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.
Preliminaries
You can complete and submit these questions before the exam starts.

(a) What is your full name?

(b) What is your student ID number?

(c) By writing my name below, I pledge on my honor that I will abide by the rules of this exam and will neither give nor receive assistance. I understand that doing otherwise would be a disservice to my classmates, dishonor me, and could result in me failing the class.
1. (8.0 points) Next Big Thing

(a) The following environment diagram was generated by a program:

In this series of questions, you’ll fill in the blanks of the program that follows so that its execution matches the environment diagram.

```python
def know(me):
    def who(you):
        light.___________ # (a)
        return light[-3]()
        light = [lambda: me, ___________] # (b)
        return light
    g = ___________ # (c)
g[1](1)
g.pop(___________) # (d)
```

In this series of questions, you’ll fill in the blanks of the program that follows so that its execution matches the environment diagram.
i. (2.0 pt) Which of these could fill in blank (a)? **Select all that apply!**
- □ `append([lambda: you])`
- □ `append(lambda you: you)`
- □ `append([lambda you: you])`
- □ `extend([lambda: you])`
- □ `extend([lambda you: you])`
- □ `append(lambda: 0)`
- □ `extend([lambda: 0])`
- □ `append(lambda: 1)`
- □ `extend([lambda: 1])`

ii. (2.0 pt) What line of code could go in blank (b)?

iii. (2.0 pt) Which of these could fill in blank (c)?
- ○ `know(0)`
- ○ `know(1)`
- ○ `know`
- ○ `[lambda: 0, lambda: 1]`
- ○ `[lambda: 1, lambda: 0]`
- ○ `[]`

iv. (2.0 pt) Which of these could fill in blank (d)? **Select all that apply!**
- □ `g[0]()`
- □ `g[1]()`
- □ `g[2]()`
- □ `g[3]()`
- □ `g[-1]()`
- □ `g[-2]()`
- □ `g[-3]()`
- □ `1`
- □ `0`
- □ `2`
2. (15.0 points) Linked Trees

(a) (7.0 points) Pruning

Definition: We call a tree shrinking if all of each node’s branches have fewer branches than the node itself.

Write a function `prune_shrinking_tree` which takes in a tree `t`. It should return a new tree which is shrinking, by pruning off the excess rightmost branches of each node. **Do not prune more than the required number.**

```python
def prune_shrinking_tree(t):
    ""
    >>> t1 = Tree(1, [Tree(2, [Tree(4), Tree(5), Tree(6)]), Tree(3)])
    >>> prune_shrinking_tree(t1)
    Tree(1, [Tree(2, [Tree(4)]), Tree(3)])
    >>> t1
    Tree(1, [Tree(2, [Tree(4), Tree(5), Tree(6)]), Tree(3)])
    >>> t2 = Tree(1, [Tree(2), Tree(3)])
    >>> prune_shrinking_tree(t2)
    Tree(1, [Tree(2), Tree(3)])
    >>> t3 = Tree(1, [Tree(2, [Tree(6, [Tree(8)], Tree(7)]), Tree(3), Tree(4), Tree(5)])
    >>> prune_shrinking_tree(t3)
    Tree(1, [Tree(2, [Tree(6, [Tree(8)], Tree(7)]), Tree(3), Tree(4), Tree(5)])
    ""
    def helper(t, k):
        if __________:  
            # (a)
            return ____________  
            # (b)
        else:
            prune_ct = ____________(___________, __________)  
            # (c) (d) (e)
            new_branches = [helper(b, prune_ct) for b in ___________]
            # (f)
            return ____________  
            # (g)
            return helper(t, len(t.branches) + 1)
```

i. Which of these could fill in blank (a)?

- t.is_leaf()
- t is Link.empty
- is_leaf(t)
- t.is_leaf
- len(t) == 0
- len(t) == 1
- t < 10
- t == ''
ii. What line of code could go in blank (b)?

iii. Which of these could fill in blank (c)?
- min
- max
- filter
- map
- sum

iv. Which of these could fill in blank (d)?
- k
- k - 1
- k + 1
- t.label
- t.label - 1
- t.label + 1

v. What line of code could go in blank (e)? You may not use min, max, filter, map, or sum in this line.

vi. Which of these could fill in blank (f)?
- t.branches[k+1:]
- t.branches[k-1:]
- t.branches[k:]
- t.branches[:k]
- t.branches[:k+1]
- t.branches[:k-1]

vii. What line of code could go in blank (g)? You may not use list slicing in for this blank.
(b) (2.0 points)  Linked Add

Implement a function `add_to_all` which takes in a linked list `s` and a number `x` and returns a new version of `s` with `x` added to each element.

Remember, you should not be mutating `s`!

You may not use the `map` function.

def add_to_all(s, x):
    
    >>> s = Link(3, Link(2, Link(5)))
    >>> print(add_to_all(s, 1))
    <4 3 6>
    >>> print(add_to_all(s, 0))
    <3 2 5>
    
    if ___________
    # (i)
    return s
    return Link(__________, __________)
    # (j)  (k)

i. What line of code could go in blank (i)?

ii. What line of code could go in blank (j)?

iii. What line of code could go in blank (k)?
(c) (6.0 points) Digging Deep

Definition: the depth of a node is defined as the distance from the root of the tree to that node. For example, the depth of the root node is 0, and the nodes at each of the branches of that root have depth 1.

Implement a function square_depths which takes in a Tree t and a linked list of increasing numbers depths. It should mutate t by squaring the label of every node at each depth contained in list depths.

You may need to use add_to_all in this part.

def square_depths(t, depths):
    ""
    >>> t1 = Tree(2, [Tree(3, [Tree(4)]), Tree(5)])
    >>> square_depths(t1, Link(0, Link(1))
    >>> t1
    Tree(4, [Tree(9, [Tree(4)]), Tree(25)])
    >>> t2 = Tree(2, [Tree(3, [Tree(4)]), Tree(5)])
    >>> square_depths(t2, Link(2))
    >>> t2
    Tree(2, [Tree(3, [Tree(16)]), Tree(5)])
    >>> t3 = Tree(2)
    >>> square_depths(t3, Link.empty)
    >>> t3
    Tree(2)
    ""
    if ___________:
        # (l)
        return
    if depths.first == 0:
        t.label = ___________
        # (m)
        depths = ___________
        # (n)
    for b in ___________:
        # (o)
        ________________
        # (p)

i. What line of code could go in blank (l)?

ii. What line of code could go in blank (m)?

iii. What line of code could go in blank (n)?
iv. What line of code could go in blank (o)?

v. What line of code could go in blank (p)?
3. (16.0 points) Reconstructing Ed

(a) (4.0 points) Users

The class `User` represents those who login to Edstem and make a post. Fill in the blanks for the `User`, `Student`, and `Instructor` classes such that the `__repr__` method in the `User` class returns a string that (when evaluated) creates a new instance with the same attributes as this one. See the doctests for some examples.

Instructors are admins, which means that they can view all posts, even questions not posted by themselves.

class User:
    
    >>> #### test User.__repr__, Student, Instructor ####
    >>> Instructor("Alex Kassil", "alexkassil@berkeley.edu")
    Instructor('Alex Kassil', 'alexkassil@berkeley.edu')
    >>> Student("Albert Xu", "albertxu3@berkeley.edu")
    Student('Albert Xu', 'albertxu3@berkeley.edu')
    
    admin = False
    class_name = "User"
    def __init__(self, name, email):
        self.name = name
        self.email = email

    def __repr__(self):
        return ________________
        # (a)

class Student(User):
    class_name = ________________
    # (b)

class Instructor(User):
    admin = ________________
    # (c)
    class_name = ________________
    # (d)

i. What line of code could go in blank (a)?

ii. What line of code could go in blank (b)?

iii. What line of code could go in blank (c)?
iv. What line of code could go in blank (d)?
(b) (6.0 points) Posts

The class Post represents a single post made to Edstem. Each post is a question by default, meaning it is only visible to the person who asked it or to an admin. You can also specify the announcement instance variable, which, if True, makes a post visible to everyone. For each post, the post ID represents the post number in chronological order starting with 1. The icon is “(!)” for announcements and “(?)” for all other posts.

Fill in the blanks for Post.view such that it prints the __str__ of the post after making necessary updates to the post object. Also, fill in the blanks for Post.__str__ such that it returns a string that has the post ID, followed by a colon, the icon, a space, the post title, a space, the string “<>”, the email of the User who made the post, a space, the “<> Total Views:”, a space, and finally the total number of times the post has been viewed. See the doctests for some examples.

```python
class Post:
    def __str__(self):
        if self.announcement:
            icon = "(!)"
        else:
            icon = "(?)"
        return ________________________________
    # (g)

def view(self, user):
    if user.email not in self.views:
        self.views[user.email] = 0
    self.views[user.email] += 1
    self.total_views = ________________
```

---

id = 1
def __init__(self, title, user, announcement=False):
    self.title = title
    self.user = user
    self.announcement = announcement
    self.views = {}
    self.total_views = 0
    self.id = ________________
    # (e)
    ________________
    # (f)

def __str__(self):
    if self.announcement:
        icon = "(!)"
    else:
        icon = "(?)"
    return ________________________________
    # (g)

def view(self, user):
    if user.email not in self.views:
        self.views[user.email] = 0
    self.views[user.email] += 1
    self.total_views = ________________
# (h)

print(_______________)

# (i)

i. What line of code could go in blank (e)?

ii. What line of code could go in blank (f)?

iii. What line of code could go in blank (g)?

iv. What line of code could go in blank (h)?

v. What line of code could go in blank (i)?
(c) (6.0 points) Edstem

The class Edstem represents a course Q&A forum, with some set of users and posts.

Fill in add_user and add_post such that Users and Posts are saved to the Edstem instance. Then, fill in login_and_view_all. Only added users can log in. After a successful login, a user may view all posts that are visible to them (all announcements and their own questions if they are not an admin, or everything if they are an admin). Also, fill in show_stats in order to print out the __str__ of each Post, followed by a space, the string "<> Unique Viewers:", a space, and the number of unique viewers.

class Edstem:
def add_post(self, post):
    self.posts.append(post)

def login_and_view_all(self, email):
    assert ________________
    # (k)
    for post in self.posts:
        if ________________ or ________________ or ________________:
            # (l) (m) (n)
            post.view(self.users[email])

def show_stats(self):
    for post in self.posts:
        print(post, "<> Unique Viewers:", len(________________))
        # (o)

i. What line of code could go in blank (j)?

ii. What line of code could go in blank (k)?

iii. What line of code could go in blank (l)?

iv. What line of code could go in blank (m)?

v. What line of code could go in blank (n)?

vi. What line of code could go in blank (o)?
4. (11.0 points) Ed Analysis

Ed is a Q&A Forum. The students table describes the Name and Email for each student enrolled in the CS 61A Ed. The posts table describes the email (of the poster), title, and timestamp for each post made on the CS 61A Ed. Emails are unique to students – each email can only be associated with one student.

You may assume that all timestamps are all unique, but titles in posts may not be unique.

CREATE TABLE students AS SELECT "Amritansh Saraf" AS name, "amritansh@cs61a.org" AS email UNION SELECT "Cindy Lin" , "cclin@cs61a.org" UNION SELECT "Vanshaj Singhania" , "vanshaj@cs61a.org" UNION SELECT "Marie Chorpita" , "chorpita@cs61a.org";

CREATE TABLE posts AS SELECT "vanshaj@cs61a.org" AS email, "Scheme Project EC" AS title, 1627774233 as timestamp UNION SELECT "chorpita@cs61a.org" , "Signing up for Tutoring" , 1627775133 UNION SELECT "cclin@cs61a.org" , "Doctors Hate Her!" , 1627774133 UNION SELECT "cclin@cs61a.org" , "Doctors Hate Her!" , 1627774135 UNION SELECT "vanshaj@cs61a.org" , "Scheme Project EC" , 1627784233;

(a) (2.0 points) Broken Timestamps

**Definition:** A timestamp represents a moment in time based on how many seconds (not including leap seconds) have passed since 00:00:00 UTC on January 1, 1970. So, for example, 00:01:00 UTC on January 1, 1970 would be represented as the timestamp 60. The start of the regular exam time for the Summer 2021 61A final exam, 17:00:00 UTC-7 on August 12, 2021, would be represented as 1628812800.

The timestamps in the posts table are all a week too early, and we need to fix them! Write a SQL query that selects the email, title, and timestamp columns, while adding 7 days to the timestamp.

**Hint:** there are 604800 seconds in 7 days.

You may use both commas and AND inside your answers.

Output for the sample table:

| Email          | Title                | Timestamp     |
|----------------|----------------------|---------------|
| cclin@cs61a.org| Doctors Hate Her!    | 1628378933    |
| cclin@cs61a.org| Doctors Hate Her!    | 1628378935    |
| chorpita@cs61a.org| Signing up for Tutoring | 1628379933 |
| vanshaj@cs61a.org| Scheme Project EC  | 1628379033    |

SELECT __________;
-- (a)

i. What line of code could fill in the blank (a)?
(b) (4.0 points) First

Complete a SQL query that selects a three-column table with the student name, title, and timestamp of the first post made by each student.

You may use both commas and AND inside your answers.

Output for the sample table:

| Name            | Title                     | Timestamp   |
|-----------------|---------------------------|-------------|
| Cindy Lin       | Doctors Hate Her!         | 1627774133  |
| Marie Chorpita  | Signing up for Tutoring   | 1627775133  |
| Vanshaj Singhania | Scheme Project EC       | 1627774233  |

SELECT ___________ FROM students AS a, posts AS p WHERE ___________ GROUP BY ___________;

-- (b) (c) (d)

i. What line of code could fill in the blank (b)?

ii. What line of code could fill in the blank (c)?

iii. What line of code could fill in the blank (d)?
(c) (5.0 points)  Duplicate Detection

**Definition:** *Duplicate Posts* are two posts that are made by the same student with the same *title* and within 10 seconds of each other. Recall that the *timestamp* values are measured in seconds.

Create a four-column table of author’s *name*, post *title*, and both *timestamps* for each pair of duplicate posts in the *posts* table. Only select pairs where the first post occurs *less than or equal to* 10 seconds before the second post (e.g., don’t include duplicates in the other direction)

You may not use AND, NOT, OR or AS in any of your below answers.

Output for the sample table:

| Cindy Lin | Doctors Hate Her! | 1627774133 | 1627774135 |

```sql
SELECT z.name, x.title, x.timestamp, y.timestamp
FROM ___________ AS x, ___________ AS y, ___________ AS z
WHERE ___________ AND ___________ AND ___________ AND ___________;
```

i. What line of code could fill in the blank (e)?

ii. What line of code could fill in the blank (f)?

iii. What line of code could fill in the blank (g)?

iv. What line of code could fill in the blank (h)?

v. What line of code could fill in the blank (i)?

vi. What line of code could fill in the blank (j)?
vii. What line of code could fill in the blank (k)?


viii. What line of code could fill in the blank (l)?



5. (13.0 points) Scheme

(a) (4.0 points) If Fibonacci is so great...

Definition: Each element of the fibonacci2 sequence is defined as twice the absolute value of the difference between the previous two elements. Assume that the 0th element of the fibonacci2 sequence is 0, and the 1st element is 1.

Implement the function fib2, which takes in one parameter n, a non-negative integer, and returns the nth element of the fibonacci2 sequence.

Reminder: Scheme has a built in procedure abs which returns the absolute value of the argument that is passed in.

(define (fib2 n)
  (if ___________ n
    ; (a)
    (___________ ___________ (___________ (- ___________ ___________))))

  ; (b) (c) (d) (e) (f)

(expect (fib2 0) 0)
(expect (fib2 1) 1)
(expect (fib2 2) 1)
(expect (fib2 3) 2)
(expect (fib2 4) 0)
(expect (fib2 5) 4)

i. What line of code could fill in the blank (a)?

ii. Which of these could fill in blank (b)?

  O *
  O -
  O square
  O fib2
  O fib

iii. What line of code could fill in the blank (c)?

iv. What line of code could fill in the blank (d)?
v. What line of code could fill in the blank (e)?

vi. What line of code could fill in the blank (f)?
(b) (7.0 points) The (n-1)-al Countdown

**Definition:** The *countdown sequence* of a number *n* is the sequence starting at *n* and descending to 0. For example, the *countdown sequence* of 3 is 3 2 1 0.

Implement a function `countdowns` which takes in a scheme list `lst` of non-negative integers and returns a list which is the concatenation of the *countdown sequences* of each element in `lst`.

```
(define (countdowns lst)
  (cond ((null? lst) ___________)
    ; (k)
    ((> ___________ 0) (cons (car lst)
      ; (l))
      (countdowns ___________)))
    ; (m)
    (else (cons 0 ___________))))
  ; (o)
(expect (countdowns '(3)) (3 2 1 0))
(expect (countdowns '(2 0 3)) (2 1 0 0 3 2 1 0))
(expect (countdowns '()) ())

i. What line of code could fill in the blank (k)?

ii. What line of code could fill in the blank (l)?

iii. What line of code could fill in the blank (m)?

iv. What line of code could fill in the blank (n)?
(c) (2.0 points) Tail Recursion?

i. We would like to modify the implementation of countdowns to make the function tail recursive. This could include modifications to the skeleton code. Is this possible?

- countdowns is not tail recursive but can be made tail recursive
- countdowns cannot be made tail recursive
- countdowns is already tail recursive
6. (8.0 points) All Links

(a) Implement a generator function `all_links`, which takes in `nums`, a list of equal-length lists. `all_links` should yield all linked lists `s` that can be constructed such that the first element of `s` is the first element of one of the lists in `nums`, the second element of `s` is the second element of one of the lists in `nums`, and so on. Lists can be yielded in any order. You can assume that `nums` is a non-empty list.

For example, for the second doctest `all_links([[0, 2], [1, 3]])`, there are four total linked lists we should yield. `Link(0, Link(2))` is generated from using the first element from the first list and the second element from the first list. `Link(0, Link(3))` is generated with the first element from the first list and the second element from the second list. `Link(1, Link(2))` and `Link(1, Link(3))` get the first element from the second list and the second element from the first and second lists respectively.

```python
def all_links(nums):
    """
    >>> list(all_links([[0], [1], [2]]))
    [Link(0), Link(1), Link(2)]
    >>> list(all_links([[0, 2], [1, 3]]))
    [Link(0, Link(2)), Link(0, Link(3)), Link(1, Link(2)), Link(1, Link(3))]
    """
    if len(nums[0]) == 0:
        ___
        # (a)
    else:
        rests = [__________ for x in nums]
        # (b)
        for first in [x[0] for x in nums]:
            for item in ____________:
                ___
                # (c)
                
    ___
    # (d)

i. What line of code could fill in the blank (a)?

ii. Which of these could fill in blank (b)?

- x[1:]
- x[1]
- nums[1]
- nums[1:]
- nums[-1]
- nums[:1]
- x[-1]
- x[:1]
iii. What line of code could fill in the blank (c)?

iv. What line of code could fill in the blank (d)?
7. (9.0 points) Merger

(a) (9.0 points)

Consider the function `merger`, which returns the result of merging all the terms in a sequence using `f`, a two-argument function. The function `f` is applied to the first and second elements until there is only one element in the subsequence.

For example, merging the sequence 1, 2, 3 with the function `lambda x, y: x + y` would return the result 6.

Now consider the sequence of ascending integers: 1, 2, 3, ... k and all of its unique ascending subsequences of at least length two. For example, the sequence [1,2,3,4] has the following unique ascending subsequences of length at least two: [1,2], [1,3], [1,4], [1,2,3], [1,2,4], [1,3,4], [2,3], [2,4], [2,3,4], [3,4], [1,2,3,4]. Our goal is to count the number of subsequences of `merger` that result in exactly \( N \) when merging with `f`.

For the first doctest, `f` is `lambda x, y: x + y`, \( N \) is 6, and \( K \) is 4, so only [1,2,3] and [2,4] add up to 6, meaning `count_merger(6, 4, lambda x, y: x + y)` returns 2.

Write a function `count_merger` that returns the number of ways to make exactly \( N \) using at least two unique, ascending integers from range 1 to \( K \) (inclusive) and a function `f` which is a two-argument function.

```python
def count_merger(n, k, f):
    """
    Returns the number of ways to make exactly N using at least two unique,
    ascending integers from range 1 to K (inclusive) and a function f that
    accepts two integers as arguments and returns an integer.
    Assume K >= 1.
    >>> from operator import add, mul, sub
    >>> add1_mult = lambda x, y: (x + 1) * y
    >>> count_merger(6, 4, lambda x, y: x + y) # 1 + 2 + 3 = 6, 2 + 4 = 6
    2
    >>> count_merger(36, 6, mul) # 1 * 2 * 3 * 6; 2 * 3 * 6
    2
    >>> count_merger(36, 6, add)
    0
    >>> count_merger(36, 6, add1_mult) # (5 + 1) * 6
    1
    >>> count_merger(24, 3, lambda x, y: 24) # f(1, 2); f(f(1, 2), 3); f(1, 3); f(2, 3)
    4
    >>> count_merger(1, 1, lambda x, y: x)
    0
    >>> count_merger(-2, 5, sub) # 1 - 3; 2 - 4; 3 - 5
    3
    """
    def helper(start, i):
        if i > k:
            return 0
        a = helper(start, i + 1)
        b = helper(______, i + 1)  # (a)
        if __________ == n:
            # (b)
            return __________  # (c)
        else:
            return __________  # (d)```
total = 0
i = 1
while ___________:
    # (e)
    total += ___________
    # (f)
i += 1
return total

i. What line of code could go in blank (a)?

ii. What line of code could go in blank (b)?
   - start
   - start + 1
   - helper(start, i)
   - helper(start, i + 1)
   - f(start, i)
   - f(start, i + 1)

iii. What line of code could go in blank (c)?

iv. What line of code could go in blank (d)?

v. What line of code could go in blank (e)?
   - i > 0
   - k > 0
   - i >= 0
   - k >= 0
   - i > k
   - i < k
   - i >= k
   - i <= k
vi. Which of these could fill in blank (f)?

- helper(i, i)
- helper(i, i + 1)
- helper(i, total + 1)
- helper(total, i)
- helper(total, i + 1)
- helper(total, total + 1)
8. Extra Sus

(a) Amogus’s Dilemma

In this extra credit problem, you may choose one of two options.

- Mark the choice of “Impostor” and write a positive integer in the blank below. The one student who writes the smallest unique positive integer will receive three (3) extra credit points but only if fewer than 90% of students choose the next option.
- Mark the choice of “Crewmate”. If at least 90% of students choose this option, all students who chose this option will receive one (1) extra credit point and those who marked the choice to “Impostor” will receive zero (0) extra credit points.

i.  
   ○ Impostor
   ○ Crewmate

ii. If you marked Impostor, type in a number.
No more questions.