Recreation

Given that

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

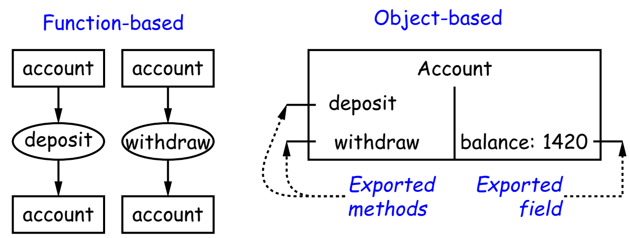
why is it not the case that

$$\begin{aligned}
\log 2 &= 1 - 1/2 + 1/3 - 1/4 + 1/5 - 1/6 + 1/7 - 1/8 + 1/9 - \ldots \\
&= (1 + 1/3 + 1/5 + 1/7 + 1/9 + \ldots) - (1/2 + 1/4 + 1/6 + 1/8 + \ldots) \\
&= (1 + 1/3 + 1/5 + 1/7 + 1/9 + \ldots) + (1/2 + 1/4 + 1/6 + 1/8 + \ldots) \\
&\quad -2(1/2 + 1/4 + 1/6 + 1/8 + \ldots) \\
&= (1 + 1/2 + 1/3 + 1/4 + \ldots) - (1 + 1/2 + 1/3 + 1/4 + \ldots) \\
&= 0?
\end{aligned}$$

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:



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:* `(head,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);
```


You Also Saw It All in CS61AS

```
(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,

  `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:

```
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" ≡ `static`.

```
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 `Account.funds()` or to `myAccount.funds()` (same thing).

Instance Methods

- Instance method such as

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

behaves sort of like a static method with hidden argument:

```
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

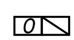
- Since real static methods don't have the invisible `this` parameter, makes no sense to refer directly to instance variables in them:

```
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'be 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 = new IntList(1,null) ⟹
```
tmp = pointer to
tmp.IntList(1, null);
L = tmp;
```


Multiple Constructors and Default Constructors

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

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

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

```
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(...)`.

```
class Foo {
   int x = 5;

   Foo(int y) {
      DoStuff(y);
   }

   Foo() {
      this(42);
   }
}
```

$\Longleftrightarrow$

```
class Foo {
   int x;

   Foo(int y) {
      x = 5;
      DoStuff(y);
   }

   Foo() {
      this(42); // Assigns to x
   }
}
```


Summary: Java vs. Python

Java

```
class Foo {
    int x = ...;
    Foo(...)
       { ... }
    int f(...)
       {...}
    static int y = 21;
    static void g(...)
       {...}
}
```

Python

```
class Foo: ...
    x = ...
    def __init__(self, ...):
        ...
    def f(self, ...):
        ...
    y = 21     # Referred to as Foo.y
    @staticmethod
    def g(...):
        ...
```

Java	Python
`aFoo.f(...)`	`aFoo.f(...)`
`aFoo.x`	`aFoo.x`
`new Foo(...)`	`Foo(...)`
`this`	`self     # (typically)`