CS 88
Fall 2021

Computational Structures in Data Science

Midterm SOLUTIONS

INSTRUCTIONS

This is your exam. Complete it either at exam.cs61a.org or, if that doesn't work, by emailing course staff with your solutions before the exam deadline.

This exam is intended for the student with email address `<EMAILADDRESS>`. If this is not your email address, notify course staff immediately, as each exam is different. Do not distribute this exam PDF even after the exam ends, as some students may be taking the exam in a different time zone.

For questions with **circular bubbles**, you should select exactly *one* choice.

○ You must choose either this option

○ Or this one, but not both!

For questions with **square checkboxes**, you may select *multiple* choices.

□ You could select this choice.

□ You could select this one too!

You may start your exam now. Your exam is due at <DEADLINE> Pacific Time. Go to the next page to begin.

- **Online Exams: You may start you exam as soon as you are given the password.**
- **You may have a digitial version of the CS88 Reference Sheet, or the PDF, but no other files.**
- Open Reference Sheet

1. **(5.0 points) WWPD**

For each of the expressions in the table below, write the output displayed by the interactive Python interpreter when the expression is evaluated. The output may have multiple lines. If an error occurs, write "Error". If a function is outputted, write "function". Your answers must fit within the boxes provided. Work outside the boxes will not be graded.

(a) (1.0 pt)

```
>>> False or 1 and 8 or True
```

```
8
```

(b) (2.0 pt)

```
>>> lucky = (lambda x: lambda y: (y - x) % 8 == 0)(8)

>>> def mystery(x, y):
...     if lucky(x):
...         print('ready')
...     while x > y:
...         x = x // 10
...         print(x)
...     return 'go'

>>> mystery(40, 2)
```

```
ready
4
0
'go'
```

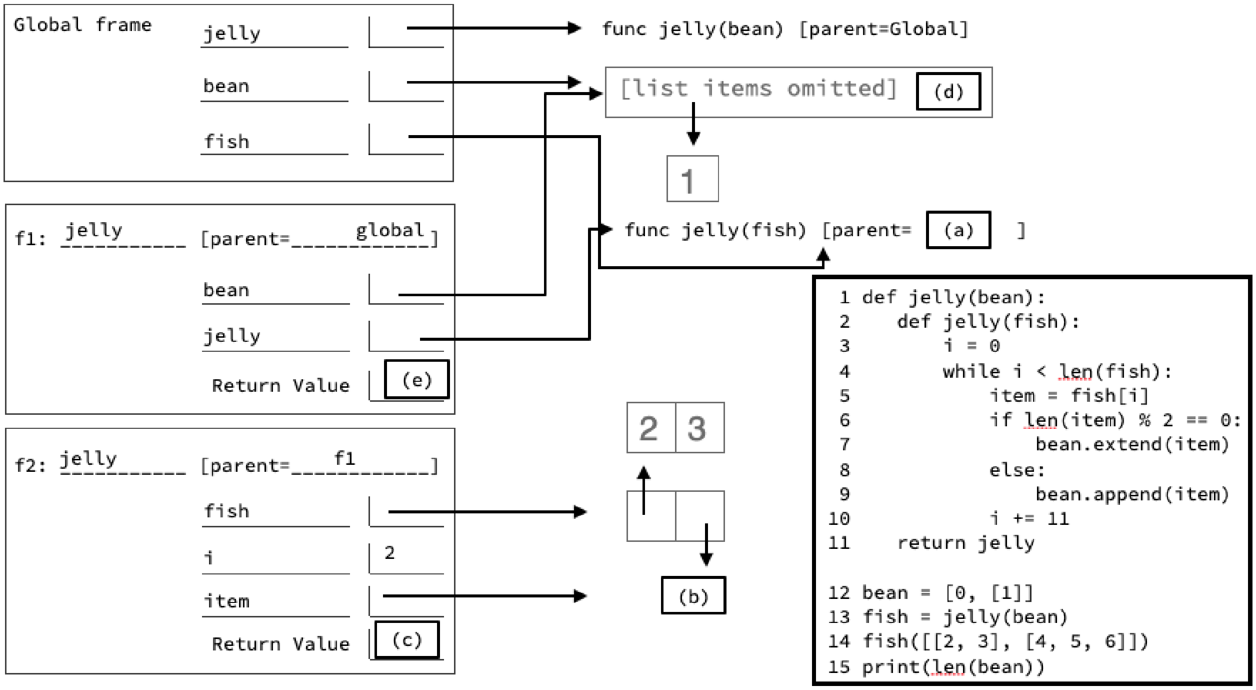
(c) (2.0 pt) Note the variable `lucky` and the `mystery` function are redefined here for your convenience.

```
>>> lucky = (lambda x: lambda y: (y - x) % 8 == 0)(8)

>>> def mystery(x, y):
...     if lucky(x):
...         print('ready')
...     while x > y:
...         x = x // 10
...         print(x)
...     return 'go'

>>> print('a', mystery(7, 9))
```

```
a go
```

2. (7.0 points) Environment Diagram Analysis

Fill in the blanks to complete the environment diagram. All the code used is in the box to the right. *Some arrows have been removed from the diagram.* You may wish to draw in the arrows, but it is not required.



```
 1 def jelly(bean):
 2     def jelly(fish):
 3         i = 0
 4         while i < len(fish):
 5             item = fish[i]
 6             if len(item) % 2 == 0:
 7                 bean.extend(item)
 8             else:
 9                 bean.append(item)
10             i += 11
11     return jelly

12 bean = [0, [1]]
13 fish = jelly(bean)
14 fish([[2, 3], [4, 5, 6]])
15 print(len(bean))
```

Question 2 Environment Diagram

(a) (1.0 pt) (a) What is the parent frame of the `jelly` function on line 2?

f1

(b) (1.0 pt) (b) What is the final value of `item` in the `f2` frame when the environment diagram is complete?

`[4, 5, 6]`

(c) (1.0 pt) (c) What is the return value of the `f2` frame?

None

(d) (2.0 pt) (d) For the variable `bean` in the `f1` frame, what is `bean[4]` when the environment diagram is complete?

`[4, 5, 6]`

(e) (1.0 pt) (e) What is the return value of frame `f1`?

func jelly(fish) [parent=f1]

(f) (1.0 pt) Line 15 What is `len(bean)` in the global frame?

5

3. (5.0 points) Just Keep Summing

Implement the function `sum_until`, which takes in an integer `total`, and returns a one-argument function, `add_num`. The `add_num` function keeps accepting integers until the sum of all the integers it has accepted reaches or exceeds the total, in which case it returns `True` or `False` respectively.

The expected behavior of the function is detailed in the doctests below.

```
def sum_until(total):
    """
    >>> f = sum_until(0)
    >>> f(0) # 0 = 0
    True
    >>> f(-7) # -7 < 0, so continue to accept more numbers
    <function sum_until.<locals>.add_num at ....>
    >>> f(-7)(5)(2) # -7 + 5 + 2 = 0
    True
    >>> f(-7)(5)(8) # -7 + 5 + 8 = 6 > 0
    False
    >>> g = sum_until(-5)
    >>> g(-6)(3) # -6 + 3 = -3 > -5
    False
    >>> g(-11)(-2)(-2)(4)(6) # -11 + -2 + -2 + 4 + 6 = -5
    True
    """
    def add_num(x):
        if x > total:
              return _____________Part A________________
        elif _____________Part B________________:
            return _____________Part C________________
        return sum_until(_____________Part D________________)
    return add_num
```

(a) (1.0 pt) Fill in the code for Part A.

```
False
```

(b) (1.0 pt) Fill in the code for Part B.

```
x == total
```

(c) (1.0 pt) Fill in the code for Part C.

```
True
```

(d) (2.0 pt) Fill in the code for Part D.

```
total - x
```

4. (7.0 points) Flip Flop

Implement the `flip_flop` function which takes in a non negative number `n` and computes the value generated when alternating between adding then subtracting each of the digits in `n` from left to right.

You may use the `get_length` function that takes in an integer `n` and returns the number of digits in `n`. This function's implementation is hidden, but you can assume it works correctly.

```
def get_length(n):
    """
    Helper function that computes the number of digits in an
    integer.
    >>> get_length(7)
    1
    >>> get_length(123)
    3
    >>> get_length(454545)
    6
    """
    # Implementation hidden

def flip_flop(n):
    """
    >>> flip_flop(124) # 1 + 2 - 4
    -1
    >>> flip_flop(7315) # 7 + 3 - 1 + 5
    14
    >>> flip_flop(61323) # 6 + 1 - 3 + 2 - 3
    3
    """
    if ____________________________________:
        ____________________________________
    else:
        last_digit = ____________________________________
        if ____________________________________:
            return ____________________________________
        else:
            return ____________________________________
```

(a) (7.0 pt) Write the fully *completed* `flip_flop` function below using the skeleton code provided. You may not add, change, or delete lines from the skeleton code.

Don't forget to use the helper function `get_length(n)`.

```
def flip_flop(n):
   if n < 10:
      return n
   else:
      last_digit = n % 10
      if get_length(n) % 2 == 0:
         return flip_flop(n // 10) + last_digit
      else:
         return flip_flop(n // 10) - last_digit
```

5. (8.0 points) Cra88y Crawl

You are working at an amusement park this summer and are in charge of the Cra88y Crawl ride! Complete the following questions to collect information that can improve visitors' experience on this ride!

The line of visitors is represented as a list of two element tuples.

- The first element in the tuple is the time when the visitor joined the line.
- The second element is the amount of time the visitor is expected to wait to begin their ride. Time is represented as the number of minutes elapsed since the amusement park opened for that day.

For example, the tuple `(80, 40)` represents that a visitor joined at the 80th minute and is expected to wait in line for 40 minutes.

(a) (3.0 pt) Complete the return statement for the `expected_start_times` function that, given a line, returns a list of the times (represented in minutes) at which every visitor is expected to start their ride!

```
def expected_start_times(line):
    """
    >>> expected_start_times([(80, 40), (105, 20)])
    [120, 125]
    >>> expected_start_times([(5, 15), (8, 12), (14, 6), (222, 3)])
    [20, 20, 20, 225]
    >>> expected_start_times([(4, 6), (5, 5), (5, 5), (6, 15), (100,
    20), (150, 0)])
    [10, 10, 10, 21, 120, 150]
    """
    return ______________________________________________
```

```
[visitor[0] + visitor[1] for visitor in line]
```

(b) **(5.0 pt)** Implement the `remove_frustrated_visitors` function that removes the tuples corresponding to visitors who are expected to wait more than `max_wait_time` minutes in line.

```
def remove_frustrated_visitors(line, max_wait_time):
    """
    >>> line_a = [(80, 40), (105, 20)] # format per tuple: (join time, expected wait time)
    >>> remove_frustrated_visitors(line_a, 15)
    >>> line_a
    []
    >>> line_b = [(5, 15), (8, 12), (14, 6), (222, 3)]
    >>> remove_frustrated_visitors(line_b, 10)
    >>> line_b
    [(14, 6), (222, 3)]
    >>> line_c = [(4, 6), (5, 5), (5, 5), (6, 15), (100, 20), (150, 0)]
    >>> remove_frustrated_visitors(line_c, 5)
    >>> line_c
    [(5, 5), (5, 5), (150, 0)]
    """
    position = 0
    while position < len(line):
        if ____________________________________:
            ____________________________________
        else:
            ____________________________________
```

Fill in the solution in the spce provided. You should not need to add or remove lines.

```
def remove_frustrated_vistiors(line, max_wait_time):
    position = 0
    while position < len(line):
        if line[position][1] > max_wait_time:
            line.pop(position)
        else:
            position += 1
```

6. (7.0 points) Chef's Assistant

You are a chef managing orders for your restaurant! Every order consists of a food item and its quantity.

Implement the function `add_new_orders` which takes in a dictionary `all_orders` representing the orders a chef is currently assigned, and mutates it to include new orders from the list `new_orders`. Each element in `new_orders` is a tuple, where the first element is the food item and the second element is that item's quantity.

```
def add_new_orders(all_orders, new_orders):
    """
    >>> order = {'fries': 3, 'burger': 4}
    >>> add_new_orders(order, [('fries', 4), ('milk', 2)])
    >>> order == {'fries': 7, 'burger': 4, 'milk': 2}
    True
    >>> add_new_orders(order, [('fries', 2), ('taco', 1)])
    >>> order == {'fries': 9, 'burger': 4, 'milk': 2, 'taco': 1}
    True
    """
    if ________________________________________:
        return
    food_item = new_orders[0][0]
    quantity = new_orders[0][1]
    if ________________________________________:
        ________________________________________
    else:
        ________________________________________
    add_new_orders(_________________________, _________________________)
```

(a) (7.0 pt) Complete the skeleton code. You may not add, change, or delete lines from the skeleton code.

```
def add_new_orders(all_orders, new_orders):
    if len(new_orders) == 0:
        return
    item = new_orders[0][0]
    quantity = new_orders[0][1]
    if item in all_orders:
        all_orders[item] += quantity
    else:
        all_orders[item] = quantity
    add_new_orders(all_orders, new_orders[1:])
```

7. (6.0 points) Smoooooooooth

Your friend is trying to implement a function `smooth` which takes in a list of integers, `lst`, and returns a ***smooth*** version of the list, where smoothing a list means connecting each of the adjacent integers in the old list with consecutive integers.

For example, the smoothed version of `[1, 5, 3]` is `[1, 2, 3, 4, 5, 4, 3]`, and the smoothed version of `[1, 3, 4, 6]` is `[1, 2, 3, 4, 5, 6]`. There is guaranteed to be at least one number in the list and there will not be identical numbers consecutively, so `[1, 1, 1, 1]` is an invalid input. Your friend's code has 3 bugs which you need to find!

```
1. def smooth(lst):
2.     new_lst = []
3.     for i in range(len(lst) - 1):
4.         curr = lst[i]
5.         next = lst[i + 1]
6.         while curr != next:
7.             new_lst + [curr]
8.             if curr > next:
9.                 curr += 1
10.             else:
11.                 curr -= 1
12.     return new_lst
```

In each box: Identify *one* of the 3 unique bugs and explain how to fix each bug. You must specify the line number you would change or delete, or between which lines you would add a new line of code.

(a) (2.0 pt)

Line 7 should be `new_lst.append(curr)`

(b) (2.0 pt)

Line 8 should be `if curr < next:`

(c) (2.0 pt)

Line 12, insert before: `new_lst.append(lst[-1])`.

8. (10.0 points) Overlap

You are working on representing users on a new messaging app called Overlap, which focuses on users' interests as a way to connect them! Every `User` has a name, a list of interests, and a list of followers!

Implement the following functions of the `User` class based on the descriptions below. For a given `User`, `a_user`, we should be able to execute:

- `a_user.add_follower(other_user)`: Takes in another User object `other_user` and adds it to this user's followers list if they are not already in the list
- `a_user.mutual_interests(other_user)`: Takes in another User object `other_user` and returns a list containing all of this user's interests that are shared with `other_user`
- `a_user.find_new_interest()`: Returns a string representing a new interest for this User. To determine this new interest, first identify this user's follower that has the largest number of mutual interests with this user. Then return a randomly selected interest from this follower. But be careful, this randomly selected interest must not already exist in this user's interests (otherwise it would not be new!). Assume that the user's interests and followers are non-empty.

```
import random

class User:
    def __init__(self, name, interests=[]):
        self.name = name
        self.interests = interests
        self.followers = []

    def add_follower(self, other_user):
        """ Part A """

    def mutual_interests(self, other_user):
        """ Part B """

    def separate_interests(self, other_user):
        """ Implementation not shown. Assume that this function takes in
        another User object and returns a list containing all
        of this user’s interests that are NOT shared with other_user"""

    def find_new_interest(self):
        """ Part C """
```

(a) i. **(3.0 pt)** Implement the `add_follower` method which takes in another `User` object, `other_user`, and adds that user to this user's followers list if they are not already in the list.

```
def add_follower(self, other_user):
    """
    >>> u1 = User('bob', ['cooking', 'archery', 'tv'])
    >>> u2 = User('alice', ['shopping', 'guitar', 'cooking'])
    >>> u3 = User('mike', ['poker', 'tv', 'cooking'])
    >>> u1.add_follower(u2)
    >>> u1.add_follower(u3)
    >>> u1.add_follower(u2) # no change
    >>> [u.name for u in u1.followers]
    ['alice', 'mike']
    """
    if ______________________________________________:
        ______________________________________________
```

Write the fully `add_follower` function below using the skeleton code provided. You may not add, change, or delete lines from the skeleton.

```
def add_follower(self, follower):
    if follower not in self.followers:
        self.followers.append(follower)
```

(b) **i.** **(3.0 pt)** Implement the `mutual_interests` method which takes in another `User` object, `other_user`, and returns a list containing all of this user's interests that are shared with `other_user`. (Again, there is *no need* to copy the doctests.)

```
def mutual_interests(self, other_user):
    """
    >>> u1 = User('bob', ['cooking', 'archery', 'tv'])
    >>> u2 = User('alice', ['shopping', 'guitar', 'cooking'])
    >>> u3 = User('mike', ['poker', 'tv', 'cooking'])
    >>> u1.mutual_interests(u2)
    ['cooking']
    >>> u1.mutual_interests(u3)
    ['cooking', 'tv']
    """
    return ____________________________________________
```

Complete the `return` statement of the `mutual_interests` function below.

```
def mutual_interests(self, other_user):
        return [i for i in self.interests if i in other_user.interests]
```

(c) **i.** **(4.0 pt)** Implement the `find_new_interest` method that returns a string representing a new potential interest for this `User`. To determine this new interest, first identify this user's most similar follower that has the largest number of mutual interests with this user. Then return a randomly selected interest from this follower. But be careful, this randomly selected interest must not already exist in this user's interests (otherwise it would not be new!).

For this problem, assume that the user's interests and followers are non-empty. Note that the `separate_interests` function (see `User` class skeleton) may be helpful here. You may use `random.choice(lst)` to return a radomly selected item from a list, `lst`.

```
def find_new_interest(self):
    """
    >>> u1 = User('bob', ['cooking', 'archery', 'tv'])
    >>> u2 = User('alice', ['shopping', 'guitar', 'cooking']) # has one in common with bob
    >>> u3 = User('mike', ['poker', 'tv', 'cooking']) # has two in common with bob
    >>> u1.add_follower(u2)
    >>> u1.add_follower(u3)
    >>> u1.find_new_interest()
    'poker'
    """
    most_similar_follower = max(
        _____________________________________,
        key = _______________________________________
    )
    return random.choice(_____________________________________________)
```

Write the fully *completed* `find_new_interest` function below using the skeleton code provided. You may not add, change, or delete lines from the skeleton code.

```
def find_new_interest(self):
    most_similar_follower =
        max(self.followers,
            key = lambda x: len(self.mutual_interests(x))
        )
    return random.choice(most_similar_follower.separate_interests(self))
```

No more questions.