Outline

1. Variables and Assignments
   - assignment operators
   - memory management and references
2. Dynamic Typing
   - types and arithmetic
   - prompting for user input

MCS 260 Lecture 4
Introduction to Computer Science
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Variables, Assignments, Dynamic Typing

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Assigning to Variables

how does an assignment work?

Stages in the execution of **x = 3**:

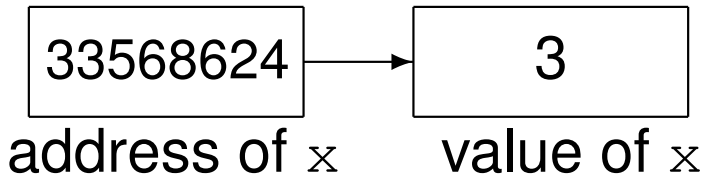
1. evaluate the right hand side of **=**
2. store the result of the evaluation in a register
3. compute the address of **x**
   and store it into the address register
4. copy the **3** from a register to the data register
5. put the value in data register at the memory location
   defined by the content of the address register

Memory Locations

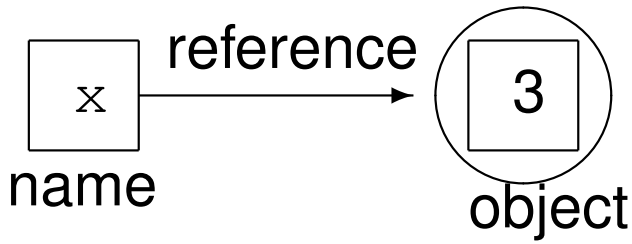
A variable has a value and an address.

```
>>> x = 3
>>> id(x)
33568624
```

The machine view:



In Python, the name `x` refers to the object 3.



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Memory Management, implicit and explicit

- Automatic allocation of memory for each object.
- Garbage collection frees space for unused variables.
- With del we may explicitly free space:

```
>>> x = 3
>>> y = x
>>> id(x)
33568624
>>> id(y)
33568624
```

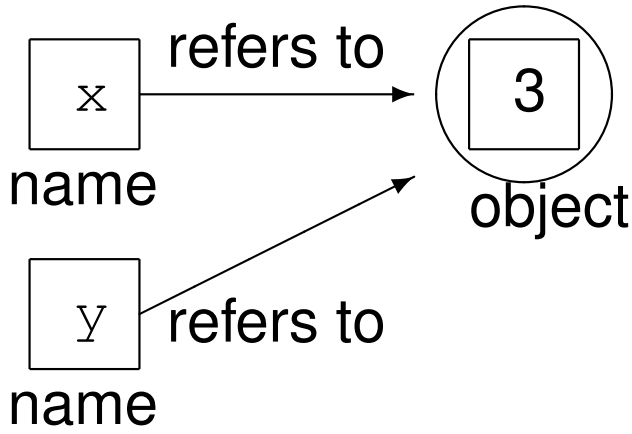
We see that both `x` and `y` refer to the same object.

```
>>> del(x)
>>> y
3
```

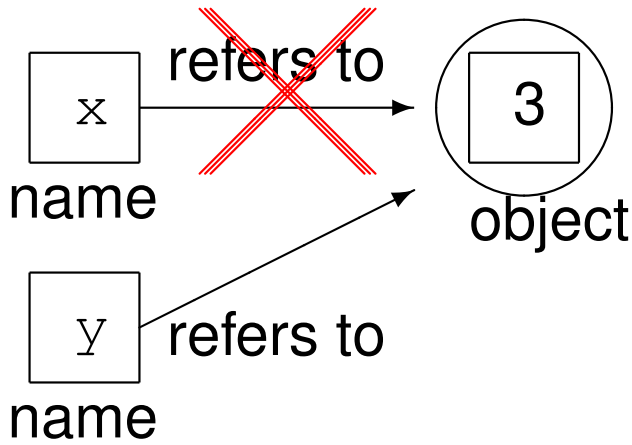
After deleting `x`, the object is still accessible via `y`.
Only after `del(y)` will memory space be released.

Deleting References

```
>>> x = 3; y = x
```




```
>>> del(x)
```



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Types of Variables – every variable has a type

- Python uses *dynamic typing*: the type of a variable is determined automatically at runtime.
  `type(name)` returns type of the variable `name`
- The type of a variable determines
  1. what kind of operations are available
  2. the outcome of those operations, e.g.: `1 + 2` $\neq$ `'1' + '2'`
- We have elementary and composite types:

  a character is an elementary type,
  while a string is a sequence of characters: a composite type.
- Elementary types: int, float, char, and boolean.
  A character is a string of length one.
  Python has no separate type for a character.
  The `+` operator applied to string concatenates.

Machine Integers

We distinguish between machine integers and long integers.

- The computer uses 32 or 64 bits to represent integers.
  First bit is sign bit: $0 = +$, $1 = -$.
- The largest machine int is $+2^{31} - 1$ or $+2^{63} - 1$:

```
>>> 2**30 + (2**30 - 1)
2147483647
>>> 2**62 + (2**62 - 1)
9223372036854775807
```

- The smallest machine int is -2^{31} or -2^{63}:

```
>>> -2**31
-2147483648
>>> -2**63
-9223372036854775808
```

In Python, the use of long integers avoids overflow and underflow.

Boolean

We can store the outcome of logical expressions:

```
>>> x = 3
>>> x == 3
True
>>> x == 4
False
```

For complicated logical expressions, we may want to save its outcome (Python session continued):

```
>>> b = _
>>> type(b)
<type 'bool'>
```

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Getting User Input

unformatted or of specific type

Two ways to prompt the user for input:

1. `s = input('Give a number : ')`
2. `n = int(input('Give a number : '))`

In both cases, the user sees `Give a number :`

The difference is in the type of the object returned

1. `input()` returns always a string
2. `int(input())` converts the input string to an integer.

Why two ways?

1. the string returned by `input()` can be cast (converted) into an integer or a float, depending on its purpose;
2. a direct conversion is good if we assume correct input.

evaluation of Python literal structures

```
>>> from ast import literal_eval
>>> sn = input('give a number : ')
give a number : 3
>>> n1 = literal_eval(sn)
>>> n1
3
>>> type(n1)
<class 'int'>
>>> sf = input('give a number : ')
give a number : 3.4
>>> n2 = literal_eval(sf)
>>> n2
3.4
>>> type(n2)
<class 'float'>
```

With `literal_eval` Python evaluates a string into the proper type.

Exercises

1. Can you explain why `1.1 + 0.1` shows `1.2000000000000002`. Why is the outcome of `1.1 + 0.1` not exact?
2. Explain why the string `'%.40e' % .5` is exactly the same as `0.5` while `'%.40e' % .1` differs from the exact `0.1`.
3. Write a Python program to convert a duration expressed in seconds in an hour, minutes, and seconds format. For example: 35781 seconds equals 9 hours, 56 minutes, and 21 seconds.
4. The formula $f = \frac{9}{5}c + 32$ converts c degrees of Celsius into f degrees of Fahrenheit. Write a Python program that prompts the user for c and prints f.
5. Modify the yield and balance program for loans, i.e.: what is the balance of a loan when making a number of payments when the interest rate is fixed?