Using Java Classes

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The `Math` Class

- The `Math` class is one of many classes in the *Java class libraries* with predefined code. It contains
  - mathematical constants and
  - methods that perform common mathematical operations.
- These methods require argument (data) on which to perform their actions, and return a result that can be used in an expression in your program.

- A complete description of the `Math` class is in the Java API online.
  - http://java.sun.com/j2se/1.5.0/docs/api

Square Root

This is called the method header

```
static double sqrt(double n)
```

- **`static`** indicates that we call this method using the name of the class.
- **`double`** indicates the data type of the answer the method returns.
- **`sqrt`** is the name of the method.
- **`(double n)`** indicates that the method requires one double argument to do it job.
- BEHAVIOR: returns the square root of the number supplied in the argument.

Example:

`sqrt` is in the `Math` class

```
double answer = Math.sqrt(16.0);  // returns 4.0
```

argument value

Exponentiation

```
static double pow(double num, double power)
```

- **`static`** indicates that we call this method using the name of the class.
- **`double`** indicates the data type of the answer the method returns.
- **pow** is the name of the method.
- **`(double num, double power)`** indicates that this method requires two double arguments on which to compute its result.
- BEHAVIOR: `pow` returns `num` raise to the specified `power`.

Example:

```
double answer = Math.pow(2.0, 3.0);  // returns 8.0
```

`The Math` Class

Math constants:

The constants e and π are defined in the `Math` class. By convention, names of constants are in <u>all upper case</u>:

- **`Math.E`** and **`Math.PI`**

Some `Math` methods:

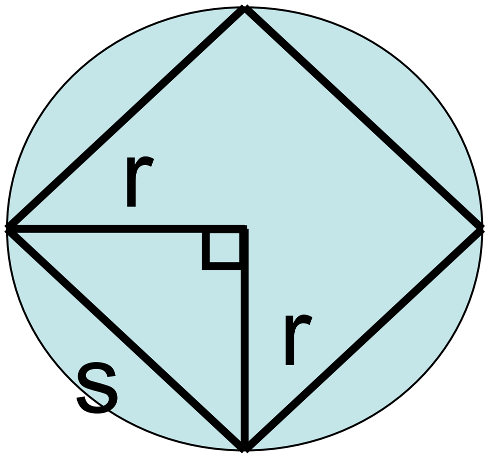
```
static double floor(double num)
static double ceil(double num)

static double sqrt(double num)

static int abs(int num)
static double abs(double num)
```

This is an example of method <u>overloading,</u> where abs is defined two ways.

Examples



```
double area = Math.PI * radius * radius;

double circumference = 2.0 * Math.PI * radius;

double side;
side = Math.sqrt(2.0 * Math.pow(radius, 2.0));

System.out.println("The square area is "
  + "at least " +  Math.floor(side * side));
```

Calling Methods

- The argument to a method is be a literal, variable, or an expression that evaluates to a value.
- The argument value must match the data type specified in the method header.
- Multiple argument values must match the number and order specified in the method header.
- The results of these methods should be the argument to another method (e.g., print), assigned to a variable, or used as part of a larger expression.

  Example:

```
Math.abs(-4.0);   // WRONG: has no effect!
```

Generating Random Numbers

- The `random` method of the `Math` class generates a random number in the range [0.0,1.0).

includes 0.0

excludes 1.0

  - The number is not truly random; it is pseudo-random.
  - The number is (approximately) uniformly distributed in the range.

Example:

```
double randNum = Math.random();
```

Generating Random Numbers

- To generate a random number in a different range, we can scale (multiply) and/or translate (add) the random number to get a new random number in that range.

Examples:

- Generate a random double in [0.0, 8.0):

```
double randNum = Math.random() * 8.0;
```

25.0 – 10.0 = 15.0

- Generate a random double in [10.0, 25.0):

```
double randNum = Math.random() * 15.0 +
                                         10.0;
```

Generating Random Integers

We can use `Math.random` to generate a random integer in some range: generate a random number in the range and then typecast to an integer.

Example:

- To generate a random integer in {0, 1, 2, …, 12}:
    - How many different integers do we want to generate? 13.
    - Generate a random double in [0.0,13.0).
    - Each range [0,1), [1,2), …, [12,13) corresponds to integers 0, 1, 2, …, 12, respectively.

```
int randNum = (int) (Math.random() * 13.0);
```

required

Generating Random Integers

Generate a random integer in {5, 15, 25,…,75}:

1. How many different integers do we want to generate?

```
Math.random();                          [0.0, 1.0);
Math.random() * 8.0;                    [0.0, 8.0);
(int) (Math.random() * 8.0)             {0,1, 2,…, 7}
```

2. What is the difference between pairs of numbers?

```
(int) (Math.random() * 8.0) * 10;       {0,10, 20,…, 70}
```

3. What is the first number?

```
(int) (Math.random() * 8.0) * 10 + 5;
```

{5, 15, 25, …, 75}

Java Data: Primitive vs Objects

Primitive data:

- Data uses a small **fixed** amount of memory.
- There are exactly eight primitive data types.

```
    byte, short, int, long, float,
    double, char, boolean
```

- Primitive data types names are in all lower case.
- A primitive is only data and has no other special abilities.
- You cannot define new primitive data types.

Java Data: Primitive vs Objects

Objects:

- An object has both *state* and *behaviors*.
- An object's current **state** (data) is defined by the values for its attributes. These values are stored internally and may require a little or a lot of memory.
- An object's **behaviors** (methods) are the actions it can perform.
- The ***type*** (or category) of an object is its **class.**
- Java has many classes already defined,

  e.g., `String`, `System`, `Scanner`.

  (Recall: Class names start with a capital letter.)

Class as a type

- A class is like a blueprint from which an object is created.
- We can create many objects from the class.
- The differences among these objects are the attribute values (data) that define the objects' state.
- For example, a class `Student` might be used to create a student object.
  - All such objects would have attributes common to students (*e.g.,* name, andrewId, courses enrolled…).
  - But each object would have its own values for these attributes, depending on which student it represents.

(Later we will see how we can define new classes.)

Object State

- What state (data) an object holds internally often is ***hidden*** from us, the user of the object. We cannot access the data directly.
- For example, a `String` object holds the string of characters in the object. But it might hold other hidden information relating to the string,

  e.g., the length of the string.
- Another example is the `System.out` object that holds information about how and to where to write text to the console.
  - We do not need to access these data in order to use the object; we just need to call the `print` or `println` methods.

Object Behaviors

- To use an object, we need to know only the *behaviors* of an object.
- An object's behaviors are defined by a set of methods associated with the object.
- For example, methods may enable you to access or change an object's attribute values, or to ask the object to perform a task.
- These methods are known as the *interface* to the object.

`String` Objects

- An **object** of **type** `String` holds a sequence of (unicode) characters.
- When we declare a variable of type `String`, it does not create an object. All you get is a way to refer to the object:

```
    String founder;
```

- To create an object we use the `new` operator:

```
  founder = new String("Carnegie");
```

constructor: sets up the object

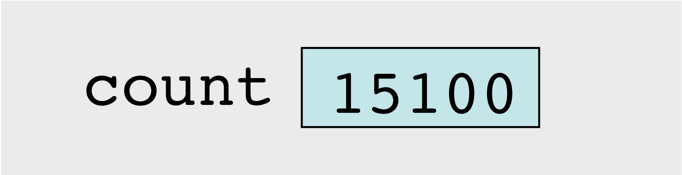
- Strings have a shortcut way of creating them:

```
  String founder2 = "Mellon";
```

Object vs Primitive Data

- A primitive variable holds an actual value:

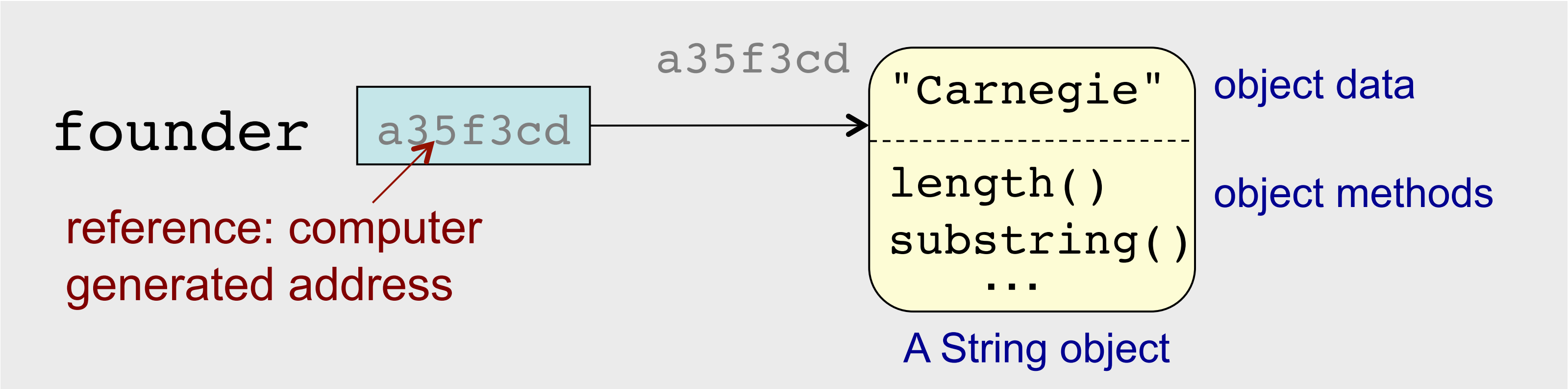
```
int count = 15100;
```



count 15100

- An object variable holds a *reference* (address) to the object (how to find the object).

```
String founder = new String("Carnegie");
```



founder

a35f3cd

a35f3cd

"Carnegie"

length()

substring()

...

object data

object methods

reference: computer generated address

A String object

Escape Sequences

- How do you include a `"` in a `String` literal?
- You cannot have a `String` literal break across lines. How do you include a line break?
- Solution: An ***escape sequence*** is a two-character sequence that represent a **single** special character.

Sequence	**Meaning**
`\t`	tab character
`\n`	newline character
`\”`	double quote
`\’`	single quote
`\\`	backslash character

No `static` qualifier

String Length

```
int length()
```

BEHAVIOR: Returns the number of characters in this string.

- `()` indicates the `length` method needs no argument values to do its job.
- Because `String` objects may have different lengths, you need to ask the object for its length. (It is non-static method.)
- Example:

```
String founder = "Carnegie";
int numChar = founder.length();
```

object dot operator method

Getting a single character

```
char charAt(int index)
```

BEHAVIOR: Returns the character at a specified index.

- Each character in a string has an ***index***

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
C	a	r	n	e	g	i	e		M	e	l	l	o	n

Example:

```
String school = "Carnegie Mellon";
char firstChar = school.charAt(0);
```

object method

WARNING: You cannot assign a `char` to a object of type `String` without first converting the `char` to a `String` object !

e.g., `String initial = "" + firstChar;`

Substrings

```
String substring(int startIndex,
                             int endIndex)
```

BEHAVIOR: Returns a new string consisting of the substring starting at `startIndex` (inclusive) and ending at `endIndex` (exclusive).

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
C	a	r	n	e	g	i	e		M	e	l	l	o	n

Example:

```
String school = "Carnegie Mellon";
String founder = school.substring(0, 8);
String founder2 = school.substring(9, 15);
```

Note: length of substring is `endIndex - startIndex`

Substrings

Another example of method overloading, where the number of parameters differs.

```
String substring(int startIndex)
```

BEHAVIOR: Returns a new string consisting of the substring starting at `startIndex` and ending at the last character in the string.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
C	a	r	n	e	g	i	e		M	e	l	l	o	n

Example:

```
String school = "Carnegie Mellon";
String founder2 = school.substring(9);
```

returns “Mellon”

Replacing Characters

```
String replace(char oldChar, char newChar)
```

BEHAVIOR: Returns a new `String` object resulting from replacing *every* occurrence of `oldChar` with `newChar`.

- The original `String` object is unchanged. (Strings are *immutable*!)

Example:

```
String founder = "Carnegie";
System.out.println(
   founder.replace('e', 'E'));
System.out.println(founder);
```

OUTPUT:

```
CarnEgiE
Carnegie
```

Changing Case

```
String toUpperCase()
```

BEHAVIOR: Returns a new `String` object with all letters converted to uppercase.

```
String toLowerCase()
```

BEHAVIOR: Returns a new `String` object with all letters converted to lowercase.

Example:

```
String founder = "Carnegie";
String upper = founder.toUpperCase();
String lower = founder.toLowerCase();
```

Immutable: You need to print or assign the result to a variable!

Method order

- The dot(.) operator is evaluated from left to right.
- If a method returns an object, you can invoke one of the returned object’s methods.
- Example:

```
String school = ”Carnegie Mellon";
System.out.println(
```

$$\underbrace{\underbrace{\texttt{school.substring(9)}}_{\texttt{"Mellon"}}\texttt{.toLowerCase()}}_{\texttt{"mellon"}}\texttt{);}$$

Reading User Input

- The **`Scanner`** class has methods for reading user input values while the program is running.
- The `Scanner` class is in the `java.util` package.
  - Related classes are grouped into *packages.*
  - Most of the classes we use are in the `java.lang` package, which is always available.
  - To use classes in other packages we must tell the compiler about these packages by using an *import declaration* before the classheader:

```
import java.util.Scanner;
```

```
public class interactiveProgram { …
```

`Scanner` Object

- First, we need to create a Scanner object using the `new` operator:

```
Scanner console = new Scanner(System.in);
```

  - **`console`** is a variable that refers to the `Scanner` object.
  - **`Scanner()`** is the *constructor* that helps set up the object.
  - **`System.in`** is an object that refers to the *standard input stream* which, by default, is the keyboard.

`Scanner` Methods

`String nextLine()`

- Reads and returns the next line of input.

`String next()`

- Reads and returns the next ***token*** (e.g., one word, one number).

`double nextDouble()`

- Reads and returns the next token as a `double` value.

`int nextInt()`

- Reads and returns the next token as an `int` value.

These methods pause until the user has entered some data and pressed the return key.

```
import java.util.Scanner;
```

Scanner Example

```
Scanner console = new Scanner(System.in);
System.out.print(
    "What is the make of your vehicle? ");
String vehicleMake = console.nextLine();

System.out.print(
        "How many miles did you drive? ");
int miles = console.nextInt();

System.out.print(
        "How many gallons of fuel did you use?
");
double gallons = console.nextDouble();
```

`Scanner` Caveats

- `nextInt`, `nextDouble`, and `next` read one **token** at a time.
  - Tokens are *delimited* by whitespace (space, tab, newline characters)
  - Several values can be on the same input line or on separate lines.
- `nextLine` reads the **rest** of the line and moves to the next line. It may return a string of no characters if it is called after calling one of the above methods.
- What happens if the user does not enter an integer when we use `nextInt`?