PREPARING FOR PRELIM 2

CS 1110: FALL 2012

This handout explains what you have to know for the second prelim. There will be a review session with detailed examples to help you study. To prepare for the prelim, you can (1) practice writing functions and classes in Python, (2) review the assignments and labs, (3) review the lecture slides, (4) **read the text**, and (5) memorize terminology listed below.

The prelim will *not* cover while loops. It covers material up to and including material in lecture on October 30th. The test will focus primarily on recursion, iteration, and classes (e.g. Assignments 4 and 5, as well as all related labs).

1. Exam Information

The exam will be held **Tuesday, November 6th from 7:30-9:00 pm**. For reasons of space, we are split across mutliple rooms.

- Students with last names A – Q meet in Kennedy 1116
- Students with last names R – T meet in Warren 131
- Students with last names U – Z meet in Warren 231

We promise that we will not get locked out this time. We have learned our lesson.

1.1. **Review Session.** There will be a review session on **Sunday, November 4** at 4pm in a room TBA. The time and place will be announced later; watch this space. It will cover material in this handout and explain the basic structure of the exam. It will also go over several sample problems to help you prepare for the exam.

2. Content of the Exam

Once again, this begin a brand new course, we are going to tell you exactly what is going to be on the exam. Again, there will be five questions, each of roughly equal weight. These five questions will be as follows:

Recursion. You will be asked to write a recursive function. It will be roughly the complexity of the recursive functions in the labs (e.g. lab 6 or lab 9). It will not be as complex as the recursive functions in Assignment 4. You should know the important points. That is

(1) precise specification
(2) base case(s)
(3) recursive case(s)
(4) progress toward termination.

You should also be prepared to draw a (short) call stack for a recursive function. Think of problem problem 5 (a) on the past exam (and not problem 5 (b)). We have not decided to add such a question yet, but in the past, the really short recursive functions are generally all-or-nothing. This type of question would allow us to test your knowledge of recursion even if you did not do so well on the programming part.

Iteration. You will be given a problem that you will need to use a for-loop to solve. You should know how to use a for-loop on a sequence if you are given one, or how to use `range()` if you are not given one. You should know how to use an *accumulator* if needed to perform calculations using a for-looop.

Classes. You should know how to create a class that includes fields, properties, a constructor, and methods. You should know the names of the three most important built-in methods (e.g. `__init__`,`__str__`, and `__eq__`), but you do not need to know the names of any of the others.

You should also know how to create a subclass, and how inheritance and overriding work in Python. You should expect to be given a base class and be asked to subclass it to provide additional functionality.

Diagramming Objects. You will be given a series of assignments and constructor calls. You will be expected to identify (1) the number of objects that are created, (2) draw folder representations of each of these, and (3) identify which folder name is inside which variable.

This is something that we have been doing all through class in lecture, but which you (admittedly) have not gotten a lot of practice with. But since we assume that you have been following lecture, we believe this is fair game for a question. There will be a sample question like this in the review session. We also talk about this question a bit more below.

Short Answer. The short answer questions will focus on terminology, particularly regarding object-oriented methodology. For this part of the test, we recommend that you review the text as well as the lecture slides. In addition, we have a provided a list of important terminology below.

The short answer questions may also include short, poutporri-style questions that were not long enough to merit a separate category of their own. For example, while you already answered a `try-except` question on the previous exam, we might give you a new one utilitizing the *dispatch on type* features in `try-except`.

3. Representing Objects as Folders

We have been representing objects as folders all semester long. In the past we have been giving them to you. Now it is time to do it on your own. Like call-frames, folders are one of these "metaphores" that everyone handles a little differently. And because Python is a bit new, we are still ironing out the details of exactly what we do and do not care about in these metaphors. Here is what we want to see in our folders.

Getting Started. Objects should look like a manilla folder. The tab of this folder is an identifier giving the name (which is usually a number) of the object. This is the object name. All other details go in the body of the folder.

Partitions. The inside of the folder is separated into class *partitions*. There should be a partition for the object's primary class as well as all of its super classes. While class `object` is the super class of every class, you *do not* need to draw the partition for that class. But you should draw the partition for every other class.

Partitions are arranged vertically with super classes on top and each partition separated by a horizontal line. In each partition, the class name for the partition goes in the right corner. The partition itself is separated in half by a dotted line. Attributes go above the line and methods go below the line.

Attributes. When listing attributes in a partition, list **properties and non-hidden fields only**. It does not make sense to draw hidden fields if they are associated with a property; that would be redundant. More importantly, the purpose of the folder is to represent the *interface* of an object. So you should never draw anything that is hidden.

If a property is overridden, put this attribute in both the original partition and the one that overrides it. The values will be the same, but we want to indicate that the setters and getters have been overridden.

Methods. When listing methods in a partition, list **unhidden methods specifically defined in that class**. Again, since the purpose of the folder is to represent the *interface*, it does not make sense to list anything that it is hidden. You should also not list anything inherited, as that will be listed in the appropriate partition of the super (or superer) class.

When listing each method, give the name of the method, the list of parameters, and the default arguments for any of these parameters if they exist. Essentially, you are giving all of the information, other than the specification, that someone would need to use this method.

Example. Suppose we are given the following classes.

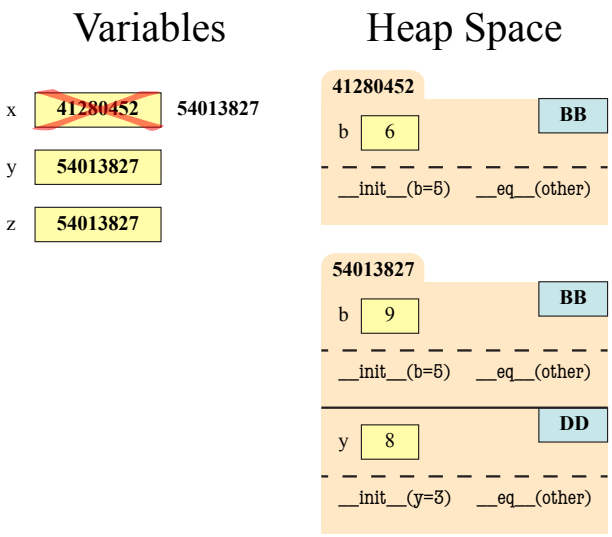
```
class BB(object):
    _b = 0 # int value

    @property
    def b(self):
        return self._b


    @b.setter
    def b(self,value):
        assert type(value) == int
        self._b = value


    def __init__(self,b=5):
        self.b = b


    def __eq__(self,other):
        ...
```

```
class DD(BB):
    _y = 0 # int value

    @property
    def y(self):
        return self._y


    @y.setter
    def y(self,value):
        assert type(value) == int
        self._y = value


    def __init__(self,y=3):
        super(DD,self).__init__(y+1)
        self.y = y


    def __eq__(self,other):
        ...
```

Suppose we ask you to "execute" the following sequence of commands:

```
>>> x = BB(6)
>>> z = DD(8)
>>> y = z
>>> x = y
```

There are three variables here and two constructor calls. You would draw two folders – one for each constructor call – in an area you label as "heap space". The variables would be drawn separately, and you would put the names of the folder in the variables. If a variable changes value, then you should not create a new variable. Instead, cross out the old value and replace it with a new one, just as we did with call frames. With the example above, your answer might look something like this:



4. Terminology and Important Concepts

Below, we summarize the terms you should know for this exam. You should be able to define any term below clearly and precisely. If it is a Python statement, you should know its syntax and how to execute it. You should know all of this *in addition to* the terminology that you had to learn for the first prelim.

Accumulator. An accumulator is just a fancy name for a variable in a for-loop that stores information computed in the for-loop and which will be still available when the for-loop is complete.

Example: In the for looop `total = 0 for x in range(5):`

```
    total = total + x
```

the variable `total` is an accumulator. It stores the sum of the values 0..4.

Attribute. Attributes are either *fields* or *properties*, and act as variables that are stored inside of an *object*. Attributes can often be modified, though not always the case, particularly when they are a *property*. Attributes typically have *invariants* which are rules specifying how the attribute may be modified.

Example: If the variable `color` stores an `RGB` object, then `color.red` is the red attribute in this object.

Bottom-Up Rule. This is the rule by which Python determines which method definition to use when a method is called. It looks at the object, and starts from the bottom class partition (the partition with no *subclass* partition). It looks for a method definition whose name matches the one given. If it does not find one, it progressively moves up to each subclass partition until it finds one. It uses the definition for the first matching method that it finds.

Class. A class is any *type* that is not built-in to Python (unlike **`int`**, **`float`**, **`bool`**, and **`str`** which are built-in). A value of this type is called an *object*.

Class definition. This is a template or blueprint for the objects (or instances) of the class. A class defines the components of each object of the class. All objects of the class have the same components, meaning they have the same attributes and methods. The only difference between objects is the values of their attributes. Using the blueprint analogy, while many houses (objects) can be built from the same blueprint, they may differ in color of rooms, wallpaper, and so on.

In Python, class definitions have the following form:

```
class <classname>(<superclass>):
    <field assignments>
    <property definitions>
    <constructor definition>
    <method definitions>
```

In most cases, we use the built-in class `object` as the *super class*.

Constructor. A constructor is a *function* that creates a *object* for a `class`. It puts the object in heap space, and returns the name of the object (e.g. the folder name) so you can store it in a variable. A constructor has the same name as the *type* of the object you wish to create.

When called, the constructor does the following:

- It creates a new object (folder) of the class, setting all the field values to their defaults.
- It puts the folder into heap space
- It executes the method `__init__` defined in the body of the class. In doing so, it
  - Passes the folder name to that parameter `self`
  - Passes the other arguments in order
  - Executes the commands in the body of `__init__`
- When done with `__init__` it returns the object (folder) name as final value of expression.

There are no return statements in the body of `__init__`; Python handles this for you automatically.

Example constructor call (within a statement) : `color = RGB(255,0,255)`

Example ***__init__*** *definition*:

```
def __init__(self,x,y):
    self.x = x
    self.y = y
```

Default Argument. A default argument is a value that is given to a parameter if the user calling the function or method does not provide that parameter. A default argument is specified by wording the parameter as an assignment in the function header. Once you provide a default argument for a parameter, all parameters following it in the header must also have default argumetns.

Example:

```
def foo(x,y=2,z=3):
    ...
```

In this example, the function calls `foo(1)`, `foo(1,0)`, `foo(1,0,0)`, and `foo(1,z=0)` are all legal, while `foo()` is not. The parameter `x` does not have default arguments, while `y` and `z` do.

Dispatch-on-Type. Dispatch-on-type refers to a function (or other Python command) that can take multiple types of input, and whose behavior depends upon the type of these inputs. Operator overloading is a special kind of dispatch-on-type where the meaning of an operator, such as +, *, or /, is determined by the class of the object on the left. Dispatch-on-type is also used by `try-except` statements.

Duck Typing. Duck typing is the act of determining if an object is of the correct "type" by simply checking if it has attributes or methods of the right names. This much weaker than using the `type()` function, because two completely different classes (and hence different types) could share the same attributes and methods. The name was chosen because "If it looks like a duck and quacks like a duck, then it must be a duck."

Encapsulation. Encapsulation is the process of hiding parts of your data and *implementation* from users that do not need access to that parts of your code. This process makes it easier for you to make changes in your own code without adversely affecting others that depend upon your code. See the definitions of *interface* and *implementation*.

Field. A field is a type of object attribute. Fields are created by assigning a value to a variable inside of the class definition.

Example fields ***minutes****,* ***hours***:

```
class Time(object):
    minutes = 0
    hours = 0
```

It is impossible to enforce invariants on fields as any value can be stored in a field at any time. Therefore, we prefer to make fields hidden (by starting their name with an underscore), and replacing them with *properties*.

Global Space. Global space is area of memory that stores global variables and function names. It is divided into the *active namespace* plus any imported *namespaces*. Values in global space remain until you explicitly erase them or until you quit Python.

Heap Space. Heap space is the area of memory that stores *objects* (e.g. folders). Objects in heap space remain until you explicitly erase them or until you quit Python. You cannot access heap space directly. You access objects with variables in global space or in a call frame that contain the name of the object in heap space.

Implementation. The implementation of a collection of Python code (either a module or a *class*) are the details that are unimportant to other users of this module or class. It includes the bodies of all functions or methods, as well as all hidden attributes and functions or methods. These can be changed at any time, as long as they agree with the specifications and invariants present in the *interface*.

Inheritance. Inheritance is the process by which an object can have a method or attribute even if that method or attribute was not explicitly mentioned in the class definition. If the class is a subclass, then any method or attribute is *inherited* from the superclass.

Interface. The interface of a collection of Python code (either a module or a *class*) is the information that another user needs to know to use that module or class. It includes the list of all class names, the list of all unhidden attributes and their invariants, and the list of all unhidden functions/methods and their specifications. It does not include the body of any function or method, and any attributes that are hidden. The interface is the hardest part of your program to make changes to, because other people rely on it in order for their code to work correctly.

Invariant. An *invariant* is a property on a attribute that must always be true. It can be a type of precondition, that prevents certain types of values from being assigned to it. It can also be a relationship between multiple attributes, requiring that when one attribute is altered, the other attributes must be altered to match.

is. The `is` operator works like == except that it compares folder names, not contents. The meaning of the operator `is` can never be changed. This is different from `==`, whose meaning is determined by the special operator method `__eq__`. If `==` is used on an object that does not have a definition for method `__eq__`, then `==` and `is` are the same.

Method. Methods are functions that are stored inside of an *object*. They are define just like a function is defined, except that they are (indented) inside-of a class defintion.

Example method `toSeconds()`:

```
class Time(object):
    # class with attributes minutes, hours def toSeconds(self):
        return 60*self.hours+self.minutes
```

Methods are called by placing the object variable and a dot before the function name. The object before the dot is passed to the method definition as the argument `self`. Hence all method definitions *must have at least one parameter.*

Example: If `t` is a time object, then we call the method defined above with the syntax `t.toSeconds()`. The object `t` is passed to `self`.

Object. An object is a value whose type is a *class*. Objects typically contain *attributes*, which are variables inside of the object which can potentially be modified. In addition, objects often have *methods*, which are functions that are stored inside of the object.

Operator Overloading. Operator overloading is the means by which Python evaluates the various operator symbols, such as +, *, /, and the like. The name refers to the fact that an operator can have many different "meanings" and the correct meaning depends on the type of the objects involved.

In this case, Python looks at the class or type of the object on the left. If it is a built-in type, it uses the built-in meaning for that type. Otherwise, it looks for the associated special method (beginning and ending with double underscores) in the class definition.

Overriding a Method. In a subclass, one can redefine a method that was defined in a superclass. This is called *overriding* the method. In general, the overriding method is called. To call an overridden method `method` of the superclass, use the notation

```
super(<classname>,self).method(...)
```

where `<classname>` is the name of the current class (e.g. the subclass).

Property. A property is a special type of attribute. It is a pair of a getter and a setter, together with a field. A property **must have an associated field** to work correctly, as the field is where it stores its value. The getter and setter are special methods that enforce the invariants for the property.

The getter and setter are each a method with the same name as the property. Python needs a *decorator* before the method to know it is the getter or setter. The decorator before a getter is `@property`. The decorator before a setter is `@<property-name>.setter`. The setter needs the property name its decorator because it is optional (the getter is not), and Python has to know which getter to associate it with.

Example property `red` in `RGB`:

```
class RGB(object):
    _red = 0

    @property # getter
    def red(self):
        return self._red


    @red.setter # setter
    def red(self,value):
        self._red = value
```

In this example, `_red` is the (hidden) field associated with this property.

Subclass. A subclass D is a class that extends another class C. This means that an instance of D inherits (has) all the attributes and methods that an instance of C has, in addition to the ones declared in D. In Python, every user-defined class must extend some other class. If you do not explicitly wish to extend another class, you should extend the built-in class called `object` (not to be confused with an object, which is an instance of a class). The built-in class `object` provides all of the special methods that begin and end with double underscores.

Try-Except Statement (Limited). A limited try-except statement is a try-except that only recovers for certain types of errors. It has the form

```
try:
    <statements>
except <error-class>:
    <statements>
```

Python executes all of the statements underneath `try`. If there is no error, then Python does nothing and skips over all the statements underneath `except`. However, if Python crashes while inside the `try` portion, it checks to see if the error object generated has class `<error-class>`. If so, it jumps over to `except`, where it executes all the statements underneath there. Otherwise, the error propagates up the call stack where it might recover in another `except` statement or not at all.

Example:

```
try:
    print 'A'
    x = 1/0 print 'B'
except ZeroDivisionError:
    print 'C'
```

This code prints out `'A'`, but crashes when it divides 1/0. It skips over the remainder of the try (so it does **not** print out `'B'`). Since the error is indeed a `ZeroDivisionError`, it jumps to the except and prints out `'C'`.

Suppose, on the other hand, the try-except had been

```
try:
    print 'A'
    x = 1/0 print 'B'
except AssertionError:
    print 'C'
```

In this case, the code prints out `'A'`, but crashes when it divides 1/0 and does not recover.