Computational Thinking

Lecture 04: Conditionals & Control Flow

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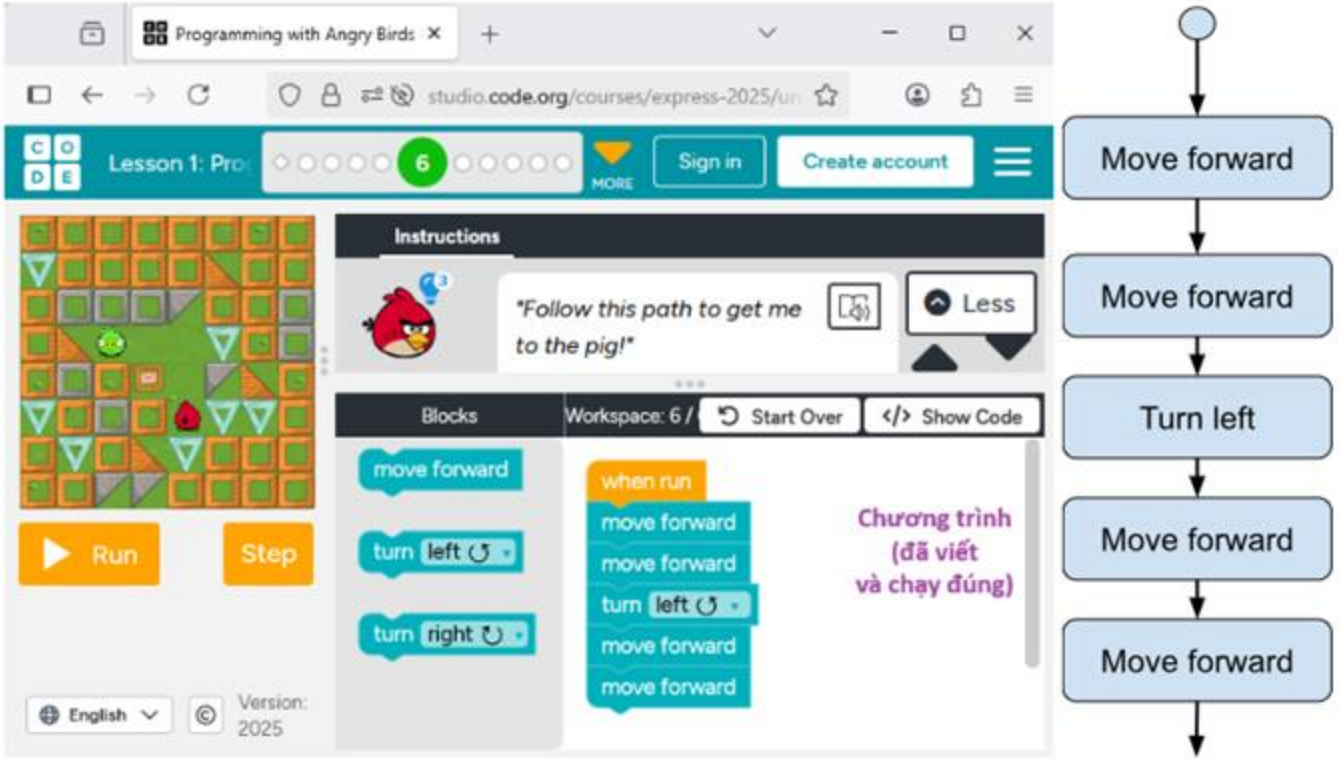
Outline

- If Statements
- Nested If Statements
- Debugging: Watches and Traces
- Testing: Code Coverage
- A Little Bit about Functions

If Statements

Program Flow

In simple programs, instructions are executed **always** in the **same order**, no matter what

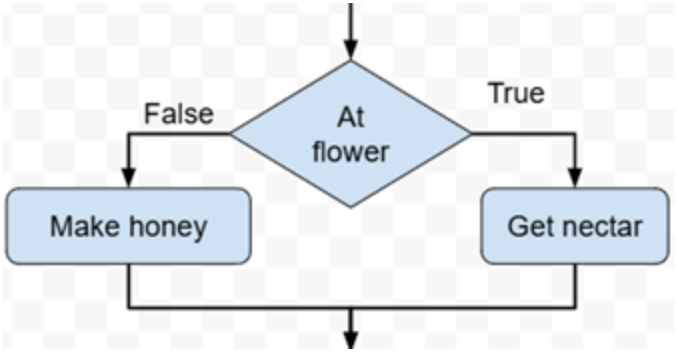


But we need choices

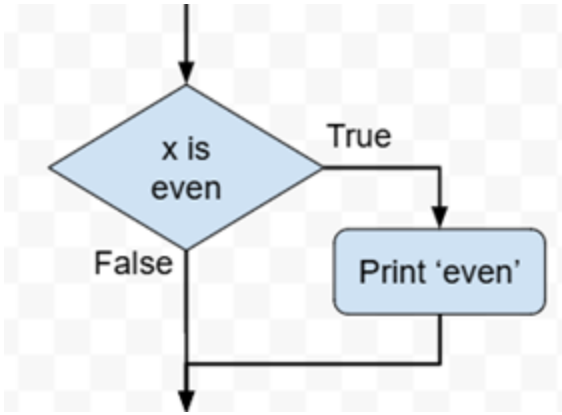
We need to make decisions!

We need a way to **control** what happens based on inputs

- If at flower,
  then get nectar
  else make honey



- If x is even, then print('even')
  else do nothing



If statement

We need to make decisions!

We need a way to **control** what happens based on inputs

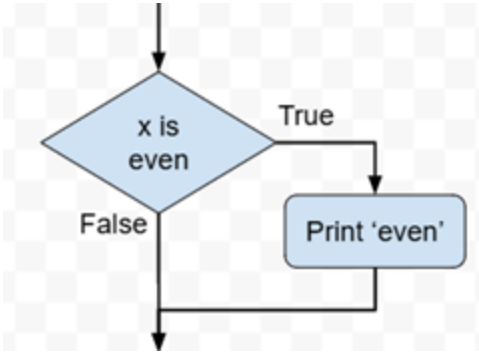
- Syntax

```
if <Boolean-expression>:
    <statement>
    …
    <statement>
```

- Example

```
if x % 2 == 0:
    print('even')
```

if ⟨Boolean-expression⟩ is True, then execute all of the statements indented directly underneath, until first non-indented statement



Examples of Boolean expressions

```
is_rainy = False
is_windy = True
temp = 12
```

Boolean variables:

```
if is_rainy:
    print("Bring an umbrella!")
```

Boolean operations:

```
if is_windy and not is_rainy:
    print("Let's fly a kite!")
```

Comparison operations:

```
if temp < 30 and is_rainy:
    print("Beware of ice!")
```

```
if temp > 70:
    print("Warm vibes!")
```

If-else statement

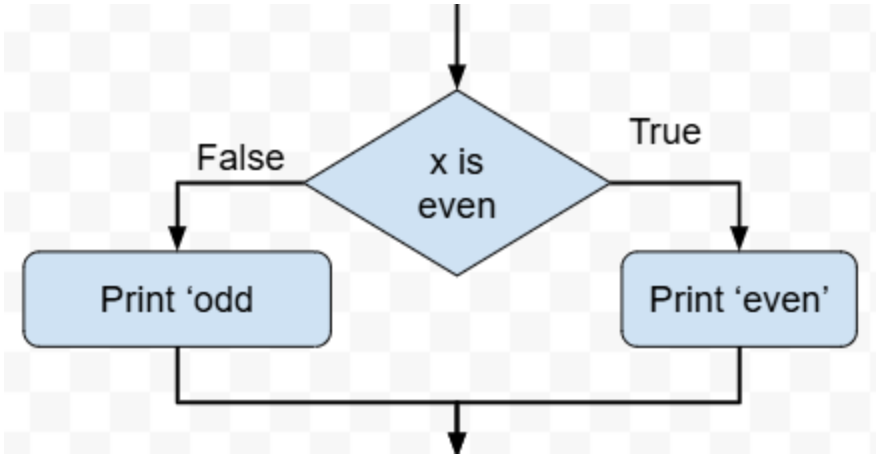
- Syntax

```
if <Boolean-expression>:
    <statement>
    …
else:
    <statement>
    …
```

if ⟨Boolean-expression⟩ is True, then execute statements indented under if;
otherwise (⟨Boolean-expression⟩ is False) execute the statements indented under else

- Example

```
if x % 2 == 0:
    print('even')
else:
    print('odd')
```



Structure vs. Flow

Program Structure

- How code is **presented** in file
  - Which lines are earlier or later in file
  - Which lines are indented inside function or if
- Defines possibilities over **multiple executions**

Program Flow

- Aka **control flow**
- Order in which lines of code are **executed**
  - Not the same as structure
  - Some statements might be skipped
  - Some statements (in function body) might be executed many times
- Defines what happens in a **single execution**

Example

Program Structure

```
# odd_even.py
x = 10
if x % 2 == 0:
    print('even')
else:
    print('odd')
```

print('odd') occurs once in the program **structure**

Program Flow

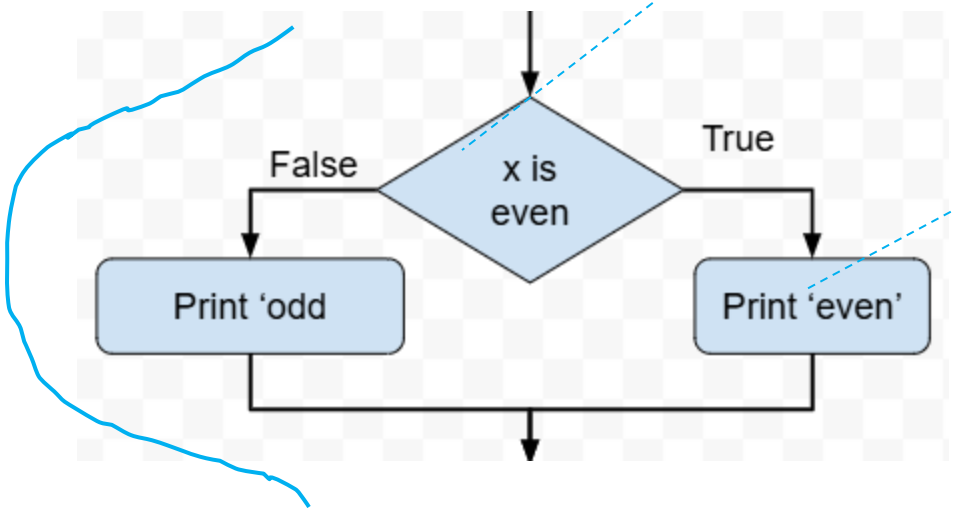
```
> python odd_even.py
even
```

program **flow** causes print('odd') to execute ZERO time

If Statements Affect Control Flow

branch point
evaluate and choose

Flow
Program only takes one path during an execution (something will not be executed!)



statements execute

Diagrams like this are called **flowcharts**

Program Flow and Variables

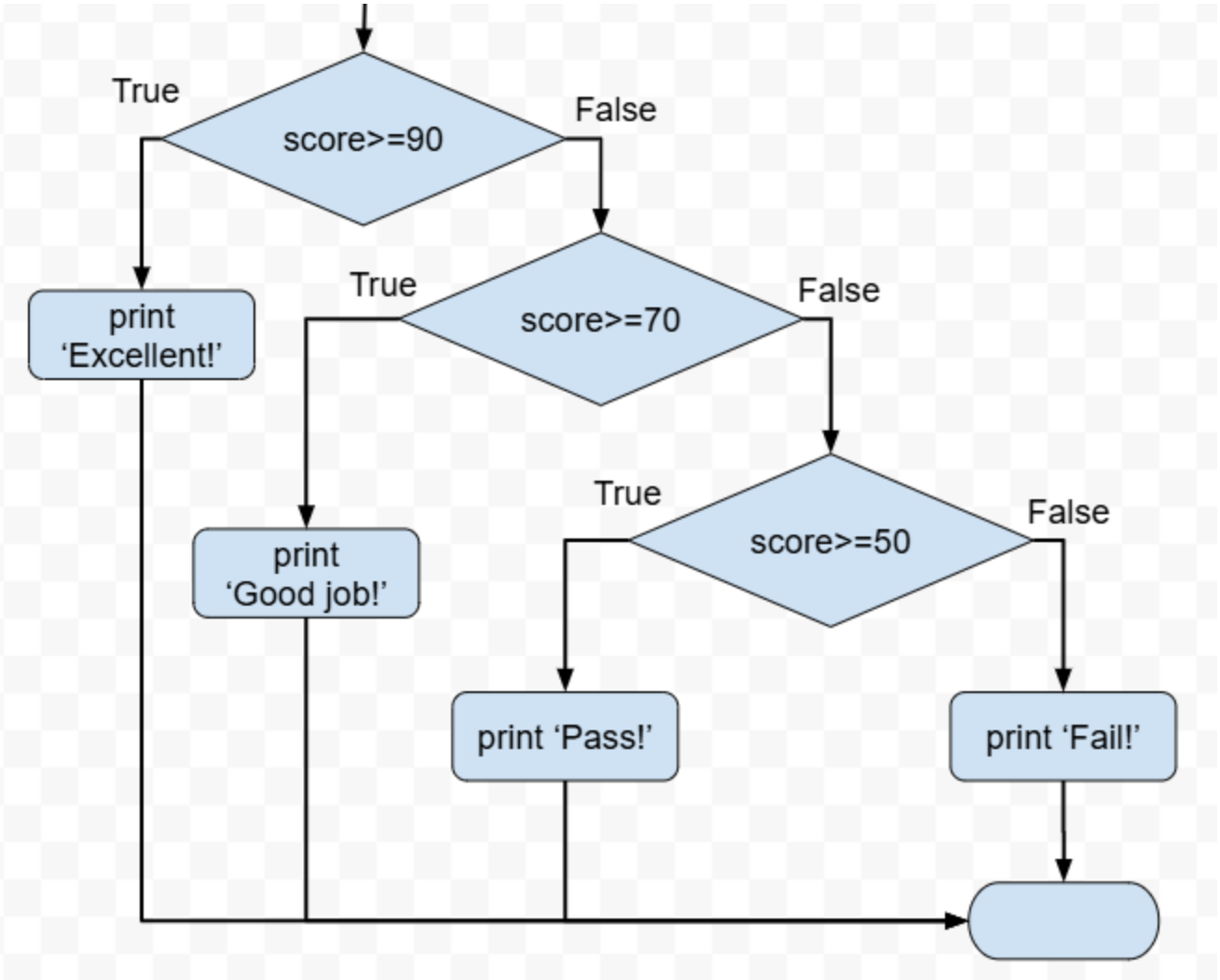
Variables created inside the body of an if continue to exist past the if:

```
a = 0
if a == 0:
    b = a + 1
print(b)
```

```
# b is created inside this block
 if the assignment is executed
```

But variable creation occurs only if the program actually executes the assignment that does the creation

Multiple choices



if-elif-else statements

Syntax

```
if <Boolean expression>:
    <statement>
    …
elif <Boolean expression>:
    <statement>
    …
…
else:
    <statement>
    …
```

Example

```
if score >= 90:
    print("Excellent!"
)
elif score >= 70:
    print("Good job!")
elif score >= 50:
    print("Pass.")
else:
    print("Fail.")
```

if-elif-else statements

Syntax

```
if <Boolean expression>:
    <statement>
    …
elif <Boolean expression>:
    <statement>
    …
…
else:
    <statement>
    …
```

Notes on use

- No limit on number of elif
  - Must be between if, else
- else is optional
  - if-elif by itself is fine
- Booleans checked in order
  - Once Python finds a true <Boolean-expression>, skips over all the others
  - else means **all** <Boolean-expression> are false

If vs. If-Elif

Series of If Statements

```
x = 0
if x == 0:
  print("x is 0!")
if x == 0:
  print("still 0!")
if x == 0:
  print("even still 0")
```

```
x is 0!
still 0!
even still 0
```

vs. If-Elif Statements

```
x = 0
if x == 0:
  print("x is 0!")
elif x == 0:
  print("still 0!")
elif x == 0:
  print("even still 0")
```

```
x is 0!
```

Nothing else gets printed!

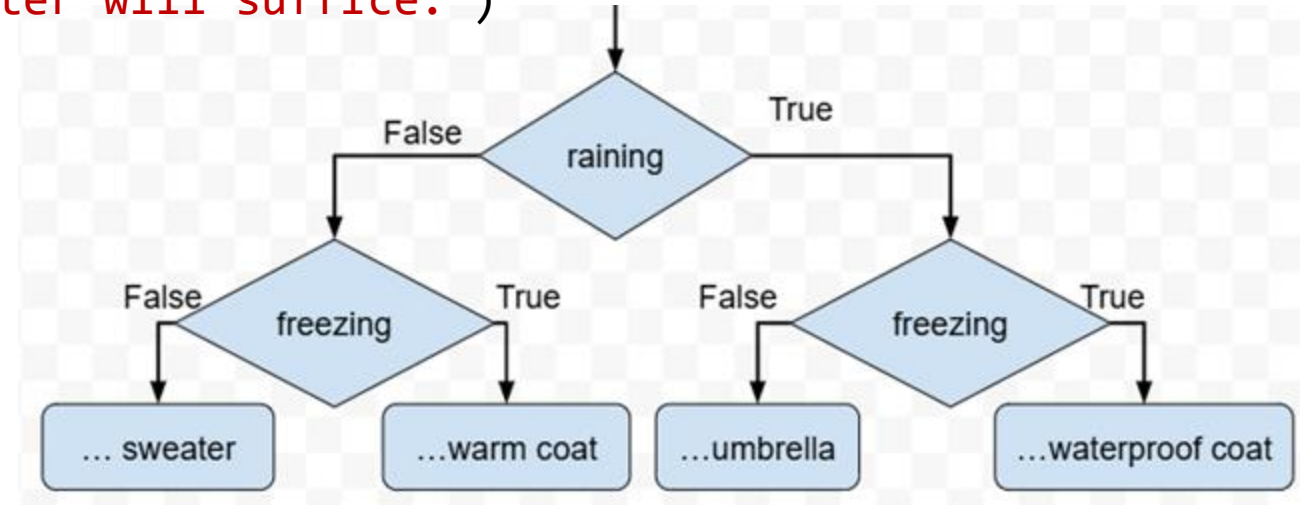
Nested if statements

The logic can get more complicated

```
# what to wear?
if raining and freezing:
    print('Wear a waterproof coat.')
elif raining and not freezing:
    print('Bring an umbrella.')
elif not raining and freezing:
    print('Wear a warm coat!')
else:
    print('A sweater will suffice.')
```

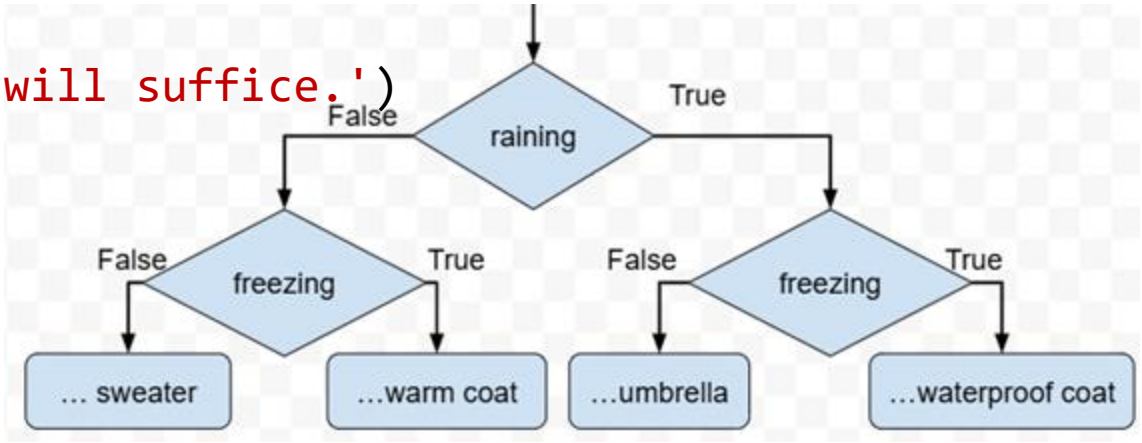
The logic can get more complicated

```
if raining and freezing:
    print('Wear a waterproof coat.')
elif raining and not freezing:
    print('Bring an umbrella.')
elif not raining and freezing:
    print('Wear a warm coat!')
else:
    print('A sweater will suffice.')
```



Nested conditions

```
if raining:
    if freezing:
        print('Wear a waterproof coat.')
    else:
        print('Bring an umbrella.')
else:
    if freezing:
        print('Wear a warm coat!')
    else:
        print('A sweater will suffice.')
```



Debugging: Watches and Traces

Debugging flow with print statements

```
# determine winner


if x_score > y_score:
    winner = "x"
else:
    winner = "y"
```

Can use **print** statements to examine program flow and variable values

"Trace" prints

```
# determine winner
print('before if')
if x_score > y_score:
    print('inside if')
    winner = "x"
else:
    print('inside else')
    winner = "y"
print('after if')
```

Can use **print** statements to examine program flow and variable values

"trace" print statements

```
before if
inside if
after if
```

x_score must have been greater than y_score

"Trace" vs. "Watch" Prints

```
# determine winner
print('before if')
if x_score > y_score:
    print('inside if')
    winner = "x"
    print('winner = '+winner)
else:
    print('inside else')
    winner = "y"
    print('winner = '+winner)
print('after if')
```

→ Traces

trace **program flow**

What code is being executed?

Place print statements at the beginning of a code block that might be skipped.

→ WATCHES

watch **data** values

What is the value of a variable?

Place print statements after assignment statements.

Testing: Code Coverage

Inspiration for Test Cases

- Previous sources of inspiration:
  - Rule of 1, 2, 0
  - Common and edge cases
- With if statements, a new source:
  - Invent enough test cases to cause every if-elif-else body to be executed
  - Including nested if statements

Testing of If Statement

```
if score >= 90:
    print("Excellent!")
elif score >= 70:
    print("Good job!")
elif score >= 50:
    print("Pass.")
else:
    print("Fail.")
```

Invent four test cases, one for each possible place control flow could reach

E.g., 91, 80, 55, 40

Testing of Nested If Statement

```
if raining:
    if freezing:
        print('Wear a waterproof coat.')
    else:
        print('Bring an umbrella.')
else:
    if freezing:
        print('Wear a warm coat!')
    else:
        print('A sweater will suffice.')
```

Again need four test cases: each possible combination of True and False

Black Box vs. Glass Box Testing

Black Box

- The function is "opaque"
- Invent test cases based solely on the specification

Glass Box

- We can "see inside" the function
- Invent test cases based also on the code that implements the function
- What we just added with examination of the code of if statements

A little bit about functions

Remember this game?

main.py

Run

```
1  def move_forward():
2      print('move forward')
3  def turn_left():
4      print('turn_left')
5
6  move_forward()
7  move_forward()
8  move_forward()
9  turn_left()
10 move_forward()
11 move_forward()
12 move_forward()
```

Output

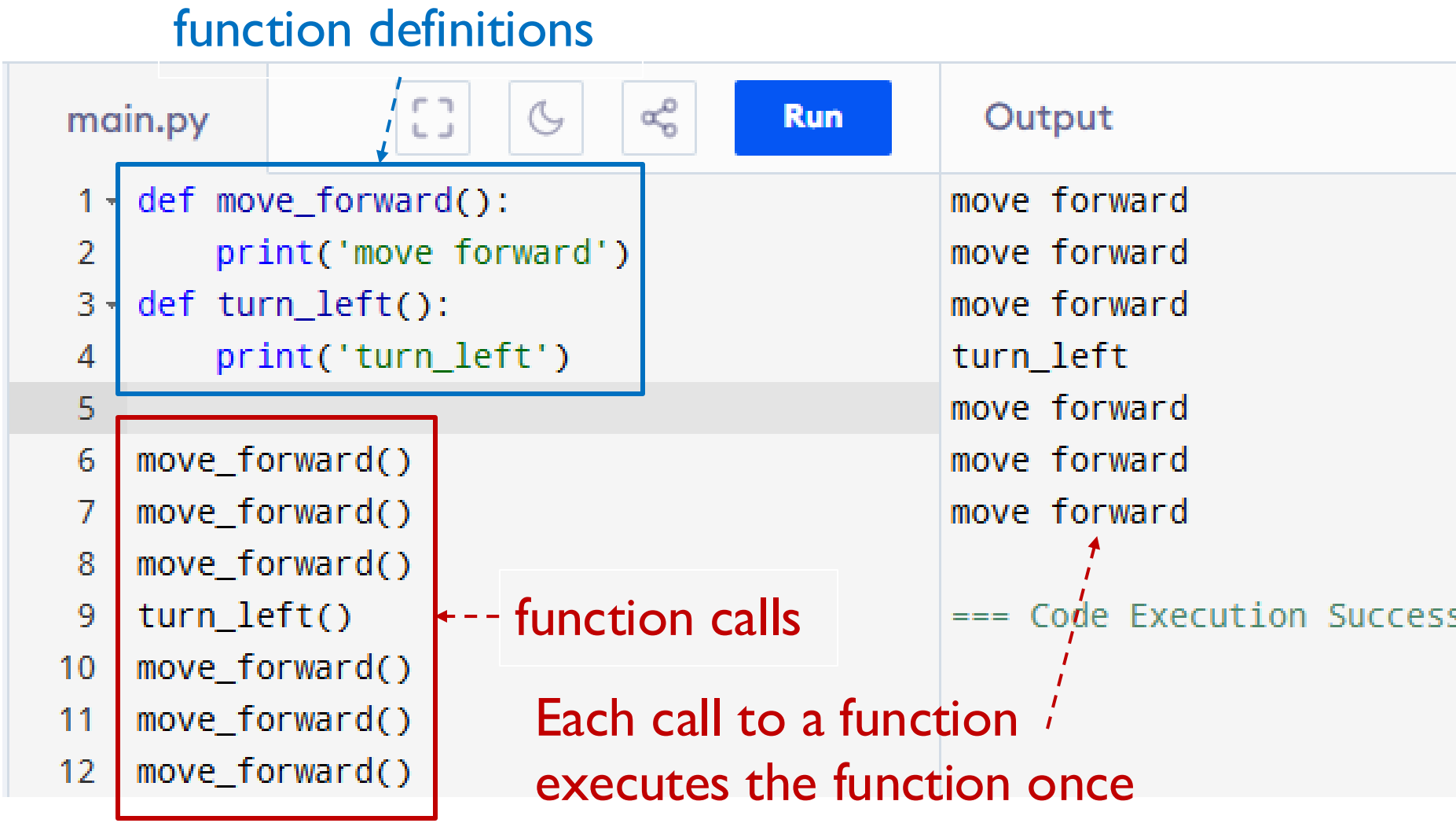
```
move forward
move forward
move forward
turn_left
move forward
move forward
move forward

=== Code Execution Successful
```

The little Scratch game's instruction set already include **move forward** and **turn left**. Python's hasn't.

So we define them ourselves. They are **functions**

A little bit about functions



Functions with arguments

```
def what_to_wear(raining, freezing):
    if raining:
        if freezing:
        ...
    else:
        if freezing:
        ...
what_to_wear(True, False)
what_to_wear(True, True)
what_to_wear(False, False)
what_to_wear(raining=False, freezing=True)
```

what_to_where can be called with different sets of values for raining and freezing. They are arguments

When you invent these tests without knowing the code inside what_to_wear, it's blackbox testing

Functions that return values

```
def what_to_wear(raining, freezing):
    if raining:
        if freezing:
            return 'Waterproof coat'
        else:
            return 'Umbrella'
    else:
        if freezing:
            return 'Warm coat'
        else:
            return 'Sweater'
today_outfit = what_to_wear(True, False)
sunny_day_outfit = what_to_wear(False, False)
```

this kind of functions are usually called to calculate some value before assign it to a variable for later use

Calling functions of a module

- In another module

```
from sample_functions import what_to_wear

today_outfit = what_to_wear(True, False)
```

File sample_functions.py

```
def what_to_wear(raining, freezing):
   if raining:
      if freezing:
          return 'Waterproof coat'
      else:
          return 'Umbrella'
   else:
      ...
```

Calling functions of a module

- Or in interactive mode

```
>>> from sample_functions import what_to_wear
>>> print_what_to_wear(True, False)
Wear a waterproof coat.
>>>
```

File sample_functions.py

```
def print_what_to_wear(raining, freezing):
    if raining:
        if freezing:
            print('Wear a waterproof coat.')
        else:
            print('Bring an umbrella.')
    else:
        ...
```

A little bit about functions

Functions are like building blocks of programs
(more on that later).
But from now on, we will use them a lot

Summary - Key Takeaways

- **If** statements control the program's flow.
  - Nested If conditions for more **complex** logic
- Program structure **differs** from program flow.
- **Test** every branch of your code.
- Use **prints** to debug program flow.
  - Trace versus Watch
- **Functions** are like **building blocks** of programs