Many of Python’s primitive types are considered immutable, meaning that once they have been created, their value cannot change. Examples of these immutable types include strings, tuples, and numbers.

However, lists, dictionaries, and some other data types that are considered mutable, meaning the values of a specific instance or object of that type may change.

Imagine you go to CREAM on Telegraph Avenue and you order an ice-cream sandwich. Suppose CREAM chooses to represent your order as a list like so:

```python
>>> sandwich = ['ice-cream', 'cookie']
```

Suppose that, while CREAM was preparing your order, you decide you want to top your sandwich with sprinkles. Without mutation, CREAM changes your order like so:

```python
# creates a new python list
>>> new_sandwich = sandwich + ['sprinkles']
>>> new_sandwich
['ice-cream', 'cookie', 'sprinkles']
>>> sandwich # the original list is unmodified
['ice-cream', 'cookie']
```

What was the point of CREAM having to make an entirely new sandwich just to add sprinkles? They could have simply modified the original sandwich! That’s what mutation is all about! Instead, they could have done:

```python
>>> sandwich.append('sprinkles') # mutates original list
>>> sandwich
['ice-cream', 'cookie', 'sprinkles']
```
1. Consider the following definitions and assignments and determine what Python would output for each of the calls below if they were evaluated in order. It may be helpful to draw the box and pointers diagrams to the right in order to keep track of the state.

```python
>>> lst1 = [1, 2, 3]
>>> lst2 = [1, 2, 3]
>>> lst1 == lst2  # compares each value

>>> lst1 is lst2  # compares references

>>> lst2 = lst1
>>> lst2 is lst1

>>> lst1.append(4)
>>> lst1

>>> lst2

>>> lst2[1] = 42
>>> lst2

>>> lst1 = lst1 + [5]
>>> lst1 == lst2

>>> lst1

>>> lst2

>>> lst2 is lst1
```
2 List Methods

In addition to the indexing operator, lists have many mutating methods. List methods are functions that are bound to a specific list. Some useful list methods are listed here:

1. `append(el)` adds `el` to the end of the list
2. `insert(i, el)` inserts `el` at index `i`
3. `remove(el)` removes the first occurrence of `el` in list, otherwise errors
4. `sort()` sorts elements of list in place

List methods are called via *dot notation*, as in:
```python
>>> colts = ['andrew luck', 'reggie wayne']
>>> colts.append('trent richardson')
```

None of the mutating list methods *return* a new list — they simply modify the original list and return `None`.

2.1 Code Writing Questions

1. Write a function `square_elements` which takes a `lst` and replaces each element with the square of that element. *Mutate lst rather than returning a new list.*
   ```python
def square_elements(lst):
    """
    >>> lst = [1, 2, 3]
    >>> square_elements(lst)
    >>> lst
    [1, 4, 9]
    """
   ```

2. Write a function that removes all instances of an element from a list.
   ```python
def remove_all(el, lst):
    """
    >>> x = [3, 1, 2, 1, 5, 1, 1, 7]
    >>> remove_all(1, x)
    >>> x
    [3, 2, 5, 7]
    """
3. Reverse a list *in place*, i.e. mutate the given list itself, instead of returning a new list.

```python
def reverse(lst):
    """ Reverses lst in place."
    x = [3, 2, 4, 5, 1]
    reverse(x)
    x
    [1, 5, 4, 2, 3]  
    """
```

4. Write a function that takes in two values \( x \) and \( \text{el} \), and a list, and adds as many \( \text{el} \)'s to the end of the list as there are \( x \)'s.

```python
def add_this_many(x, el, lst):
    """ Adds \( \text{el} \) to the end of \( \text{lst} \) the number of times \( x \) occurs in \( \text{lst} \)."
    lst = [1, 2, 4, 2, 1]
    add_this_many(1, 5, lst)
    lst
    [1, 2, 4, 2, 1, 5, 5]  
    """
```
3 Nonlocal

Until now, you’ve been able to access variables in parent frames, but you have not been able to modify them. The `nonlocal` keyword can be used to modify a variable in the parent frame outside the current frame (as long as it’s not the global frame). For example, consider `stepper`, which uses `nonlocal` to modify `num`:

```python
def stepper(num):
    def step():
        nonlocal num  # declares num as a nonlocal variable
        num = num + 1  # modifies num in the stepper frame
        return num
    return step
```

3.1 Environment Diagrams

1. Draw the environment diagram for the following series of calls after `stepper` has been defined:

```python
s = stepper(3)
s()
s()
```
2. Given the definition of `make_shopkeeper` below, draw the environment diagram.

```python
def make_shopkeeper(total_gold):
    def buy(cost):
        nonlocal total_gold
        if total_gold < cost:
            return 'Go farm some more champions'
        total_gold = total_gold - cost
        return total_gold
    return buy

infinity_edge, zeal, gold = 3800, 1100, 3800
shopkeeper = make_shopkeeper(gold - 1000)
shopkeeper(zeal)
shopkeeper(infinity_edge)
```
3.2 Some Common Misconceptions

1. What is wrong with the following code?
   ```python
   a = 5
   def adder(x):
       def add(y):
           nonlocal x, y
           x += y
           return x
       return add
   adder(2)(3)
   ```

2. What is wrong with the following code?
   ```python
   a = 5
   def another_add_one():
       nonlocal a
       a += 1
   another_add_one()
   ```