1.1 Programming (general)

Computer program basics

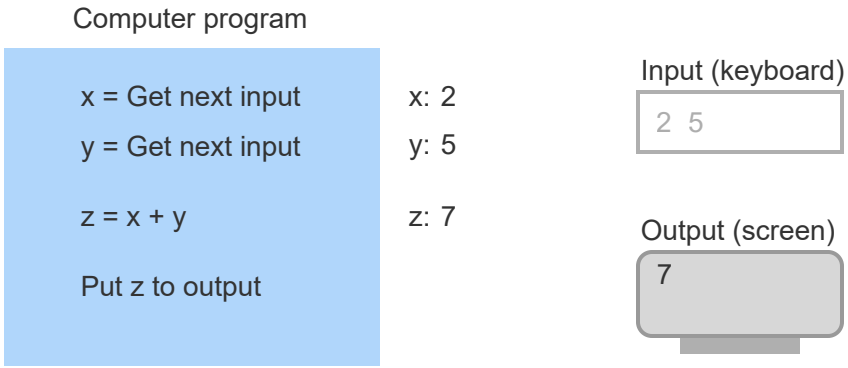
Computer programs are abundant in many people's lives today, carrying out applications on smartphones, tablets, and laptops, powering businesses like Amazon and Netflix, helping cars drive and planes fly, and much more.

A computer ***program*** consists of instructions executing one at a time. Basic instruction types are:

- ***Input***: A program receives data from a file, keyboard, touchscreen, network, etc.
- ***Process***: A program performs computations on that data, such as adding two values like x + y.
- ***Output***: A program puts that data somewhere, such as a file, screen, or network.

Programs use ***variables*** to refer to data, like x, y, and z below. The name is due to a variable's value "varying" as a program assigns a variable like x with new values.

PARTICIPATION ACTIVITY 1.1.1: A basic computer program.



Animation content:

The animation executes the following computer program:

x = Get next input
y = Get next input

z = x + y
Put z to output

Input (keyboard) is as follows:
2 5

Output (screen) is as follows:
7

Animation captions:

1. A basic computer program's instructions receive input, process the input, and produce output. This program first assigns x with what is typed on the keyboard input, in this case, 2.
2. The program's next instruction assigns y with the next input, in this case 5.
3. The program then processes the input, in this case the program assigns z with x + y (so 2 + 5 yields z of 7).
4. Finally, the program puts z (7) to output, in this case to a screen.

PARTICIPATION ACTIVITY 1.1.2: A basic computer program.

Consider the example above.

1) How many instructions does the program have?

Check Show answer

2) Suppose a new instruction were inserted as follows:

```
...
z = x + y
Add 1 to z (new instruction)
Put z to output
```

What would the last instruction output to the screen?

Check Show answer

3) Consider the instruction: z = x + y. If x is 10 and y is 20, then z is assigned with _____.

Check Show answer

A program is like a recipe

Some people think of a program as being like a cooking recipe. A recipe consists of *instructions* that a chef executes, like adding eggs or stirring ingredients.

Baking chocolate chip cookies from a recipe

- Mix one stick of butter and one cup of sugar.
- Add egg and mix until combined.
- Stir in flour and chocolate.
- Bake at 350°F for 8 minutes.

Likewise, a computer program consists of instructions that a computer executes, like multiplying numbers or outputting a number to a screen.

A first programming activity

Below is a simple tool that allows a user to rearrange pre-written instructions (in no particular programming language). The tool illustrates how a computer executes each instruction one at a time, assigning variable m with new values throughout, and outputting ("printing") values to the screen.

PARTICIPATION ACTIVITY 1.1.3: A first programming activity.

Execute the program and observe the output. Click and drag the instructions to change the order of the instructions, and execute the program again. Can you make the program output a value greater than 500? How about greater than 1,000?

Run program

```
m = 5

put m

m = m * 2
put m

m = m * m
put m

m = m + 15
put m
```

m:

PARTICIPATION ACTIVITY 1.1.4: Instructions.

1) Which instruction completes the program to compute a triangle's area?
base = Get next input
height = Get next input
Assign x with base * height

____

Put x to output

- Multiply x by 2
- Add 2 to x
- Multiply x by 1/2

2) Which instruction completes the program to compute the average of three numbers?
x = Get next input
y = Get next input
z = Get next input

____

Put a to output

- a = (x + y + z) / 3
- a = (x + y + z) / 2
- a = x + y + z

Computational thinking

Mathematical thinking became increasingly important throughout the industrial age, enabling people to successfully live and work. In the information age, many people believe ***computational thinking***, or creating a sequence of instructions to solve a problem, will become increasingly important for work and everyday life. A sequence of instructions that solves a problem is called an ***algorithm***.

PARTICIPATION ACTIVITY 1.1.5: Computational thinking: Creating algorithms to draw shapes using turtle graphics.

A common way to become familiar with algorithms is called turtle graphics: You instruct a robotic turtle to walk a certain path via instructions such as "Turn left", "Walk forward 10 steps", or "Pen down" (to draw a line while walking).

The six-instruction algorithm shown below ("Pen down", "Forward 100", etc.) draws a triangle.

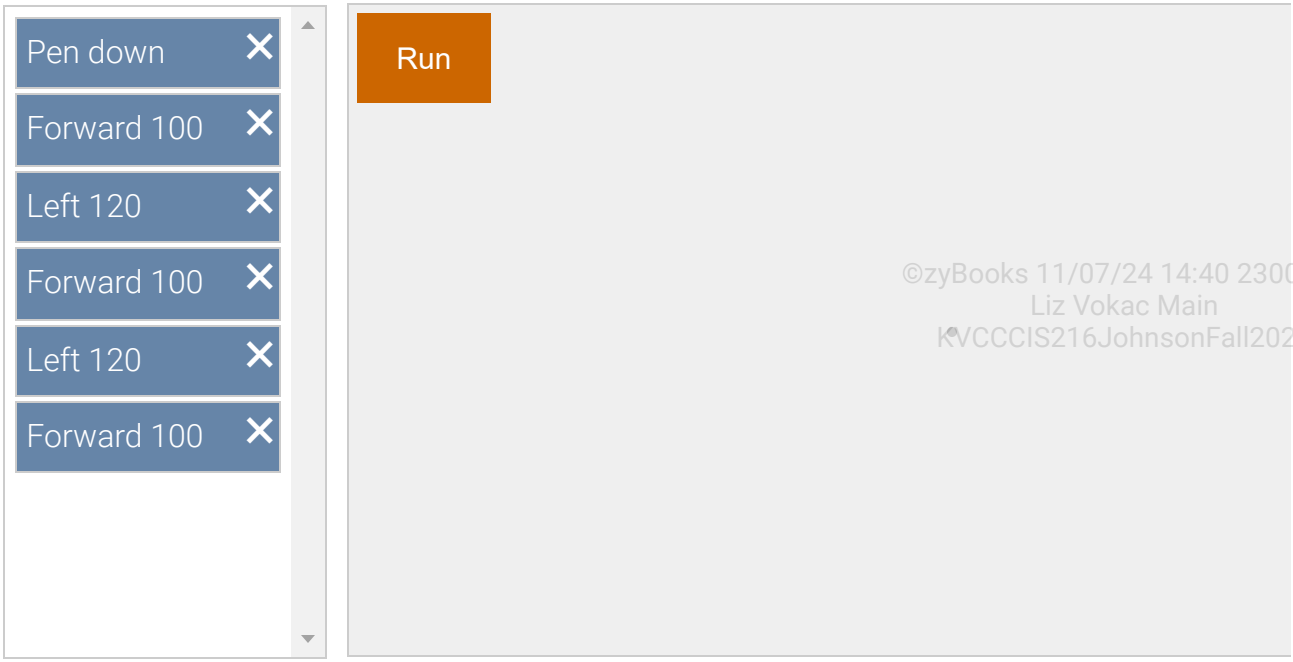
1. Press "Run" to see the instructions execute from top to bottom, yielding a triangle.
2. Can you modify the instructions to draw a square? Hint: "Pen down", "Forward 100", "Left 90", "Forward 100", "Left 90" -- keep going!
3. Experiment to see what else you can draw.

Note: The values after a left or right turn are angles in degrees.

How to:

- Add an instruction: Click an orange button ("Pen up", "Pen down", "Forward", "Turn left").
- Delete an instruction: Click its "x".
- Move an instruction: Drag it up or down.

Pen up | Pen down | Forward | Turn left | Clear



1.2 Programming using Python

Python interpreter

The ***Python interpreter*** is a computer program that executes code written in the Python programming language. An ***interactive interpreter*** is a program that allows the user to execute one line of code at a time.

Code is a common word for the textual representation of a program (and hence programming is also called *coding*). A ***line*** is a row of text.

The interactive interpreter displays a ***prompt*** (">>>") that indicates the interpreter is ready to accept code. The user types a line of Python code and presses the enter key to execute the code. Initially, you may think of the interactive interpreter as a powerful calculator. The example program below calculates a salary based on a given hourly wage, the number of hours worked per week, and the number of weeks per year. The specifics of the code are described elsewhere in the chapter.

PARTICIPATION ACTIVITY 1.2.1: The Python interpreter.

```
>>> wage = 20
>>> hours = 40
```

Python interpreter

```
>>> weeks = 52
>>> salary = wage * hours * weeks
>>> print(salary)
41600
>>> hours = 35
>>> salary = wage * hours * weeks
>>> print(salary)
36400
>>>
```

Name	Value
wage	20
hours	35
weeks	52
salary	36400

Animation content:

Static figure: A computer is running the python interpreter.

Step 1: After each press of the enter key, the python interpreter executes the line of code.

The python interpreter executes the following lines of code, one at a time:
>>> wage = 20
>>> hours = 40
>>> weeks = 52

The python interpreter associates the name wage with the value 20, the name hours with the value 40, and the name weeks with the value 52.

Step 2: The python interpreter can be used as a calculator to perform a variety of calculations.

The python interpreter executes the following line of code:
>>> salary = wage * hours * weeks

The python interpreter substitutes the name wage with the value 20, the name hours with the value 40, and the name weeks with the value 52. The python interpreter then computes a product of 41600 and associates the name salary with the value 41600.

Next, the python interpreter executes the following line of code:
>>> print(salary)

The python interpreter outputs the value associated with the name salary, so the python interpreter displays the value 41600.

Step 3: Users can change values and execute calculations again.

The python interpreter executes the following lines of code, one at a time:

```
>>> hours = 35
>>> salary = wage * hours * weeks
>>> print(salary)
```

The python interpreter associates the name hours with the value 35. The python interpreter then substitutes the name wage with the value 20, the name hours with the value 35, and the name weeks with the value 52. Next, the python interpreter computes a product of 36400 and associates the name salary with the value 36400. Finally, the python interpreter outputs the value associated with the name salary, so the python interpreter displays the value 36400.

Animation captions:

1. After each press of the enter key, the python interpreter executes the line of code.
2. The python interpreter can be used as a calculator to perform a variety of calculations.
3. Users can change values and execute calculations again.

PARTICIPATION ACTIVITY 1.2.2: Match the Python terms with their definitions.

If unable to drag and drop, refresh the page.

Prompt **Code** **Line** **Interpreter**

	A program that executes computer code.
	The text that represents a computer program.
	Informs the programmer that the interpreter is ready to accept commands.
	A row of text.

Reset

Executing a Python program

The Python interactive interpreter is useful for simple operations or programs consisting of only a few lines. However, entering code line-by-line into the interpreter quickly becomes unwieldy for any program spanning more than a few lines.

Instead, a programmer can write Python code in a file then provide that file to the interpreter. The interpreter begins by executing the first line of code at the top of the file and continues until the interpreter reaches the end.

- A ***statement*** is a program instruction. A program mostly consists of a series of statements, and each statement usually appears on its own line.
- ***Expressions*** are code that return a value when evaluated; for example, the code `wage * hours * weeks` is an expression that computes a number. The symbol `*` is used for multiplication. The names wage, hours, weeks, and salary are ***variables***, which are named references to values stored by the interpreter.
- A new variable is created by performing an ***assignment*** using the = symbol, such as `salary = wage * hours * weeks`, which creates a new variable called salary.
- The ***print()*** function displays variables or expression values.
- Characters such as "#" denote ***comments***, which are optional but can be used to explain portions of code to a human reader.
- Many code editors color certain words, as in the below program, to assist a human reader in understanding various words' roles.

PARTICIPATION ACTIVITY 1.2.3: Executing a simple Python program.

file.py

```
wage = 20
hours = 40
weeks = 52
salary = wage * hours * weeks

print('Salary is:', salary)

hours = 35
salary = wage * hours * weeks
print('New salary is:', salary)
```

Python interpreter

```
>>>
```

Name	Value
wage	20
hours	35
weeks	52
salary	36400

```
Salary is: 41600
New salary is: 36400
```


Animation content:

Static figure:
File labeled file.py.
Begin Python code:

```
wage = 20
hours = 40
weeks = 52
salary = wage * hours * weeks

print('Salary is:', salary)

hours = 35
salary = wage * hours * weeks
print('New salary is:', salary)
```

End Python code.
Also present are a box to show the program's output and a representation of a Python interpreter. The Python interpreter contains a box with the prompt ">>>" and a table with columns Name and Value.
Step 1: The Python interpreter reads a file line by line. Variables wage, hours, and weeks are named references that refer to values stored by the interpreter. First, the Python interpreter reads the first line of file.py, "wage = 20". The line is highlighted in file.py, and then the text of the line is copied to the prompt box in the Python interpreter, so that it reads ">>> wage = 20". Then wage and 20 are added to the Python interpreter's table under columns Name and Value respectively. These steps are repeated as the lines "hours = 40" and "weeks = 52" are each read by the interpreter and the variables and values are stored in the table. Finally, the table in the Python interpreter reads as follows:

Name	Value
wage	20
hours	40
weeks	52

Step 2: 20 * 40 * 52 is computed, and the variable salary is assigned with the value. The Python interpreter reads the next line, which reads "salary = wage * hours * weeks". The values associated with wage, hours, and weeks , which are 20, 40, and 52 respectively, are located in the Python interpreter's table. The Python interpreter calculates the value of 20 * 40 * 52, which is 41600. The variable salary and the value 41600 are added to the Python interpreter's table, which now reads as follows:

Name	Value
wage	20

hours	40
weeks	52
salary	41600

Step 3: The print statement prints "Salary is:" to the screen and displays the value of the variable salary. The Python interpreter reads the next line in file.py, "print('Salary is:', salary)". The variable name salary is located in the table and its associated value, 41600, is substituted for the variable salary in the Python interpreter's prompt box. The print statement is interpreted and a statement is printed in the program output box so that it reads as follows:
Begin output:
Salary is: 41600
End output.
Step 4: Values can be overwritten if the same variable name is used. The Python interpreter reads the next line in file.py, which says "hours = 35". In the Python interpreter's table, the value associated with the name hours is changed to 35. The Python interpreter reads the next line in file.py, which says, "salary = wage * hours * weeks". As before, the variables wage, hours, and weeks are located in the interpreter's table. The Python interpreter calculates 20 * 35 * 52, which is 36400. In the Python interpreter's table, the value associated with the variable name salary is changed to 36400. The table now reads:

Name	Value
wage	20
hours	35
weeks	52
salary	36400

The Python interpreter reads the final line of file.py, which says, "print('New salary is:', salary)".The variable salary is located in the Python interpreter's table and its value, 36400, is highlighted. In the Python interpreter's prompt box, the 36400 is substituted for the variable salary, so that the line in the prompt box reads, ">>> print('New salary is:', 36400)". The print statement is interpreted and an assembled string is printed in the program output box so that the box reads as follows:
Begin output:
Salary is: 41600
New salary is: 36400
End output.

Animation captions:

1. The Python interpreter reads a file line by line. Variables wage, hours, and weeks are named references that refer to values stored by the interpreter.
2. 20 * 40 * 52 is computed, and the variable salary is assigned with the value.
3. The print statement prints "Salary is:" to the screen and displays the value of the variable salary.
4. Values can be overwritten if the same variable name is used.

PARTICIPATION ACTIVITY 1.2.4: Python basics.

1) What is the purpose of variables?

- To store values for later use.
- To instruct the processor to execute an action.
- To automatically color text in the editor.

2) The code `20 * 40` is an expression.

- True
- False

3) How are most Python programs developed?

- By writing code in the interactive interpreter.
- By writing code in files.

4) Comments are required in a program.

- True
- False

zyDE 1.2.1: A first program.

Below is the zyBooks Development Environment (zyDE), a web-based programming practice environment. Click run to execute the program, then observe the output. Change 20 to a different number such as 35 and click run again to see the different output.

Load default template... Run

```
wage = 20
hours = 40
weeks = 52
salary = wage * hours * week

print('Salary is:', salary)

hours = 35
salary = wage * hours * week
print('New salary is:', sala
```


1.3 Basic input and output

Basic text output

Text is output from a Python program using the built-in function ***print( )***. Ex: `print('hello world!')`. Text enclosed in quotes is known as a ***string***. Text in strings may have letters, numbers, spaces, or symbols like @ or #.

PARTICIPATION ACTIVITY 1.3.1: Executing a simple Python program.

```
# Each print statement starts on a new line
print('Hello there.')
print('My name is...')
print('Carl?')
```



```
Hello there.
My name is...
Carl?
```

Animation content:

Static figure: a block of code with the contents:

```
print('Hello there.')
print('My name is...')
print('Carl?')
```


and the output of the code:

```
Hello there.
My name is...
Carl?
```

Animation captions:

1. A program runs line by line, starting from the top. The first line prints "Hello there."
2. Each print statements puts their output on a new line.

PARTICIPATION ACTIVITY 1.3.2: Basic text output.

Select the line that will print the given string. If none of the options are valid, select `N/A`.

1) Welcome!

- `print(Welcome!)`
- `print('Welcome!")`
- `print('Welcome!')`
- N/A

2) Password is: BaNaNa123

- `print('Welcome!')`
- `print 'Password is: BaNaNa123'`
- `print('Password is: BaNaNa123')`
- N/A

3) Pikachu is the superior warrior

- `print(Pikachu is the superior warrior")`
- `("Pikachu is the superior warrior")`
- `print()"Pikachu is the superior warrior"`
- N/A

PARTICIPATION ACTIVITY 1.3.3: Basic text output.

Write a line of Python code that prints the given text.

1) *Hello*

Check Show answer

2) *Email sent!*

Check Show answer

3) *bill.gates99@msft.com*

Check Show answer

CHALLENGE ACTIVITY 1.3.1: Output an eight with asterisks.

Complete the program with five print statements to output the following figure with asterisks.

```
*****
*   *
*****
```

```
*   *
*****
```

Note: Whitespace (blank spaces/blank lines) matters; make sure your whitespace matches *exactly* the expected output.

Learn how our autograder works

566436.4601014.qx3zqy7

```
1
2 ''' Your solution goes here '''
3
```

Run

View your last submission

Output variables and multiple values

The value of a variable can be printed out via: `print(variable_name)` (without quotes around the variable name). A single output line may include multiple strings and variables separated by commas. A space character is automatically added between each.

PARTICIPATION ACTIVITY 1.3.4: Printing variables and multiple values.


```
wage = 400
print('Your daily wage is $', wage)

weekly_wage = 2000
print('$', wage, 'per day is $', weekly_wage, 'per week')
```

400	wage
2000	weekly_wag

```
Your daily wage is $ 400
$ 400 per day is $ 2000 per week
```


Animation content:

Static figure: a block of code containing:

wage = 400
print('Your daily wage is $', wage)
weekly_wage = 2000
print('$', wage, 'per day is $', weekly_wage, 'per week')

and the output of the code:

Your daily wage is $ 400
$ 400 per day is $ 2000 per week

Animation captions:

1. A program runs line by line, starting from the top. wage is set to a value of 400, and then print is used to output a string and the value of wage.
2. weekly_wage is set to 2000, and then print is used to output multiple strings and values on a single line.

PARTICIPATION ACTIVITY 1.3.5: Basic variable output.

What's the output of the code?

1)
```
num_wheels = 4
print(num_wheels)
```

- 4
- num_wheels
- num_wheels = 4

2)
```
num_wheels = 4
print('Number of wheels:', num_wheels)
```

- 4
- Number of wheels
- Number of wheels: 4
- Number of wheels:4

3)
```
num_wheels = 4
vehicle_type = 'pickup truck'
print('A', vehicle_type, 'has', num_wheels, 'wheels')
```

- Apickuptruckhas4wheels
- A vehicle_type has num_wheels wheels
- A pickup truck has 4 wheels

PARTICIPATION ACTIVITY 1.3.6: Basic variable output.

Write the most direct single line of code to print the desired string, using the variables provided below. Do not include any numbers directly in your answer.

```
num_fruit_types = 2
num_apples = 3
num_bananas = 5
```

1) *Number of apples: 3*

Check Show answer

2) *I have 2 types of fruit*

Check Show answer

3) *3 apples and 5 bananas*

Check Show answer

PARTICIPATION ACTIVITY 1.3.7: Single print statement.

Write the output generated by the `print()`, using the variables provided below.


```
pet = 'dog'
pet_name = 'Gerald'
age = 22
```

1) `print('You are', age, 'years old.')`

Check Show answer

2) `print(pet_name, 'the', pet, 'is', age)`

Check Show answer

Keeping output on the same line

Each use of `print()` outputs on a new line. However, sometimes a programmer may want to keep output on the same line. Adding `end=' '` inside of `print()` keeps the output of the next print on the same line, separated by a single space character. Ex: `print('Hello', end=' ')`. Any character, or multiple characters, can be used instead of a space character.

Figure 1.3.1: Printing text on the same row.

```
# Including end=' ' keeps output on same line
print('Hello there.', end=' ')
print('My name is...', end=' ')
print('Carl?')
```

```
Hello there. My name is... Carl?
```


PARTICIPATION ACTIVITY 1.3.8: Printing text on the same row.

1) Which pair of statements prints the output *Halt! No access!* on the same line?

- print('Halt!')
print('No access!')
- print('Halt!', end=' ')
print('No access!')
- print(Halt!, end=' ')
print(No Access!, end=' ')

Moving output to the next line

Output can be moved to the next line using the ***newline character*** "\n". Ex: `print('1\n2\n3')` prints "1" on the first line, "2" on the second line, and "3" on the third line of output.

An ***escape sequence*** is a string that has a special meaning, like the newline character "\n", that always starts with a backslash "\". Other escape sequences exist, such as "\t" to insert a tab, or "\\" to print an actual backslash character.

Any space, tab, or newline is called ***whitespace***.

PARTICIPATION ACTIVITY 1.3.9: Newline characters and escape sequences.


```
print('Name\tJob\n------------------')

print('Ann\tDeveloper\nJoe\tInfluencer')
```

```
Name        Job
------------------
Ann         Developer
Joe         Influencer
```

Animation content:

Static figure: a code block with the contents:

```
print('Name\tJob\n------------------')
print('Ann\tDeveloper\nJoe\tInfluencer')
```

and the formatted output of the code:

```
Name        Job
------------------
Ann         Developer
Joe         Influencer
```

Animation captions:

1. A line of Python executes that prints "Name", followed by a "\t" escape sequence to insert whitespace. Then "Job" is printed, followed by a newline "\n" and a series of hyphens.
2. A single line of Python prints two lines of output "Ann Developer" and "Joe Influencer", using "\t" and "\n" to format the output.

PARTICIPATION ACTIVITY 1.3.10: Output simulator.

The tool below supports a subset of Python, allowing for experimenting with printing output. The activity is marked as complete upon interacting with the tool.

The variable `country_name = 'China'` has been defined and can be used in the simulator.

Try printing the following outputs:

- `The population of China was 1.34 billion in 2011.`
-
```
Population of China in 2011:
1.34 billion
```

Note: Use a newline character "\n" to force output to the next line. Commas can be used to output multiple strings.

```
print('Change this string!'
)
```

```
Change this string!
```


NOTE: In a normal programming environment, program input is typed in as the program runs and completed by pressing the enter key. Pressing the enter key will insert a newline. Since zyBooks input is pre-entered, the enter key press cannot be inferred. Thus, activities that require pre-entered input may need extra newline characters or blank print statements in zyBooks compared to other environments.

CHALLENGE ACTIVITY 1.3.2: Enter the output.

Type the program's output.

Note:

- `print(string1, string2)` adds a single space between string1 and string2.
- `print()` automatically adds a newline after the output. So, **don't forget to press the *Enter* or *Return* key** to add an additional newline as needed.

▶ **Click here for example**

566436.4601014.qx3zqy7

Start

Type the program's output

```
print('Sam is great.')
```

```
Sam is great.
```


1 2 3

Check Next

Basic input

Many useful programs allow a user to enter values, such as typing a number, a name, etc.

The ***input()*** function is used to read input from a user. The statement `best_friend = input()` will read text entered by the user, and assign the result as a new string to the best_friend variable. The input() function causes the program to wait until the user has entered text and pushed the return key.

PARTICIPATION ACTIVITY 1.3.11: A program can get an input value from the keyboard.


```
print('Enter name of best friend:', end=' ')
best_friend = input()
print('My best friend is', best_friend)
```


```
Enter name of best friend: Marty McFly

My best friend is Marty McFly
```

Animation content:

Static Figure:
Begin Python code:
print('Enter name of best friend:', end=' ')
best_friend = input()
print('My best friend is', best_friend)
End Python code.
An output console is shown with two output line present, 'Enter name of best friend:
Marty McFly' and 'My best friend is Marty McFly'.
Two memory spaces are shown, one empty and the other occupied with the value 'Marty McFly' for variable best_friend.
An input box is shown, occupied with the input 'Marty McFly'.

Step 1: The input() statement gets an input value from the keyboard and puts that value into the best_friend variable.
The Python code line, print('Enter name of best friend:', end=' ') executes. The text 'Enter name of best friend:' is outputted to the output console. Next, the Python code line, best_friend = input() is executed. 'Marty McFly' is inputted by the user and is assigned to the variable best_friend.

Step 2: best_friend's value can then be used in subsequent processing and outputs.
The Python code line, print('My best friend is', best_friend)executes. The text, 'My best friend is Marty McFly' is outputted to the output console.

Animation captions:

1. The input() statement gets an input value from the keyboard and puts that value into the best_friend variable.
2. best_friend's value can then be used in subsequent processing and outputs.

PARTICIPATION ACTIVITY 1.3.12: Reading user input.

1) What's the value of dog_name after the following code executes?

```
dog_name = input()
```

- Whatever value was entered by the user.
- dog_name is never assigned a value.

2) Which statement reads a user-entered string into variable num_cars?

- `num_cars = input`
- `input() = num_cars`
- `num_cars = input()`

PARTICIPATION ACTIVITY 1.3.13: Reading user input.

1) Complete a statement that reads a user-entered string into variable my_var.

Check Show answer

2) Write a program that accepts two unique user inputs. Assign the first input to variable x, and the second

input to variable y. (Hint: you can use input() multiple times in a program).

Check Show answer

Converting input types

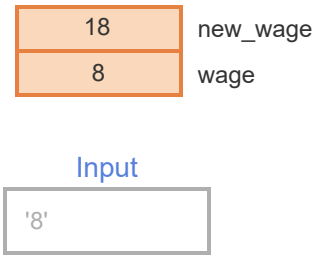
The string '123' (with quotes) is fundamentally different from the integer 123 (without quotes). The '123' string is a sequence of the characters '1', '2', and '3' arranged in a certain order, whereas 123 represents the integer value one-hundred twenty-three. Strings and integers are each an example of a ***type***; a type determines how a value can behave. For example, integers can be divided by 2, but not strings (what sense would `"Hello" / 2` make?). Types are discussed in detail later on.

Reading from input always results in a string type. However, often a programmer wants to read in an integer, and then use that number in a calculation. If a string contains only numbers, like '123', then the ***int()*** function can be used to convert that string to the integer 123.

PARTICIPATION ACTIVITY 1.3.14: Converting input to integers to perform calculations.

```
print('Enter wage:', end=' ')
wage = int(input())


new_wage = wage + 10
print('New wage:', new_wage)
```

```
Enter wage:  8

New wage: 18
```



Animation content:

Static Figure:
Begin Python code:
print('Enter wage:', end=' ')
wage = int(input())

```
new_wage = wage + 10
print('New wage:', new_wage)
```

End Python code.

An output console is shown with two output lines present, 'Enter wage: 8' and 'New wage: 18'. Two memory spaces are shown, one occupied with the value 8 for the variable wage, and the other occupied with the value 18 for the variable new_wage.

An input box is shown, occupied with the input '8'.

Step 1: The Python code line, print('Enter wage:', end=' ') executes. The text 'Enter wage: ' is outputted to the output console. Next, The Python code line, wage = int(input()) is executed. '8' is inputted by the user and returned by the input() function.

Step 2: The int() function then runs the '8' value returned by the input function as int('8'). The result is an integer value 8. The integer value 8 is assigned to the variable wage.

Step 3: The Python code line, new_wage = wage + 10 executes. new_wage is assigned a value of 8 + 10 = 18. The Python code line, print('New wage:', new_wage) executes. The text 'New wage: 18' is outputted to the output console.

Animation captions:

1. input() reads an input value '8' from the keyboard as a new string.
2. int() converts '8' from a string to an integer type, and the integer is stored as the variable wage.
3. The integer value of wage can then be used to perform a calculation, like adding 10 to create a new variable new_wage.

PARTICIPATION ACTIVITY 1.3.15: Converting user input to integers.

1) Type a statement that converts the string '15' to an integer and assigns my_var with the result.

Check Show answer

2) Complete the code so that new_var is equal to the entered number plus 5.

```
my_var = int(input())
new_var =
```

Check Show answer

Input prompt

Adding a string inside the parentheses of input() displays a prompt to the user before waiting for input and is a useful shortcut to adding an additional print statement line.

Figure 1.3.2: Basic input example.

```
hours = 40
weeks = 52
hourly_wage = int(input('Enter hourly wage:
'))

print('Salary is', hourly_wage * hours *
weeks)
```

```
Enter hourly wage:
12
Salary is 24960
...
Enter hourly wage:
20
Salary is 41600
```

NOTE: The below tool requires input to be pre-entered. This is a current limitation of the web-based tool and atypical of conventional Python environments, where users enter input as the program runs. For conventional behavior, you may copy-paste the program into a local environment, such as IDLE.

zyDE 1.3.1: Basic input.

Run the program and observe the output. Change the input box value from 3 to another number, and run again.

Load default template...

```
1 human_years = int(input('Enter age of dog (in human years):
2 print()
3
4 dog_years = 7 * human_years
5
6 print(human_years, 'human years is about', end=' ')
7 print(dog_years, 'dog years.')
8
```

3

Run

CHALLENGE ACTIVITY 1.3.3: Read user input and print to output.

The first line of code provided in the code window reads an integer value from input into **user_num1**.
The second line of code provided in the code window reads an integer value from input into **user_num2**.

Complete the program as follows:

1. Write a line of code that reads an integer value from input into **user_num3**.
2. Write a print() statement that outputs the product of user_num1, user_num2, user_num3.

Note:

- The product is user_num1 * user_num2 * user_num3.
- Our autograder automatically runs your program several times, testing different input values each time to ensure your program works for any values.

See How to Use zyBooks for info on how our automated program grader works.

566436.4601014.qx3zqy7


```
user_num1 = int(input()) # Reads user_num1 from input
user_num2 = int(input()) # Reads user_num2 from input

''' Your solution goes here '''

```

Run

View your last submission

CHALLENGE ACTIVITY 1.3.4: Input/Output.

566436.4601014.qx3zqy7

Start

This challenge activity consists of a series of auto-generated, randomized questions allowing unlimit
correctly answer a question at each level before proceeding to the next level. The purpose of this first
yourself with how the autograder works.

Click each step for instructions:

- **Step 1**
- **Step 2**
- **Step 3**

Learn how our autograder works

```
1
2 ''' Your code goes here '''
3
```


1 2 3 4

Check Next level

1.4 Errors

Syntax errors

As soon as a person begins trying to program, that person will make mistakes. One kind of mistake, a ***syntax error***, violates a programming language's rules on how symbols can be combined to create a program. An example is putting multiple prints on the same line.

The interpreter will generate a message when encountering a syntax error. The error message will report the number of the offending line, in this case 7, allowing the programmer to fix the problem. Sometimes error messages can be confusing. Below, the message "invalid syntax" is not very precise but is the best information that the interpreter reports. With enough practice, a programmer becomes familiar with common errors and avoids them, preventing headaches later.

Note that syntax errors are found *before* the program is run by the interpreter. In the example below, none of the prints prior to the error is in the output.

Figure 1.4.1: A program with a syntax error.

```
print('Current salary is', end='
')
print(45000)

print('Enter new salary:', end='
')
new_sal = int(input())

print(new_sal) print(user_num)
```

```
File "<main.py>", line 7
    print(new_sal)
print(user_num)
                  ^
SyntaxError: invalid syntax
```


PARTICIPATION ACTIVITY 1.4.1: Syntax errors.

Find the syntax errors. Assume variable num_dogs exists.

1) print(num_dogs).

- Error
- No Error

2) print("Dogs: " num_dogs)

- Error
- No Error

3) print('Woof!")

- Error
- No Error

4) print(Woof!)

- Error
- No Error

5) print("Hello + friend!")

- Error
- No Error

PARTICIPATION ACTIVITY 1.4.2: Common syntax errors.

Treat the following lines of code as a continuous program. Find and click on the three syntax errors.

1)

```
triangle_base = 0    # Triangle base (cm)
triangle_height = 0  # Triangle height (cm)
triangle_area = 0
      # Triangle area (cm**2)

print('Enter triangle base (cm): ')
triangle_base = int(input()
```


2)

```
print('Enter triangle height (cm): ')
triangle_height = int(input())
```

```
# Calculate triangle area

triangle_area = (triangle_base * triangle_height) / 2

Print out the triangle base, height, and area
```

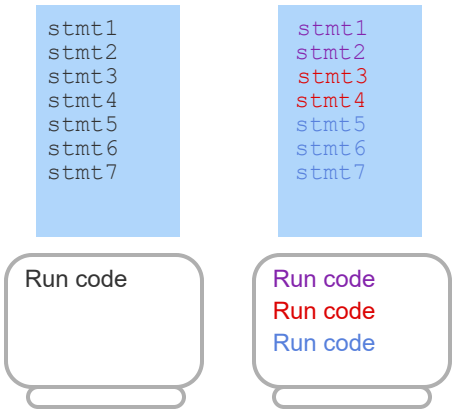
3)

```
print('Triangle area = (', end=' ')

print(triangle_base, end=' ')

print(*, end=' ')

print(triangle_height, end=' ')

print(') / 2 = ', end=' ')
print(triangle_area, end=' ')
print('cm**2')
```


Good coding practice

New programmers will commonly write programs with many syntax errors, leading to many frustrating error messages. *To avoid continually encountering error messages, a good practice is to execute the code frequently, writing perhaps a few (three to five) lines of code and then fixing errors, then writing a few more lines and running again and fixing errors, and so on.* Experienced programmers may write more lines of code each time, but typically still run and test syntax frequently.

PARTICIPATION ACTIVITY 1.4.3: Run code frequently to avoid many errors.



Animation content:

Static figure: A code block and an output console are displayed.
Begin pseudocode:
stmt1
stmt2
stmt3
stmt4
stmt5
stmt6
stmt7
End pseudocode.
Step 1: Writing many lines of code without compiling is bad practice. The text, Run code, is displayed in the output console.
Step 2: New programmers should compile their program every three to five lines. A new code block and output console are displayed. The lines of pseudocode, stmt1, stmt2, appear in the code block and the text, Run code, is displayed in the output console. The lines of pseudocode, stmt3, stmt4, appear in the code block and the text, Run code, is displayed in the output console. The lines of pseudocode, stmt5, stmt6, stmt7, appear in the code block and the text, Run code, is displayed in the output console.

Animation captions:

1. Writing many lines of code without running the code is bad practice.
2. New programmers should run the program after writing every three to five lines of code.

PARTICIPATION ACTIVITY 1.4.4: Testing for syntax errors.

1) Experienced programmers write an entire program before running and testing the code.
   - True
   - False

Runtime errors

The Python interpreter is able to detect syntax errors when the program is initially loaded, prior to actually executing any of the statements in the code. However, just because the program loads and executes does not mean the program is correct. The program may have another kind of error called a

runtime error, in which a program's syntax is correct but the program attempts an impossible operation, such as dividing by zero or multiplying strings together (like 'Hello' * 'ABC').

A runtime error halts the execution of the program. Abrupt and unintended termination of a program is often called a ***crash*** of the program.

Consider the below program that begins executing, prints the salary, and then waits for the user to enter an integer value. The int() statement expects a number to be entered, but gets the text 'Henry' instead.

Figure 1.4.2: Runtime errors can crash the program.

The program crashes because the user enters 'Henry' instead of an integer value.

```
print('Salary is', end=' ')
print(20 * 40 * 50)

print('Enter integer: ',
end=' ')
user_num = int(input())
print(user_num)
```

```
Salary is 40000
Enter integer:  Henry
Traceback (most recent call last):
 File "<stdin>", line 5, in <module>
ValueError: invalid literal for int() with base
10: 'Henry'
```

Runtime errors are categorized into types that describe the sort of error that has occurred. Above, a *ValueError* occurred, indicating that the wrong sort of value was passed into the int() function. Other examples include a NameError and a TypeError, both described in the table below.

Common error types

Table 1.4.1: Common error types.

Error type	Description
SyntaxError	The program contains invalid code that cannot be understood.
IndentationError	The lines of the program are not properly indented.
ValueError	An invalid value is used, which can occur if giving letters to int().
NameError	The program tries to use a variable that does not exist.

TypeError	An operation uses incorrect types, which can occur if adding an integer to a string.

PARTICIPATION ACTIVITY 1.4.5: Match the lines of code with the error type that they produce.

Match the following lines of code with the correct error type. Assume that no variables exist.

If unable to drag and drop, refresh the page.

IndentationError | NameError | TypeError | SyntaxError | ValueError

	lyric = 99 + " bottles of pop on the wall"
	print("Friday, Friday")
	int("Thursday")
	day_of_the_week = Friday
	print('Today is Monday")

Reset

Logic errors

Some errors may be subtle enough to silently misbehave, instead of causing a runtime error and a crash. An example might be if a programmer accidentally typed "2 * 4" rather than "2 * 40". The program would load correctly but would not behave as intended. Such an error is known as a ***logic error***, because the program is logically flawed. A logic error is often called a ***bug***.

Figure 1.4.3: The programmer made a mistake that happens to be correct syntax but has a different meaning.

The below program attempts to calculate a 5% raise for an employee's salary. The programmer made a mistake by assigning raise_percentage with 5, instead of 0.05, thus giving a happy employee a 500% raise.

```
current_salary = int(input('Enter current salary:
'))

raise_percentage = 5   # Logic error gives a 500%
raise instead of 5%.
new_salary = current_salary + (current_salary *
raise_percentage)
print('New salary:', new_salary)
```

```
Enter current
salary: 10000
New salary: 60000
```


The programmer clearly made an error, but the code is actually correct syntax; it just has a different meaning than intended. So the interpreter will not generate an error message, but the program's output is not what the programmer expects – the new computed salary is too high. These mistakes can be very hard to debug. Paying careful attention and running code after writing just a few lines can help avoid mistakes.

zyDE 1.4.1: Fix the bug.

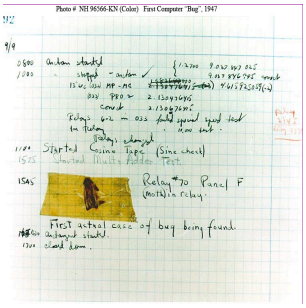
Click run to execute the program and note the incorrect program output. Fix the bug in the program.

Load default template... Run

```
1 num_beans = 500
2 num_jars = 3
3 total_beans = 0
4
5 print(num_beans, 'beans in',
6 print(num_jars, 'jars yields'
7 total_beans = num_beans * nur
8 print('total_beans', 'total')
9
```


Figure 1.4.4: The first bug.

A sidenote: The term "bug" to describe a runtime error was popularized in 1947. That year, engineers working with pioneering computer scientist Grace Hopper discovered their program on a Harvard University Mark II computer was not working because a moth was stuck in one of the relays (a type of mechanical switch). They taped the bug into their engineering log book, which is still preserved today (http://en.wikipedia.org/wiki/Computer_bug).



CHALLENGE ACTIVITY 1.4.1: Basic syntax errors.

Retype the statements, correcting the syntax error in each print statement.

```
print('Predictions are hard.")
print(Especially about the future.)
user_num = 5
print('user_num is:' user_num)
```

See How to Use zyBooks for info on how our automated program grader works.

566436.4601014.qx3zqy7

```
1
2 ''' Your solution goes here '''
3
```

Run

View your last submission

1.5 Development environment

Integrated development environment (IDE)

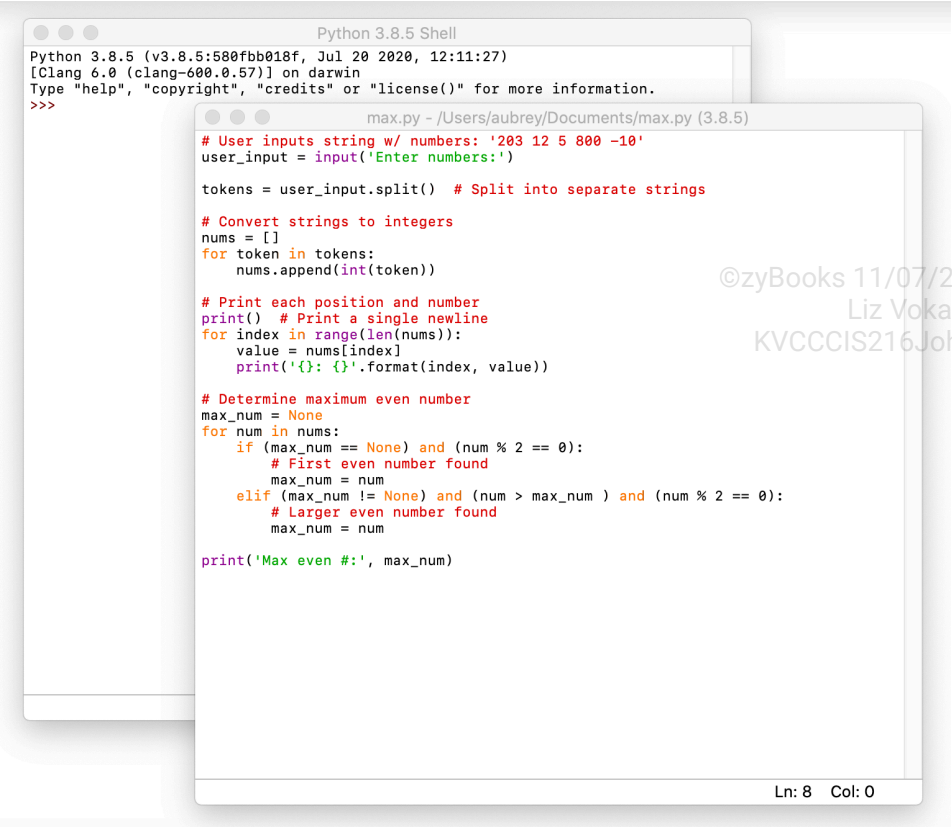
This web material embeds a Python interpreter so that the reader may experiment with Python programming. However, for normal development, a programmer installs Python as an application on a local computer. Macintosh and Linux operating systems usually include Python, while Windows does not. Programmers can download the latest version of Python for free from https://python.org.

Code development is usually done with an ***integrated development environment***, or ***IDE***. There are various IDEs that can be found online; some of the most popular are listed below.

- IDLE is the official Python IDE that is distributed with the installation of Python from https://python.org. IDLE provides a basic environment for editing and running programs.
- PyDev (http://pydev.org) is a plugin for the popular Eclipse program. PyDev includes extra features such as code completion, spell checking, and debugging, which are useful tools while programming.
- For learning purposes, web-based tools like CodePad (http://www.codepad.co) or Repl (http://www.repl.it) are helpful.

There are many other editors available, some of which are free, while others require a fee or subscription. Finding the right IDE is sometimes like finding a pair of jeans that fits just right. Try a Google search for "Python IDE" and explore the options.

Figure 1.5.1: IDLE environment for coding and running Python.



PARTICIPATION ACTIVITY 1.5.1: Development environment basics.

1) Python comes pre-installed on Windows machines.
   - True
   - False

2) Python code can be written in a simple text editor, such as Notepad (Windows).
   - True
   - False

1.6 Computers and programs (general)

Figure 1.6.1: Looking under the hood of a car.

Source: zyBooks

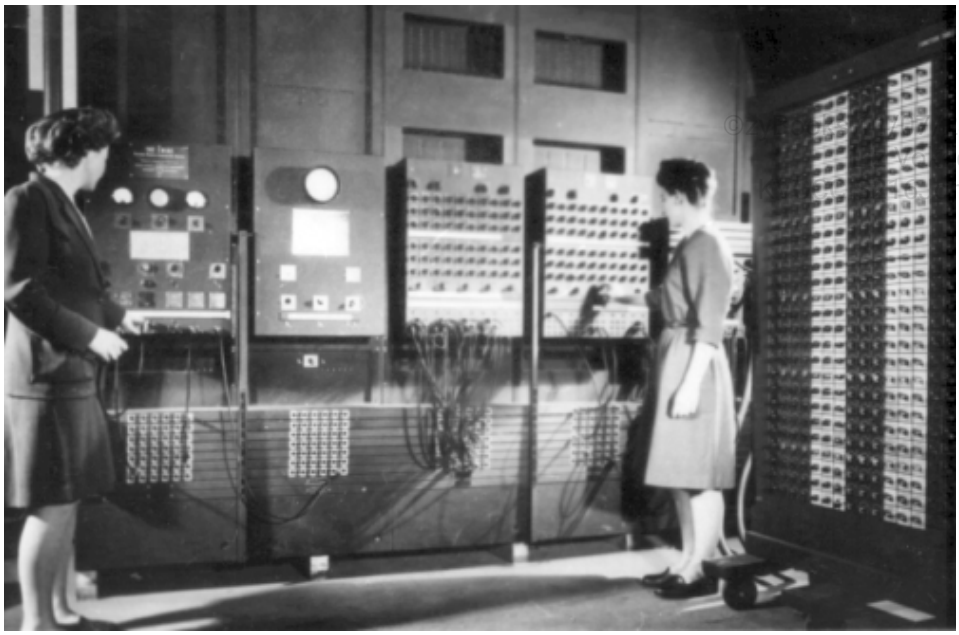
A car owner benefits from knowing how a car works under the hood. Similarly, a programmer benefits from knowing how a computer works "under the hood." This section provides a brief introduction.

Switches

When people in the 1800s began using electricity for lights and machines, they created switches to turn objects on and off. A *switch* controls whether or not electricity flows through a wire. In the early 1900s, people created special switches that could be controlled electronically, rather than by a person moving the switch up or down. In an electronically controlled switch, a positive voltage at the control input allows electricity to flow, while a zero voltage prevents the flow. Such switches were useful for routing telephone calls. Engineers realized they could use electronically controlled switches to perform simple calculations. The engineers treated a positive voltage as a "1" and a zero voltage as a "0". 0s and 1s are known as ***bits*** (*b*inary dig*its*). They built connections of switches, or *circuits*, to perform calculations such as multiplying two numbers.

PARTICIPATION ACTIVITY 1.6.1: A bit is either 1 or 0, like a light switch is either on or off (click the switch).

Figure 1.6.2: Early computer made from thousands of switches.



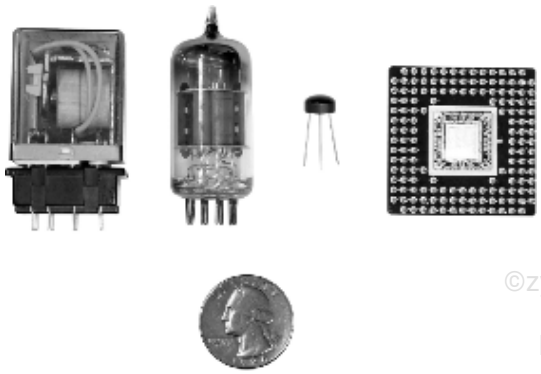
Source: ENIAC computer (U. S. Army Photo / Public domain)

These circuits became increasingly complex, leading to the first electronic computers in the 1930s and 1940s, consisting of about 10,000 electronic switches and occupying entire rooms as in the above figure. Early computers performed thousands of calculations per second, such as calculating tables of ballistic trajectories.

Processors and memory

To support different calculations, circuits called ***processors*** were created to process (or *execute*) a list of desired calculations, each called an ***instruction***. The instructions were specified by configuring external switches, as in the images below. Processors used to take up entire rooms. Today, these processors fit on a chip about the size of a postage stamp, containing millions or even billions of switches.

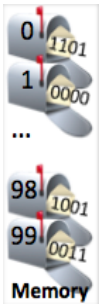
Figure 1.6.3: As switches shrank, so did computers. The computer processor chip on the right has millions of switches.



Source: zyBooks

Instructions are stored in a memory. A ***memory*** is a circuit that can store 0s and 1s in each of a series of thousands of addressed locations, like a series of addressed mailboxes that each can store an envelope (the 0s and 1s). Instructions operate on data, which is also stored in memory locations as 0s and 1s.

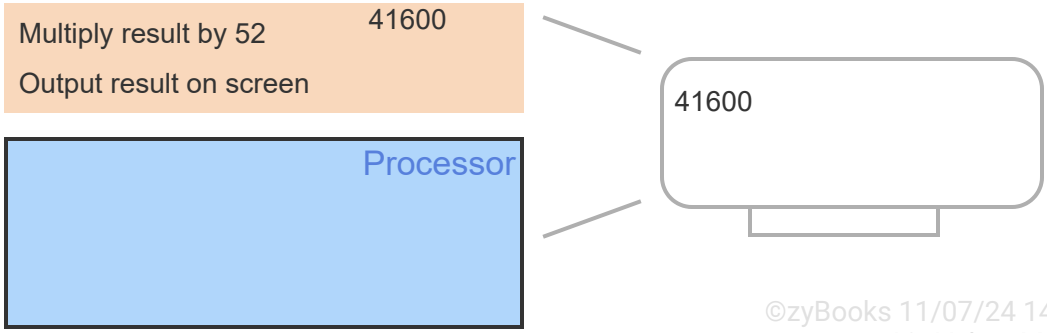
Figure 1.6.4: Memory.



Thus, a computer is basically a processor interacting with a memory. In the following example, a computer's processor executes program instructions stored in memory, also using the memory to store temporary results. The example program converts an hourly wage ($20/hr) into an annual salary by multiplying by 40 (hours/week) and then by 52 (weeks/year), outputting the final result to the screen.

PARTICIPATION ACTIVITY 1.6.2: Computer processor and memory.

Multiply 20 by 40 Memory



Animation content:

Static Figure:
Three instructions, "Multiply 20 by 40", "Multiply result by 52", and "Output result on screen" as well as the data value 41600 are shown within a box representing memory. An empty box representing a processor is shown. An empty output screen is shown.

Step 1: The processor computes data, while the memory stores data (and instructions).
The instruction, "Multiply 20 by 40" moves from memory to the processor. The computed data value is 800, which is then sent back and stored in memory.

Step 2: Previously computed data can be read from memory.
The instruction, "Multiply result by 52" along with the recently computed and stored data value, 800, moves from memory to the processor. The new commutated data value is 41600. 41600 is then sent back and stored in memory.

Step 3: Data can be output to the screen.
The instruction, "Output result on screen" along with the recently computed and stored data value, 41600, moves from memory to the processor. The data value, 41600 is outputted to the output screen.

Animation captions:

1. The processor computes data, while the memory stores data (and instructions).
2. Previously computed data can be read from memory.
3. Data can be output to the screen.

The arrangement is akin to a chef (processor) who executes instructions of a recipe (program), where each instruction modifies ingredients (data), with the recipe and ingredients kept on a nearby counter (memory).

Instructions

Below are some sample types of instructions that a processor might be able to execute, where *X*, *Y*, *Z*, and *num* are each an integer.

Table 1.6.1: Sample processor instructions.

Add X, #num, Y	Adds data in memory location *X* to the number *num*, storing result in location *Y*
Sub X, #num, Y	Subtracts *num* from data in location *X*, storing result in location *Y*
Mul X, #num, Y	Multiplies data in location *X* by *num*, storing result in location *Y*
Div X, #num, Y	Divides data in location *X* by *num*, storing result in location *Y*
Jmp Z	Tells the processor that the next instruction to execute is in memory location *Z*

For example, the instruction "Mul 97, #9, 98" would multiply the data in memory location 97 by 9, storing the result into memory location 98. So if the data in location 97 were 20, then the instruction would multiply 20 by 9, storing the result 180 into location 98. That instruction would actually be stored in memory as 0s and 1s, such as "011 1100001 001001 1100010", where 011 specifies a multiply instruction, and 1100001, 001001, and 1100010 represent 97, 9, and 98 (as described previously). The following animation illustrates the storage of instructions and data in memory for a program that computes F = (9*C)/5 + 32, where C is memory location 97 and F is memory location 99.

PARTICIPATION ACTIVITY 1.6.3: Memory stores instructions and data as 0s and 1s.

Location	Memory	Meaning
0	011 1100001 001001 1100010	Mul 97, #9, 98
1	100 1100010 000101 1100010	Div 98, #5, 98
2	001 1100010 100000 1100011	Add 98, #32, 99
3	101 00000000000000000000	Jmp 0
4	??	
...		
96	??	
97	00000000000000000010100	20
98	??	
99	??	

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0
4	??
96	??
97	20
98	??
99	??

Animation content:

Static figure:

Location	Memory	Meaning
0	011 1100001 001001 1100010	Mul 97, #9, 98
1	100 1100010 000101 1100010	Div 98, #5, 98
2	001 1100010 100000 1100011	Add 98, #32, 99
3	101 00000000000000000000	Jmp 0
??	??	??
97	00000000000000000010100	20

Step 1: Memory stores instructions and data as 0s and 1s.

Location	Memory
0	011 1100001 001001 1100010
1	100 1100010 000101 1100010
2	001 1100010 100000 1100011
3	101 00000000000000000000
??	??
97	00000000000000000010100

Step 2: This zyBook will commonly draw the memory with the corresponding instructions and data to improve readability.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99

3	Jmp 0
??	??
97	20

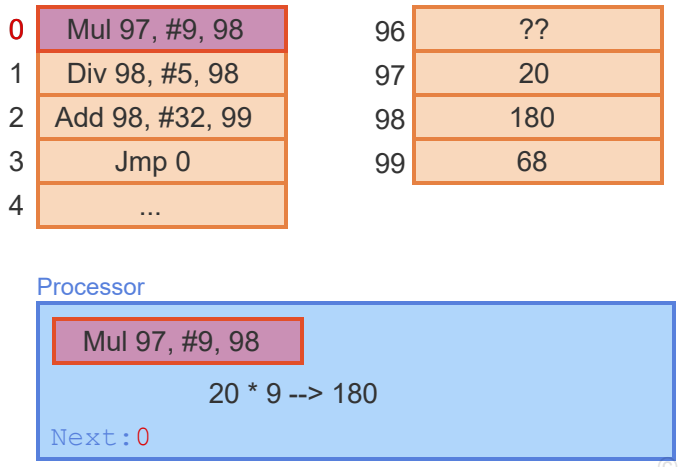
Animation captions:

1. Memory stores instructions and data as 0s and 1s.
2. This zyBook will commonly draw the memory with the corresponding instructions and data to improve readability.

The programmer-created sequence of instructions is called a ***program***, ***application***, or just ***app***.

When powered on, the processor starts by executing the instruction at location 0, then location 1, then location 2, etc. The above program performs the calculation over and over again. If location 97 is connected to external switches and location 99 to external lights, then a computer user (like the women in the above picture) could set the switches to represent a particular Celsius number, and the computer would automatically output the Fahrenheit number using the lights.

PARTICIPATION ACTIVITY 1.6.4: Processor executing instructions.



Animation content:

Static figure: Memory locations 0 to 3 store instructions, while memory locations 96 to 99 store data. A processor reads an instruction and 'Next' keeps track of the location of the next instruction.

Location	Memory

0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	180
99	68

Step 1: The processor starts by executing the instruction at location 0.
Memory before the processor executes the instruction at location 0.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	??
99	??

Processor executes the instruction at location 0.

Next	Location	Memory	Processor
0	0	Mul 97, #9, 98	20 * 9 --> 180

Memory after the processor executes the instruction at location 0.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	180
99	??

Step 2: The processor next executes the instruction at location 1, then location 2. 'Next' keeps track of the location of the next instruction.

Memory before the processor executes the instruction at location 1.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	180
99	??

Processor executes the instruction at location 1.

Next	Location	Memory	Processor
1	1	Div 98, #5, 98	180 / 5 --> 36

Memory after the processor executes the instruction at location 1.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	36
99	??

Processor executes the instruction at location 2.

Next	Location	Memory	Processor

2	2	Add 98, #32, 99	36 + 32 --> 68

Memory after the processor executes the instruction at location 2.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	36
99	68

Step 3: The Jmp instruction indicates that the next instruction to be executed is at location 0, so Next is assigned with 0.

Next	Location	Memory	Processor
3	3	Jmp 0	Next: 0

Step 4: The processor executes the instruction at location 0, performing the same sequence of instructions over and over again.

Memory before the processor executes the instruction at location 0.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99

3	Jmp 0

Location	Memory
96	??
97	20
98	36
99	68

Processor executes the instruction at location 0.

Next	Location	Memory	Processor
0	0	Mul 97, #9, 98	20 * 9 --> 180

Memory after the processor executes the instruction at location 0.

Location	Memory
0	Mul 97, #9, 98
1	Div 98, #5, 98
2	Add 98, #32, 99
3	Jmp 0

Location	Memory
96	??
97	20
98	180
99	68

Animation captions:

1. The processor starts by executing the instruction at location 0.
2. The processor next executes the instruction at location 1, then location 2. 'Next' keeps track of the location of the next instruction.
3. The Jmp instruction indicates that the next instruction to be executed is at location 0, so Next is assigned with 0.
4. The processor executes the instruction at location 0, performing the same sequence of instructions over and over again.

PARTICIPATION ACTIVITY 1.6.5: Computer basics.

1) A bit can only have the value of 0 or 1.
   - True
   - False

2) Switches have gotten larger over the years.
   - True
   - False

3) Memory stores bits.
   - True
   - False

4) The computer inside a modern smartphone would have been huge in 1960.
   - True
   - False

5) A processor executes instructions such as Add 200, #9, 201, represented as 0s and 1s.
   - True
   - False

Writing computer programs

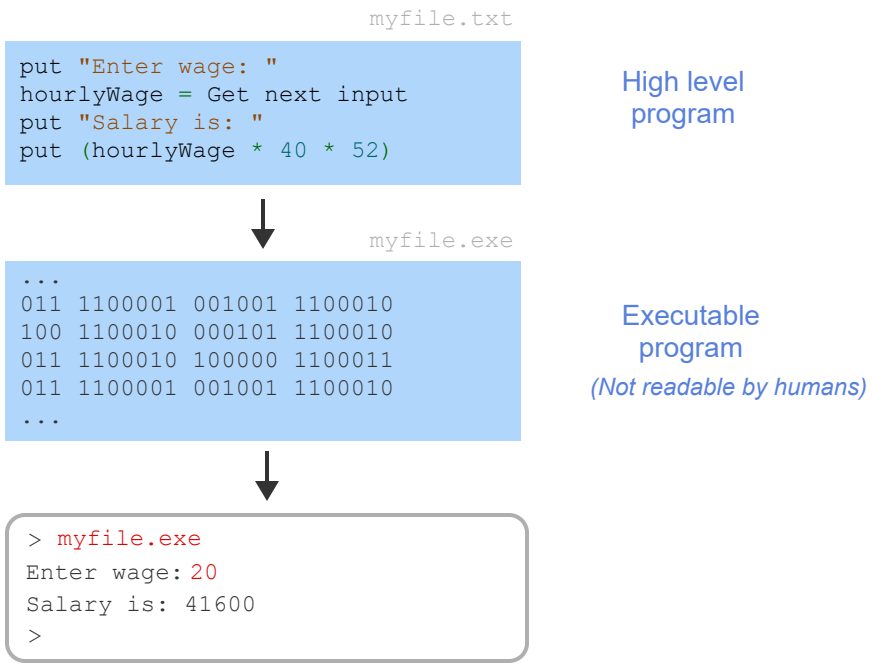
In the 1940s, programmers originally wrote each instruction using 0s and 1s, such as "001 1100001 001001 1100010". Instructions represented as 0s and 1s are known as ***machine instructions***, and a

sequence of machine instructions together form an ***executable program*** (or an *executable*). Because 0s and 1s are hard to comprehend, programmers soon created programs called *assemblers* to automatically translate instructions for humans, such as "Mul 97, #9, 98", known as ***assembly*** language instructions, into machine instructions. The assembler program thus helped programmers write more complex programs.

In the 1960s and 1970s, programmers created ***high-level languages*** to support programming using formulas or algorithms, so a programmer could write a formula such as `F = (9 / 5) * C + 32`. Early high-level languages included *FORTRAN* (for "Formula Translator") or *ALGOL* (for "Algorithmic Language"), which were more closely related to how humans thought than were machine or assembly instructions.

To support high-level languages, programmers created ***compilers***, which are programs that automatically translate high-level language programs into executable programs.

PARTICIPATION ACTIVITY 1.6.6: Program compilation and execution.



Animation content:

Static figure: Two files and a terminal are shown. The first file, myFile.txt, contains a high level program in pseudocode.
Begin pseudocode:
put "Enter wage: "
hourlyWage = Get next input
put "Salary is: "
put (hourlyWage * 40 * 52)

End pseudocode.

The higher level program myfile.txt is translated into an executable program myfile.exe. The second myfile.exe contains machine instructions written in binary code, and is not readable by humans.

A terminal is displayed with the following text:
> myfile.exe
Enter wage: 20
Salary is: 41600
>

Step 1: A programmer writes a high-level program. A code block containing the file myfile.txt is shown, which is a high level program.

Step 2: The programmer runs a compiler, which converts the high-level program into an executable program. A new code block containing myfile.exe is shown, which is an executable program and not readable by humans.

Step 3: Users can then run the executable. An output console appears below myfile.exe. The user inputs "myfile.exe" in order to run the executable in the terminal. The terminal responds with "Enter wage: ", and the user inputs "20". The terminal returns "Salary is: 41600", and finishes running the executable.

Animation captions:

1. A programmer writes a high-level program.
2. The programmer runs a compiler, which converts the high-level program into an executable program.
3. Users can then run the executable.

PARTICIPATION ACTIVITY 1.6.7: Programs.

If unable to drag and drop, refresh the page.

Application **Machine instruction** **Assembly language** **Compiler**

	Translates a high-level language program into low-level machine instructions.
	Another word for program.

	A series of 0s and 1s, stored in memory, that tells a processor to carry out a particular operation like a multiplication.
	Human-readable processor instructions

Reset

Note (mostly for instructors): Why introduce machine-level instructions in a high-level language book? Because a basic understanding of how a computer executes programs can help students master high-level language programming. The concept of sequential execution (one instruction at a time) can be clearly made with machine instructions. Even more importantly, the concept of each instruction operating on data in memory can be clearly demonstrated. Knowing these concepts can help students understand the idea of assignment (x = x + 1) as distinct from equality, why x = y; y = x does not perform a swap, what a pointer or variable address is, and much more.

1.7 Computer tour

The term *computer* has changed meaning over the years. The term originally referred to a person that performed computations by hand, akin to an accountant ("We need to hire a computer"). In the 1940s and 1950s, the term began to refer to large machines like in the earlier photo. In the 1970s and 1980s, the term expanded to also refer to smaller home/office computers known as personal computers or PCs ("personal" because the computer wasn't shared among multiple users like the large ones) and to portable/laptop computers. In the 2000s and 2010s, the term covered other computing devices such as pads, book readers, and smartphones. The term computer even refers to computing devices embedded inside other electronic devices, such as medical equipment, automobiles, aircraft, consumer electronics, and military systems.

In the early days of computing, the physical equipment was prone to failures. As equipment stabilized and programs increased in size and functionality, the term "software" became popular to distinguish a computer's programs from the "hardware" on which they ran.

A computer typically consists of several components (see animation below):

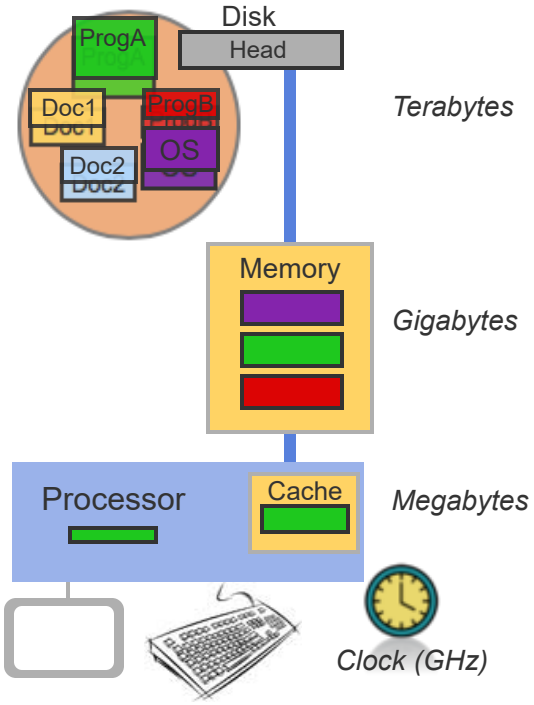
- ***Input/output devices***: A ***screen*** (or monitor) displays items to a user. The above examples displayed textual items, but today's computers display graphical items too. A ***keyboard*** allows a user to provide input to the computer, typically accompanied by a *mouse* for graphical displays. Keyboards and mice are increasingly being replaced by *touchscreens*. Other devices provide

additional input and output means, such as microphones, speakers, printers, and USB interfaces. I/O devices are commonly called *peripherals*.

- ***Storage***: A ***disk*** (aka *hard drive*) stores files and other data, such as program files, songs and movies, or office documents. Disks are *non-volatile*, meaning they maintain their contents even when powered off. They do so by orienting magnetic particles in a 0 or 1 position. The disk spins under a head that pulses electricity at just the right times to orient specific particles (you can sometimes hear the disk spin and the head clicking as the head moves). New *flash* storage devices store 0s and 1s in a non-volatile memory rather than disk, by tunneling electrons into special circuits on the memory's chip, and removing them with a "flash" of electricity that draws the electrons back out.
- ***Memory***: ***RAM*** (random-access memory) temporarily holds data read from storage and is designed so any address can be accessed much faster than from a disk. The "random access" term comes from accessing any memory location quickly and in arbitrary order, without spinning a disk to get a proper location under a head. RAM is more costly per bit than disk due to RAM's higher speed. RAM chips typically appear on a printed circuit board along with a processor chip. RAM is volatile, losing its contents when powered off. Memory size is typically listed in bits, or in bytes where a ***byte*** is 8 bits. Common sizes involve megabytes (million bytes), gigabytes (billion bytes), or terabytes (trillion bytes).
- ***Processor***: The ***processor*** runs the computer's programs, reading and executing instructions from memory, performing operations, and reading and writing data from and to memory. When powered on, the processor starts executing the program. The first instruction is typically at memory location 0. That program is commonly called the BIOS (basic input/output system), which sets up the computer's basic peripherals. The processor executes a program called an *operating system (OS)*. The ***operating system*** allows a user to run other programs and interfaces with the many other peripherals. Processors are also called *CPUs* (central processing unit) or *microprocessors* (a term introduced when processors began fitting on a single chip, the "micro" suggesting its small size). Because speed is so important, a processor may contain a small amount of RAM on its own chip, called ***cache*** memory, accessible in one clock tick rather than several, for maintaining a copy of the most-used instructions/data.
- ***Clock***: A processor's instructions execute at a rate governed by the processor's ***clock***, which ticks at a specific frequency. Processors have clocks that tick at rates such as 1 MHz (1 million ticks/second) for an inexpensive processor ($1) like those found in a microwave oven or washing machine, to 1 GHz (1 billion ticks/second) for costlier ($10-$100) processors like those found in mobile phones and desktop computers. Executing about one instruction per clock tick, processors thus execute millions or billions of instructions per second.

Computers typically run multiple programs simultaneously, such as a web browser, an office application, and a photo editing program. The operating system runs a little of program A, then a little of program B, etc., switching between programs thousands of times a second.

PARTICIPATION ACTIVITY 1.7.1: Some computer components.



Animation content:

Static figure: A computer's disk, memory, cache, and processor are displayed.

Step 1: A disk is able to store Terabytes of data and may contain various programs such as ProgA, ProgB, Doc1, Doc2, and OS. The memory is able to store gigabytes of data. User runs ProgA. The disk spins and the head loads ProgA from the disk, storing the contents into memory. The memory now stores the OS and ProgA. From memory, ProgA is locally stored in cache. The cache is able to store megabytes of data. The processor executes ProgA from the cache.

Step 2: The OS runs ProgB. The disk spins and the head loads ProgB from the disk, storing the contents into memory. The memory now stores the OS, ProgA, and ProgB. From memory, ProgB is locally stored in cache, replacing ProgA. The processor executes ProgB, instead of ProgA.

Step 3: The OS lets ProgA run again. ProgA is already in memory so there is no need to read ProgA from the disk. From memory, ProgA is locally stored in cache, replacing ProgB. The processor executes ProgA, instead of ProgB.

Animation captions:

1. A disk is able to store Terabytes of data and may contain various programs such as ProgA, ProgB, Doc1, Doc2, and OS. The memory is able to store gigabytes of data. User runs ProgA. The disk spins and the head loads ProgA from the disk, storing the contents into memory.

2. The OS runs ProgB. The disk spins and the head loads ProgB from the disk, storing the contents into memory.
3. The OS lets ProgA run again. ProgA is already in memory so there is no need to read ProgA from the disk.

After computers were invented and occupied entire rooms, engineers created smaller switches called ***transistors***, which in 1958 were integrated onto a single chip called an ***integrated circuit*** or ***IC***. Engineers continued to find ways to make smaller transistors, leading to what is known as ***Moore's law***: The doubling of IC capacity roughly every 18 months, which continues today.[1] By 1971, Intel produced the first single-IC processor named the 4004, called a *microprocessor* with 2,300 transistors. New, more powerful microprocessors appeared every few years, and by 2012, a single IC had several *billion* transistors containing multiple processors, each called a *core*.

PARTICIPATION ACTIVITY 1.7.2: Computer components.

If unable to drag and drop, refresh the page.

Moore's law **Disk** **Cache** **Clock** **Operating system** **RAM**

	Manages programs and interfaces with peripherals.
	Non-volatile storage with slower access.
	Volatile storage with faster access usually located off the processor chip.
	Relatively small, volatile storage with fastest access located on the processor chip.
	Measures the speed at which a processor executes instructions.
	The doubling of IC capacity roughly every 18 months.

Reset

Adding RAM to increase speed

A common way to make a PC faster is to add more RAM. A processor spends much of its time moving instructions and data between memory and storage, because not all of a program's instructions and data may fit in memory—just like a chef walks back and forth between a stove and a pantry. Just as adding a larger table next to the stove allows ingredients to be close by, a larger memory allows more instructions and data to be close to the processor. Moore's law results in continued price reductions for RAM, so adding RAM to a several-year-old PC can yield speed increases for little cost.

Exploring further:

- What's Inside My Computer? from howstuffworks.com.
- How Microprocessors Work from howstuffworks.com.

(*1) Moore actually said every 2 years. And the actual trend has varied from 18 months. The key is that doubling occurs roughly every couple years, causing enormous improvements over time. Wikipedia: Moore's law.

1.8 Language history

Scripting languages and Python

As computing evolved throughout the 1960s and '70s, programmers created ***scripting languages*** to execute programs without the need for compilation. A ***script*** is a program whose instructions are executed by another program called an ***interpreter***. Interpreted execution is slower because it requires multiple interpreter instructions to execute one script instruction. But the advantages include avoiding the compilation step during programming and running the same script on different processors as long as each processor has an interpreter installed.

In the late 1980s, Guido van Rossum began creating a scripting language called ***Python*** and an accompanying interpreter. He derived Python from an existing language called ABC. The name Python came from the TV show Monty Python's Flying Circus, of which van Rossum was a fan. The goals for the language included simplicity and readability, while providing as much power and flexibility as other scripting languages such as Perl.

Python 1.0 was released in 1994 with support for some functional programming constructs derived from Lisp. Python 2.0 was released in 2000 and introduced automatic memory management (garbage collection) and features from Haskell and other languages. Python 2 officially reached "end-of-life" (no more fixes or support) in 2020 (Source: Python.org). Python 3.0 was released in 2008 to rectify various language design issues. Python 2.7 still remained popular for years, due largely to third-party libraries supporting only Python 2.7. Python 3.0 is not ***backward compatible***, so Python 2.7 programs cannot run on Python 3.0 or later interpreters. However, Python 3.x versions have become widely used as new projects adopted the version.

Python is an ***open-source*** language, meaning the user community participates in defining the language and creating new interpreters. The language is also supported by a large community of programmers. A January 2023 survey that measured the popularity of various programming languages found that Python (16.36%) is the most popular language (source: www.tiobe.com/tiobe-index/).

PARTICIPATION ACTIVITY 1.8.1: Python background.

1) Python was first implemented in 1960.
   - True
   - False

2) Python is a high-level language that excels at creating exceptionally fast-executing programs.
   - True
   - False

3) A major drawback of Python is that Python code is more difficult to read than code in most other programming languages.
   - True
   - False

1.9 Why whitespace matters

Whitespace and precise formatting

For program output, ***whitespace*** is any blank space or newline. Most coding activities require a student program's output to match exactly the expected output, including whitespace. Students learning programming often complain:

"My program is correct, but the system is complaining about output whitespace."

However, correctness often includes formatting.

PARTICIPATION ACTIVITY 1.9.1: Precisely formatting a meeting invite.

Kia Smith is inviting you
to a video meeting.

Join meeting:
http://www.zoomskype.us/5592

Phone:
1-669-555-2634 (San Jose)
1-929-555-4000 (New York)

Meeting ID: 5592

Reminder: 10 min before

Kia Smith is inviting you to a video meeting. Join meeting:

http://www.zoomskype.us/5592 Phone:
1-669-555-2634 (San Jose)
1-929-555-4000 (New York)

Meeting ID: 5592
---------- Reminder: 10 min before

Animation content:

Static figure: Two examples of meeting invites. The first example was programmed with whitespace in mind, the second example was programmed without being careful with whitespace. Example 1:
Kia Smith is inviting you
to a video meeting.

Join meeting:
http://www.zoomskype.us/5592

Phone:
1-669-555-2634 (San Jose)
1-929-555-4000 (New York)

Meeting ID: 5592

Reminder: 10 min before
Example 2:

```
Kia Smith is inviting you to a video
meeting. Join meeting:

http://www.zoomskype.us/5592 Phone:
1-669-555-2634 (San Jose)
1-929-555-4000 (New York)

Meeting ID: 5592
---------- Reminder: 10 min
before
```


Step 1: This program for online meetings not only computes a schedule and creates a unique meeting ID, but the program also outputs text formatted neatly for a calendar event. The following text appears: Kia Smith is inviting you
to a video meeting.

```
Join meeting:
  http://www.zoomskype.us/5592

Phone:
  1-669-555-2634 (San Jose)
  1-929-555-4000 (New York)

Meeting ID: 5592
------------------------
```

Step 2: A calendar program may append more text after the meeting invitation text. The following text appears on the next line: Reminder: 10 min before.

Step 3: The programmer of the invitation on the right wasn't careful with whitespace. "Join meeting" is buried, the link is hard to see, and the "Phone" text is dangling at a line's end. The following text appears: Kia Smith is inviting you to a video
meeting. Join meeting:

```
http://www.zoomskype.us/5592 Phone:
1-669-555-2634 (San Jose)
1-929-555-4000 (New York)

Meeting ID: 5592
------------------------
```


Step 4: The programmer also didn't end with a newline, causing subsequent text to appear at the end of a line, and even wrap to the next line. This output looks unprofessional. The following text appears on the same line: Reminder: 10 min
before

Animation captions:

1. This program for online meetings not only computes a schedule and creates a unique meeting ID, but the program also outputs text formatted neatly for a calendar event.
2. A calendar program may append more text after the meeting invitation text.
3. The programmer of the invitation on the right wasn't careful with whitespace. "Join meeting" is buried, the link is hard to see, and the "Phone" text is dangling at a line's end.
4. The programmer also didn't end with a newline, causing subsequent text to appear at the end of a line, and even wrap to the next line. This output looks unprofessional.

PARTICIPATION ACTIVITY 1.9.2: Program correctness includes correctly formatted output.

Consider the example above.

1) The programmer on the left intentionally inserted a newline in the first sentence, namely "Kia Smith ... video meeting". Why?

   - Probably a mistake
   - So the text appears less jagged
   - To provide some randomness to the output

2) The programmer on the right side did not end the first sentence with a newline. What effect did that omission have?

   - "Join meeting" appears on the same line.
   - No effect

3) The programmer on the left neatly formatted the link, the "Phone:" text, and phone numbers. What did the programmer on the right side do?

   - Also neatly formatted those items.
   - Output those items without neatly formatting.

4) On the right, why did the "Reminder..." text appear on the same line as the separator text "------"?

- Because programs behave erratically.
- Because the programmer didn't end the output with a newline.

5) Whitespace _____ important in program output.
   - is
   - is not

Programming is all about precision

Programming is all about *precision*. Programs must be created precisely to run correctly. Ex:

- = and == have different meanings.
- Using i where j was meant can yield a hard-to-find bug.
- Not considering that n could be 0 in sum/n can cause a program to fail entirely in rare but not insignificant cases.
- Counting from i being 0 to i < 10 vs. i <= 10 can mean the difference between correct output and a program outputting garbage.

In programming, every little detail counts. Programmers must pay extreme *attention to detail*.

Thus, another reason for caring about whitespace in program output is to help new programmers get into a "precision" mindset when programming. Paying careful attention to details like whitespace instructions, carefully examining feedback regarding whitespace differences, and then modifying a program to exactly match expected whitespace are exercises that strengthen attention to detail. Such attention can lead programmers to make fewer mistakes when creating programs, spend less time debugging, and instead create programs that work correctly.

PARTICIPATION ACTIVITY 1.9.3: Thinking precisely, and attention to detail.

Programmers benefit from thinking precisely and paying attention to details. The following questions emphasize attention to detail. See if you can get all of the questions correct on the first try.

1) How many times is the letter F (any case) in the following?
   If Fred is from a part of France, then of course Fred's French is good.

Check Show answer

2) How many differences are in these two lines?
Printing A linE is done using println
Printing A linE is done using print1n

Check Show answer

3) How many typos are in the following?
Keep calmn and cary on.

Check Show answer

4) If I and E are adjacent, I should come before E, except after C (where E should come before I). How many violations are in the following?
BEIL CEIL ZIEL YIEIK TREIL

Check Show answer

5) A password must start with a letter, be at least six characters long, include a number and a special symbol, but not include any whitespace. How many of the following passwords are valid?
hello goodbye Maker1 dog!three Oops_again 1augh#3

Check Show answer

Programmer attention to details

The focus needed to answer the above correctly on the first try is the kind of focus needed to write correct programs. Due to this fact, some employers give "attention to detail" tests to people applying for programming positions. See for example this test, or this article discussing the issue.

1.10 Python example: Salary calculation

This section contains a very basic example for starters; the examples increase in size and complexity in later sections.

NOTE: This section does not have any activity to be recorded as completed, and thus doesn't count towards a student's activity completion percentages. The example is included by popular request of students, who often ask for more examples -- and research indeed shows that students learn a lot by studying and tinkering with examples.

zyDE 1.10.1: Executing Python code using the interpreter.

The following program calculates yearly and monthly salary given an hourly wage. The program assumes 40 work hours per week and 50 work weeks per year.

1. Insert the correct number in the code below to print a monthly salary. Then run the program. The monthly salary should be 3333.333...

Load default template... Run

```
1  hourly_wage = 20
2
3  print('Annual salary is: ')
4  print(hourly_wage * 40 * 50)
5  print()
6
7  print('Monthly salary is: ')
8  print(((hourly_wage * 40 * 5
9  print()
10
11 # FIXME: The above is wrong.
```

```
12 #        the 1 so that the s
13 #        outputs monthly sal
14
15
16
```


1.11 Additional practice: Output art

The following is a sample programming lab activity; not all classes using a zyBook require students to fully complete this activity. No auto-checking is performed. Users planning to fully complete this program may want to first develop their code in a separate programming environment.

Pictures made entirely from keyboard characters are known as ASCII art. ASCII art can be complex, fun to make, and enjoyable to view. Take a look at Wikipedia: ASCII art for examples. Searching on the web for "ASCII art (some item)" can find ASCII art versions of an item. Ex: Searching for "ASCII art cat" turns up thousands of examples of cats, most much more clever than the cat below.

The following program outputs a simple triangle.

Figure 1.11.1: Output art: Print a triangle.

```
print('  *  ')
print(' *** ')
print('*****')
```

```
  *
 ***
*****
```

zyDE 1.11.1: Create ASCII art.

Create different versions of the below programs. First run the code, then alter the code to print the desired output.

Print a tree by adding a base under a four-level triangle:

```
   *
  ***
 *****
*******
  ***
```

Load default template... Run

```
1 print('   *   ')
2 print('  ***  ')
3 print(' ***** ')
4 print('*******')
5
```


zyDE 1.11.2: Create ASCII art.

Complete the cat drawing below. Note the '\' character is actually displayed by printing the two character sequence '\\'.

```
/\     /\
  o   o
 =     =
   ---
```

Load default template... Run

```
1 print('/\\       /\\')
2 print('  o    ')
3
```

zyDE 1.11.3: Create ASCII art.

Be creative: Print something you'd like to see that is more impressive than the previous programs.

No template provided

Run

```
1
```

1.12 zyLab training: Basics

While the zyLab platform can be used without training, a bit of training may help some students avoid common issues.

The assignment is to get an integer from input, and output that integer squared, ending with newline. (Note: This assignment is configured to have students programming directly in the zyBook. Instructors may instead require students to upload a file). Below is a program that's been nearly completed for you.

1. Click "Run program". The output is wrong. Sometimes a program lacking input will produce wrong output (as in this case), or no output. Remember to always pre-enter needed input.
2. Type 2 in the input box, then click "Run program", and note the output is 4.

3. Type 3 in the input box instead, run, and note the output is 6.

When students are done developing their program, they can submit the program for automated grading.

1. Click the "Submit mode" tab
2. Click "Submit for grading".
3. The first test case failed (as did all test cases, but focus on the first test case first). The highlighted arrow symbol means an ending newline was expected but is missing from your program's output.

Matching output exactly, even whitespace, is often required. Change the program to output an ending newline.

1. Click on "Develop mode", and change the output statement to output a newline: `print(user_num_squared)`. Type 2 in the input box and run.
2. Click on "Submit mode", click "Submit for grading", and observe that now the first test case passes and 1 point was earned.

The last two test cases failed, due to a bug, yielding only 1 of 3 possible points. Fix that bug.

1. Click on "Develop mode", change the program to use * rather than +, and try running with input 2 (output is 4) and 3 (output is now 9, not 6 as before).
2. Click on "Submit mode" again, and click "Submit for grading". Observe that all test cases are passed, and you've earned 3 of 3 points.

LAB ACTIVITY | 1.12.1: zyLab training: Basics | 3 / 3

main.py — Load default template...

```
1 user_num = int(input())
2 user_num_squared = user_num * user_num   # Bug here; fix it when instructed
3
4 print(user_num_squared)  # Output formatting issue here; fix it when instructed
5
```

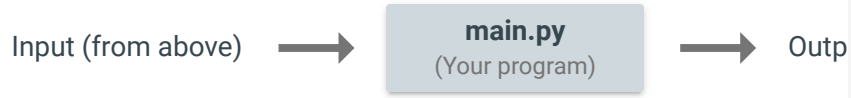
Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

5

Run program



Program output displayed here

Coding trail of your work What is this?

```
9/5 R------0---0-3 min:7
```

1.13 zyLab training: Interleaved input / output

Auto-graded programming assignments have numerous advantages, but have some challenges too. Students commonly struggle with realizing that example input / output provided in an assignment's specification interleaves input and output, but the program *should only output the output parts*. If a program should double its input, an instructor might provide this example:

```
Enter x:
5
x doubled is: 10
```


Students often incorrectly create a program that outputs the 5. Instead, the program should only output the output parts:

```
Enter x:
x doubled is: 10
```

The instructor's example is showing both the output of the program, AND the user's input to that program, assuming the program is developed in an environment where a user is interacting with a

program. But the program itself doesn't output the 5 (or the newline following the 5, which occurs when the user types 5 and presses enter).

Also, if the instructor configured the test cases to observe whitespace, then according to the above example, the program should output a newline after `Enter x:` (and possibly after the 10, if the instructor's test case expects that).

The program below *incorrectly* echoes the user's input to the output.

1. Try submitting it for grading (click "Submit mode", then "Submit for grading"). Notice that the test cases fail. The first test case's highlighting indicates that output 3 and newline were not expected. In the second test case, the -5 and newline were not expected.
2. Remove the code that echoes the user's input back to the output, and submit again. Now the test cases should all pass.

LAB ACTIVITY | 1.13.1: zyLab training: Interleaved input / output | 2 / 2

main.py — Load default template...

```
1 print('Enter x: ')
2 x = int(input())
3
4 double_x = x*2
5 print('x doubled is:', double_x)
```

Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

```
5
```

Run program Input (from above) → main.py (Your program) → Outp

Program output displayed here

Coding trail of your work What is this?

```
9/5 R0-2 min:3
```

1.14 zyLab training*: One large program

Most zyLabs are designed to be completed in 20 - 25 minutes and emphasize a single concept. However, some zyLabs (such as the one large program or OLP) are more comprehensive and may take longer to complete.

Incremental development is a good programming practice and is the process of writing, compiling, and testing a small amount of code, then repeating the process with a small amount more (an incremental amount), and so on.

Suggested process to complete longer zyLabs:

- Implement Step 1 and submit for grading. Only one test will pass.
- Continue to implement one step at a time and resubmit for grading. At least one additional test should pass after each step.
- Continue until all steps are completed and all tests pass.

Program Specifications For practice with incremental development, write a program to output three statements as specified.

Step 1 (4 pts). Use `print()` to output "Step 1 complete". Submit for grading to confirm one of three tests passes.

Output should be:

```
Step 1 complete
```

Step 2 (3 pts). Use `print()` to output "Step 2 as well". Submit for grading to confirm two of three tests pass.

Output should be:

```
Step 1 complete
Step 2 as well
```

Step 3 (3 pts). Use `print()` to output "All steps now complete". Submit for grading to confirm all tests pass.

Output should be:

```
Step 1 complete
Step 2 as well
All steps now complete
```


LAB ACTIVITY | 1.14.1: zyLab training*: One large program | 10 / 10

main.py — Load default template...

```
1 # Type your code here.
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → main.py (Your program) → Outp

Program output displayed here

Coding trail of your work What is this?

```
9/5 R-0-4-7-10
```

1.15 LAB: Formatted output: Hello World!

This section's content is not available for print.

1.16 LAB: Formatted output: No parking sign

This section's content is not available for print.

1.17 LAB: Input: Welcome message

This section's content is not available for print.

1.18 LAB: Input: Mad Lib