Welcome!

We'll get started shortly. Please take the Zoom poll in the meanwhile!

CS 49 Week 4

Surajit A. Bose

How to get hold of me / get help from other resources

- Surajit's office hours
  - ~~Fridays 12 noon–1p, directly after section~~ **No office hours this week due to Presidents' Day holiday**
  - By appointment on Zoom
- Post on the section forum, usually get a response within 2 hours
- Email bosesurajit@fhda.edu or Canvas inbox, 24 hr turnaround
- The github repo has section materials, starter code, and solutions

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- Canvas inbox for Lane
- The main forum for the course on the Code in Place site
- Lane's office hours
- Online or in-person tutoring (Room 3600)
- One-on-one code reviews with Sarah or Lia

Goals

- To understand the fundamentals of Python programming
    - Console input and output
    - Variables and expressions
    - External modules and libraries: **`math`**, **`round`**, and **`ai`**
    - Constants
    - Rounding decimal numbers

Agenda

- Console input and output
- Worked example: Agreement Bot
- Variables and expressions
- Worked example: Fahrenheit to Celsius
- External modules and libraries
- Constants
- Worked examples: Roll Dice, Pythagorean Theorem
- Rounding decimal numbers

Console Input and Output

The console, aka the terminal

```
Terminal
%
```

Strings

- For writing to or reading from the console (or a file), Python uses strings
- A string is a sequence of zero or more characters enclosed in quotation marks
- Quotation marks can be single or double, as long as the same kind is used at the beginning and end of the string
- Example strings:

```
"CS 49 is a fun and useful class!"
'Today I ate approximately 3.14 slices of pie.'
""      # this is an empty string
' '     # this is a string containing a space character
"Don't drink the water."  # note the single quote
```

Console output via `print()`

- The command used for console output is `print()`
- Sample program in Python that prints `hello, world` to the screen:

```
def main()
    print("hello, world")

if __name__ == "__main__":
    main()
```

- The string `hello, world` will be printed to screen without the quotation marks

Getting user input at the console

- The program can get information from the user via the `input()` command
- The parentheses contain the **prompt** to be printed onscreen
- The program prints the prompt and waits for the user to enter something
- Sample `input()` command asking for the user's favorite animal:

```
fave_animal = input("What is your favorite animal? ")
```

- The prompt is a string
- For good formatting, put a space at the end of the prompt (before the close quote)
- The user input needs to be stored in a **variable** for the program's use
- Here, `fave_animal` is the variable storing what the user enters at the prompt

Printing variables using f-strings

- Python provides a mechanism called **f-strings** to print a variable's value
- **f-strings** is short for **format strings**
- To print an f-string:
  - Use the character **`f`** before the open quotation marks inside the parentheses following **`print`**
  - Put the variable's name in braces, i.e., {curly brackets}, at the place in the string where it should be printed
- Example:

```
print(f"My favorite animal is also {fave_animal}!")
```

- Worked example: Agreement Bot

Variables and Expressions

Variables

- A variable is a **named** place in memory that holds a **value** of a particular **type**
- A variable is a **location in memory**
- The variable **is** or **has** a **name**. The name is an identifier or tag that specifies the memory location
- The variable **has** or **holds** a **value**, such as 8.04, -16, or "steve@apple.com"
- The value is of a specific **type**. The basic or primitive types in Python are:
  - a **`float`** (a number with decimal places, could be positive, negative, or 0.0)
  - an **`int`** (an integer, could be positive, negative, or zero)
  - a **`str`** (a string, a sequence of characters enclosed in single or double quotes)
  - a **`bool`** (a boolean, for two specific values **`True`** and **`False`** used when evaluating conditions)

Variable assignment (Slide 1 of 2)

- Variables are **assigned** using a single equal sign:

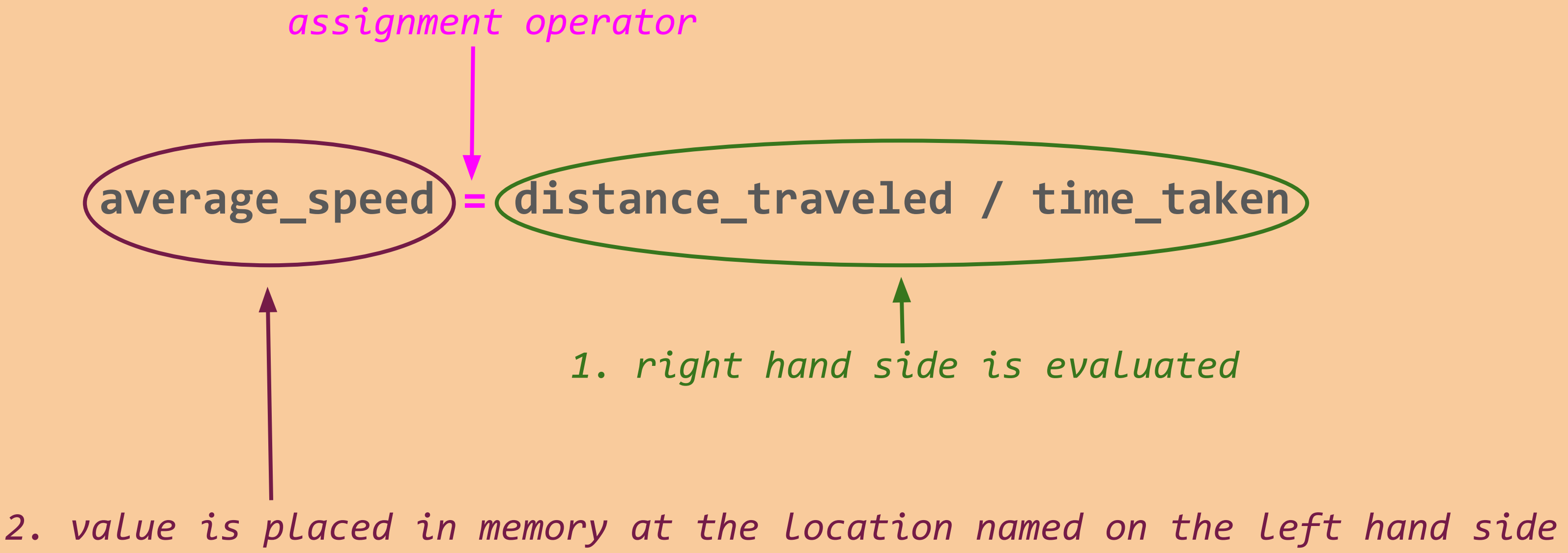
```
num_planets = 8
```

- The right hand side of the equal sign is **evaluated**
- The value is then assigned to the variable on the left hand side
- For example, given the command:

```
average_speed = distance_traveled / time_taken
```

- First, `distance_traveled / time_taken` is calculated
- The resulting value is then placed in memory with the name `average_speed`

Variable assignment (Slide 2 of 2)


assignment operator
average_speed = distance_traveled / time_taken
1. right hand side is evaluated
2. value is placed in memory at the location named on the left hand side

Arithmetic expressions (Slide 1 of 3)

- An expression is a statement that can be evaluated
- With Karel, we've seen conditions, boolean expressions such as **`front_is_clear()`** or **`beepers_present()`** that evaluate to **`True`** or **`False`**
- There are also arithmetic expressions: Given **`x = 9`** and **`y = 2`**,

```
z = x + y      # z = 11        z = x // y     # z = 4
z = x - y      # z = 7         z = x % y      # z = 1
z = x * y      # z = 18        z = x ** y     # z = 81
z = x / y      # z = 4.5       z = -y         # z = -2
```

Arithmetic expressions (Slide 2 of 3)

- The symbols `+`, `*`, `/`, etc. are the **operators**
- The terms operated on (`x` and `y` in the previous slide) are the **operands**
- Typically, the result or value of an arithmetic expression is stored in a variable (`z` in the previous slide)
- Keep in mind the difference between these three operators:
    - `/` will always result in a `float`
    - `//` will always result in an `int`, any remainder being discarded
    - `%` is the modulus operator for the remainder of integer division
- Given `x = 8` and `y = 2`, what is the value and type of these expressions?

```
x ** y   # ?          x / y   # ?          x < y   # ?
```

Arithmetic expressions (Slide 3 of 3)

- The symbols `+`, `*`, `/`, etc. are the **operators**
- The terms operated on (`x` and `y` in the previous slide) are the **operands**
- Typically, the result or value of an arithmetic expression is stored in a variable (`z` in the previous slide)
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  - `/` will always result in a `float`
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  - `%` is the modulus operator for the remainder of integer division
- Given `x = 8` and `y = 2`, what is the value and type of these expressions?

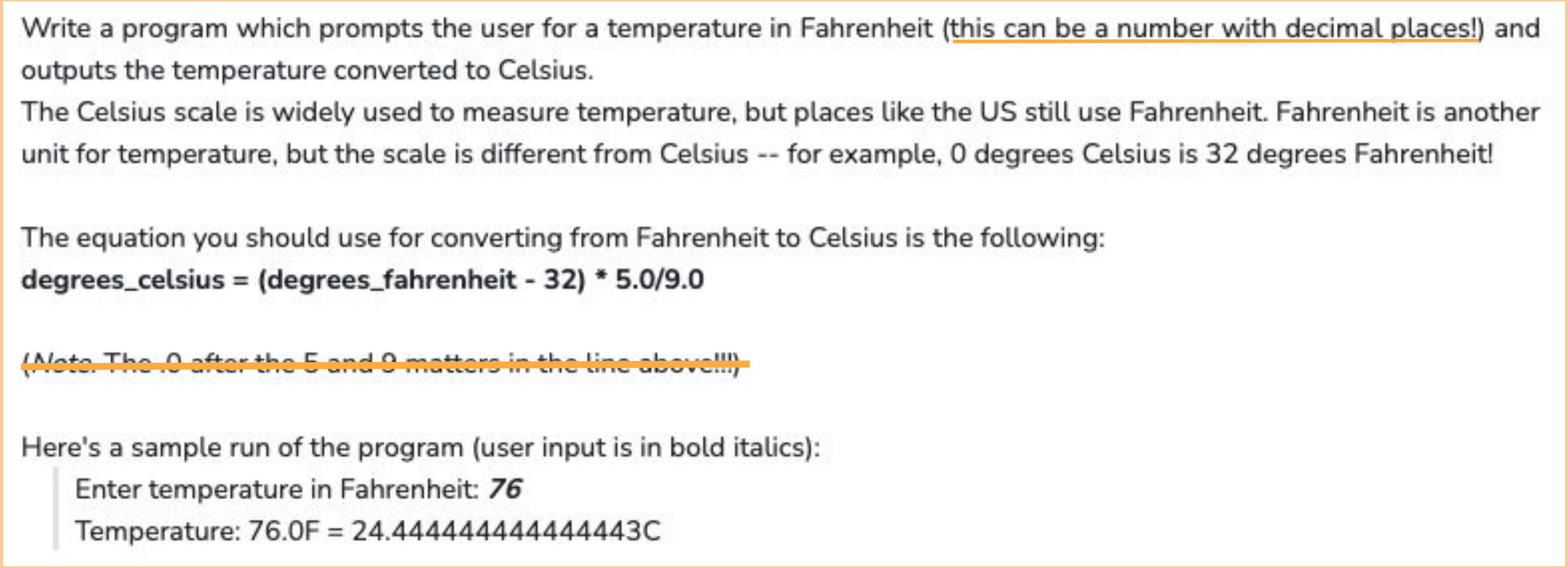
```
x ** y  # 64        x / y  # 4.0           x < y  # False
```

More about types

- All console input and output is done with type `str`
- When the user inputs a number, we need to convert it from `str` to `float` or `int` as appropriate
- This is done by **casting** the input as the appropriate type
- Conversely, when the program prints numbers to screen, they need to be converted to `str`
- Sample program: Add Two Numbers
- **f-strings** automatically cast variables to `str` for output
- Change the print statement to use an **f-string** to avoid explicit casts and having to use the + sign!

Worked Example: Converting Temperatures

Worked example: Fahrenheit to Celsius



Write a program which prompts the user for a temperature in Fahrenheit (this can be a number with decimal places!) and outputs the temperature converted to Celsius.
The Celsius scale is widely used to measure temperature, but places like the US still use Fahrenheit. Fahrenheit is another unit for temperature, but the scale is different from Celsius -- for example, 0 degrees Celsius is 32 degrees Fahrenheit!

The equation you should use for converting from Fahrenheit to Celsius is the following:
degrees_celsius = (degrees_fahrenheit - 32) * 5.0/9.0

~~(Note: The .0 after the 5 and 9 matters in the line above!!!)~~

Here's a sample run of the program (user input is in bold italics):

```
Enter temperature in Fahrenheit: 76
Temperature: 76.0F = 24.444444444444443C
```

Solution design

- Get input from the user and store it in a variable
  - What would be a good variable name?
  - What type will the variable be?
- Cast the variable to the appropriate type
  - As what type should the value be cast?
- Apply the conversion formula and store the result in a variable
  - What would be a good variable name?
- Use an f-string to print the result to the screen

Modules and Libraries

The **`random`** module

- A module is a python file containing pre-existing code that provides useful functionality
- The **`random`** module which allows us to generate pseudo-random numbers
- **`random.randint(x, y)`** will generate an **`int`** between **`x`** and **`y`** inclusive
- **`random.random()`** will generate a **`float`** between 0 and 1, not including 1
- **`random.uniform(x, y)`** will generate a **`float`** between **`x`** and **`y`** inclusive
- For debugging, **`random.seed(x)`** will set the seed for the random generator to a specified value **`x`** so that the sequence of random numbers generated is the same each time the program is run

The **`math`** and **`ai`** libraries (Slide 1 of 3)

- Loosely speaking, a library is a collection of many modules
- The **`ai`** library provides an interface to ChatGPT
- The **`math`** library provides functionality such as calculating square roots
- To use such external libraries in our own programs, we need to use an **`import`** statement such as **`from ai import call_gpt`**, **`import random`**, or **`import math`**
- We've seen such a statement before: do you recall where?

The **`math`** and **`ai`** libraries (Slide 2 of 3)

- Loosely speaking, a library is a collection of many modules
- The **`ai`** library provides an interface to ChatGPT
- The **`math`** library provides functionality such as calculating square roots
- To use such external libraries in our own programs, we need to use an **`import`** statement such as **`from ai import call_gpt`**, **`import random`**, or **`import math`**
- We've seen such a statement before:

```
from karel.stanfordkarel import *
```

The **`math`** and **`ai`** libraries (Slide 3 of 3)

- When using a statement like **`import math`** without using **`from`**, we have to specify the name of the library or module (here, **`math`**) in the command
- For example, the command to calculate the square root of 25 is:

```
math.sqrt(25)
```

- By contrast, when using a statement like **`from ai import call_gpt`**, you don't have to specify the name of the library (here, **`ai`**) in your command:

```
call_gpt("What is the capital of South Africa? ")
```

- In both cases, for the result to be useful, we'll need to store it in a variable

Constants

Constants

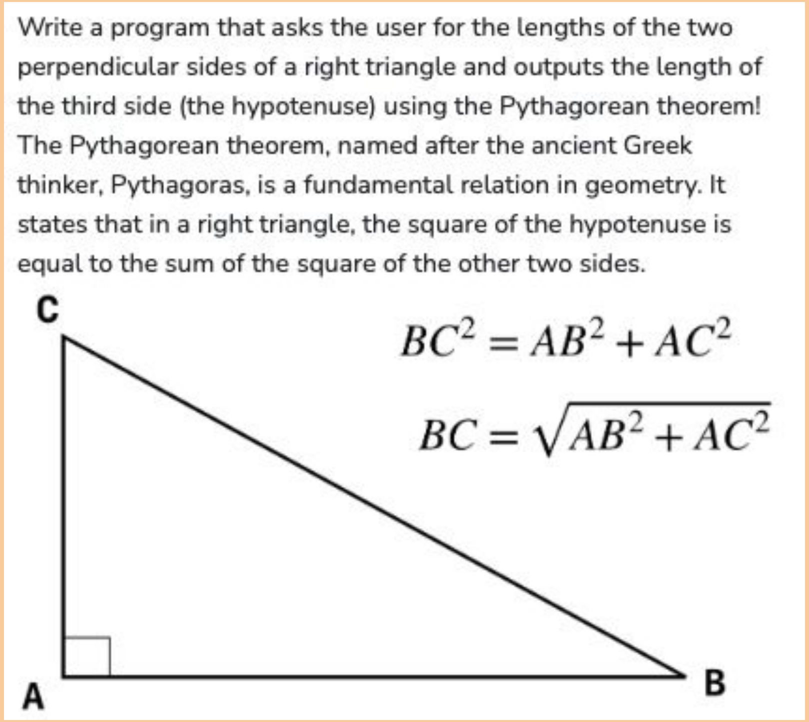
- In Python, a constant is a variable whose value does not change during the execution of the program
- By convention, constants are named in **`UPPER_SNAKE_CASE`**
- Why use constants?
    - To avoid "magic numbers"
    - To allow easy updates
    - To follow the principle of programming for the general case
- Unlike most other programming languages, Python does not enforce constants; they are a convention
- Sample program: Roll_Dice

The structure of a Python program

- Python programs have a typical order:
  - Comment with filename, program overview, and programmer name
  - **`from x import y`** statements
  - **`import z`** statements
  - constants
  - **`main()`** function
  - helper functions
  - guard clause and invocation of **`main()`**
- A template for your use is on the section github repo

Worked Example: Pythagorean Theorem

Pythagorean theorem



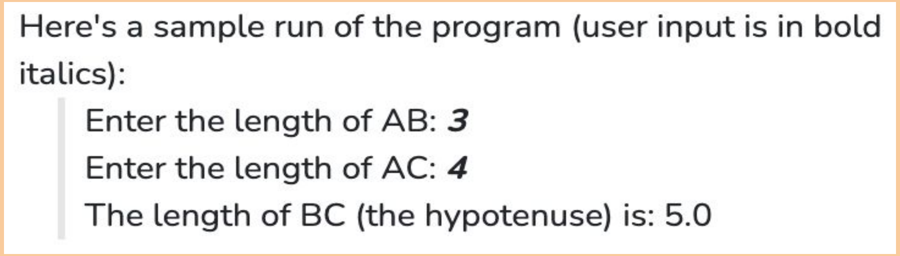
Write a program that asks the user for the lengths of the two perpendicular sides of a right triangle and outputs the length of the third side (the hypotenuse) using the Pythagorean theorem! The Pythagorean theorem, named after the ancient Greek thinker, Pythagoras, is a fundamental relation in geometry. It states that in a right triangle, the square of the hypotenuse is equal to the sum of the square of the other two sides.

$$BC^2 = AB^2 + AC^2$$

$$BC = \sqrt{AB^2 + AC^2}$$

Solution design

- Get len_AB from user and convert to appropriate type
- Get len_AC from user and convert to appropriate type
- Compute sum of squares
- Compute len_BC
- Display len_BC



Here's a sample run of the program (user input is in bold italics):

```
Enter the length of AB: 3
Enter the length of AC: 4
The length of BC (the hypotenuse) is: 5.0
```

Built-in functions: `round()`

- In addition to the functionality provided by modules and libraries, Python also has its own suite of built-in functions
- One such function is **`round()`**, used to round a **`float`** to the nearest **`int`** or to a specified number of decimal spaces
- Example:

```
round(3.1415)       # result: 3
round(3.1415, 3)    # result: 3.142
```

That's all, folks!

Next up: Control Flow in Python

Bonus Slides

More about variables and operators

More about variable names

Variable names (Slide 1 of 3)

- A variable is a **named** place in memory that holds a **value** of a certain **type**
- Names are case sensitive: `cumulative_GPA` is different from `cumulative_gpa`
- Restrictions on names (enforced by Python):
  - Must begin with a letter or an underscore
  - Must not be a reserved word like `for` or `def`
- Warning about names (not enforced by the language):
  - Should not replicate the name of a built-in function like `print` or `round`
- Conventions about names (style guidelines):
  - Should be short but descriptive
  - Should be in `snake_case` if longer than one word long

Variable names (Slide 2 of 3)

- Which of the following variable names meet the specified standards?
  - Must begin with a letter or underscore[1]
  - Must not be a reserved word such as **`for`** or **`def`**[1]
  - Should not replicate names for built-in functions like **`print()`**[2]
  - Should be in **`snake_case`** if more than one word long[3]
  - Should be short but descriptive[3]
- [1]illegal in Python to violate this; [2]legal but extremely inadvisable; [3]recommended convention

```
result   101_dalmatians   num_students   pass   input
numStudents   longitude   y   total   main   1atitude
```

Variable names (Slide 3 of 3)

- Which of the following variable names meet the specified standards?
  - Must begin with a letter or underscore[1]
  - Must not be a reserved word such as **`for`** or **`def`**[1]
  - Should not replicate names for built-in functions like **`print()`**[2]
  - Should be in **`snake_case`** if more than one word long[3]
  - Should be short but descriptive[3]
- **`red`**: illegal in Python to violate this; **`purple`**: legal but extremely inadvisable; **`brown`**: legal but against recommended convention; **`green`**: fine

```
result    101_dalmatians   num_students   pass    input
numStudents   longitude   y   total   main    1atitude
```

More about variable values

Variable value (Slide 1 of 3)

- A variable is a **named** place in memory that holds a **value** of a particular **type**
- Value:
  - Assigned to a variable with the equals sign, e.g. **`answer = 42`**
  - This is also called "binding": the value **`42`** is bound to the variable **`answer`**
  - The assigned value can be an expression, e.g.
    `gpa = qual_points / num_credits`
  - The right hand side of the equals sign is **evaluated** , then the result is placed into the variable on the left hand side
  - This means we can have commands like
    `balance = balance + interest`

Variable value (Slide 2 of 3)

- As we saw with `input()`, a value can be **cast** to a different type
- Given `int_val = 3`, what would the results be of the following cast operations?

```
float_val = float(int_val)
str_val = str(int_val)
str_float_val = str(float_val)
int_val_2 = int(str_float_val)

e = 2.7183
int_e = int(e)
```

Variable value (Slide 3 of 3)

- As we saw with **`input()`**, a value can be **cast** to a different type
- Given **`int_val = 3`**, what would the results be of the following cast operations?

```
float_val = float(int_val)        # result: 3.0
str_val = str(int_val)            # result: '3'
str_float_val = str(float_val)    # result: '3.0'
int_val_2 = int(str_float_val)    # result: error

e = 2.7183
int_e = int(e)                    # result: 2
```

More about variable types

Variable type (Slide 1 of 3)

- With arithmetic expressions, the type of the result depends on both the operator and the operands
  - **`/`** always results in a **`float`**, **`//`** always in an **`int`**
  - All the others will result in an **`int`** if both operands are **`int`**s, or a **`float`** if either of the operands is a **`float`**
- What are the types of the following values?

```
35      beepers_present()     8.13          53 + 72
12 * 6      "7 + 11"        12 / 6.0        12 / 6
'front_is_clear()'          wage_rate * hours_worked
```

Variable type (Slide 2 of 3)

- With arithmetic expressions, the type of the result depends on both the operator and the operands
  - `/` always results in a **`float`**, `//` always in an **`int`**
  - All the others will result in an **`int`** if both operands are **`int`**s, or a **`float`** if either of the operands is a **`float`**
- Types: **`red`**, **`str`**; **`green`**, **`int`**; **`purple`**, **`float`**; **`brown`**, **`bool`**; **`pink`**, can't say

```
35      beepers_present()     8.13          53 + 72
12 * 6       "7 + 11"       12 / 6.0        12 / 6
'front_is_clear()'          wage_rate * hours_worked
```

Variable type (Slide 3 of 3)

- Watch out for floating point values! They are not stored precisely:

```
x = 1.9
y = 1
z = x - y
print(z)                # 0.8999999999999999
```

- Precision of `floats` is not reliable beyond the precision determinable by the inputs. Here, the value of **z** is not reliable past one decimal place.
- Can use `round(a, b)` where **a** is the value to round, **b** the number of decimal places:

```
print(round(z, 1))      # 0.9
```

More about operators

Operator Precedence

- Operators have the following precedence:

`( )`	parentheses
`**`	exponentiation
`-`	unary negation
`*`, `/`, `//`, `%`	multiplication, division, integer division, modulus
`+`, `-`	addition, subtraction

- Operators with the same precedence (e.g., multiplication, division) are evaluated from left to right
- To make code easier to read, use parentheses rather than relying on precedence: though they are the same, `a + (b * c)` is more readable than `a + b * c`

Compound Operators (Slide 1 of 2)

- Compound operators: **+=**, **-=**, ***=**, etc. combine the arithmetic and assignment operators in a single command
- Given initial values **x = 3** and **y = 2**, what would the following expressions sequentially evaluate to?

```
x *= y      # x = x * y
x += 4      # x = x + 4
x /= y      # x = x / y
x %= y      # x = x % y
```

Compound Operators (Slide 2 of 2)

- Compound operators: **+=**, **-=**, ***=**, etc. combine the arithmetic and assignment operators in a single command
- Given initial values **x = 3** and **y = 2**, what would the following expressions sequentially evaluate to?

```
x *= y      # x = x * y     x = 6
x += 4      # x = x + 4     x = 10
x /= y      # x = x / y     x = 5.0
x %= y      # x = x % y     x = 2.0
```

- Notice that the type of the result depends on both the operators and the operand