Control Structure: *Multiple Selections*

01204111 Computers and Programming

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Outline

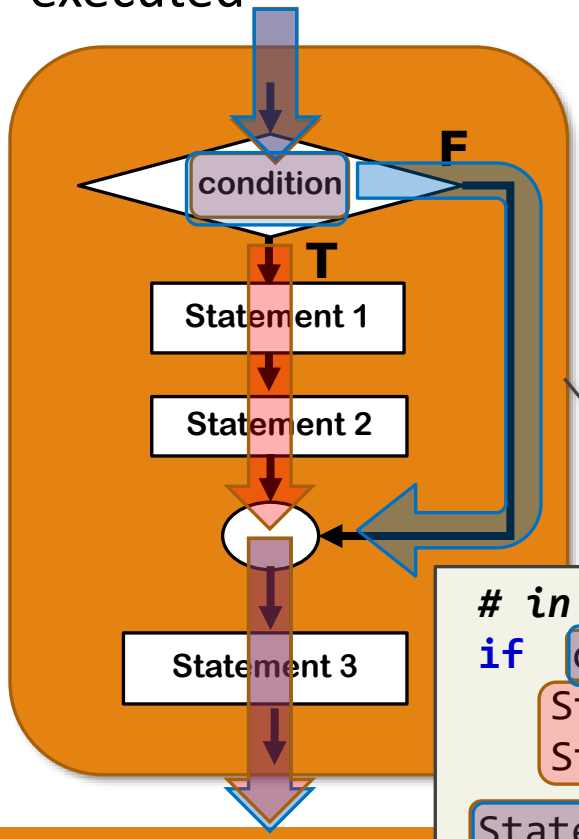
- ***Introduction to multiple selections***
- Nested Conditionals
- Chained Conditionals
- Programming examples

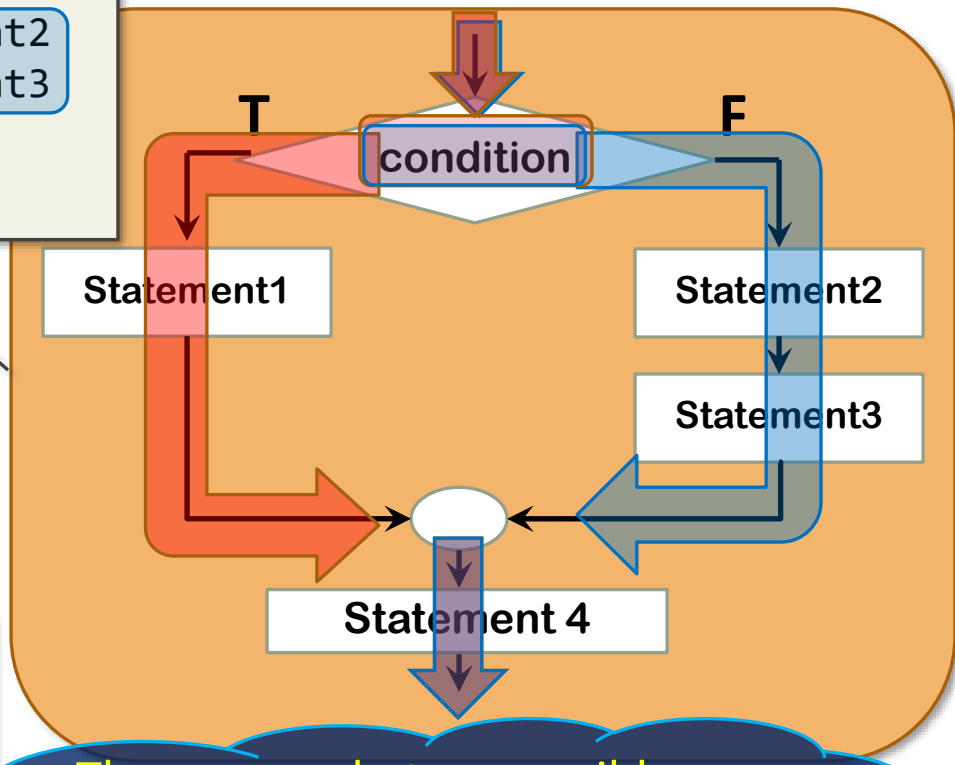
Review : Basic Selections

*A single **if** statement*
selects whether or not a code block is to be executed

```
# in Python
if condition :
    Statement1
else:
    Statement2
    Statement3
Statement4
```

*A single **if-else** statement*
selects one of two statements (or blocks) to be executed.



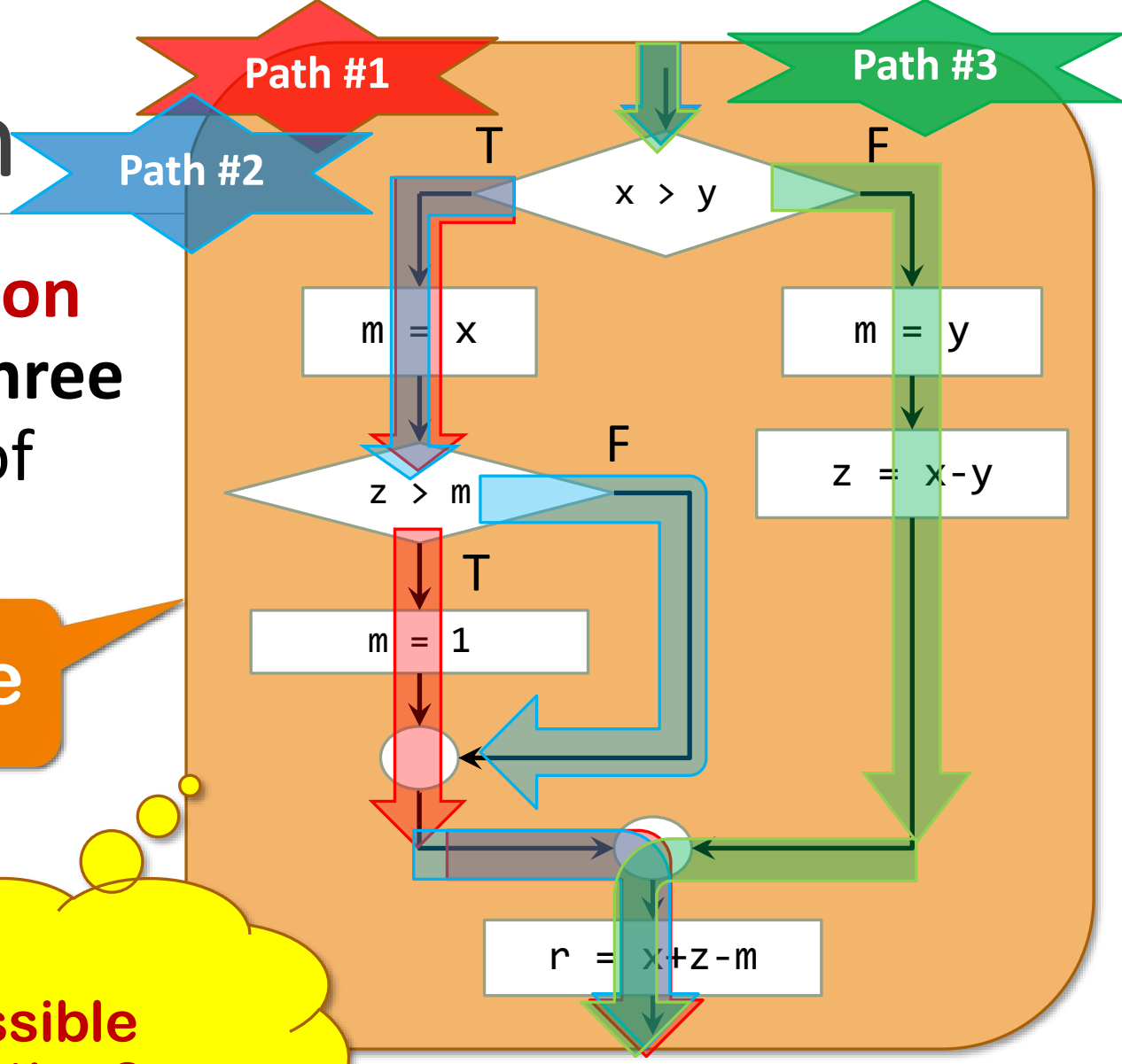



```
# in Python
if  condition :
    Statement1
    Statement2
Statement3
```

There are only ***two*** possible paths of execution in both constructs.

Introduction

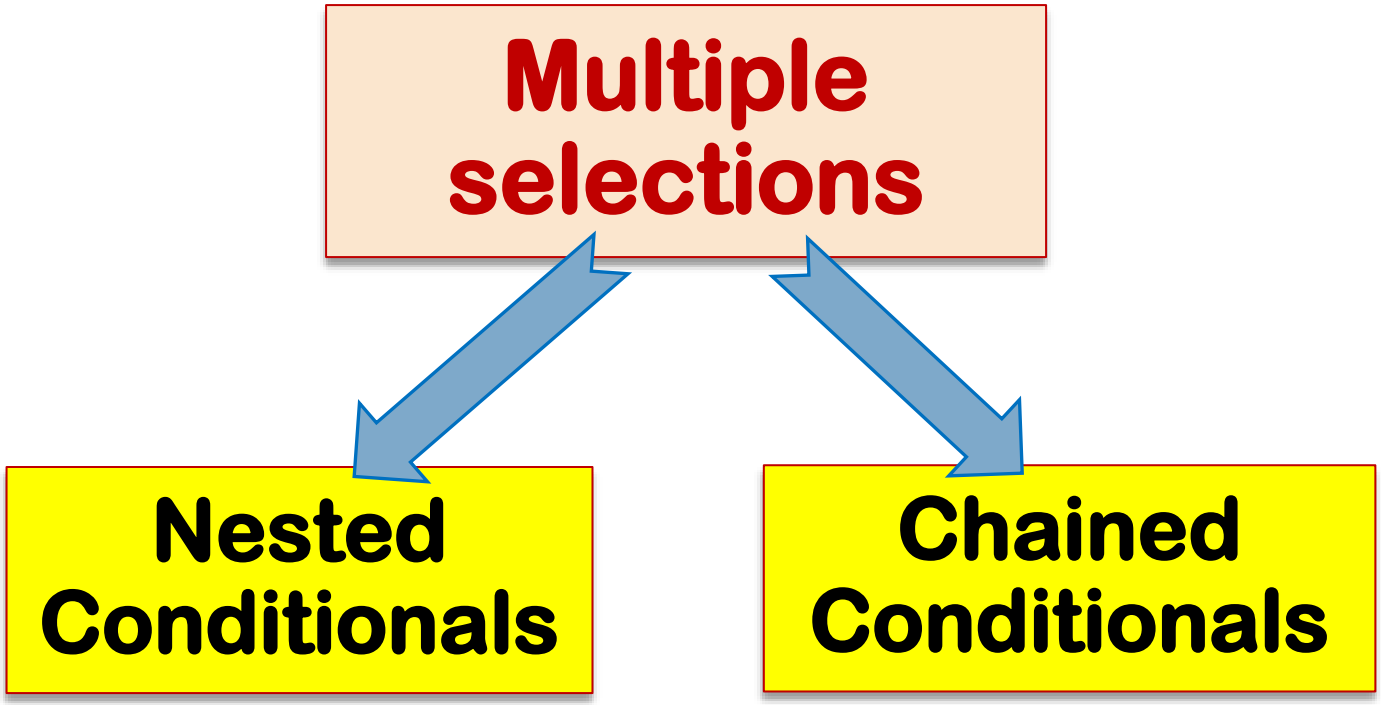
- **Multiple selection** selects one of **three or more** paths of execution.



Example

How many possible paths of execution?

How to do multiple selections in Python



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- ***Nested Conditionals***
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- Programming examples

How *nested conditionals* are possible in Python

Each of these yellow boxes is actually **a single statement**.

```
pass
```

```
x = y+1
```

```
print('hi')
```

```
if x > y:
    m = x
```

```
if x > y:
    m = x
    z = x+y
```

```
if x > y:
    m = x
    z = x+y
else:
    m = y
```

```
if x > y:
    m = x
    z = x+y
else:
    m = y
    z = x-y
```

so each can be put here:

```
if condition :
    statement1
    statement2
else:
    statement3
    statement4
    statement5
```

or here:

Example in Python

When an ***if*** or ***if-else*** statement is put within another ***if*** or ***if-else*** *statement*, we calls it a **nested conditional construct**.

```
if x > 0:
    i = 2
    if y > 1:
        k = 2
else:
    if z < 10:
        k = 5
        if y > 5:
            k = x+y
        else:
            k = x-y
```

In Python, indentation is very, very important !

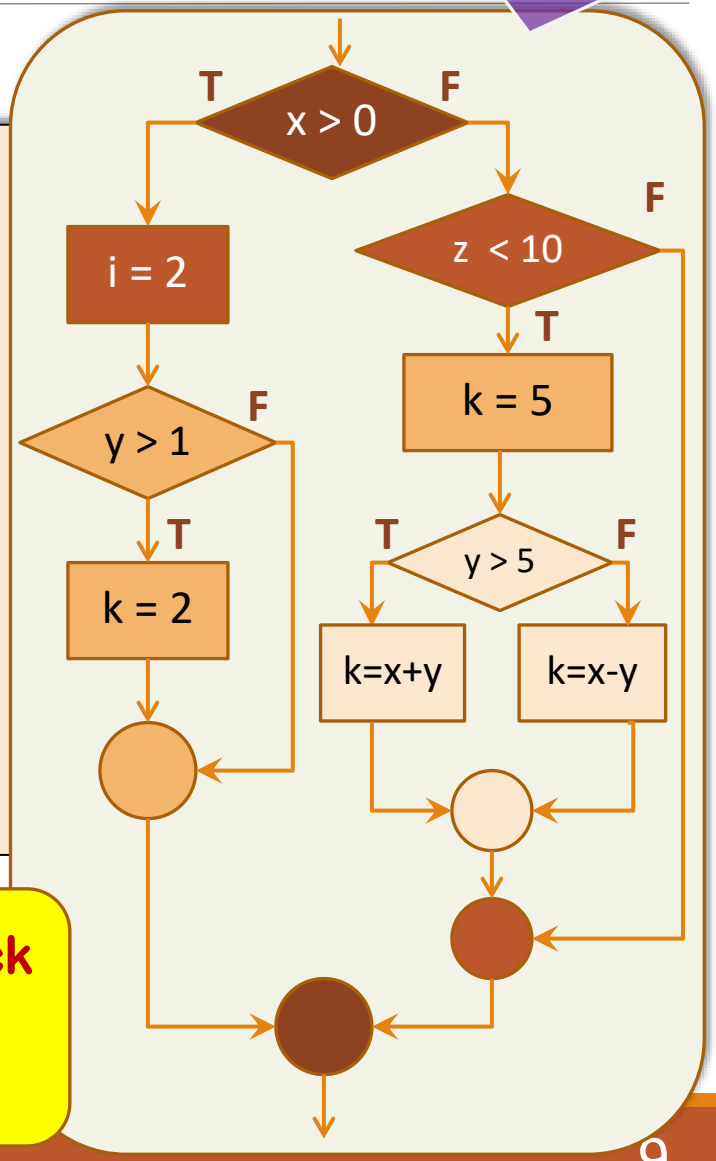
Nested conditionals start as just a single statement

A single statement

```
if x > 0:
    i = 2
    if y > 1:
        k = 2
else:
    if z < 10:
        k = 5
        if y > 5:
            k = x+y
        else:
            k = x-y
```

```
if x > 0:
    i = 2
    if y > 1:
        k = 2
else:
    if z < 10:
        k = 5
        if y > 5:
            k = x+y
        else:
            k = x-y
```

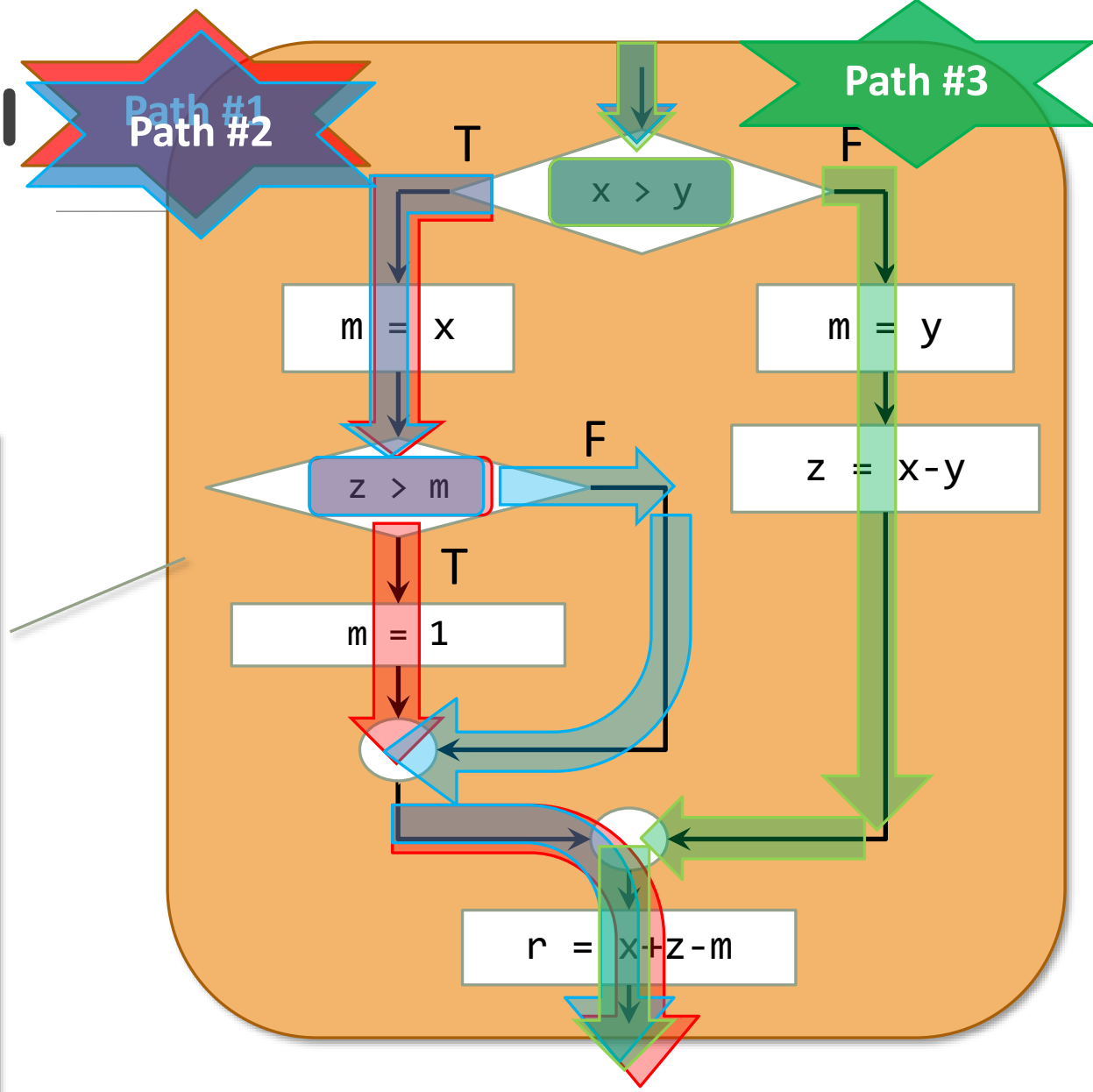
Flow of execution



Recall that a code block follows the line that ends with a colon.

Flow-of-Control Example

```
# in Python
if x > y:
    m = x
    if z > m:
        m = 1
else:
    m = y
    z = x-y
r = x+z-m
```



Programming Example on Nested Conditionals

Task: The maximum of three numbers

- **Write a program that**
  - *reads three numbers.*
  - *computes and prints the maximum of the three.*

Sample Run

```
Enter 1st number: 25.5
Enter 2nd number: 30
Enter 3rd number: 20.2
The max is 30
```

Sample Run

```
Enter 1st number: 0
Enter 2nd number: -10
Enter 3rd number: -7
The max is 0
```

Sample Run

```
Enter 1st number: 50
Enter 2nd number: 5
Enter 3rd number: 50
The max is 50
```

The maximum of three numbers - Ideas

What is the maximum of 3 numeric values?

- **Answer**: *The value that is not less than the other two.*
- Therefore, to find the maximum is *to look for a value that is not less than the other two*.
- It's OK if some of them are equal, or even all of them are equal.

Topmost level

- **The main routine:**
  - Reads three numbers.
  - Computes the max by calling max_of_three()
  - Prints the max.

```
# --- main --- #
x = float(input("Enter 1st number: "))
y = float(input("Enter 2nd number: "))
z = float(input("Enter 3rd number: "))
max = max_of_three(x,y,z)
print(f"The maximum number is {max}")
```

The function max_of_three() – Design

- Now it's time to write the function max_of_three().
- There are many ways to write it.
- We'll show a few different ways so as to demonstrate the use of nested conditionals.

The function max_of_three() – *Version 1*

Algorithm

if (**a** is not less than the other two)

a is the max

else *# a is not the max*

Compete **b** with **c** for the max

```
def max_of_three(a, b, c):
    if a >= b and a >= c: # check a
        return a
    else:  # a is not the max
        if b > c:
            return b
        else:
            return c
```

Efficiency:
2 or 3 comparisons depending on the inputs

The function max_of_three() – *Version 2*

Algorithm

if (**a** > **b**) *# so **a** may be the max*

Compete **a** with **c** for the max

else *# so **b** may be the max*

Compete **b** with **c** for the max

```
def max_of_three(a, b, c):
    if a > b:    # a may be the max
        if a > c:
            return a
        else:
            return c
    else:        # b may be the max
        if b > c:
            return b
        else:
            return c
```

Efficiency:
exactly two comparisons in all cases

The function max_of_three() – *Version 3*

Algorithm

- Let **max** be the value of **a**
- **if** (**b** > **max**) then
  Let **max** be the value of **b**
- **if** (**c** > **max**) then
  Let **max** be the value of **c**

```
def max_of_three(a, b, c):
    max = a
    if b > max:
        max = b
    if c > max:
        max = c
    return max
```

This is actually a sequence of two if statements, not a nested if construct.

Efficiency: *exactly two comparisons in all cases*

This version can be easily extended to 4 or more numbers.

How?

The function max_of_three() – *Version 4*

- No **if**- or **if-else** statements used.
- No need to write the function max_of_three().
- Throw away the main routine.

Hmm…?

- **In fact, no need to write a program at all!**

Amitta Buddh…???

Nammo Amitta Pythonic Buddha!

```
>>> max(5,6)
6
>>> max(5,6,4)
6
>>> max(5,7,10,3)
10
>>> max(3,70,5,8,10,15,75,8,40)
75
>>> type(max)
<class 'builtin_function_or_method'>
```

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- Introduction to multiple selections
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- ***Chained conditionals***
- Programming examples

Chained Conditionals

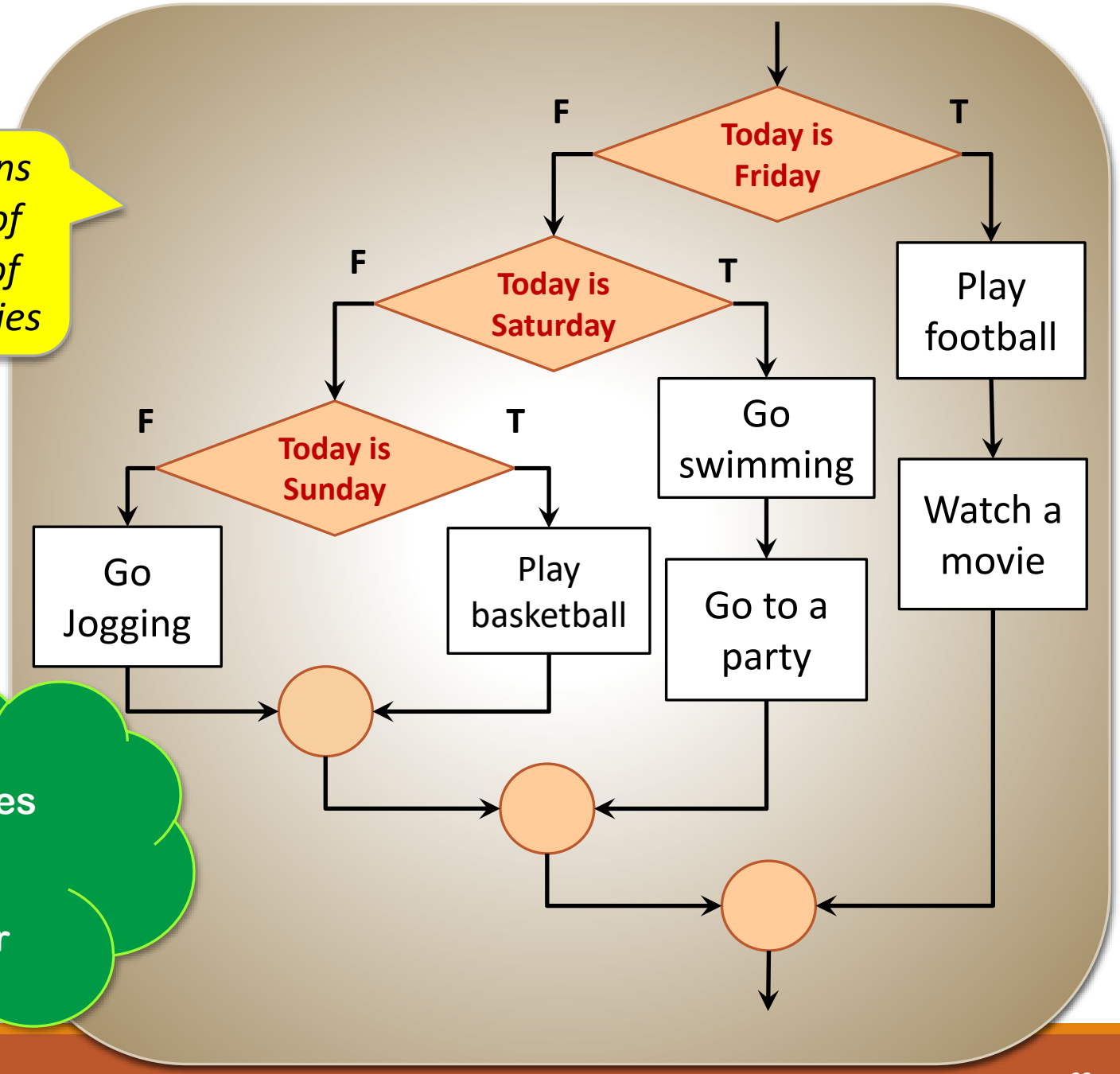
- What is a chained conditional ?

The use of an orderly sequence of k conditions ($k \geq 2$) to select one of k+1 code blocks to execute.

- It is also informally called the ***if-elseif-else*** *control structure*.

Example

Use 3 conditions to select one of the four sets of planned activities



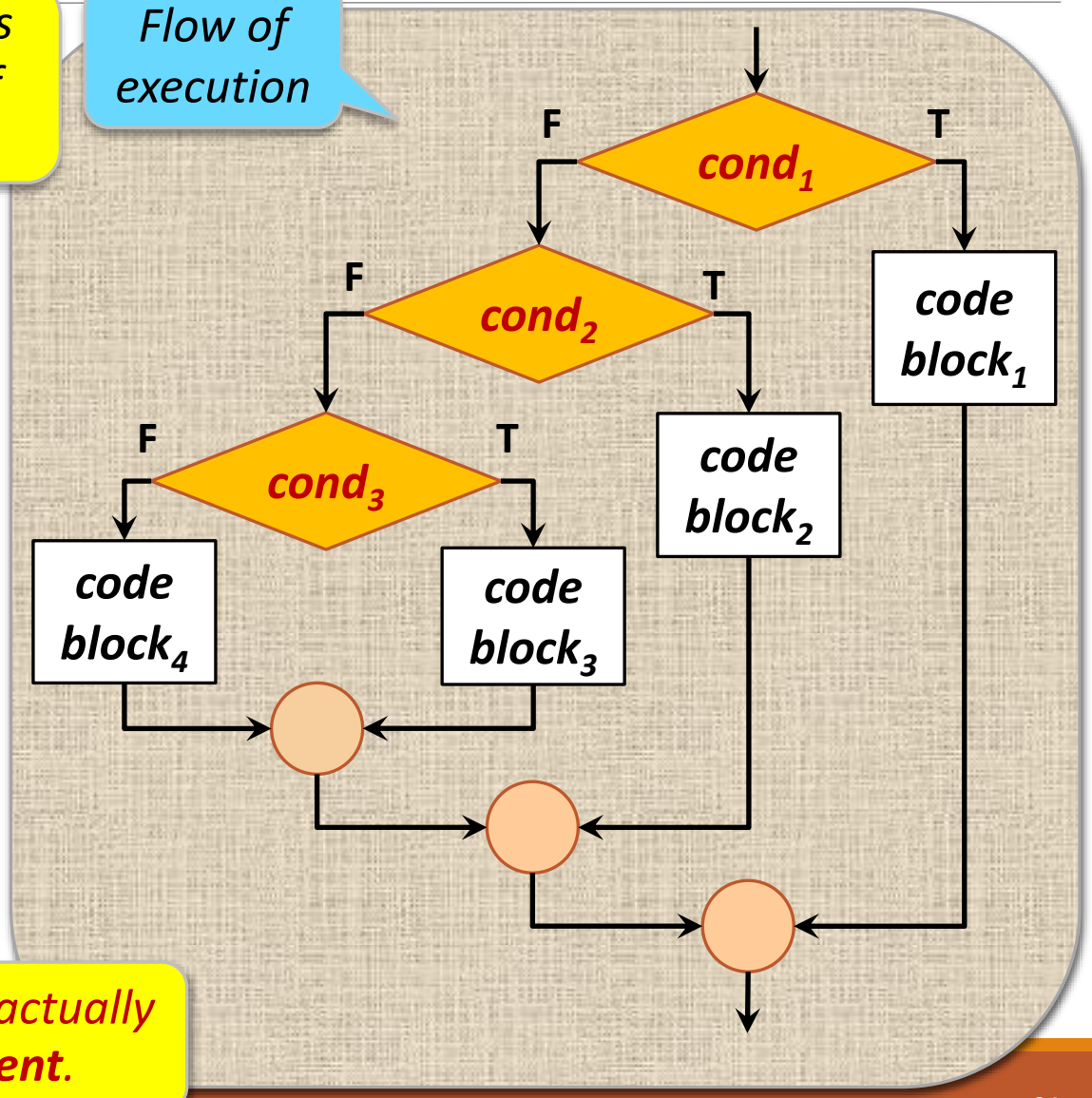
What are the planned activities on Monday, Tuesday, Wednesday, or Thursday?

Chained conditionals in Python implemented by nested conditionals

Use 3 conditions to select one of 4 code blocks

Flow of execution

```
if cond1:
    code_block1
else:
    if cond2:
        code_block2
    else:
        if cond3:
            code_block3
        else:
            code_block4
```



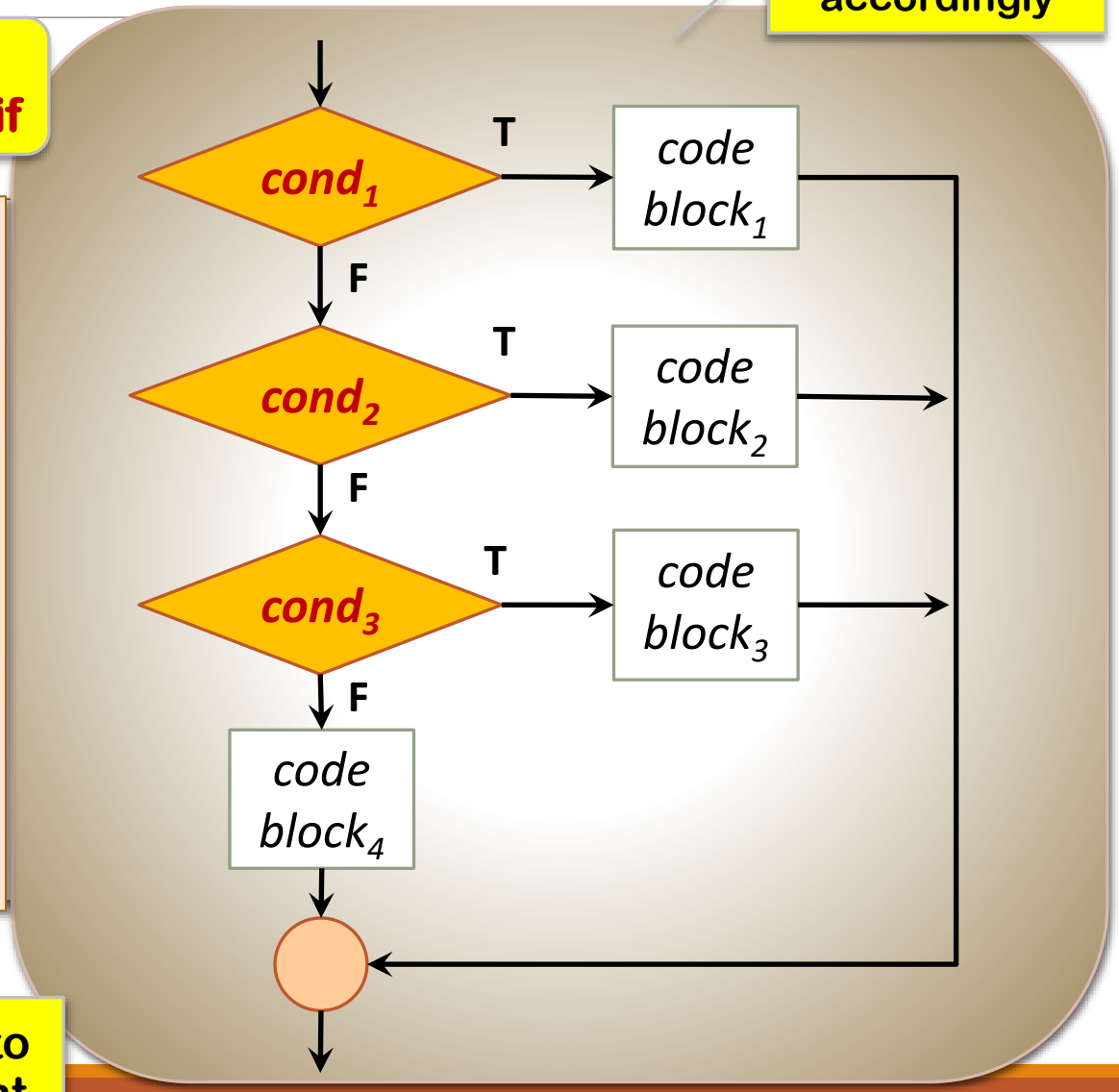
Note that this whole box is actually ***a single Python statement****.*

Chained conditionals in Python implemented by if-elif-else statements

Then, rearrange the flowchart accordingly

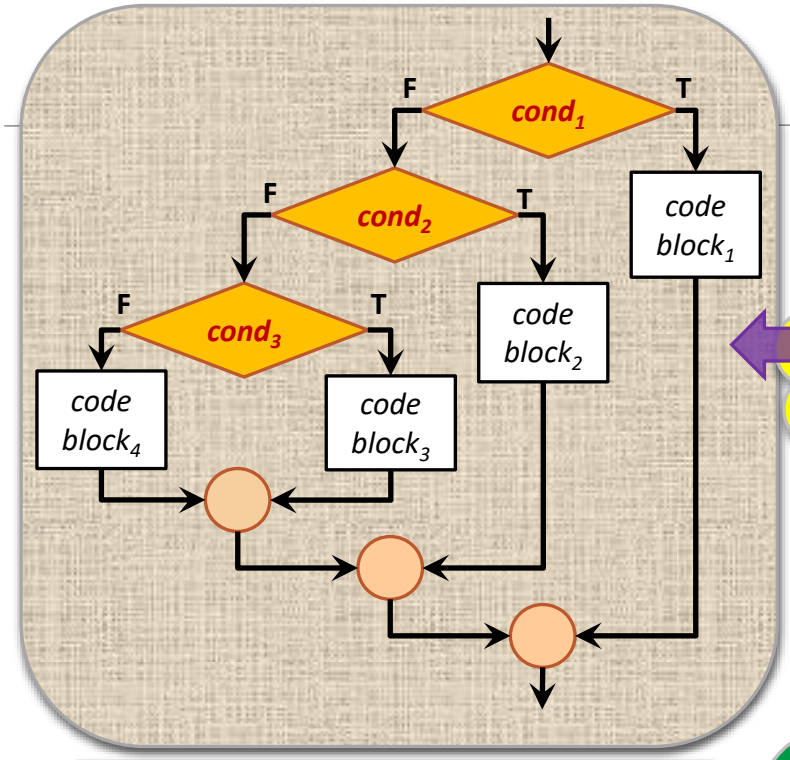
else: followed by if can be replaced by Python keyword elif

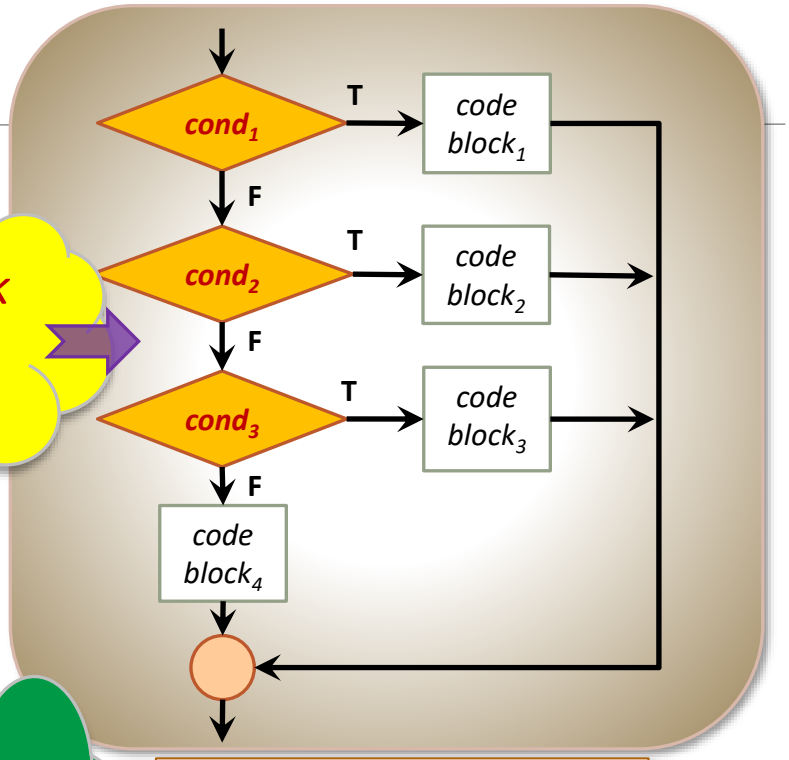
```
if    cond1:
      code_block1
elif  cond2:
      code_block2
elif  cond3:
      code_block3
else:
      code_block4
```



Then you must re-indent them to become an if-elif-else statement

The flow charts of both implementations show that





Both work exactly the same.

```
if cond1:
    code_block1
else:
    if cond2:
        code_block2
    else:
        if cond3:
            code_block3
        else:
            code_block4
```

Therefore, these two Python constructs work exactly the same too.

```
if    cond1:
    code_block1
elif cond2:
    code_block2
elif cond3:
    code_block3
else:
    code_block4
```

Example: Check how an integer is divided by 5

- Write a function **divfive()** to check how an integer is divided by 5:

Sample Run

```
>>> divfive(50)
50 is divisible by 5
>>> divfive(54)
54 is not divisible by 5
the remainder is 4
>>> divfive(53)
53 is not divisible by 5
the remainder is 3
>>> divfive(52)
52 is not divisible by 5
the remainder is 2
>>> divfive(51)
51 is not divisible by 5
the remainder is 1
```

divfive() - *version 1*

This version is to show that you can have as many elif-clauses as you need.

```
def divfive(d):     # version 1
    rem = d % 5
    if rem == 1:
        print(d, 'is not divisible by 5')
        print('the remainder is 1')
    elif rem == 2:
        print(d, 'is not divisible by 5')
        print('the remainder is 2')
    elif rem == 3:
        print(d, 'is not divisible by 5')
        print('the remainder is 3')
    elif rem == 4:
        print(d, 'is not divisible by 5')
        print('the remainder is 4')
    else:
        print(d, 'is divisible by 5')
```

divfive() - *version 2*

This version is to show that you can have no else-clause at all if you don't need it.

```
def divfive(d):    # version 2
    rem = d % 5
    if rem == 0:
        print(d, 'is divisible by 5')
    elif rem == 1:
        print(d, 'is not divisible by 5')
        print('the remainder is 1')
    elif rem == 2:
        print(d, 'is not divisible by 5')
        print('the remainder is 2')
    elif rem == 3:
        print(d, 'is not divisible by 5')
        print('the remainder is 3')
    elif rem == 4:
        print(d, 'is not divisible by 5')
        print('the remainder is 4')
```

divfive() - *version 3*

This version is to show that you can have no elif-clauses at all if you don't need them.

```
def divfive(d): # version 3
    rem = d % 5
    if rem == 0:
        print(d, 'is divisible by 5')
    else:
        print(d, 'is not divisible by 5')
        print('the remainder is', rem)
```

This becomes an ordinary if-else statement.

You should convince yourself that all these three versions produce exactly the same result.

More Programming Example on Chained Conditionals

Task: BMI and Weight Status

- Write a function bmi_and_status() that
  - *receives **weight** (in kg) and **height** (in meters) as parameters*
  - *computes the **body-mass index (BMI)** and returns the **BMI** and **weight status**.*

BMI and Weight Status - Idea

- Given the *weight* (in kilograms) and the *height* (in meters) of a person, the **Body-Mass Index (BMI)** of the person can be computed by the formula:

$$\text{BMI} = \frac{\text{weight}}{(\text{height}) \times (\text{height})}$$

- The **Weight Status** of a person is categorized by the BMI as follows:

BMI	Weight Status
BMI < 18.5	Underweight
18.5 ≤ BMI < 25.0	Normal
25.0 ≤ BMI < 30.0	Overweight
BMI ≥ 30.0	Obese

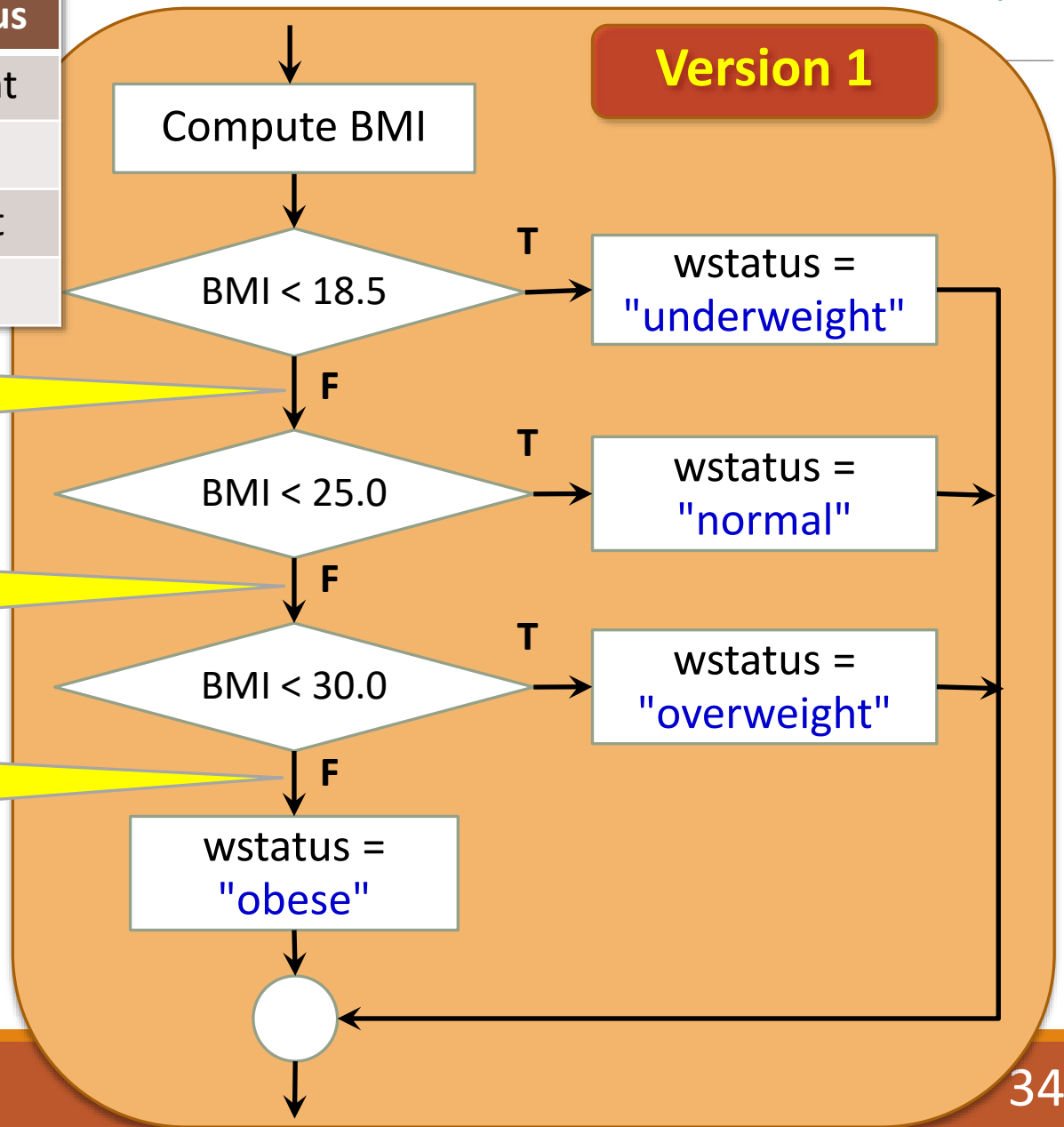
BMI and Weight Status – Algorithm

BMI	Weight Status
BMI < 18.5	Underweight
18.5 ≤ BMI < 25.0	Normal
25.0 ≤ BMI < 30.0	Overweight
BMI ≥ 30.0	Obese

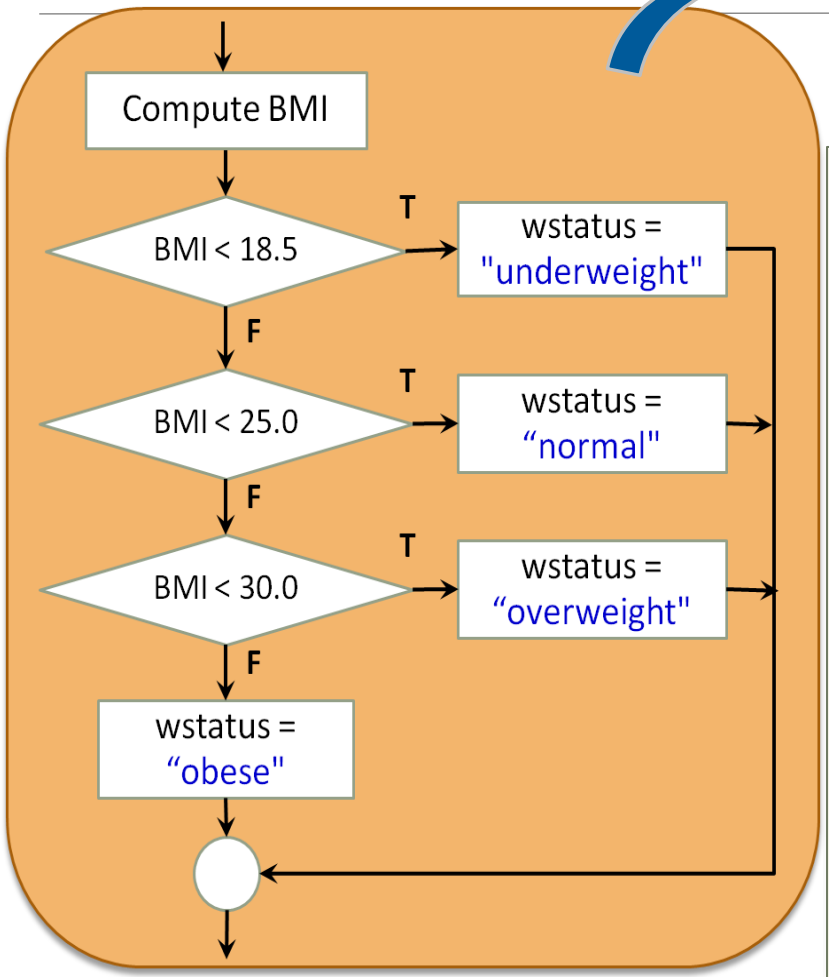
Here, it's certain that BMI ≥ 18.5

Here, it's certain that BMI ≥ 25.0

Here, it's certain that BMI ≥ 30.0



BMI and Weight Status – Python Code : Version 1




```python
def bmi_and_status(weight, height):
    bmi = weight/(height*height)

    if bmi < 18.5:
        wstatus = "underweight"
    elif bmi < 25.0:
        wstatus = "normal"
    elif bmi < 30.0:
        wstatus = "overweight"
    else:
        wstatus = "obese"

    return bmi, wstatus
```

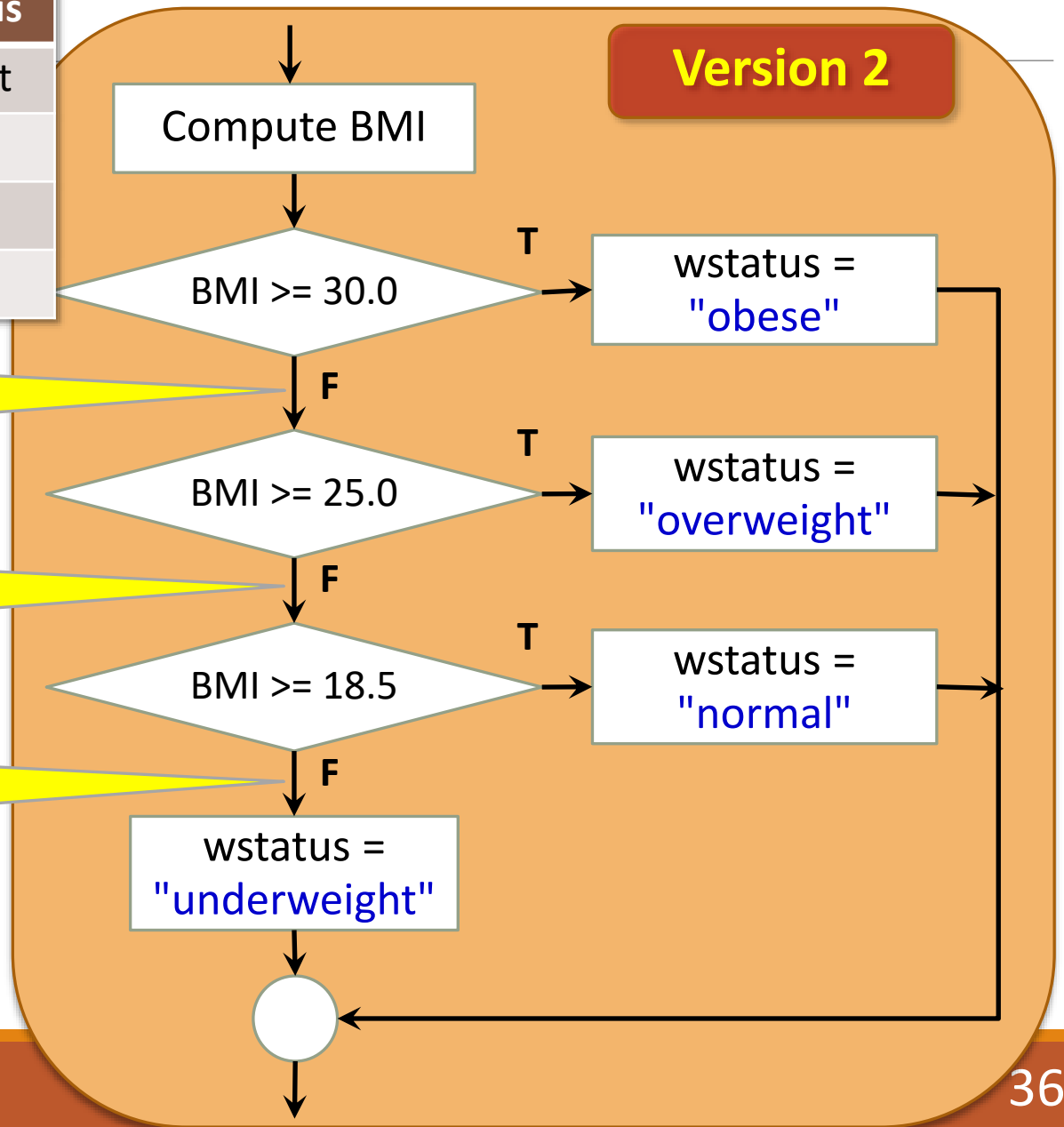
BMI and Weight Status – another equivalent algorithm

BMI	Weight Status
BMI < 18.5	Underweight
18.5 ≤ BMI < 25.0	Normal
25.0 ≤ BMI < 30.0	Overweight
BMI ≥ 30.0	Obese

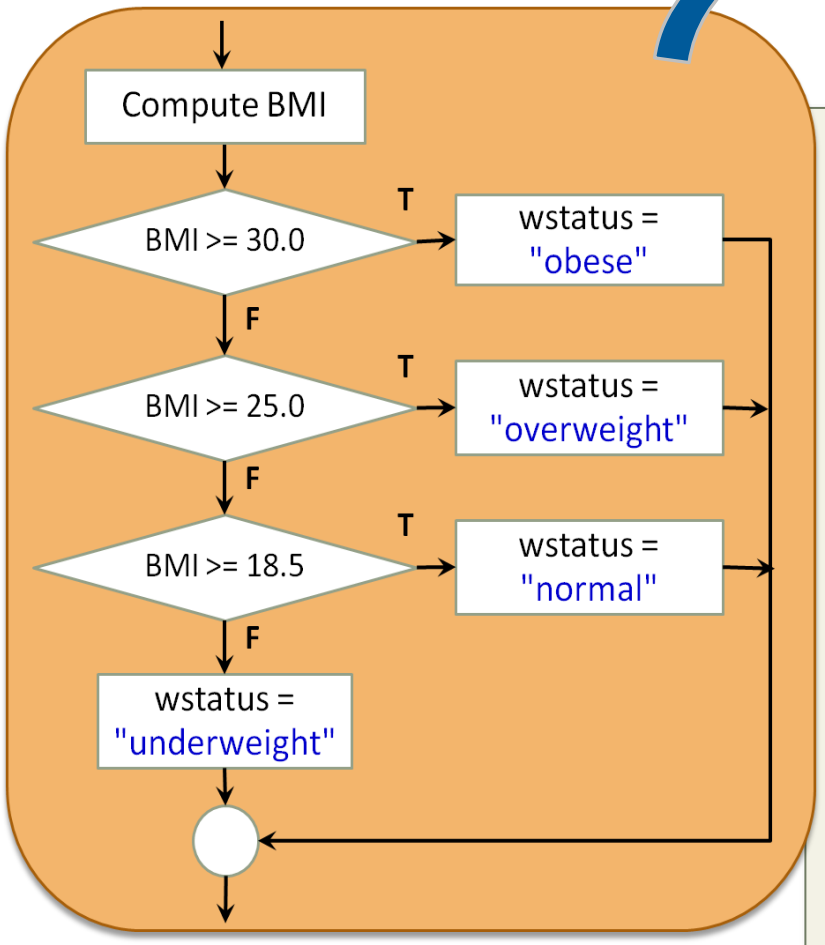
Here, it's certain that BMI < 30.0

Here, it's certain that BMI < 25.0

Here, it's certain that BMI < 18.5



BMI and Weight Status – Python Code : Version 2




```python
def bmi_and_status(weight, height):
    bmi = weight/(height*height)

    if bmi >= 30.0:
        wstatus = "obese"
    elif bmi >= 25.0:
        wstatus = "overweight"
    elif bmi >= 18.5:
        wstatus = "normal"
    else:
        wstatus = "underweight"

    return bmi, wstatus
```

Next: *Write a main routine to test it*

```
def bmi_and_status(weight, height): # version 1
    bmi = weight/(height*height)

    if bmi < 18.5:
        wstatus = "underweight"
    elif bmi < 25.0:
        wstatus = "normal"
    elif bmi < 30.0:
        wstatus = "overweight"
    else:
        wstatus = "obese"

    return bmi, wstatus
```

```
# ---- main routine ---- #
weight = float(input("Enter your weight (in kilograms): "))
height = float(input("Enter your height (in meters): "))
bmi, status = bmi_and_status(weight, height)
print(f"BMI is {bmi:.2f}, weight status: {status}")
```

Test the program, thoroughly

Try input values that yield all possible outputs

```
Enter your weight (in kilograms): 70
Enter your height (in meters): 2
BMI is 17.50, weight status: underweight
```

```
Enter your weight (in kilograms): 80
Enter your height (in meters): 1.8
BMI is 24.69, weight status: normal
```

```
Enter your weight (in kilograms): 90
Enter your height (in meters): 1.8
BMI is 27.78, weight status: overweight
```

```
Enter your weight (in kilograms): 100
Enter your height (in meters): 1.8
BMI is 30.86, weight status: obese
```

```
Enter your weight (in kilograms): 74
Enter your height (in meters): 2
BMI is 18.50, weight status: normal
```

```
Enter your weight (in kilograms): 100
Enter your height (in meters): 2
BMI is 25.00, weight status: overweight
```

```
Enter your weight (in kilograms): 120
Enter your height (in meters): 2
BMI is 30.00, weight status: obese
```

Also try some inputs that hit all the three boundary cases 18.5, 25.0, 30.0

Conclusion

- A **basic selection** control structure uses a single **if-** or **if-else** statement to select one of two paths of execution.
- A **mutiple selection** control structure selects one of three or more paths of execution.
- To do a multiple selection in Python, we may use **nested conditionals** or **chained conditionals**.
- We've got a **nested conditional** when we put one or more ***if*** or ***if-else*** statements in a code block within another ***if*** or ***if-else*** *statement*. This naturally gives rise to many different paths of execution.
- A **chained conditional** is the use of an orderly sequence of k conditions, $k \geq 2$, to select one of k+1 code blocks to execute. In Python, a chained conditional can be conveniently implemented by an **if-elif-else** statement.

References

- **if-elif-else** statement in Python:
  - https://docs.python.org/3/reference/compound_stmts.html#the-if-statement
  - https://docs.python.org/3/tutorial/controlflow.html#if-statements
- Good tutorials for multiple selections:
  - http://interactivepython.org/runestone/static/thinkcspy/Selection/Nestedconditionals.html
  - http://interactivepython.org/runestone/static/thinkcspy/Selection/Chainedconditionals.html
  - https://www.programiz.com/python-programming/if-elif-else

Major Revision History

- August 2016 – Chalermsak Chatdokmaiprai
  - originally created for C#
- July 31, 2017 – Chalermsak Chatdokmaiprai
  - adapted and enhanced for Python

Constructive comments or error reports on this set of slides would be welcome and highly appreciated. Please contact Chalermsak.c@ku.ac.th