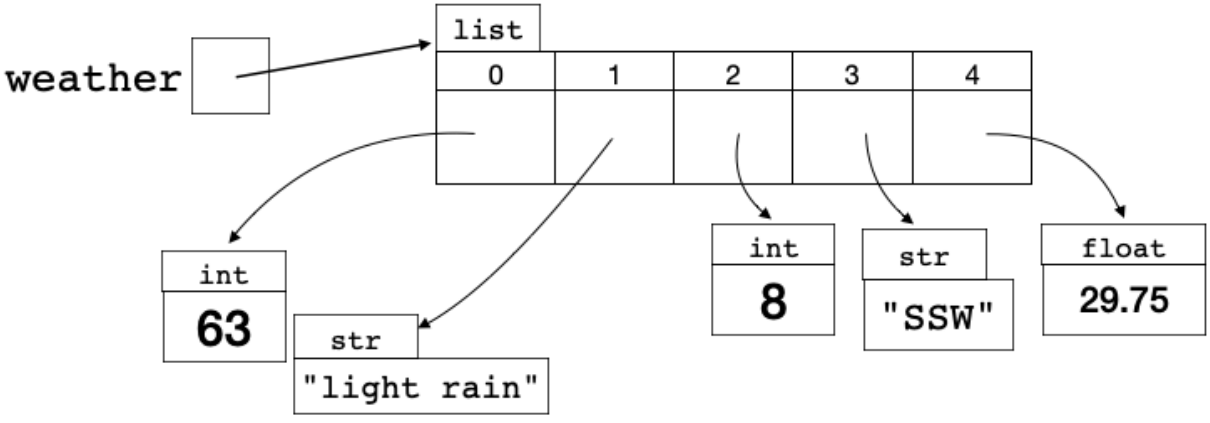


CSCI 141

Scott Wehrwein

Variables are References
Mutability's Implications

Goals

- Understand the implications of variables holding references to mutable objects:
  - Multiple variables can refer to the same object.
- Be able to draw memory diagrams for code snippets involving mutable objects.
- Know how to query or modify lists using the following: `index, insert, remove, del`

I want to show you something weird.

I want to show you something weird.

- Demo:

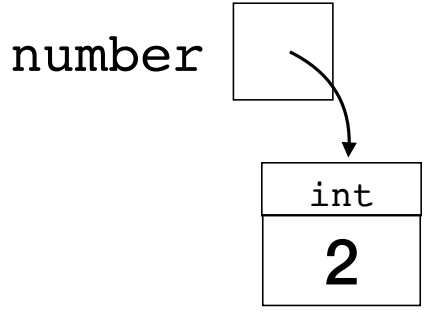
```
a = [4, 5]

b = a

b[0] = 1

print(a[0])
```

Objects and Variables: Digging a little deeper

When we talked about variables...

Sometimes I got lazy and wrote:

but what's truly happening is:



All variables store references to **objects.**

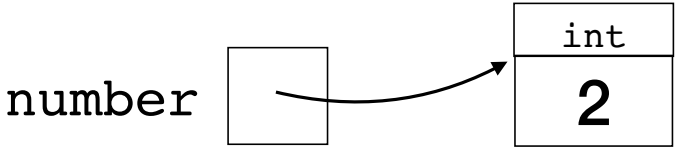
Objects can have any type

All variables store references to objects

In code:

```
number = 2
```

In memory:

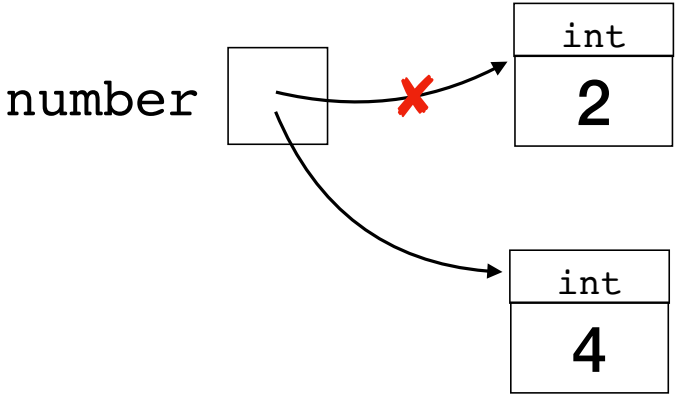


All variables store references to objects

In code:

```
number = 2

number = 4
```

In memory:



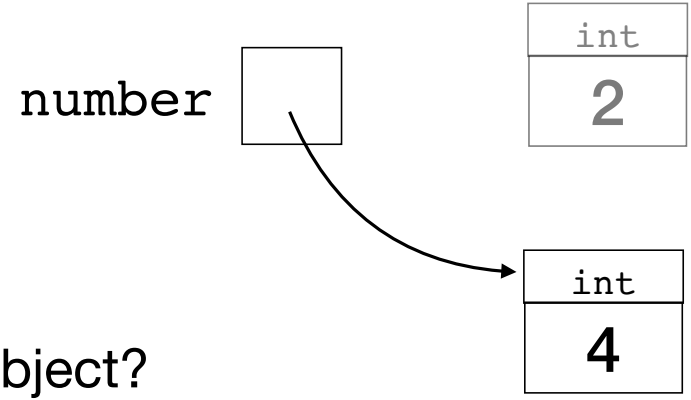
Like strings, `ints` are immutable:
You can't change its value.
You can only make a new one with a different value.

All variables store references to objects

In code:

```
number = 2

number = 4
```

In memory:



Aside: What happens to the 2 object?

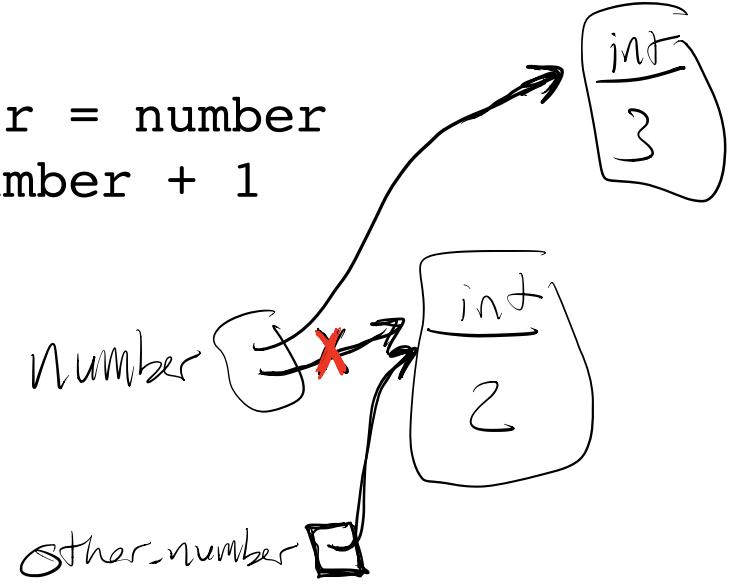
- If no variables refer to it, Python deletes it automatically.
- This is called *garbage collection*.

For immutable objects, the fact that variables hold references doesn't have many interesting consequences.

Example

Execute the following, drawing and updating the memory diagram for each variable and object involved.

```
number = 2
other_number = number
number = number + 1
```



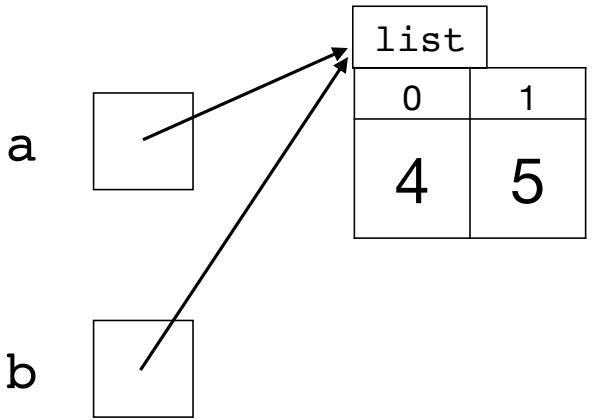
All variables store references to objects

What about **mutable** objects?

In code:

```
a = [4, 5]

b = a
```

In memory:



The value of `a` is a *reference* to that list object, so the new value of `b` is also a *reference* to that **same** list!

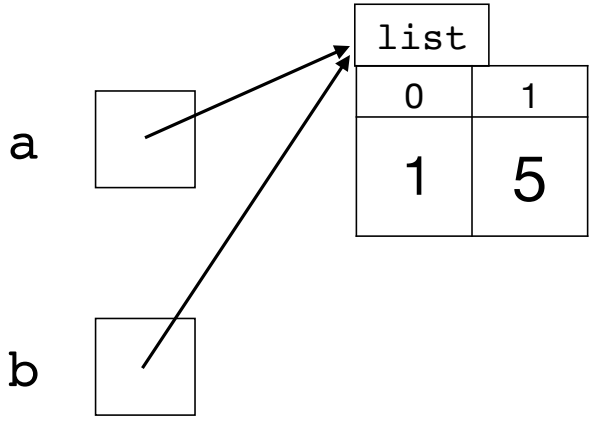
All variables store references to objects

What about **mutable** objects?

In code:

```
a = [4, 5]

b = a

b[0] = 1

print(a)

[1, 5] # !!!
```

In memory:



More than one variable can refer to the **same object.**

Don't make this mistake

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

you **did not** just create a copy of `a`

To create a true copy of a **mutable** object, you **can't** simply assign the object to a new variable.

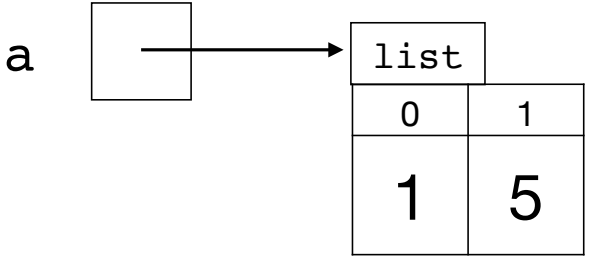
List elements store references to objects

List elements are just like variables!

In code:

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

In memory:



I lied to you again!

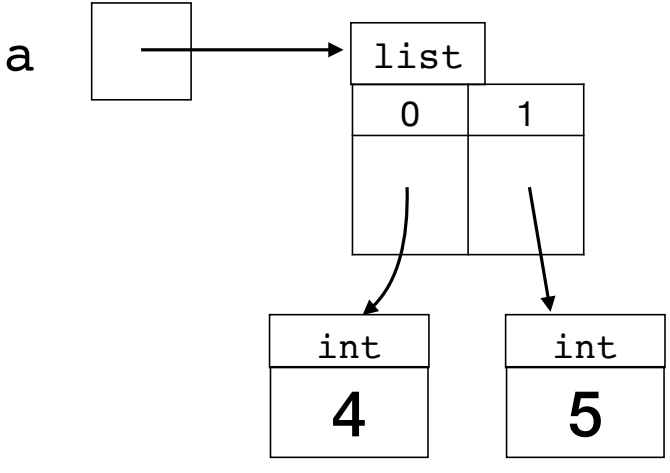
List elements store references to objects

List elements are just like variables!

In code:

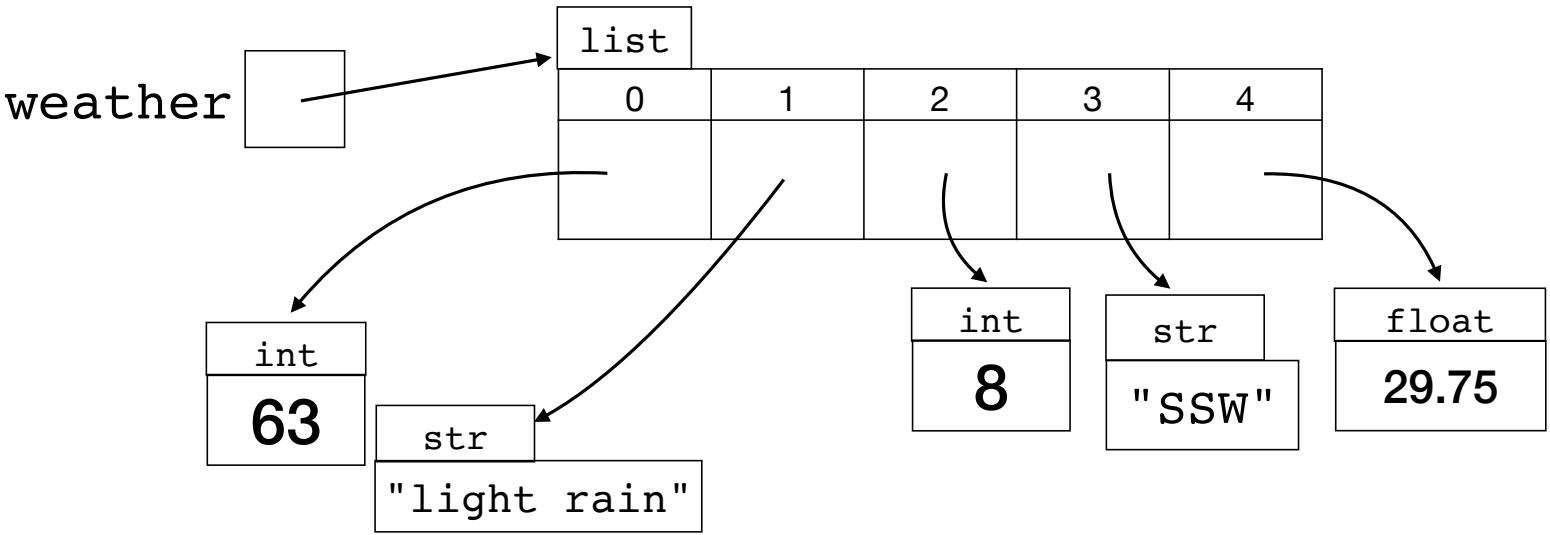
```
a = [4, 5]
```

In memory (the true picture):



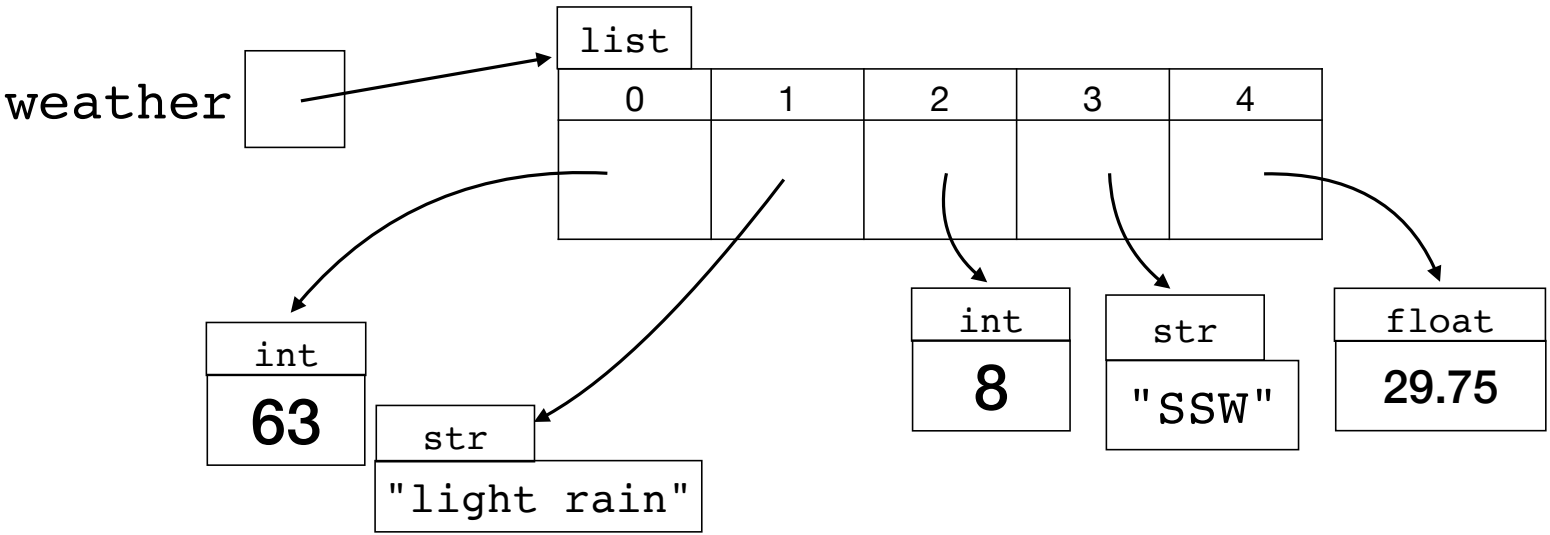
List elements store references to objects

```
weather = [63, "light rain", 8, "SSW", 29.75]
```



List elements store references to objects

```
weather = [63, "light rain", 8, "SSW", 29.75]
weather[1] = "cloudy"
```



List elements store references to objects

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weather = [63, "light rain", 8, "SSW", 29.75]
weather[1] = "cloudy"
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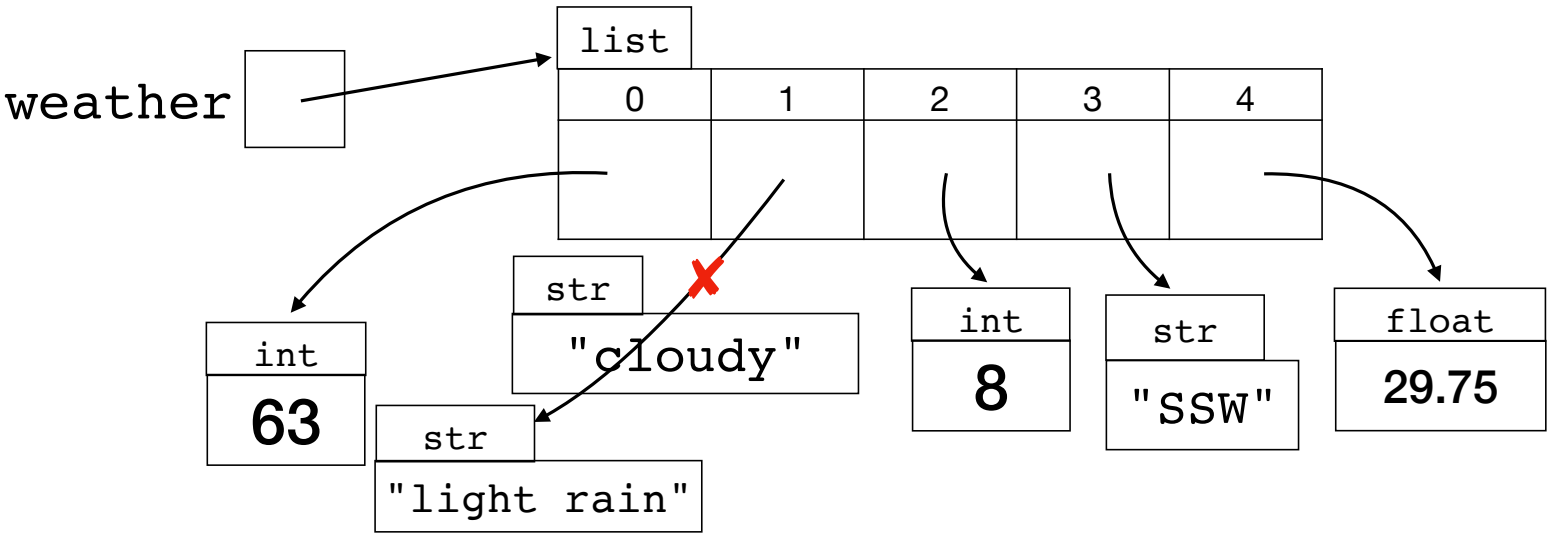
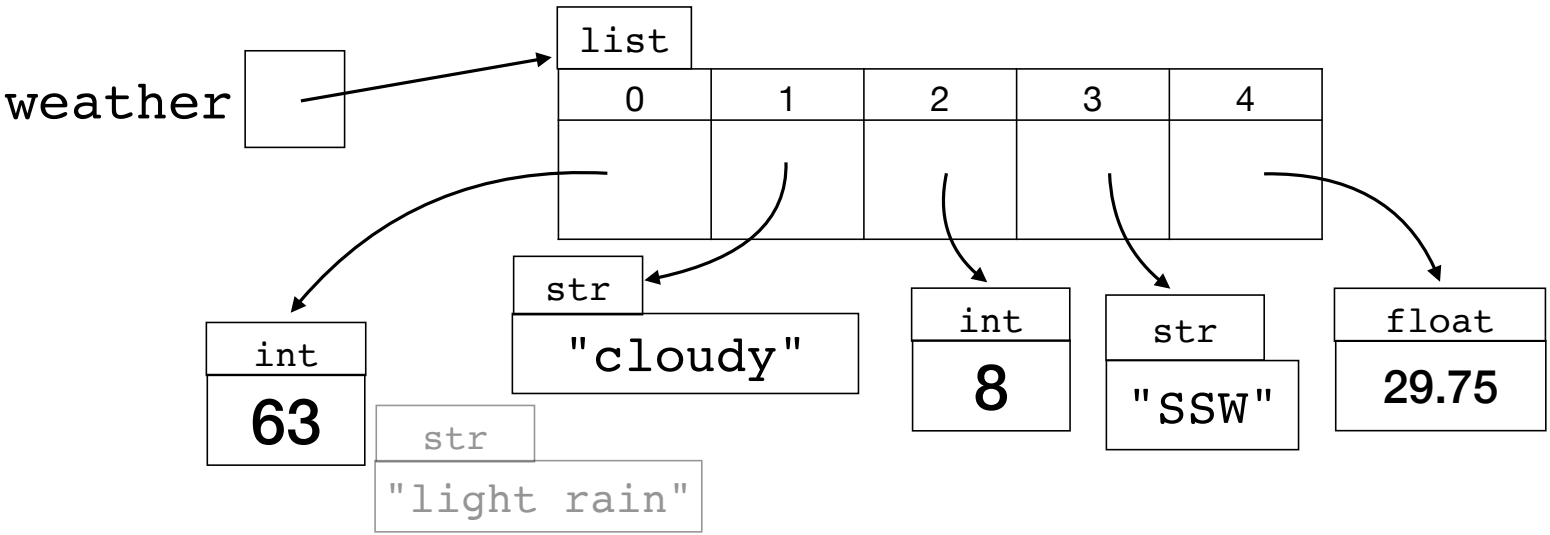


List elements store references to objects

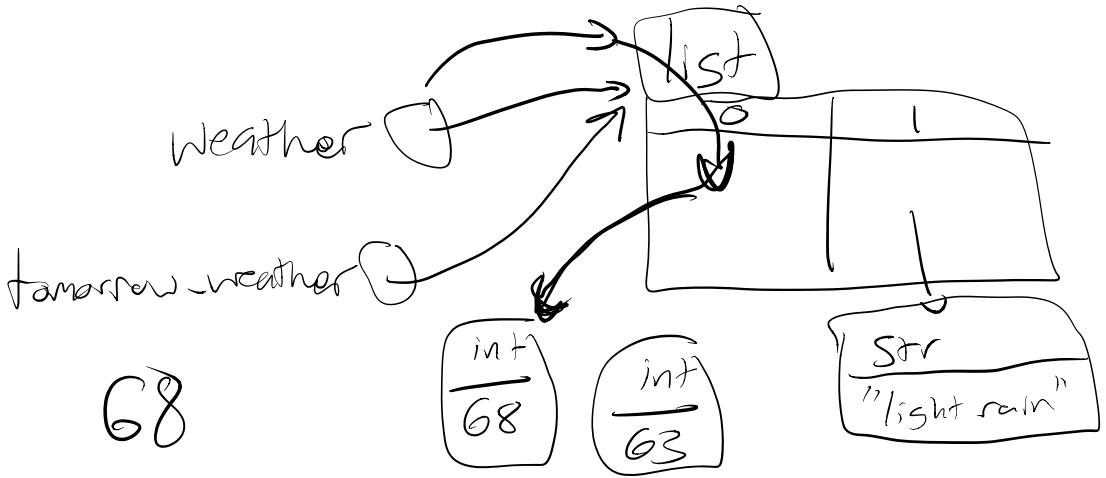
```
weather = [63, "light rain", 8, "SSW", 29.75]
weather[1] = "cloudy"
```



Example

Draw and update the memory diagram as the following code is executed.

```
weather = [63, "light rain"]
tomorrow_weather = weather
tomorrow_weather[0] = 68
print(weather[0])
```



Creating lists vs Creating references

- A list literal creates a new list

```
a = [4, 5, 6]
```

- List assignment does not create a new list

```
b = a
```

- List concatenation creates a new list

```
c = a + b
```

- List slicing creates a new list

```
d = a[:1]
```

A few more list operations:

`my_list.index(value)`
Return the index of the first occurrence of `value` in `my_list`
Throw an error if `value` is not in `my_list`.

`my_list.insert(index, value)`
Inserts `value` into `my_list` at `index`, shifting all following elements one spot to the right.

`my_list.remove(value)`
Removes the first item from the list whose value is equal to `value`.
Causes an error if `value` is not in `my_list`.

```
del my_list[index]
```
Removes the element at `index`, shifting all following elements one spot to the left.

index, insert, remove, del: Demo

```
abc = ["B", "C"]
abc.index("C")
abc.index("F")
abc.insert(0, "A")
abc.remove("C")
abc.remove("F")
del abc[0]
```

Problem 3

Write a function that returns a true copy (i.e., a different list object containing the same values) of a given list.

```
def copy_list(in_list):
    """ Return a new list object containing
        the same elements as in_list.
        Precondition: in_list's contents are
        all immutable. """
```

Hint: one possible approach uses a loop and the `append` method.

Problem 4

```
def snap(avengers):
    """ Remove a randomly chosen half of the
        elements from the given list of avengers
    """
```