CS 1110 Prelim 2 Solutions, April 2024

1. [8 points] **Iteration and lists.** It's election time! Every vote counts, but let's make *some* votes count more than others. Implement the following function, making effective use of for-loops.

```
def amplify_my_vote(ballots, chosen):
    """    Modifies the list `ballots` as follows:
    Every vote for the `chosen` candidate is added a second time
    to the end of the ballot list.

    Note: the votes should not be considered case sensitive. If the
    chosen candidate is "Matt", the function SHOULD double votes
    for "MATT" "matt" "MAtt"...  with their original cases.

    This function does not return anything.

    Examples:

    amplify_my_vote(["Ada", "Bob", "Caz", "Deb"], "Ada")
            ballots becomes ["Ada", "Bob", "Caz", "Deb", "Ada"]

    amplify_my_vote(["ada", "bob", "ADA", "deb"], "Ada")
            ballots becomes ["ada", "bob", "ADA", "deb", "ada", "ADA"]

    amplify_my_vote(["Leo", "Mik", "Leo"], "")
            ballots becomes/remains ["Leo", "Mik", "Leo"]

    amplify_my_vote([], "Ada")
            ballots becomes/remains []

    Preconditions:
       ballots: a (possibly empty) list of str
       chosen: a (possibly empty) str                    """

    # Solution #1: add them directly (note: must use indicies!)
    for i in range(len(ballots)):
        if ballots[i].lower() == chosen.lower():
            ballots.append(ballots[i])

    # Solution #2: add them afterwards (note: can loop thru elements)
    adds = []
    for s in ballots:
        if s.lower() == chosen.lower():
            adds.append(s)
    for a in adds:
        ballots.append(a)
```

2. [14 points] **Dictionaries.** Implement this function according to its specification:

```
def get_mapping(word1, word2):
    """
    Returns the dictionary that contains the mapping that would turn
    `word1` into `word2` or None if no such mapping exists (meaning no
    1-for-1 character replacement can produce `word2` from `word1`)

    In this dictionary, the key is the character from `word1` and
    the value is the character it should be replaced with in order
    to produce `word2`

    A character may be replaced by itself ('love'->'love').
    More than 1 character may be replaced by the same character ('rap'->'ooo')
    One character may NOT be replaced by multiple characters ('moo'->'mop')

    Examples:

    word1: 'love'   , word2: 'love'
          the function returns {'l':'l','o':'o','v':'v','e':'e'}

    word1: 'book'   , word2: 'seem'
          the function returns {'b':'s', 'o':'e', 'k':'m'}

    word1: 'sassy'  ,  word2: 'daddy'
          the function returns {'s':'d', 'a':'a', 'y':'y'}

    word1: 'rap'    ,  word2: 'ooo'
          the function returns {'r':'o','a':'o','p':'o'}

    word1: ''       ,  word2: ''
          the function returns {}

    word1: 'lovely' ,  word2: 'lo'
          the function returns None

    word1: 'moo'    ,  word2: 'mop'
          the function returns None

    Precondition:  `word1` and `word2` are (possibly empty) strings
                   of exclusively lower case letters a-z

    """
```

Please implement your function on the next page!

```
def get_mapping(word1, word2):

    if len(word1) != len(word2):
        return None

    mapping = {}

    for i in range(len(word1)):
        c1 = word1[i]
        c2 = word2[i]
        if c1 in mapping:
            c_new = mapping[c1]
            if c2 != c_new:
                return None
        else:
            mapping[c1] = c2
    return mapping
```

3. [14 points] **Recursion.** Imagine that we are representing Python modules Python classes. Let `Module` be a class whose objects have the following two attributes:

```
name    [str] - unique non-empty name of module
imps    [possibly empty list of Module] - modules that need to be
        imported in order for this module to work correctly
```

Implement the following **function** (*not* an object method), making effective use of recursion. For-loops are allowed as long as your solution is fundamentally recursive.

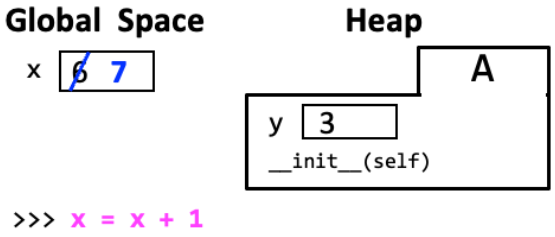
```
def depends_on(mod, target):
    """Returns: True if Module `mod` depends on a Module named `target`
                False otherwise

    Directly, a Module depends on itself and its imports. Indirectly, a
    Module also depends on all of the Modules that its imports depend on.
    So if A imports B, and B imports C, then A depends on C.

    Parameter `mod` : the Module we're interested in
    Precondition: `mod` is a Module object

    Parameter `target` : name of the Module we want to know if `mod` depends on
    Precondition: `target` is a str

    ------   Here is a simplified example from A6 ------
    m1 = Module("math",[])           # imports nothing
    m2 = Module("consts",[])         # imports nothing
    m3 = Module("cnlasserts", [m1])  # imports math
    m4 = Module("player", [m2, m3])  # imports consts, cnlasserts

    depends_on(m1, "math")  Returns True  (math depends on itself)
    depends_on(m2, "math")  Returns False (consts imports nothing)
    depends_on(m3, "math")  Returns True  (cnlasserts imports math)
    depends_on(m4, "math")  Returns True  (player depends on math (via cnlasserts))

    """
```

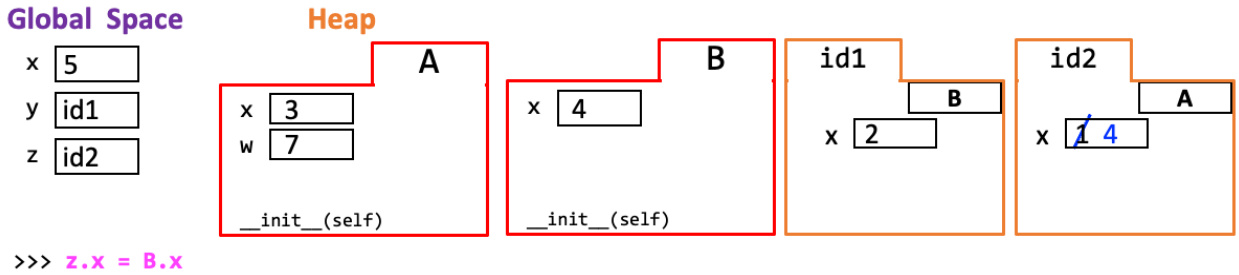
Please implement your function on the next page!

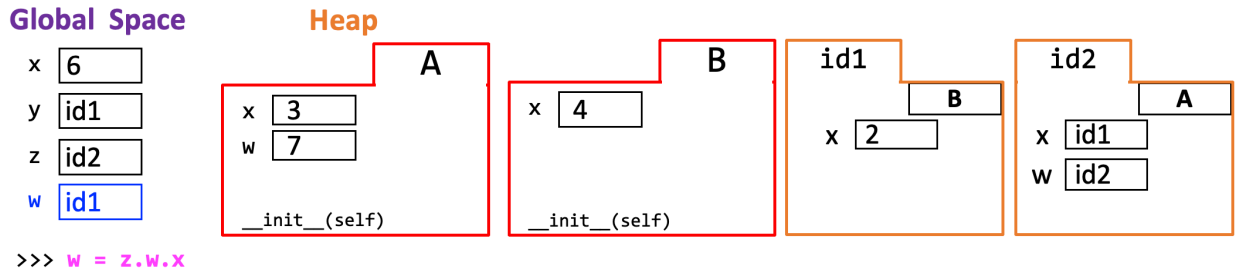
```
def depends_on(mod, target):

    if (mod.name == target):
        return True

    for i in mod.imps:
        if depends_on(i, target):
            return True
    return False
```

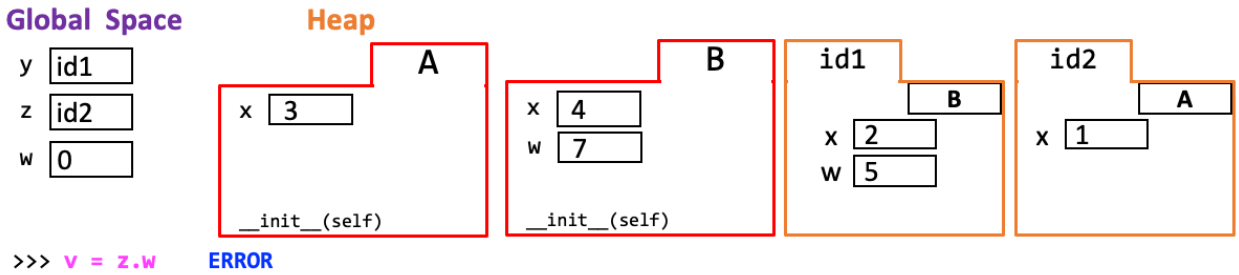
4. [8 points] **Visualizing Python.** For this question, you will be shown the state of memory before a single assignment statement is executed. Modify the drawing to show how memory changes after that single assignment statement has been executed. If at any point an error is thrown, please write **ERROR** next to the assignment statement; only draw the changes to memory that would occur before the error occurs. Each part is independent.

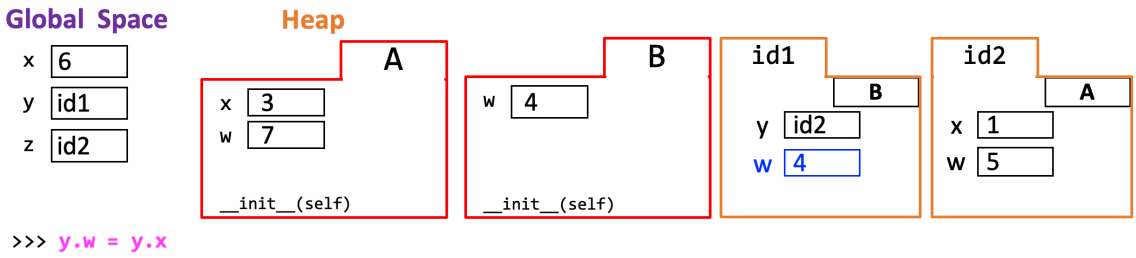
Notice: there is no Call Stack.
(The assignment statements are not inside functions or methods.)
To the right is an example. The statement to execute is shown in **pink** and the answer is shown in **blue**.



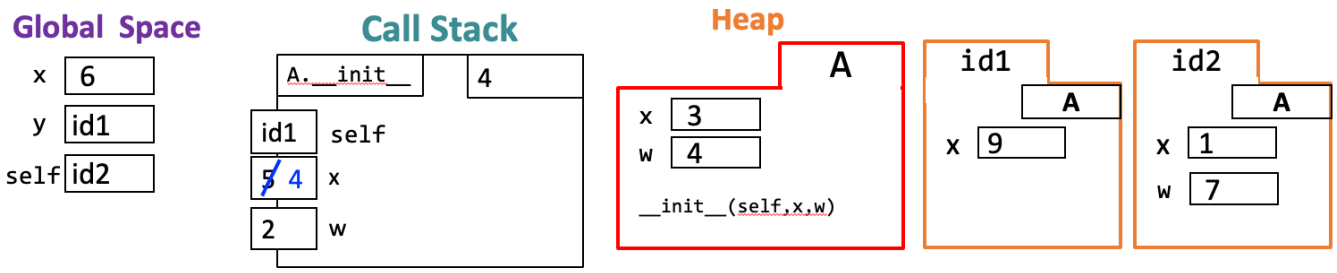


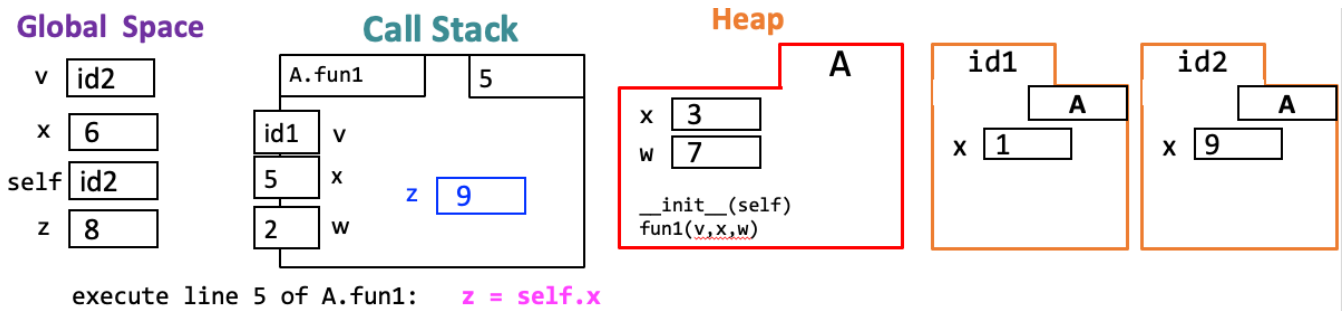


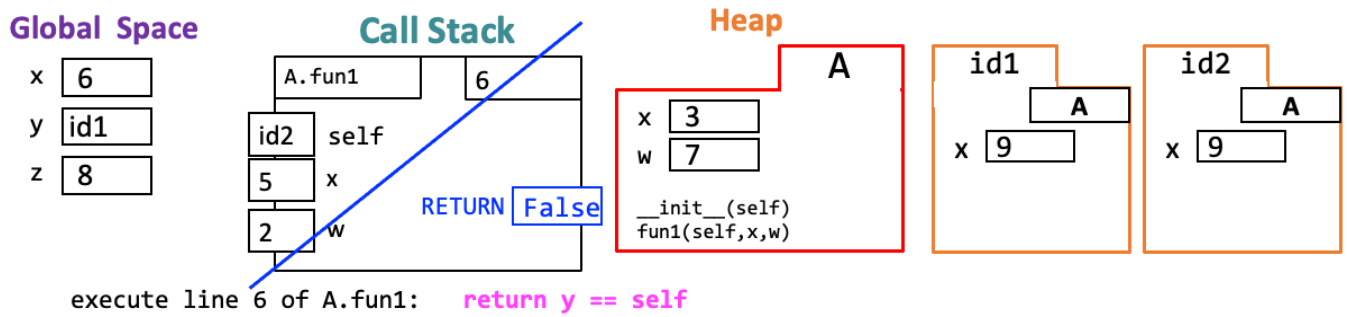


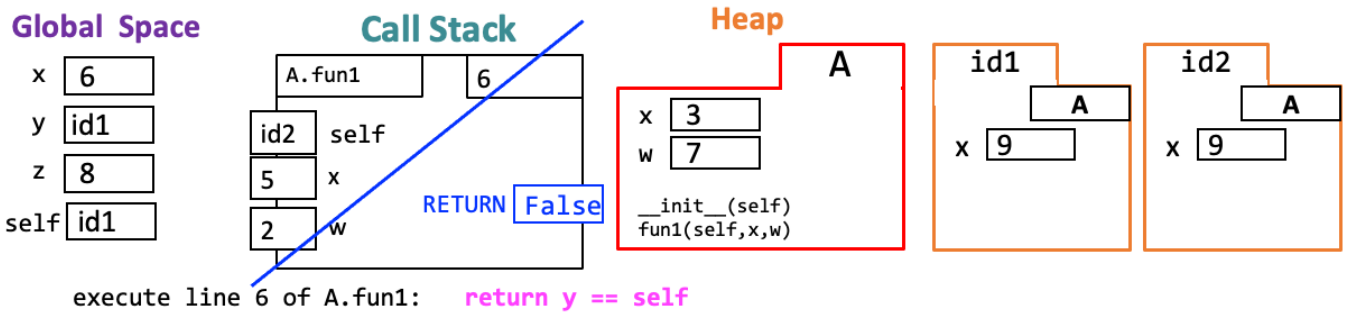


5. [8 points] **Visualizing Methods.** For this question, you will be shown the state of memory before a single Python statement is executed. Modify the drawing to show how memory changes after that single statement has been executed. If at any point an error is thrown, please write **ERROR** next to the assignment statement; only draw the changes to memory that would occur before the error occurs. Do not worry about changing the Program Counter in the top right corner of the call frame. (Since we are not showing you the code, you can't know what the next line of executable code will be). Once again, each part is independent. Notice that there is a call stack: each line being executed exists inside a method.






Global Space
x 6
y id1
z 8
Call Stack
A.fun1
6
id2 self
5 x
2 w
RETURN False
Heap
A
x 3
w 7
__init__(self)
fun1(self,x,w)
id1
A
x 9
id2
A
x 9
execute line 6 of A.fun1: return y == self


Global Space
x 6
y id1
z 8
self id1
Call Stack
A.fun1
6
id2 self
5 x
2 w
RETURN False
Heap
A
x 3
w 7
__init__(self)
fun1(self,x,w)
id1
A
x 9
id2
A
x 9
execute line 6 of A.fun1: return y == self

6. **Classes.** Consider the following class, defined as follows:

```
class SandwichOrder:
    """A class to represent a sandwich order

    3 Class Attributes:
        total_orders:  [int] the total number of sandwich orders
        total_revenue: [float] total revenue from all sandwich orders
        PRICES:        [dict] prices of 'bread', 'protein', 'cheese', 'topping'

    6 Instance Attributes:
        name:        [str] name of the customer, for example 'Luke Calka'
        bread:       [str] name of the bread, for example 'Wheat'
        protein:     [str] name of the protein, for example 'Ham',
                       empty string ('') indicates no protein on the sandwich
        with_cheese: [bool] True if the Sandwich should have cheese on it
        toppings:    [list of str without duplicates]
        price:       [float] should ALWAYS represent the price of this sandwich
    """

    # Class Attributes
    # These should ALWAYS accurately reflect the state of all orders made
    total_orders = 0               # the number of sandwich orders
    total_revenue = 0.0            # the total prices across all orders


    PRICES = {'bread': 2.00, 'protein': 4.00, 'cheese': 1.50, 'topping': 0.50}
             # PRICES are by category:
             #              all proteins cost $4
             #              each topping costs $0.50
             #              ... and so forth
```

(a) [8 points] Implement this method of `SandwichOrder` according to its specification:

```
def calculate_price(self):
    """
    Calculates the price of the sandwich order based on the PRICES of
    bread, protein, cheese, and toppings.

    The price should be assigned to the object's `price` attribute.
    Returns: Nothing!

    Example:
       If sandwich order has wheat bread, turkey protein, cheese,
          and 3 toppings: lettuce, tomato and mayo
    price would be: 2.00 (bread) + 4.00 (protein) + 1.50 (cheese) +
    + 0.50 (topping) + 0.50 (topping) + 0.50 (topping) = $9.00

    Precondition: the identifier self is an initialized SandwichOrder with
       attributes name, bread, protein, with_cheese, and toppings
    """
    self.price = SandwichOrder.PRICES['bread']
    if self.protein != "":
        self.price += SandwichOrder.PRICES['protein']
    if self.with_cheese:
        self.price += SandwichOrder.PRICES['cheese']
    self.price += (len(self.toppings) * SandwichOrder.PRICES['topping'])

    # alternate price calculation, using a for loop:
    #
    # for topping in self.toppings:
    #     self.price += SandwichOrder.PRICES['topping']
```

(b) [12 points] Implement the `__init__` method of `SandwichOrder` according to its specification. Avoid redundancies between your code here and the previous page.

```
def __init__(self, name, bread, protein, cheese, tops=None):
    """
    Initializes a new instance of a SandwichOrder with given parameters.
    Calculates initial price of the sandwich.
    Also updates relevant Class Attributes as necessary.

    Example calls:
    s1 = SandwichOrder('John Wick', 'Wheat', '', True, ['Pickles', 'Mayo'])
    s2 = SandwichOrder('Max Rockatansky', 'Sourdough', 'Chicken', False)

    parameters name, bread, protein, and cheese can all be assigned to
    their respective instance attributes (see class specification)

    toppings: should be assigned the empty list [] if no list is provided
                (i.e., `tops` has the default value None)
              should be assigned the list id `tops` if a list IS supplied as
                an argument (do not create a new list)

    Preconditions: name: non-empty str
                   bread: non-empty str
                   protein: (possibly empty) str
                   cheese: bool, False means no cheese please
                   tops: None or [list of str] of chosen toppings
                         items in tops are guaranteed to be unique
    """

    self.name = name
    self.bread = bread
    self.protein = protein
    self.with_cheese = cheese
    self.toppings = tops
    if tops is None:
        self.toppings = []
    self.calculate_price()
    SandwichOrder.total_orders += 1
    SandwichOrder.total_revenue += self.price
```

7. [10 points] **Debugging.** Consider the following two classes and 3 lines of code that use them:

```
class Engine:
    """    A class to represent an engine.

    2 Instance Attributes:
    max_time,   INVARIANT: non-empty str of digits, example: '1000'
    curr_usage, INVARIANT: int >= 0
    """
    # Attributes can be changed, but the INVARIANTS must always be satisfied.
    # Example: curr_usage should never go negative or become a float.
    def __init__(self, maxi):
        """
        Initializes: the Engine with the given maximum time.
                     the current usage to zero.

        Precondition: maxi: a str, a positive number ending in 'h', like '25h'
        """
        self.max_time = maxi.replace('h', '')
        self.curr_usage = 0

class Airplane:
    """    A class to represent an airplane with some number of engines
    Instance Attribute `engines`: a (possibly empty) list of Engine
    """
    def __init__(self, engines):
        """  Initializes: the Airpline with the given engine list """
        self.engines = engines

    def use_engine(Engine, engine, hour):
        """ Increases `engine`'s current usage by `hour`
        Preconditions: engine is a int, 0 <= engine < len(self.engines)
                       hour is a int >= 0                              """
        Engine.engines[engine].curr_usage += Engine.engines[engine].hour


    def needs_service(self):
        """   True if any engine's usage reaches its max.   """
        i = 0
        while i < len(self.engines):
            eng = self.engines[i]
            if eng.curr_usage >= eng.max_time:
                return True
            i = i + 1
            return False

a = Airplane([Engine('2500h'), Engine('2500h')])
a.use_engine(0, 100)
print(a.needs_service())
```

When the given code is run in Python, the following error is reported:

```
Traceback (most recent call last):
  File "airplane.py", line 46, in <module>
    a.use_engine(0, 100)
  File "airplane.py", line 32, in use_engine
    Engine.engines[engine].curr_usage += Engine.engines[engine].hour
AttributeError: 'Engine' object has no attribute 'hour'
```

(a) Fix the code so that the line of code throwing the above error can successfully execute. **Fix only the code that is responsible for throwing the error.** Mark your fix(es) with the label **FIX1**.

FIX1: `Engine.engines[engine].curr_usage += ~~Engine.engines[engine].~~hour`

Note: the fact that the first parameter is called 'Engine' is weird but it does not affect correctness and should not be changed.

(b) You fix the above error and rerun the code. Now a new error is reported:

```
Traceback (most recent call last):
  File "airplane.py", line 47, in <module>
    print(a.needs_service())
  File "airplane.py", line 40, in needs_service
    if eng.curr_usage >= eng.max_time:
TypeError: '>=' not supported between instances of 'int' and 'str'
```

Fix the code to remove only this new error. **Fix only the code that is responsible for throwing the error. Pay attention to the invariants that must remain satisfied.** Mark your fix(es) with the label **FIX2**.

Line 40 should cast `eng.max_time` to be an int like so: `int(eng.max_time)`

(c) Now that you've dealt with these errors, let's address the functionality of one last method. The `needs_service` method should return `True` if at least one engine's `curr_usage` is greater than or equal to its `max_time`, otherwise return `False`. When we run the above code (after fixing parts (a) and (b)), it prints `False`. Is there a bug in the `needs_service` method?

Circle One: Yes No

There is a bug!

If you answered Yes, fix the bug and mark your fix(es) with the label **FIX3**. If you answered No, provide a test (like lines 45-47) that when run, will correctly print `True`.

The `return False` on line 43 needs to be un-indented. Currently the while loop only checks engine 0 and then returns.