Learning Objectives

After completing this unit, you should be able to:

- Explain the difference between an assembler, compiler, and interpreter.
- Name and describe at least six different programming languages.
- Compare and contrast imperative programming with object-oriented.
- Trace the execution of Python if/else statements and while loops.
- Program a Finch robot to move in a specific pattern and change colors.
- Determine the value of logic expressions (using `and`, `or`, `not`) in Python.
- Implement a Python function that computes a mathematical formula.

Textbook Sections

6.1 Historical Perspective
6.2 Traditional Programming Concepts
6.3 Procedural Units

Video Lectures

- More Python
- Grace Hopper on Letterman

Assignments

Act08 Programming Languages; Chapter 6 Problems
Lab08 Finch / Python Tutor; Finch robot dance party

Unit 8 Checklist: Oct 21 – Oct 27

Before Wednesday	**Date Completed**
FINISH models 1 and 2 of Prog Langs activity	
READ textbook 6.1 Historical Perspective (take notes) ANSWER questions 1 and 2 in your notes	
WATCH video lecture: More Python (take notes)	
READ tutorial: Finch video, docs, examples	
START Lab08: Finch robot dance party	(10 pts)
Before Friday	**Date Completed**
READ textbook 6.2 Traditional Prog. Concepts (take notes) ANSWER questions 2 and 4 in your notes	
READ textbook 6.3 Procedural Units (take notes) ANSWER questions 1 and 4 in your notes	
DO tutorial: Codecademy (3. Conditionals and Control Flow)	
START Act08 exercises (complete at least 75%)	(15 pts)
Before Monday	**Date Completed**
COMPARE your Lab08 and Act08 with the solutions in Canvas	
SUBMIT Quiz08 – 1st attempt closed: see what you don't know	
STUDY your notes, ask questions on Piazza, meet with the TAs	
SUBMIT Quiz08 – 2nd attempt open: try to get the full 10 points	(10 pts)

TAKE Exam08	(40 pts)

Activity 8: Programming Languages

Model 1 Low-Level Languages

The following program, shown in three different languages, calculates the sum of numbers from 1 to 10. In other words, it adds $1 + 2 + \ldots + 10 = 55$.

Machine Code
(1st Generation)

```
0x000:
0x000: 700001000000000000

0x100:
0x100:
0x100: 30f00b00000000000000
0x10a: 30f30100000000000000
0x114: 30f10200000000000000
0x11e: 30f20100000000000000

0x128: 2017
0x12a: 6107
0x12c: 734601000000000000

0x135:
0x135: 6013
0x137: 6021

0x139: 2017
0x13b: 6107
0x13d: 743501000000000000

0x146:
0x146: 00
```

Y86-64 Assembly
(2nd Generation)

```
.pos 0 code
    jmp _start

.pos 0x100 code
_start:
    irmovq  $0xb,  %rax
    irmovq  $0x1,  %rbx
    irmovq  $0x2,  %rcx
    irmovq  $0x1,  %rdx

    rrmovq  %rcx,  %rdi
    subq    %rax,  %rdi
    je      done

loop:
    addq    %rcx,  %rbx
    addq    %rdx,  %rcx

    rrmovq  %rcx,  %rdi
    subq    %rax,  %rdi
    jne     loop

done:
    halt
```

Standard C
(3rd Generation)

```
int main()
{
    int upper = 11;
    int sum = 1;
    int val = 2;

    while (val < upper)
    {
        sum = sum + val;
        val++;
    }
}
```

Questions (15 min) Start time: _____

1. Compare the length of each program. Do not count labels (e.g, `0x000:`, `.pos 0 code`) or punctuation (e.g., `{`, `}`).

   a) How many instructions of machine code?

   b) How many instructions of assembly code?

   c) How many non-blank, non-brace lines of C code?

2. All data values for this program are stored in registers named `%rax`, `%rbx`, etc.

   a) In which register is the sum stored?

   b) In which register is the next value to add stored?

3. The instruction `irmovq` means "move immediate value to register". Immediate values begin with a dollar sign (`$`), and registers begin with a percent sign (`%`).

   a) What is the value 11 in assembly code?

   b) Does assembly use decimal or hexadecimal?

   c) Does Standard C use decimal or hexadecimal?

4. In terms of the machine, what does an assignment statement do? As part of your answer, name the instructions in Model 1 that perform assignment.

5. Consider the line "`rrmovq %rcx, %rdi`". The instruction `rrmovq` means "move (copy) register to register".

   a) What is stored in register `%rcx`?

   b) Where is this value copied to?

6. The instruction `subq` means "subtract". Given two registers R and T, `subq` performs $R - T$ and stores the result in T.

   a) What is stored in register `%rax`?

   b) In what case would `%rax` $-$ `%rdi` be zero?

7. The instruction `je` means "jump if the last operation's result equals 0", and the instruction `jne` means "jump if the last operation's result does not equal 0". Circle the portion of assembly code that corresponds to the `while` loop in C.

Model 2 High-Level Languages

In addition to adding the numbers from 1 to 10, this program prints (displays) the result on the screen using Standard I/O.

Standard C
(3rd Generation)

```
#include <stdio.h>

int main()
{
    int upper = 11;
    int sum = 1;
    int val = 2;

    while (val < upper)
    {
        sum = sum + val;
        val++;
    }

    printf("Sum = %d\n", sum);
}
```

Python
(4th Generation)

```
upper = 11
isum = 1
val = 2

while val < upper:

    isum = isum + val
    val = val + 1


print("Sum = " + str(isum))
```

Questions (10 min)

Start time: _____

8. Compare the C code with the Python code.

   a) Circle the lines of C code that were not present in Model 1.

   b) Which lines of C are not present (i.e., needed) in Python?

   c) What punctuation used in C is not required in Python?

9. Without using braces, how does Python know which lines are part of the `while` loop?

10. Why does Python use the name `isum` instead of `sum`? Hint: type `sum` into a Python shell.

11. In Python, the `range` function can be used to generate a sequence of numbers. Use a Python shell to answer this question.

a) What is the result of `list(range(5))`?

b) What is the result of `str(range(5))`? `'[0, 1, 2, 3, 4]'`

c) What do the `list` and `str` functions do?

d) What is the result of `sum(range(5))`?

e) What does the `sum` function do?

12. Rewrite the entire program of Model 2 using one line of Python code. Hint: you'll need to use `print`, `str`, `sum`, and `range`.

13. Based on Model 1 and Model 2, what does it mean to be low-level vs high-level?

Chapter 6: Programming Languages

Answer the following questions using the textbook, your individual notes, and the Internet.

1. What is the difference between an *assembler*, a *compiler*, and an *interpreter*?

2. What is the difference between *declarative* statements, *imperative* statements, and *comments*? Why do programming languages need all three?

3. Draw parentheses to show operator precedence. What is the value of number?

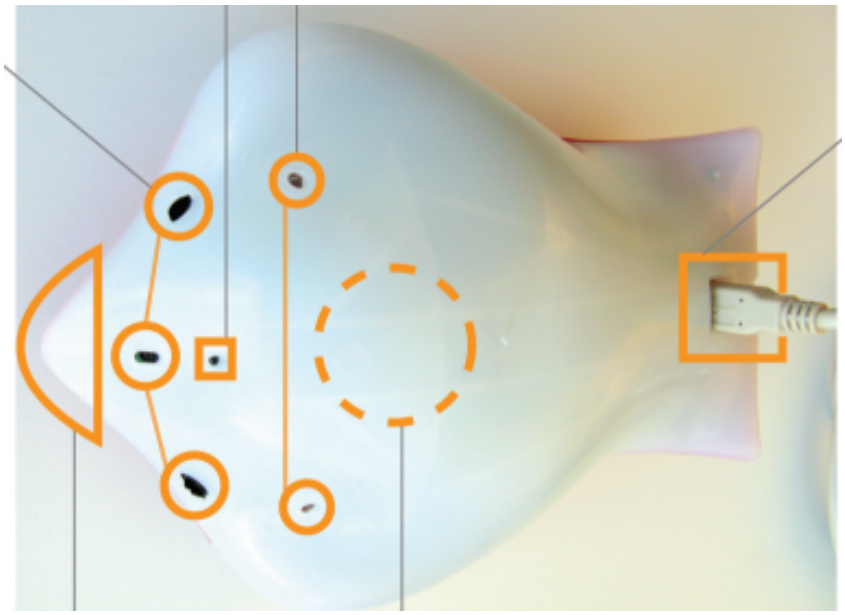
```
number = 1 + 2 * 3 - 4 / 5 + 6 * 7 - 8 / 9
```

4. Rewrite the following instructions in Python using a single if-else statement.

```
     if (X = 5) goto 50
     goto 60
50   print the value of Z
     goto 100
60   print the value of Y
100  . . .
```

5. Why is the "goto" statement no longer popular in high-level programming languages?

6. Label and describe each component of the Finch robot in the diagram below:



7. Explain what each of the following lines of code does:

a) `finch.wheels(1.0, -1.0)`

b) `finch.led(0, 255, 0)`

c) `finch.buzzer(0.5, 440)`

8. What does a Finch robot have to do with object-oriented programming? What "data" does a finch object contain?