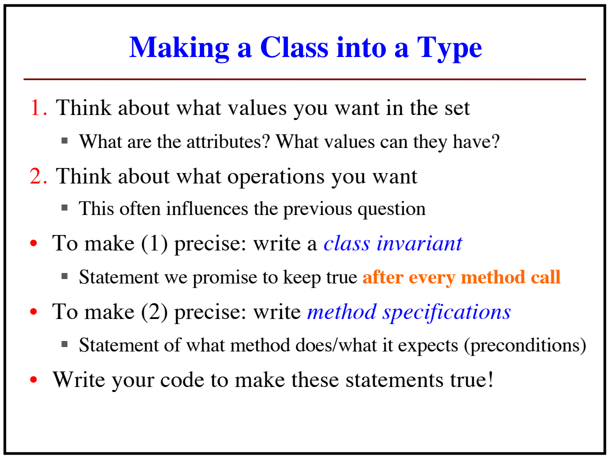
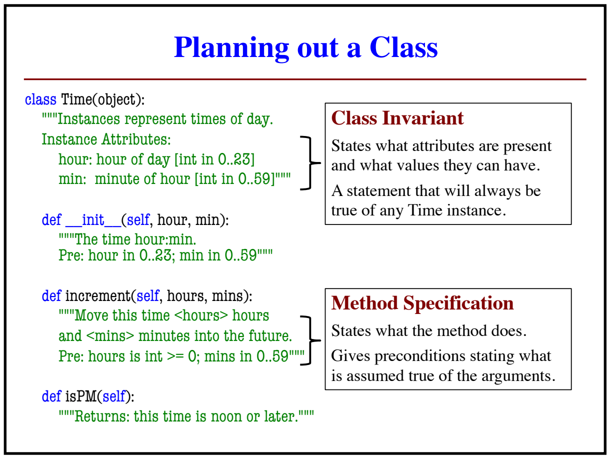


Making a Class into a Type

1. Think about what values you want in the set
   - What are the attributes? What values can they have?
2. Think about what operations you want
   - This often influences the previous question

- To make (1) precise: write a *class invariant*
  - Statement we promise to keep true **after every method call**
- To make (2) precise: write *method specifications*
  - Statement of what method does/what it expects (preconditions)
- Write your code to make these statements true!



Planning out a Class

```
class Time(object):
    """Instances represent times of day.
    Instance Attributes:
        hour: hour of day [int in 0..23]
        min:  minute of hour [int in 0..59]"""

    def __init__(self, hour, min):
        """The time hour:min.
        Pre: hour in 0..23; min in 0..59"""

    def increment(self, hours, mins):
        """Move this time <hours> hours
        and <mins> minutes into the future.
        Pre: hours is int >= 0; mins in 0..59"""

    def isPM(self):
        """Returns: this time is noon or later."""
```

Class Invariant

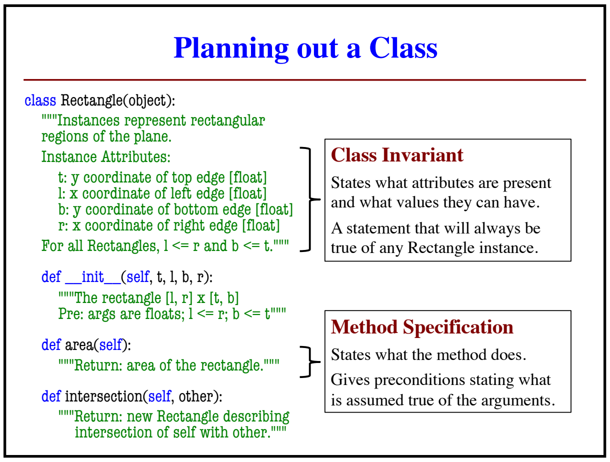
States what attributes are present and what values they can have.

A statement that will always be true of any Time instance.

Method Specification

States what the method does.

Gives preconditions stating what is assumed true of the arguments.



Planning out a Class

```
class Rectangle(object):
    """Instances represent rectangular
    regions of the plane.
    Instance Attributes:
        t: y coordinate of top edge [float]
        l: x coordinate of left edge [float]
        b: y coordinate of bottom edge [float]
        r: x coordinate of right edge [float]
    For all Rectangles, l <= r and b <= t."""

    def __init__(self, t, l, b, r):
        """The rectangle [l, r] x [t, b]
        Pre: args are floats; l <= r; b <= t"""

    def area(self):
        """Return: area of the rectangle."""

    def intersection(self, other):
        """Return: new Rectangle describing
           intersection of self with other."""
```

Class Invariant

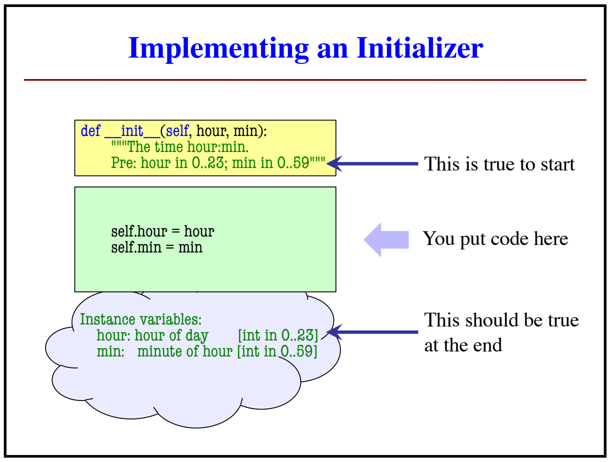
States what attributes are present and what values they can have.

A statement that will always be true of any Rectangle instance.

Method Specification

States what the method does.

Gives preconditions stating what is assumed true of the arguments.



Implementing an Initializer

```
def __init__(self, hour, min):
    """The time hour:min.
    Pre: hour in 0..23; min in 0..59"""
```

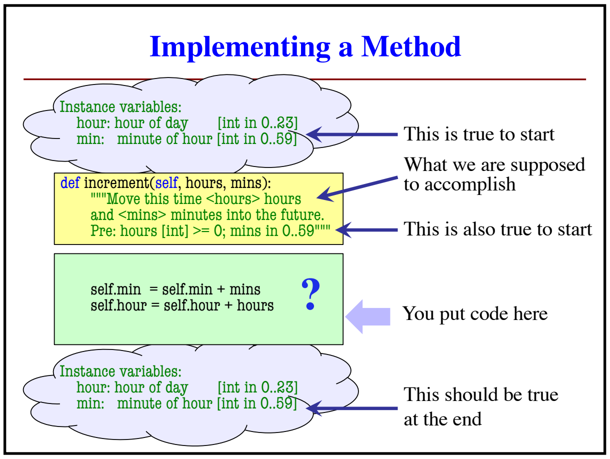
This is true to start

```
    self.hour = hour
    self.min = min
```

You put code here

```
Instance variables:
    hour: hour of day       [int in 0..23]
    min:   minute of hour [int in 0..59]
```

This should be true at the end



Implementing a Method

```
Instance variables:
    hour: hour of day       [int in 0..23]
    min:   minute of hour [int in 0..59]
```

This is true to start

```
def increment(self, hours, mins):
    """Move this time <hours> hours
    and <mins> minutes into the future.
    Pre: hours [int] >= 0; mins in 0..59"""
```

What we are supposed to accomplish

This is also true to start

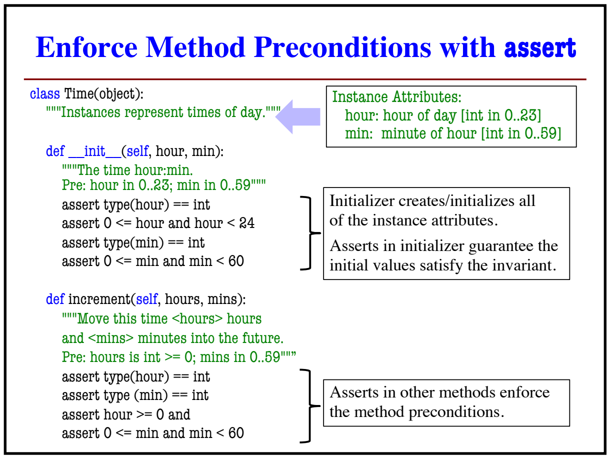
```
    self.min  = self.min + mins
    self.hour = self.hour + hours
```

?

You put code here

```
Instance variables:
    hour: hour of day       [int in 0..23]
    min:   minute of hour [int in 0..59]
```

This should be true at the end



Enforce Method Preconditions with assert

```
class Time(object):
    """Instances represent times of day."""

    def __init__(self, hour, min):
        """The time hour:min.
        Pre: hour in 0..23; min in 0..59"""
        assert type(hour) == int
        assert 0 <= hour and hour < 24
        assert type(min) == int
        assert 0 <= min and min < 60

    def increment(self, hours, mins):
        """Move this time <hours> hours
        and <mins> minutes into the future.
        Pre: hours is int >= 0; mins in 0..59"""
        assert type(hour) == int
        assert type (min) == int
        assert hour >= 0 and
        assert 0 <= min and min < 60
```

```
Instance Attributes:
    hour: hour of day [int in 0..23]
    min:  minute of hour [int in 0..59]
```

Initializer creates/initializes all of the instance attributes.

Asserts in initializer guarantee the initial values satisfy the invariant.

Asserts in other methods enforce the method preconditions.

Hiding Methods From Access

- Put underscore in front of a method will make it **hidden**
  - Will not show up in help()
  - But it is still there…
- Hidden methods
  - Can be used as **helpers** inside of the same class
  - But it is bad style to use them outside of this class
- Can do same for attributes
  - Underscore makes it hidden
  - Do not use outside of class

```
class Fraction(object):
    """Instance attributes:
        numerator:   top      [int]
        denominator: bottom [int > 0]"""

    def _is_denominator(self,d):
        """Return: True if d valid denom"""
        return type(d) == int and d > 0

    def __init__(self,n=0,d=1):
        assert self._is_denominator(d)
        self.numerator = n
        self.denominator = d
```

HIDDEN

Helper method

Enforcing Invariants

```
class Fraction(object):
    """Instance attributes:
        numerator:   top     [int]
        denominator: bottom [int > 0]
    """
```

Invariants: Properties that are always true.

- These are just comments!
  - `>>> p = Fraction(1,2)`
  - `>>> p.numerator = 'Hello'`
- How do we prevent this?

- **Idea**: Restrict direct access
  - Only access via methods
  - Use asserts to enforce them
- Examples:

```
def getNumerator(self):
    """Returns: numerator"""
    return self.numerator

def setNumerator(self,value):
    """Sets numerator to value"""
    assert type(value) == int
    self.numerator = value
```

Data Encapsulation

- **Idea**: Force the user to only use methods
- Do not allow direct access of attributes

Setter Method

- Used to change an attribute
- Replaces all assignment statements to the attribute
- **Bad**:
  `>>> f.numerator = 5`
- **Good**:
  `>>> f.setNumerator(5)`

Getter Method

- Used to access an attribute
- Replaces all usage of attribute in an expression
- **Bad**:
  `>>> x = 3*f.numerator`
- **Good**:
  `>>> x = 3*f.getNumerator()`

Data Encapsulation

```
class Fraction(object):
    """Instance attributes:
        _numerator:   top     [int]
        _denominator: bottom [int > 0]"""

    def getDenomenator(self):
        """Returns: numerator attribute"""
        return self._denomenator

    def setDenomenator(self, d):
        """Alters denomenator to be d
        Pre: d is an int > 0"""
        assert type(d) == int
        assert 0 < d
        self._denominator = d
```

Do this for all of your attributes

Getter

Setter

Naming Convention
The underscore means “should not access the attribute directly.”

Precondition is same as attribute invariant.

Mutable vs. Immutable Attributes

Mutable

- Can change value directly
  - If class invariant met
  - **Example**: t.color
- Has both getters and setters
  - Setters allow you to change
  - Enforce invariants w/ asserts

Immutable

- Can’t change value directly
  - May change “behind scenes”
  - **Example**: t.x
- Has only a getter
  - No setter means no change
  - Getter allows limited access

Properties: Invisible Setters and Getters

```
class Fraction(object):
    """Instance attributes:
        _numerator:   [int]
        _denominator: [int > 0]"""

    @property
    def numerator(self):
        """Numerator value of Fraction
        Invariant: must be an int"""
        return self._numerator

    @numerator.setter
    def numerator(self,value):
        assert type(value) == int
        self._numerator = value
```

`>>> p = Fraction(1,2)`

`>>> x = p.numerator`

⇩ Python converts to

`>>> x = p.numerator()`

`>>> p.numerator = 2`

⇩ Python converts to

`>>> p.numerator(2)`