Recreation

Given that

\[ \log(1 + x) = x - \frac{1}{2}x^2 + \frac{1}{3}x^3 - \ldots \]

why is it not the case that

\[ \log 2 = 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \frac{1}{6} + \frac{1}{7} - \frac{1}{8} + \frac{1}{9} - \ldots \]

\[ = (1 + \frac{1}{3} + \frac{1}{5} + \frac{1}{7} + \frac{1}{9} + \ldots) - (\frac{1}{2} + \frac{1}{4} + \frac{1}{6} + \frac{1}{8} + \ldots) \]

\[ = (1 + \frac{1}{3} + \frac{1}{5} + \frac{1}{7} + \frac{1}{9} + \ldots) + (\frac{1}{2} + \frac{1}{4} + \frac{1}{6} + \frac{1}{8} + \ldots) \]

\[ - 2(\frac{1}{2} + \frac{1}{4} + \frac{1}{6} + \frac{1}{8} + \ldots) \]

\[ = (1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \ldots) - (1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \ldots) \]

\[ = 0? \]
CS61B Lecture #7: Object-Based Programming

Basic Idea.

- **Function-based programs** are organized primarily around the functions (methods, etc.) that do things. Data structures (objects) are considered separate.

- **Object-based programs** are organized around the types of objects that are used to represent data; methods are grouped by type of object.

- Simple banking-system example:

  ![Diagram showing function-based and object-based accounts](image)

  **Function-based**
  - account
  - deposit
  - withdraw
  - account

  **Object-based**
  - Account
    - deposit
    - withdraw
    - balance: 1420
  - Exported methods
  - Exported field
Philosophy

• Idea (from 1970s and before): An abstract data type is
  - a set of possible values (a domain), plus
  - a set of operations on those values (or their containers).

• In IntList, for example, the domain was a set of pairs: \((\text{head}, \text{tail})\), where head is an int and tail is a pointer to an IntList.

• The IntList operations consisted only of assigning to and accessing the two fields (head and tail).

• In general, we prefer a purely procedural interface, where the functions (methods) do everything—no outside access to the internal representation (i.e., instance variables).

• That way, implementor of a class and its methods has complete control over behavior of instances.

• In Java, the preferred way to write the “operations of a type” is as instance methods.
You Saw It All (Maybe) in CS61A: The Account Class

class Account:
    balance = 0
    def __init__(self, balance0):
        self.balance = balance0
    def deposit(self, amount):
        self.balance += amount
        return self.balance
    def withdraw(self, amount):
        if self.balance < amount:
            raise ValueError("Insufficient funds")
        else:
            self.balance -= amount
        return self.balance

myAccount = Account(1000)
print(myAccount.balance)
myAccount.deposit(100)
myAccount.withdraw(500)

public class Account {
    public int balance;
    public Account(int balance0) {
        this.balance = balance0;
    }
    public int deposit(int amount) {
        balance += amount; return balance;
    }
    public int withdraw(int amount) {
        if (balance < amount)
            throw new IllegalStateException("Insufficient funds");
        else balance -= amount;
        return balance;
    }
}

Account myAccount = new Account(1000);
print(myAccount.balance)
myAccount.deposit(100)
myAccount.withdraw(500)
(define-class (account balance0)
   (instance-vars (balance 0))
   (initialize
    (set! balance balance0)))

(method (deposit amount)
   (set! balance (+ balance amount))
   balance)

(method (withdraw amount)
   (if (< balance amount)
    (error "Insufficient funds")
    (begin
     (set! balance (- balance amount))
     balance)))

(define my-account
  (instantiate account 1000))
(ask my-account 'balance)
(ask my-account 'deposit 100)
(ask my-account 'withdraw 500)

public class Account {
   public int balance;
   public Account(int balance0) {
      balance = balance0;
   }
   public int deposit(int amount) {
      balance += amount; return balance;
   }
   public int withdraw(int amount) {
      if (balance < amount)
         throw new IllegalStateException("Insufficient funds");
      else balance -= amount;
      return balance;
   }
}

Account myAccount = new Account(1000);
myAccount.balance
myAccount.deposit(100);
myAccount.withdraw(500);
The Pieces

- **Class declaration** defines a *new type of object*, i.e., new type of structured container.

- **Instance variables** such as `balance` are the simple containers within these objects (*fields* or *components*).

- **Instance methods**, such as `deposit` and `withdraw` are like ordinary (static) methods that take an invisible extra parameter (called `this`).

- The **new operator** creates (*instantiates*) new objects, and initializes them using constructors.

- **Constructors** such as the method-like declaration of `Account` are special methods that are used only to initialize new instances. They take their arguments from the **new** expression.

- **Method selection** picks methods to call. For example,

  ```java
  myAccount.deposit(100)
  ```

  tells us to call the method named `deposit` that is defined for the object pointed to by `myAccount`. 
Getter Methods

• Slight problem with Java version of Account: anyone can assign to the balance field

• This reduces the control that the implementor of Account has over possible values of the balance.

• Solution: allow public access only through methods:

```java
public class Account {
    private int _balance;
    ...
    public int balance() { return _balance; }
    ...
}
```

• Now Account._balance = 1000000 is an error outside Account.

• (I use the convention of putting ‘_’ at the start of private instance variables to distinguish them from local variables and non-private variables. Could actually use balance for both the method and the variable, but please don’t.)
Class Variables and Methods

• Suppose we want to keep track of the bank’s total funds.

• This number is not associated with any particular Account, but is common to all—it is *class-wide*. In Java, “class-wide” ≡ \texttt{static}.

```java
public class Account {

    private static int _funds = 0;

    public int deposit(int amount) {
        _balance += amount;
        _funds += amount;   // or this._funds or Account._funds
        return _balance;
    }

    public static int funds() {
        return _funds;       // or Account._funds
    }

    ...  // Also change withdraw.
}
```

• From outside, can refer to either \texttt{Account.funds()} or \texttt{myAccount.funds()} (same thing).
Instance Methods

- Instance method such as

```java
int deposit(int amount) {
    _balance += amount;
    _funds += amount;
    return balance;
}
```

behaves sort of like a static method with hidden argument:

```java
static int deposit(final Account this, int amount) {
    this._balance += amount;
    _funds += amount;
    return this._balance;
}
```

- NOTE: Just explanatory: Not real Java (not allowed to declare 'this'). (**final** is real Java; means "can’t change once initialized.")
Calling Instance Method

/** (Fictional) equivalent of deposit instance method. */
static int deposit(final Account this, int amount) {
    this._balance += amount;
    _funds += amount;
    return this._balance;
}

• Likewise, the instance-method call myAccount.deposit(100) is like a call on this fictional static method:
    Account.deposit(myAccount, 100);

• Inside a real instance method, as a convenient abbreviation, one can leave off the leading 'this.' on field access or method call if not ambiguous. (Unlike Python)
'Instance' and 'Static' Don't Mix

• Since real static methods don't have the invisible this parameter, makes no sense to refer directly to instance variables in them:

```java
public static int badBalance(Account A) {
    int x = A._balance;  // This is OK
    // (A tells us whose balance)
    return _balance;      // WRONG! NONSENSE!
}
```

• Reference to _balance here equivalent to this._balance,

• But this is meaningless (whose balance?)

• However, it makes perfect sense to access a static (class-wide) field or method in an instance method or constructor, as happened with _funds in the deposit method.

• There's only one of each static field, so don't need to have a 'this' to get it. Can just name the class (or use no qualification inside the class, as we've been doing).
Constructors

• To completely control objects of some class, you must be able to set their initial contents.

• A constructor is a kind of special instance method that is called by the new operator right after it creates a new object, as if

\[ L = \text{new IntList}(1, \text{null}) \implies \begin{cases} 
\text{tmp} = \text{pointer to } 0 \\
\text{tmp.IntList}(1, \text{null}); \\
L = \text{tmp}; 
\end{cases} \]
Multiple Constructors and Default Constructors

- **All** classes have constructors. In the absence of any explicit constructor, get **default constructor**, as if you had written:

  ```java
  public class Foo {
      public Foo() {
      }
  }
  ```

- **Multiple overloaded** constructors possible, and they can use each other (although the syntax is odd):

  ```java
  public class IntList {
      public IntList(int head, IntList tail) {
          this.head = head; this.tail = tail;
      }
      
      public IntList(int head) {
          this(head, null); // Calls first constructor.
      }
      ...
  }
  ```
Constructors and Instance Variables

- Instance variables initializations are moved inside constructors that don't start with `this(...).

```java
class Foo {
    int x = 5;
    Foo(int y) {
        DoStuff(y);
    }
    Foo() {
        this(42);
    }
}
```

```java
class Foo {
    int x;
    Foo(int y) {
        x = 5;
        DoStuff(y);
    }
    Foo() {
        this(42); // Assigns to x
    }
}
```
## Summary: Java vs. Python

<table>
<thead>
<tr>
<th>Java</th>
<th>Python</th>
</tr>
</thead>
<tbody>
<tr>
<td>class Foo {</td>
<td>class Foo: ...</td>
</tr>
<tr>
<td>int x = ...;</td>
<td>x = ...</td>
</tr>
<tr>
<td>Foo(...)</td>
<td>def <strong>init</strong>(self, ...):</td>
</tr>
<tr>
<td>{ ... }</td>
<td>...</td>
</tr>
<tr>
<td>int f(...)</td>
<td>def f(self, ...):</td>
</tr>
<tr>
<td>{...}</td>
<td>...</td>
</tr>
<tr>
<td>static int y = 21;</td>
<td>y = 21</td>
</tr>
<tr>
<td>static void g(...)</td>
<td># Referred to as Foo.y</td>
</tr>
<tr>
<td>{...}</td>
<td>@staticmethod</td>
</tr>
<tr>
<td>}</td>
<td>def g(...):</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>

- aFoo.f(...)  
- aFoo.x
- new Foo(...)
- this

- aFoo.f(...)  
- aFoo.x
- new Foo(...)
- self  # (typically)