MUTABLE DATA STRUCTURES AND DATA ABSTRACTIONS

COMPUTER SCIENCE MENTORS 61A

February 13 to February 17, 2016

1 Lists

1. Draw box-and-pointer diagrams for the following:

```
>>> a = [1, 2, 3]
>>> a
```

Solution:
`[1, 2, 3]`

```
>>> a[2]
```

Solution: 3

```
>>> b = a
>>> a = a + [4, 5]
>>> a
```

Solution:
`[1, 2, 3, 4, 5]`

```
>>> b
```

Solution:
```
[1, 2, 3]
```

```
>>> c = a
>>> a = [4, 5]
>>> a
```

Solution:
```
[4, 5]
```

```
>>> c
```

Solution:
```
[1, 2, 3, 4, 5]
```

```
>>> d = c[0:2]
>>> c[0] = 9
>>> d
```

Solution:
```
[1, 2]
```

Solution: Box and pointer diagram in Python Tutor - tinyurl.com/week5-bap

2. Write a function that takes in a list `nums` and returns a new list with only the primes from `nums`. Assume that `is_prime(n)` is defined. You may use a `while` loop, a `for` loop, or a list comprehension.
   def `all_primes(nums):`

Solution:

```
result = []
for i in nums:
    if is_prime(i):
        result = result + [i]
return result

List comprehension:
return [x for x in nums if is_prime(x)]
```

2 Data Abstraction

3. The following is an **Abstract Data Type (ADT)** for elephants. Each elephant keeps track of its name, age, and whether or not it can fly. Given our provided constructor, fill out the selectors:

```
def elephant(name, age, can_fly):
    """
    Takes in a string name, an int age, and a boolean can_fly.
    Constructs an elephant with these attributes.
    >>> dumbo = elephant("Dumbo", 10, True)
    >>> elephant_name(dumbo)
    "Dumbo"
    >>> elephant_age(dumbo)
    10
    >>> elephant_can_fly(dumbo)
    True
    """
    return [name, age, can_fly]
def elephant_name(e):
```

Solution:

```
    return e[0]
```

```
def elephant_age(e):
```

Solution:

```
    return e[1]
```

```
def elephant_can_fly(e):
```

Solution:

```
    return e[2]
```

4. This function returns the correct result, but there's something wrong about its implementation. How do we fix it?

```
def elephant_roster(elephants):
    """
    Takes in a list of elephants and returns a list of their
       names.
    """
    return [elephant[0] for elephant in elephants]
```

Solution:
elephant[0] is a Data Abstraction Violation (DAV).
We should use a selector instead.

5. Fill out the following constructor for the given selectors.

```
def elephant(name, age, can_fly):
```

Solution:

```
    return [[name, age], can_fly]
```

```
def elephant_name(e):
    return e[0][0]
def elephant_age(e):
    return e[0][1]
def elephant_can_fly(e):
    return e[1]
```

6. How can we write the fixed `elephant_roster` function for the constructors and selectors in the previous question?

Solution: No change is necessary to fix `elephant_roster` since using the `elephant` selectors "protects" the roster from constructor definition changes.

7. **(Optional)** Fill out the following constructor for the given selectors.

```
def elephant(name, age, can_fly):
    """
    >>> chris = elephant("Chris Martin", 38, False)
    >>> elephant_name(chris)
        "Chris Martin"
    >>> elephant_age(chris)
        38
    >>> elephant_can_fly(chris)
        False
    """
    def select(command)
```

Solution:

```
        if command == "name":
            return name
        elif command == "age":
            return age
        elif command == "can_fly":
            return can_fly
        return "Breaking abstraction barrier!"
```

```
    return select
def elephant_name(e):
    return e("name")
def elephant_age(e):
    return e("age")
def elephant_can_fly(e):
    return e("can_fly")
```

3 Trees

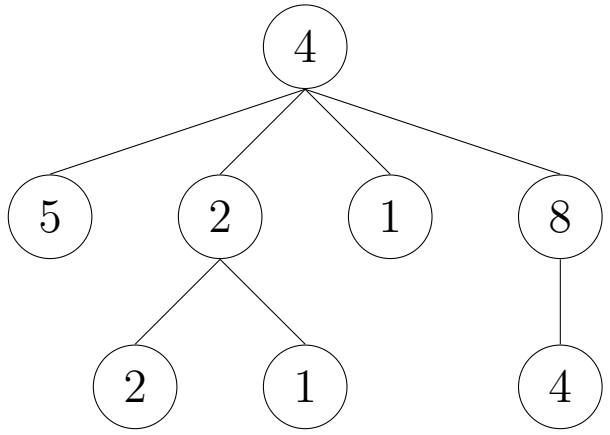
Things to remember

```
def tree(label, branches=[]):
    return [label] + list(branches)

def label(t):
    return t[0]

def branches(t): # Always returns a list of trees
    return t[1:]
```

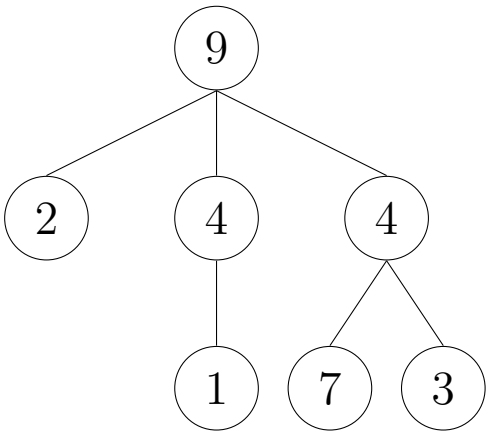
8. Draw the tree that is created by the following statement:

```
tree(4,
    [tree(5, []),
     tree(2,
        [tree(2, []),
         tree(1, [])]),
     tree(1, []),
     tree(8,
        [tree(4, [])])])
```

Solution:



9. Construct the following tree and save it to the variable `t`.



Solution:
```
t = tree(9, [tree(2, []),
             tree(4, [tree(1, [])]),
             tree(4, [tree(7, []),
                      tree(3, [])])])
```

10. What would this output?

```
>>> label(t)
```

Solution: 9

```
>>> branches(t)[2]
```

Solution:
```
tree(4, [tree(7, []), tree(3, [])])
```

```
>>> branches(branches(t)[2])[0]
```

Solution:
```
tree(7, [])
```

11. Write the Python expression to get the integer 2 from t.

Solution:
```
label(branches(t)[0])
```

12. Write the function `sum_of_nodes` which takes in a tree and outputs the sum of all the elements in the tree.

```
def sum_of_nodes(t):
    """
    >>> t = Tree(...) # Tree from question 2.
    >>> sum_of_nodes(t) # 9 + 2 + 4 + 4 + 1 + 7 + 3 = 30
    30
    """
```

Solution:

```
    total = label(t)
    for branch in branches(t):
        total += sum_of_nodes(branch)
    return total

    Alternative solution:
    return label(t) +\
           sum([sum_of_nodes(b) for b in branches(t)])
```