {
    String w, v;

    System.out.print(‘‘Enter a four letter word: ’’)
    w = Keyboard.readString();

    v = ‘‘’’;
    v = ‘‘’’ + w.charAt( 0 ) + v;
    v = ‘‘’’ + w.charAt( 1 ) + v;
    v = ‘‘’’ + w.charAt( 2 ) + v;
    v = ‘‘’’ + w.charAt( 3 ) + v;

    System.out.println(v);
  }
}
```

An example

- Implementation

```
import cs1.Keyboard;
public class Reverse {
  public static void main(String[] args)
  {
    String w, v;

    System.out.print(‘‘Enter a four letter word: ’’)
    w = Keyboard.readString();

    v = ‘‘’’ + w.charAt( 3 ) + w.charAt( 2 )
        + w.charAt( 1 ) + w.charAt( 0 );

    System.out.println(v);
  }
}
```

Another example

- Problem: Given a four letter word, determine whether the word is a palindrome

- Analysis:
  - Information involved: a four letter word, *w*.
  - Input: *w*
  - Output: true if the word is a palindrome, false otherwise
  - Definitions:
    - ∗ A word is a *palindrome* if it is the same as its own reverse, e.g. (noon, radar, wow, pop, 2002, ...)
  - Restrictions: *w* is assumed to have only four letters

Another example

- Design:

1. Obtain word *w*

2. Compute the reverse of *w*: let *v* be the reverse of *w*

3. Compare *v* and *w*. Let *result* be true if *w* and *v* are equal, and false otherwise.

4. Print *result*

Another example

```
import cs1.Keyboard;
public class Palindromes {
  public static void main(String[] args)
  {
    String w, v;
    boolean result;

    System.out.print(‘‘Enter a four letter word: ’’)
    w = Keyboard.readString();

    v = ‘‘’’;
    v = v + w.charAt(3);
    v = v + w.charAt(2);
    v = v + w.charAt(1);
    v = v + w.charAt(0);

    result = v.equals(w);

    System.out.println(result);
  }
}
```

Another example

- Design (alternative):

1. Obtain word *w*

2. Compare the first character of *w* with its last character and the second character with the thirs character. Let result be true if both comparisons yield true, and false otherwise.

3. Print *result*

Characters

- Values of the `char` data type can be compared using the traditional relational operators:

```
char a = ’P’, b = ’Q’;
boolean c, d, e, f, g, h;
c = a == b;    // c == false
d = a != b;    // d == true
e = a < b;     // e == true
f = a > b;     // f == false
g = a <= b;    // g == true
h = a >= b;    // h == false

char a = ’Q’, b = ’Q’;
boolean c, d, e, f, g, h;
c = a == b;    // c == true
d = a != b;    // d == false
e = a < b;     // e == false
f = a > b;     // f == false
g = a <= b;    // g == true
h = a >= b;    // h == true
```

Another example

```
import cs1.Keyboard;
public class Palindromes {
  public static void main(String[] args)
  {
    String w;
    boolean result;

    System.out.print(‘‘Enter a four letter word: ’’)
    w = Keyboard.readString();

    result = w.charAt(0) == w.charAt(3)
           && w.charAt(1) == w.charAt(2);

    System.out.println(result);
  }
}
```

Class libraries

- Classes have a dual role:
  - as data types (of objects)
  - as modules
- Methods can be seen as "services" provided by these modules
- A *class library* is a collection of classes which has already been created by someone else, and which we can use in our programs
- Java has a Standard Library which includes classes for many different purposes
- Class libraries are organized in *packages*
- A *package* is a collection of classes

Class libraries

- Some packages from the Standard Java Library include:
  - `java.applet`: for creating programs which are easily transported accross the Web
  - `java.awt`: for creating GUIs (Graphical User Interfaces)
  - `java.io`: for handling files in secondary storage, or some communications
  - `java.lang`: general support
  - `java.math`: computations with high precision
  - `java.security`: support for security
  - `java.text`: for text manipulation
  - `java.util`: general utilities

- The full list of packages and classes in the Standard Library can be found at:

  `http://java.sun.com/j2se/1.4.2/docs/api/`

Class libraries

- Whenever we want to use a class `C` from a package `p`, we must use the import declaration at the top of the file:

```
import p.C;
```

- For example, the `Keyboard` class is defined in the package `cs1`, so we must use

```
  import cs1.Keyboard;
```

  whenever we want to use it.

- Another example: the package java.util includes many useful classes such as `Currency` and `Calendar`. To use them we must add at the top of the file:

```
import java.util.Currency;
import java.util.Calendar;
```

Class libraries

- If we want to import all classes of a package `p`, we use

  ```
  import p.*;
  ```

- For instance:

  ```
  import java.util.*;
  ```

- The package `java.lang` is automatically imported in every program.

- Class `String` is defined in the `java.lang` package

- Class `Math` is also defined in the `java.lang` package

Static methods

- So far, all method calls that we have used take the form

  objectreference.*methodname*(*parameters*)

- But there are some methods that take the form

  classname.*methodname*(*parameters*)

- These are called *static methods*

- Static methods do not represent operations on objects, but services provided by a class

- For example:

  ```
  i = Keyboard.readInt();
  ```

Static methods and class libraries

The Math class has many useful static methods, such as:

Method	Description
`static int abs(int num)`	returns the absolute value of `num`
`static double pow(double num, double power)`	returns $\mathtt{num}^{\mathtt{power}}$
`static double sqrt(double num)`	returns $\sqrt{\mathtt{num}}$
`static double sin(double angle)`	returns $\sin(\mathtt{angle})$
`static double cos(double angle)`	returns $\cos(\mathtt{angle})$
`static double tan(double angle)`	returns $\tan(\mathtt{angle})$
`static double floor(double num)`	returns the largest integer less or equal to `num`
`static double ceil(double num)`	returns the smallest integer greater or equal to `num`

Static methods and class libraries

```
double cathetus1, cathetus2, hypothenuse;
cathetus1 = 3.0;
cathetus2 = 4.0;
hypothenuse = Math.sqrt( Math.pow( cathetus1, 2 ) +
                         Math.pow( cathetus2, 2 ) );
```

Statements

- Variable declaration

```
type variable;
```

- Assignment

```
variable = expression;
```

- Method invocation

```
objectreference.methodname(parameters);
```

or

```
classname.methodname(parameters);
```

Statements

- Variable declaration

```
type variable;
```

- Assignment

```
variable = expression;
```

- Method invocation

```
objectreference.methodname(parameters);
```

or

```
classname.methodname(parameters);
```

- Conditional
- Loop