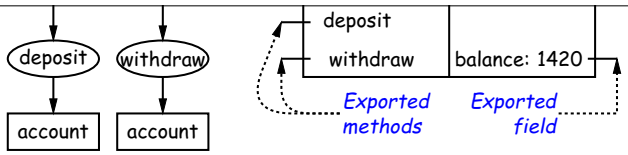
$\log(\quad) \qquad 2 \qquad 3$

why is it not the case that

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

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:



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.

```
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
```

```
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);
```



```
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 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);
```


ject, 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

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

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 dis-

please don't.)

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.
}
```



```
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.")

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)

visible `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

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
[0|\]
   tmp.IntList(1,
null);
   L = tmp;
```


- **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) {
```



```
        ...
    }
```


inside constructors that don't start with `this(...)`.


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

    Foo() {
        this(42);
    }
}
class Foo {
    int x;

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

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

Java	Python

class Foo {
int x = ...;
Foo(...)
{ ... }
int f(...)
{...}
static int y = 21;
static void g(...)
{...}
}
	class Foo: ...
	x = ...
	def __init__(self, ...):
	...
	def f(self, ...):
	...
	y = 21 # Referred to as Foo.y
	@staticmethod
	def g(...):
	...

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