Name:_____ **Partner:** _____

Python Activity 17: Identity & Value

How do variables actually work?

Learning Objectives

Students will be able to:

Content:

- Describe what the built-in function ***id(..)*** does
- Explain the difference between ***identity*** and ***value***
- Summarize how ***memory address*** relates to ***mutability***
- Describe what the ***is*** operator does

Process:

- Write code that uses the ***is*** operator to *appropriately* compare objects
- Write code to *mutate* a mutable object
- Write code to determine what other ***object*** types are mutable

Prior Knowledge

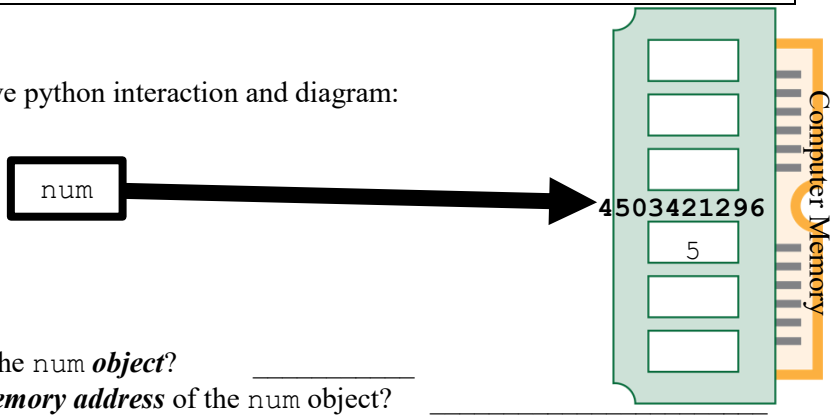
- Python concepts: lists, strings, boolean operators

Critical Thinking Questions:

1. Examine the sample interactive python interaction and diagram:

Interactive Python

```
>>> num = 5
>>> id(num)
4503421296
```



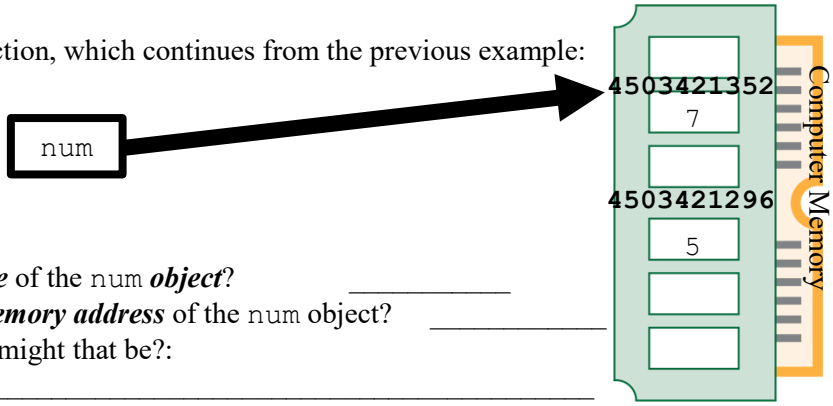
   a. What is the ***value*** of the `num` ***object***? _____
   b. What might be the ***memory address*** of the `num` object? _____
   c. What might the built-in function `id(..)` do?:

   _____

2. Examine the following interaction, which continues from the previous example:

Continued

```
>>> num = num + 2
>>> id(num)
4503421352
```



   a. What is now the ***value*** of the `num` ***object***? _____
   b. What might be the ***memory address*** of the `num` object? _____
   c. What changed? Why might that be?:

   _____

FYI: Everything in Python is an ***object***. When an object is created, it is assigned an address in memory (or ***identity***). An object's identity never changes. An object also has a ***value***. Objects whose value *can* change are ***mutable***. Objects whose value *cannot* change are ***immutable***. ***Variable*** names *point* to memory addresses of a stored value.

3. Observe the following interaction in interactive python:

```
0 >>> plants1 = ["jade", "aloe", "fig"]
1 >>> id(plants1)
2 4336302400
3 >>> plants2 = plants1
4 >>> id(plants2)
5 4336302400
6 >>> plants1 == plants2
7 True
8 >>> plants1 is plants2
9 True
```

a. How do the identities of `plants1` and `plants2` compare?

_____

What might the `plants2 = plants1` line do?

_____

How does it affect the ***memory address*** of `plants2`?

_____

b. Why values do `plants1` and `plants2` point to?

_____

Why does the `plants1 == plants2` line return its boolean value?

_____

FYI: The values outputted by the ***id(..)*** function can change between python sessions, or on one machine versus another. Therefore, the *value* is not the important part of ***id()***, just whether two ***id()***s match!

4. Observe the following interaction in interactive python:

```
>>> plants1 = ["jade", "aloe", "fig"]
>>> id(plants1)
4336302400
>>> plants2 = ["jade", "aloe", "fig"]
>>> id(plants2)
4336284224
>>> plants1 == plants2
True
>>> plants1 is plants2
False
```

a. How do the identities of `plants1` and `plants2` compare in this example?

_____

What did we do differently in this example, compared to the previous one?

_____

How might this have impacted the result of `plants1 is plants2`?

_____

What does this suggest about the `is` operator?

_____

b. Why does the `plants1 == plants2` line return its boolean value?

_____

c. What does the above code tell us about the difference between the == operator and the `is` operator? _____

FYI: The ***is*** operator essentially uses the ***id(..)*** function to compare the *addresses* of two objects. The = = operator compares their *values*.

5. Observe the following session in interactive python:

```
0 >>> plant = "spider"
1 >>> plant[-1] = "s"
2 TypeError: 'str' object does not support item assignment
3 >>> plants = ["jade", "aloe", "fig"]
4 >>> plants[-1] = "cactus"
```

a. What is the programmer trying to do on lines 0 & 1? (*Hint: what appears on the lefthand side of an assignment operator? The righthand side?)*

_____

b. Why might line 1 cause an error for string `plant`, but not line 4 with list `plants`?

_____

c. What is likely contained in list `plants` at the end of this code?

_____

FYI: ***Mutable*** objects are *changea*ble. Lists can be *changed* using **indexing**, which means we can put an indexed list on the *lefthand* side of an assignment operator and reassign its values!

d. Are **strings** mutable? How do you know?

_____

6. Observe the following session in interactive python:

```
>>> plants1 = ["jade", "aloe", "fig"]
>>> plants2 = plants1
```

a. Draw a diagram, similar to questions 1 & 2 that shows the two variables above, pointing to their values in memory:

b. Modify your diagram above to incorporate this interaction:

```
>>> plants1 = plants1 + ["pothos"]
>>> plants1 is plants2
False
```

c. What might `plants1` now point to? `plants2`?

_____

d. What change might you expect to see in the id of `plants1` and `plants2`, when reassigning plants1?

_____

FYI: ***Concatenation*** + always returns a new object.

7. Observe the following session in interactive python:

```
>>> plants1 = ["jade", "aloe", "fig"]
>>> plants2 = plants1
>>> plants1 += ["zz"]
>>> plants1
['jade', 'aloe', 'fig', 'zz']
>>> plants2
['jade', 'aloe', 'fig', 'zz']
```

a. Circle the new **operator** being used in this example, that wasn't in the previous example.

b. Draw a diagram, similar to questions 1 & 2 that shows the two variables above, pointing to their values in memory at the end of the code:

c. How does the **+** operator differ from the **+=** operator, with mutable objects (like lists)?

_____

FYI: ***Mutable*** objects are *changea*ble. Lists can be *changed* using the **append operator +=, indexing**, and other methods we will learn about later.

Application Questions: Use the Python Interpreter to check your work

1. Write and execute code to determine if the following ***object types*** are mutable or not:

Lists: _____

_____

Strings _____

Integers _____

Floats: _____

Booleans: _____

2. *This example/information will not be on any exam or homework!*
Observe the following interaction in interactive python:

```
>>> tea1 = "assam"
>>> id(tea1)
4462577328
>>> tea2 = "assam"
>>> id(tea2)
4462577328
>>> tea1 == tea2
True
>>> tea1 is tea2
True
```

a. Why does the `tea1 == tea2` line return its boolean value?

_____

b. Why might the `tea1 is tea2` line return its boolean value?

_____

c. What does the above code and previous example tell us about the difference between strings and lists?

_____

_____

d. What does the above code and previous example tell us about the difference between immutable and mutable objects when creating new values?

_____

FYI: Python has a *confusing* optimization where small numbers (-5…255) are remembered in an *integer pool* and short strings (less than 20 characters `and` created at compile-time `and` lack special characters) are *interned*, so these values created separately will point to the same memory address. With strings, Python may intern more than just the specified strings above.
Do not rely on this behavior!