REPETITION AND SELECTION

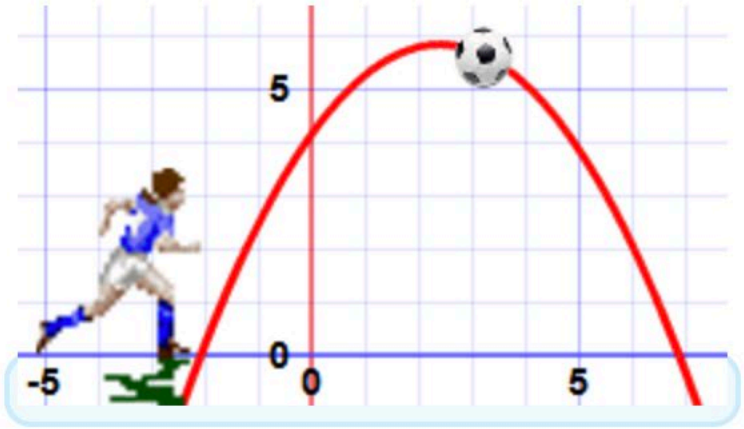
Example: Solving a Quadratic Eqt.

An example of a **Quadratic Equation**:

this makes it Quadratic

$$5x^2 + 3x + 3 = 0$$

Quadratic Equations make nice curves, like this one:



Example: Solving a Quadratic Eqt.

Standard Form

The **Standard Form** of a Quadratic Equation looks like this:

$$ax^2 + bx + c = 0$$

- **a**, **b** and **c** are known values. **a** can't be 0.
- "**x**" is the **variable** or unknown (we don't know it yet).

Example: Solving a Quadratic Eqt.

- Remember what we learned in high school…

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

- Let's try to implement it in Python

solve_qe1.py - /Volumes/GoogleDrive/My Drive/Courses/YSC2221/Lectur

```
from math import sqrt

def solve_qe(a,b,c):
    delta = b**2 - 4*a*c
    ans1 = (-b + sqrt(delta))/(2*a)
    ans2 = (-b - sqrt(delta))/(2*a)
    print("The two solutions are " + str(ans1)
          + " and " + str(ans2))
```

```
>>> solve_qe(1,5,6)
The two solutions are -2.0 and -3.0
>>> solve_qe(1,4,4)
The two solutions are -2.0 and -2.0
>>>
```

However…

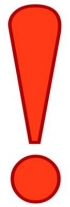
```
>>> solve_qe(1,-5,6)
The two solutions are 3.0 and 2.0
>>> solve_qe(1,1,8)
Traceback (most recent call last):
  File "<pyshell#4>", line 1, in <module>
    solve_qe(1,1,8)
  File "C:\Users\dcschl\Google Drive\Courses\YSC22
21\Lectures\solve_qe1.py", line 5, in solve_qe
    ans1 = (-b + sqrt(delta))/(2*a)
ValueError: math domain error
```

- Why?

solve_qe1.py - /Volumes/GoogleDrive/My Drive/Courses/YSC2221/Lectur

```
from math import sqrt

def solve_qe(a,b,c):
    delta = b**2 - 4*a*c
    ans1 = (-b + sqrt(delta))/(2*a)
    ans2 = (-b - sqrt(delta))/(2*a)
    print("The two solutions are " + str(ans1)
          + " and " + str(ans2))
```



delta = 25-24 = 1 > 0

```
>>> solve_qe(1,-5,6)
The two solutions are 3.0 and 2.0
>>> solve_qe(1,1,8)
Traceback (most recent call last):
  File "<pyshell#4>", line 1, in <module>
    solve_qe(1,1,8)
  File "C:\Users\dcschl\Google Drive\Courses\YSC22
21\Lectures\solve_qe1.py", line 5, in solve_qe
```

delta = 1 – 32 = -31 < 0

Example: Solving a Quadratic Eqt.

- Remember what we learned in high school…

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

- If delta < 0
  - The equation has no real solution

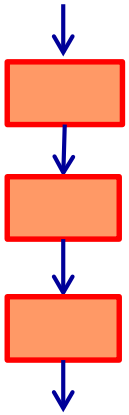
- So we cannot call sqrt() if delta is negative

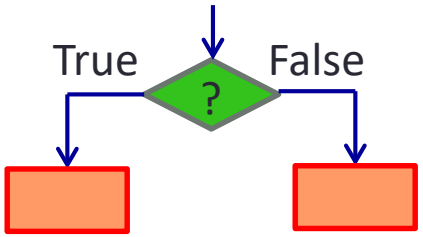
CONTROL STRUCTURES

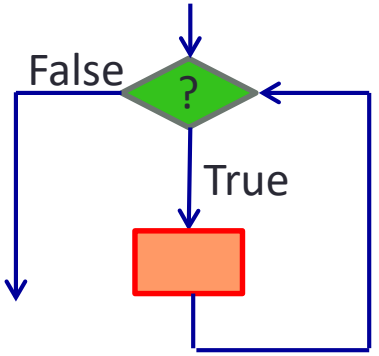
The basic building blocks of programming

Control Structures

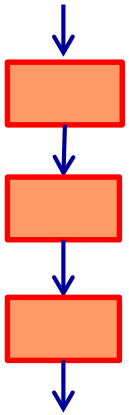
Sequence	• Default
Selection	• Also called branching
Repetition	• Also called loop







Control Structure: Sequence

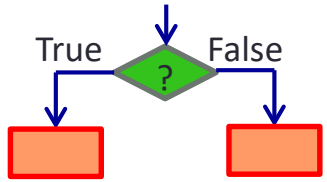


Method 1 Making Vanilla Pound Cake

1. Gather your ingredients. Pound cake is one of the simplest cakes to bake. ...
2. Preheat the oven to 325 degrees.
3. Grease a cake pan. ...
4. Cream the butter and sugar. ...
5. Add the eggs and vanilla. ...
6. Stir in the cake flour. ...
7. Pour the batter into the pan. ..
8. Bake the cake for an hour and 15 minutes.

4 Ways to Bake a Cake - wikiHow
www.wikihow.com/**Bake-a-Cake**

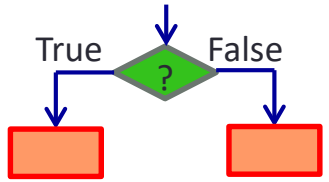
Control Structure: Selection



- If the player strikes a “3”
  - Give him a bear
- Else
  - Let him choose a water gun or a candy

Making Choices

Control Structure: Selection



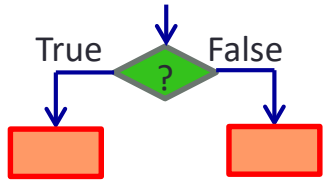

```
If (a condition is true)
  Do A
Else
  Do B
```

Can be MORE THAN one single instruction

- For example:

```
If (I have $10000000000000000)
  Buy a car
  Eat a lot of buffets
  Go travel
  Quit NUS!
Else
  Be good and study
```

Control Structure: Selection




```
If (a condition is true)
  Do A
Else
  Do B
```

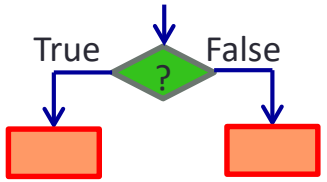
Can be MORE THAN one single instruction

- For example:

```
If (I have $10000000000000000)
  If (I am heartless)
    Buy a car
    Eat a lot of buffets
    Go travel
    Quit NUS!
  Else
       donate all the money to charity
Else
  Be good and study
```

Nested “if”

Control Structure: Selection



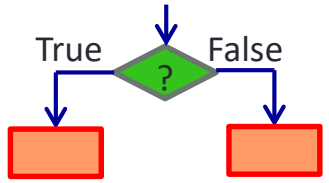

```
If (a condition is true)
  Do A
Else
  Do B
```

Can be **WITHOUT** "else"

- For example:

```
If (I have $10000000000000000)
  Buy a car
  Eat a lot of buffets
  Go travel
  Quit NUS!
Else
  Be good and study
```

Control Structure: Selection




```
If (a condition is true)
  Do A
Else
  Do B
```

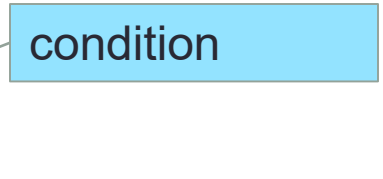
Can be MORE THAN one single instruction

- For example:

```
If (I have $10000000000000000)
  Buy a car
  Eat a lot of buffets
  Go travel
  Quit NUS!
Else
  Be good and study
```

Condition

```
def solve_qe(a,b,c):
    delta = b**2 - 4*a*c
    if delta >= 0:
        ans1 = (-b + sqrt(delta))/(2*a)
        ans2 = (-b - sqrt(delta))/(2*a)
        print("The two solutions are " + str(ans1)
              + " and " + str(ans2))
    else:
        print("The equation has no real root")
```



If the condition is True

```
def solve_qe(a,b,c):
    delta = b**2 - 4*a*c
    if delta >= 0:
        ans1 = (-b + sqrt(delta))/(2*a)
        ans2 = (-b - sqrt(delta))/(2*a)
        print("The two solutions are " + str(ans1)
              + " and " + str(ans2))
    else:
        print("The equation has no real root")
```

If the condition is False

```
def solve_qe(a,b,c):
    delta = b**2 - 4*a*c
    if delta >= 0:
        ans1 = (-b + sqrt(delta))/(2*a)
        ans2 = (-b - sqrt(delta))/(2*a)
        print("The two solutions are " + str(ans1)
              + " and " + str(ans2))
    else:
        print("The equation has no real root")
```

Conditional

Syntax

```
if <expr>:
    statement(s)
```

Example

```
>>> my_money = 1000
>>> if my_money > 0:
        print('Good')
'Good'
```

Conditional

Syntax

```
if <expr>:
    statement(s)
```

indentation

Example

```
>>> my_money = 1000
>>> if my_money > 0:
        print('Good')
        print('Good')
        print('Good')

'Good'
'Good'
'Good'
```

Conditional

Syntax

```
if <expr>:
    statement(s)
else:
    statement(s)
```

Example

```
>>> my_account = 1000
>>> if my_account > 0:
        print('rich')
else:
        print('broke')
'rich'
```

Conditional (Nested)

Syntax

```
if <expr>:
    if <expr>:
        statement(s)
```

Example

```
a = 4
if a < 10:
    if a < 1:
        print('Here')
```

Print nothing

Conditional

Syntax

```
if <expr>:
    statement(s)
else:
    statement(s)
```

Example

```
>>> my_account = 1000
>>> if my_account < 0:
        print('poor')
    else:
        if my_account > 1:
            print('v rich')

v rich
```

Clumsy

Conditional

Syntax

```
if <expr>:
    statement(s)
elif <expr>:
    statements(s)
else:
    statement(s)
```

Example

```
>>> a = -3
>>> if a > 0:
        print('yes')
elif a == 0:
        print('no')
else:
        print('huh')
'huh'
```

Conditional

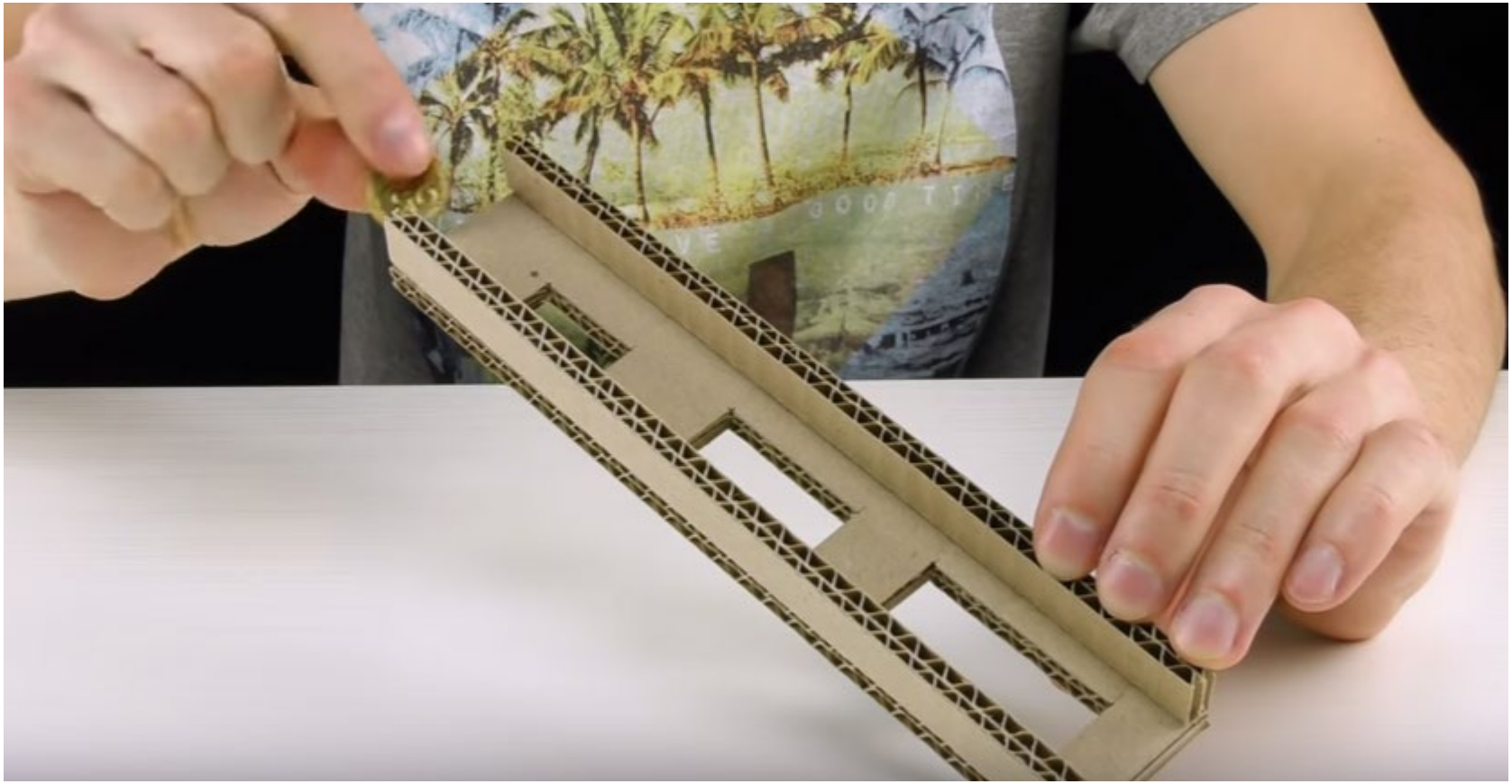
Syntax

```
if <expr>:
    statement(s)
elif <expr>:
    statements(s)
elif <expr>:
    statements(s)
else:
    statement(s)
```

Can be many

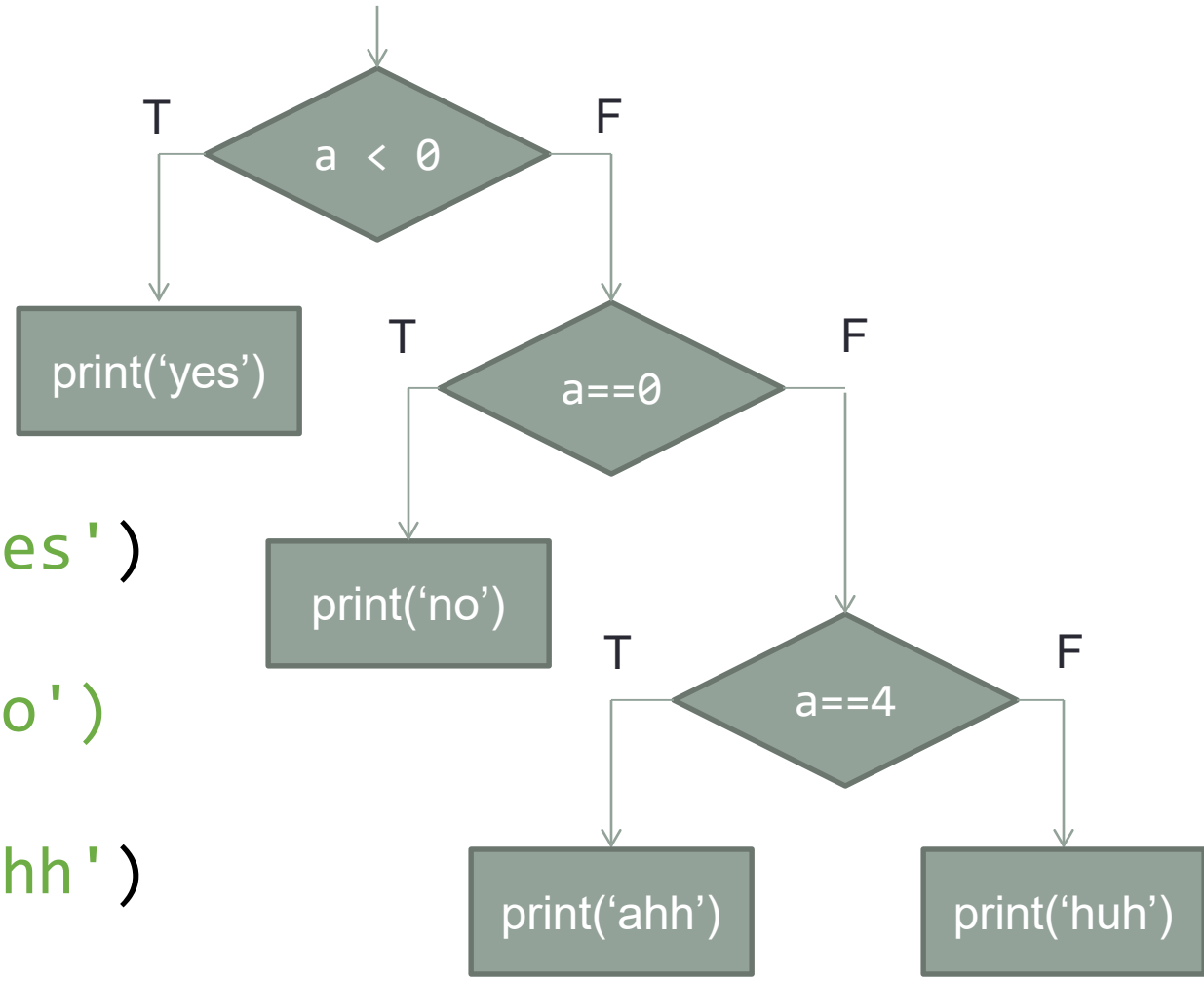
Example

```
>>> a = 4
>>> if a > 0:
        print('yes')
elif a == 0:
        print('no')
elif a == 4:
        print('ahh')
else:
        print('huh')
'yes'
```



e.g.

```
>>> a = 4
>>> if a < 0:
        print('yes')
elif a == 0:
        print('no')
elif a == 4:
        print('ahh')
else:
        print('huh')
'ahh'
```



Homework: Figure out ALL conditions

```
def solve_qe(a,b,c):
    delta = b**2 - 4*a*c
    if delta >= 0:
        ans1 = (-b + sqrt(delta))/(2*a)
        ans2 = (-b - sqrt(delta))/(2*a)
        print("The two solutions are " + str(ans1)
              + " and " + str(ans2))
    else:
        print("The equation has no real root")
```

condition

Repetition


I will not argue with idiots on YouTube.
I will not argue with idiots on YouTube.
I will not argue with idiots on YouTube.
I will not argue with idiots on YouTube.
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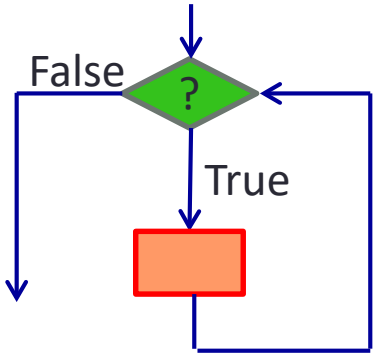
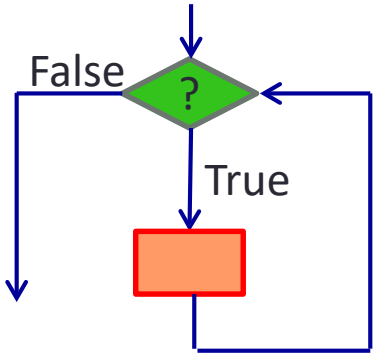
Control Structure: Repetition



- While there are prizes left
  - Play Plinko and give prizes

Control Structure: Repetition



- While (a condition)
  - Do something

- For example

```
While (I am hungry)
  Eat a bun
```

- Again, can be more than one single instruction

```
While(I have money in bank)
  Take money out from bank
  Eat an expensive meal
  While(I have money in my wallet)
    Go Shopping
```

Iteration

the act of repeating a process with the aim of approaching a desired goal, target or result.

- Wikipedia

Three Types of Loops

- Must run exactly N times
- Run any number of times
- Run at most N times
  - Check all True (or check all False)
  - Find any True (or False)

Three Types of Loops

- **Must run exactly N times**
- Run any number of times
- Run at most N times
  - Check all True (or check all False)
  - Find any True (or False)

Repetition Flow Control: “For”

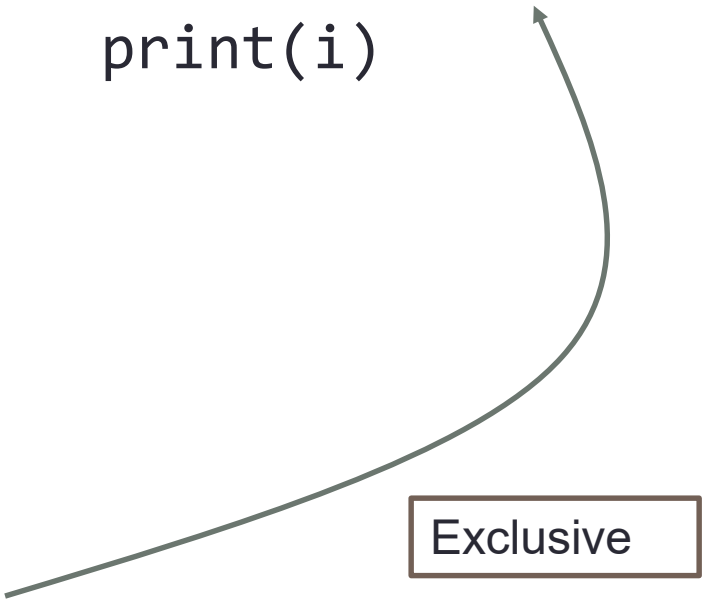
Syntax

```
for i in range(n,m):
    statement(s)
```

Example

```
for i in range(0,5):
    print(i)
```

```
0
1
2
3
4
```



Repetition Flow Control: “For”

Example

```
for i in range(0,5):
    print(i)
```

```
0
1
2
3
4
```

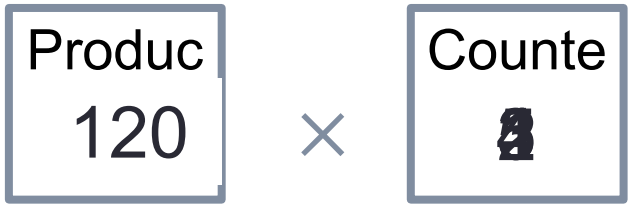
Interpreted as

```
i=0
print(i)
i=1
print(i)
i=2
print(i)
i=3
print(i)
i=4
print(i)
```

Iterative Factorial

Idea

- Start with 1, multiply by 2, multiply by 3, … , multiply by n.
- $n! = 1 \times 2 \times 3 \cdots \times n$



Iterative Factorial

- $n! = 1 \times 2 \times 3 \cdots \times n$
- **Computationally**
- Starting:
- product = 1
- counter = 1
- Iterative (repeating) step:
- product ← product × counter
- counter ← counter + 1
- End:
- product contains the result

Computing Factorial

- $n! = 1 \times 2 \times 3 \cdots \times n$
- Factorial rule:
- product ← product × counter
- counter ← counter + 1

```
def factorial(n):
    product = 1
    for counter in range(2, n+1):
        product = product * counter
    return product
```

non-inclusive.
Up to n.

product	counter
1	2
1x2 = 2	3
1x2x3=6	4
1x2x3x4=24	5
120	6
720	7

```
factorial(6)
```

for loop

- for <var> in <sequence>:
- <body>

- sequence
  - a sequence of values
- var
  - variable that take each value in the sequence
- body
  - statement(s) that will be evaluated for each value in the sequence

range function

- range([start,] stop[, step])

- creates a sequence of integers
  - from start (inclusive) to stop (non-inclusive)
  - incremented by step

Examples

```
for i in range(10):
    print(i)

for i in range(3, 10):
    print(i)

for i in range(3, 10, 4):
    print(i)
```

EXAMPLE

Flipping coins

Flipping a coin

- A coin is “fair” if the probably of getting a head is equal to a tail
  - P(head) == P(tail) == 0.5
- How to test a coin is fair?
- Flip 1000 times!

Write a Pseudo Code for the Experiment

- I will flip a coin 1000 times and FOR EACH FLIP
  - I will record how many times I had flipped
  - If it is a head, I will record the number of heads

What you repeat for EACH time

Flipping Coins

```
import random

def flipCoins():
    print('I will flip a coin 1000 times. ')
    print('Guess how many times it will come up heads. ')

    heads = 0
    for flip in range(0,1000):
        if random.randint(0, 1) == 1:
            heads = heads + 1
```

Randomly generate either 0 or 1

while loop

- while <expression>:
- <body>

- expression
  - Predicate (condition) to stay within the loop
- body
  - Statement(s) that will be evaluated if predicate is True

Repetition (Infinite)

```
while True:
    print('Ah...')
```

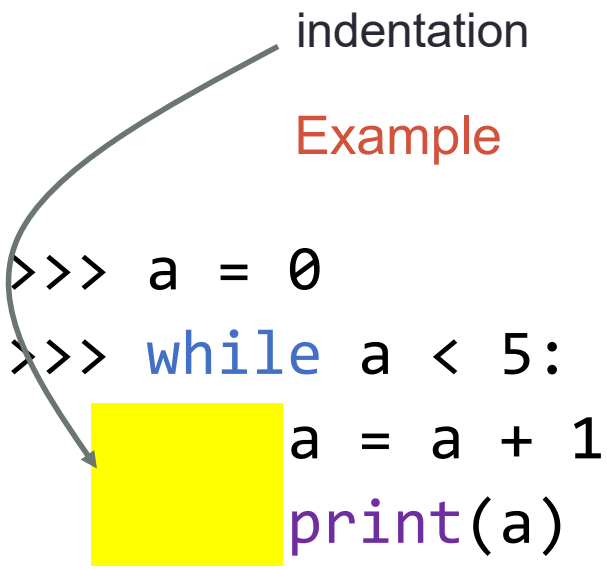
```
a = 0
while a > 0:
    a = a + 1
    print(a)
```

A programmer was walking out of door for work, his wife said “while you're out, buy some milk” and he never came home.

Repetition

Syntax

```
while <expr>:
    statement(s)
```



Example

```
>>> a = 0
>>> while a < 5:
        a = a + 1
        print(a)
1
2
3
4
5
```

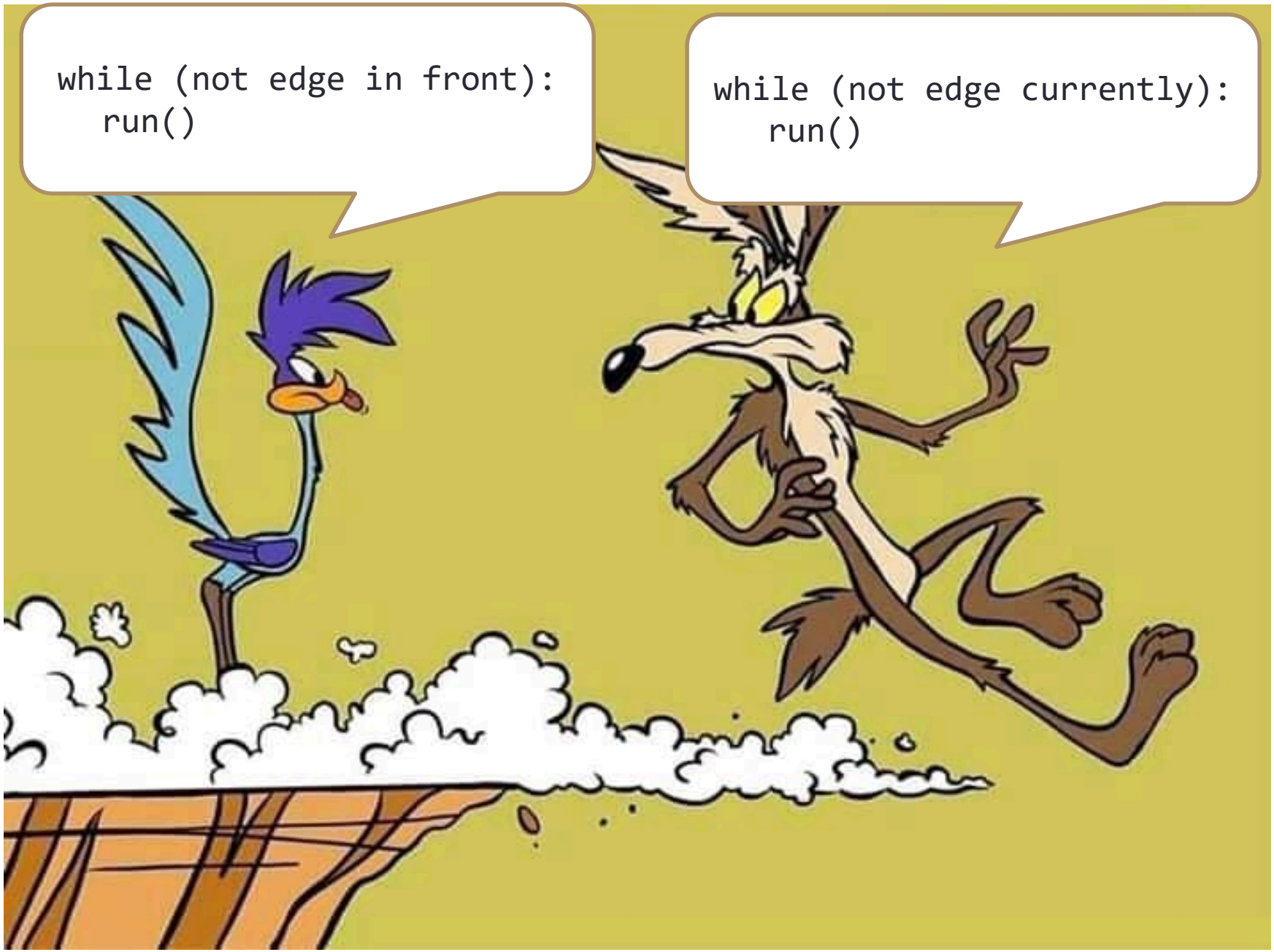
Another Iterative process

```
def factorial(n):
    product, counter = 1, 1
    while counter <= n:
        product = (product *
                   counter)
        counter = counter + 1
    return product

factorial(6)
```

product	counter
1	1
1	2
2	3
6	4
24	5
120	6
720	7

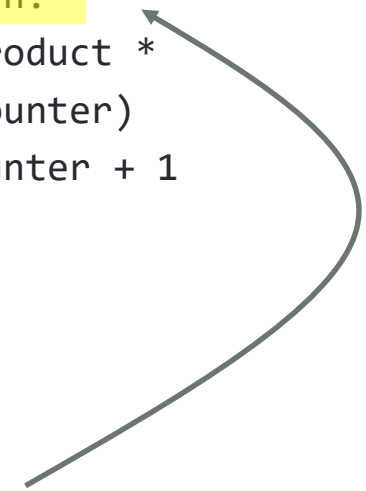
counter > n (7 > 6)
return product (720)


while (not edge in front):
run()
while (not edge currently):
run()

Another Iterative process

```
def factorial(n):
    product, counter = 1, 1
    while counter <= n:
        product = (product *
                   counter)
        counter = counter + 1
    return product

factorial(6)
```



“<=“ or “<“ ?

product	counter
1	1
1	2
2	3
6	4
24	5
120	6
720	7

counter > n (7 > 6)
return product (720)

```
import random

def flipCoins():
    print('I will flip a coin 1000 times. ')
    print('Guess how many times it will come up heads. ')
    flips = 0
    heads = 0
    while flips < 1000:
        if random.randint(0, 1) == 1:
            heads = heads + 1
        flips = flips + 1
```

Randomly generate either 0 or 1

Repetition (nested)

inentation

Syntax

```
while <expr>:
    while <expr>:
        statement(s)
```

```
#
##
###
#
##
###
#
##
###
#
##
###
```

Example

```
def nestedWhile():
    i = 0
    while i < 5:
        i += 1
        j = 0
        while j < 3:
            j += 1
            print ('#' * j)
```

Repetition, a Very Common Pattern

9 out of 10 times you will do

```
>>> a = 0
>>> while a < N:
        a = a + 1
        do something
```

For loop

```
for i in range(0,N):
    do something
```

Three Types of Loops

- Must run exactly N times
- **Run any number of times**
- Run at most N times
  - Check all True (or check all False)
  - Find any True (or False)

Sum Some Numbers

```
Please enter a number of type 'bye' to sum:
12
Please enter a number of type 'bye' to sum:
99
Please enter a number of type 'bye' to sum:
123
Please enter a number of type 'bye' to sum:
2
Please enter a number of type 'bye' to sum:
bye
The sum of all numbers is 236
>>>
```

Sum Some Numbers

- You do not know how many numbers will the user enter

```
def sumNumbers():
    sumSoFar = 0
    print("Please enter a number of type \'bye\' to sum:")
    num = input()
    while num != 'bye':
        sumSoFar += int(num)
        print("Please enter a number of type \'bye\' to sum:")
        num = input()

    print("The sum of all numbers is " + str(sumSoFar))
```

Why do we need to repeat these?

```
def sumNumbers():
    sumSoFar = 0
    print("Please enter a number of type \'bye\' to sum:")
    num = input()
    while num != 'bye':
        sumSoFar += int(num)
        print("Please enter a number of type \'bye\' to sum:")
        num = input()

    print("The sum of all numbers is " + str(sumSoFar))
```

Loop Terminating Condition

- Must run exactly N times
- **Run any number of times**
- Run at most N times
  - Check all True (or check all False)
  - Find any True (or False)

- If we do not know how many times do we need, when do we know we finish looping?

Loop Terminating Condition

- When will the loop terminate?

```
def sumNumbers():
    sumSoFar = 0
    print("Please enter a number of type \'bye\' to sum:")
    num = input()
    while num != 'bye':
        sumSoFar += int(num)
        print("Please enter a number of type \'bye\' to sum:")
        num = input()

    print("The sum of all numbers is " + str(sumSoFar))
```

- When
  - num == ‘bye’? Or
  - num!= ‘bye’ ?

Loop Terminating Condition

- When will the loop terminate?

```
def sumNumbers():
    sumSoFar = 0
    print("Please enter a number of type \'bye\' to sum:")
    num = input()
    while num != 'bye':
        sumSoFar += int(num)
        print("Please enter a number of type \'bye\' to sum:")
        num = input()

    print("The sum of all numbers is " + str(sumSoFar))
```

- The loop body will keep repeating if the condition is true
- The you break the loop if the condition is not true anymore

Three Types of Loops

- Must run exactly N times
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  - **Check all True** (or check all False)
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Check if a String is all Alphabets

- Given a string, example, `'abc123'`
- Check if all the characters are alphabets
  - Return True or False

- In real life, how do you check?

- For example, if you are the teacher with a lot of test scripts, how do you check if "all are marked"?

Goal: All Scripts Are Marked

- I just need one of the answers:
  - Yes: if all are marked
  - No: if there exists one not marked
- How do you come out with the answer “Yes”?
  - You check the scripts one-by-one
  - If the current one is marked, do nothing, just check the next
  - Until finishing all scripts
- How do you come out with the answer “No”?
  - You check the scripts one-by-one
  - If the current one is marked, do nothing, check the next
    - If the current one is not marked?!
    - DONE!!! Just say “No”!

Goal: All Scripts Are Marked

- I just need one of the answers:
  - Yes: if all are marked
  - No: if there exists one not marked
- Combining
  - You check the scripts one-by-one
  - If the current one is marked, do nothing, check the next
    - Else return “No”!
  - Until finishing all scripts all checked, return “Yes”

Goal: All are Alphabet

- I just need one of the answers:
  - Yes: if all are alphabet
  - No: if there exists one not alphabet
- Combining
  - You check the character one-by-one
  - If the current one is alphabet, do nothing, check the next
    - Else return “No”!
  - Until finishing all character all checked, return “Yes”

Which line you repeat a lot of times?

Goal: All are Alphabet

- I just need one of the answers:
  - Yes: if all are alphabet
  - No: if there exists one not alphabet
- Combining
  - You check the character one-by-one
    - If the current one is alphabet, do nothing, check the next
      - Else return “No”!
  - Until finishing all character all checked, return “Yes”

In Python, you indent the statements needed to be loop

Goal: All are Alphabets

- Combining
  - You check the character one-by-one
    - If the current one is NOT alphabet, return “No”!
  - Until finishing all character all checked, return “Yes”

```
def checkAllAlpha(string):
    l = len(string)
    for i in range(l):
        if not isAlphabet(string[i]):
            return False
    return True
```

Goal: All are Alphabets

- Combining
  - You check the character one-by-one
    - If the current one is NOT alphabet, return “No”!
  - Until finishing all character all checked, return “Yes”

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Goal: All are Alphabets

- Combining
  - You check the character one-by-one
    - If the current one is NOT alphabet, return “No”!
  - Until finishing all character all checked, return “Yes”

```
def checkAllAlpha(string):
    l = len(string)
    for i in range(l):
        if not isAlphabet(string[i]):
            return False
    return True
```

How many times?

- How many times we reach this line if len(string) = N?
  - You check the character one-by-one
    - If the current one is NOT alphabet, return “No”!
  - Until finishing all character all checked, return “Yes”

```
def checkAllAlpha(string):
    l = len(string)
    for i in range(l):
        if not isAlphabet(string[i]):
            return False
    return True
```

- Worst case: N times
- But maybe less than N

Provided that we have a function

- To check if a character is an alphabet

```
def isAlphabet(s):
    if s >= 'a' and s <= 'z':
        return True
    if s >= 'A' and s <= 'Z':
        return True
    return False
```

Three Types of Loops

- Must run exactly N times
- Run any number of times
- **Run at most N times**
  - Check all True **(or check all False)**
  - Find any True (or False)

- Check all True similar to check all False
  - E.g. check if all characters are NOT alphabet?

```
def checkAllNotAlpha(string):
    l = len(string)
    for i in range(l):
        if isAlphabet(string[i]):
            return False
    return True
```

Three Types of Loops

- Must run exactly N times
- Run any number of times
- **Run at most N times**
  - Check all True (or check all False)
  - **Find any True (or False)**

- Check any True?
  - Return the reverse of “check all False”

```
def checkAnyAlpha(string):
    return not checkAllNotAlpha(string)
```

“For” vs “While”

- When to use “for” and when to use “while”?
- “For”
  - You know how many times before hand
  - Namely, anything in the body of the loop will NOT change the number of times you repeat the loop
  - E.g. printing out all the data in a spreadsheet
- “While”
  - You may not know how many times you need to repeat
  - The number of times is depended on the “condition”, in which, may change unpredictably inside the loop
  - E.g. while the player haven’t guess the right answer, keep guessing

Lastly: break & continue

```
for j in range(10):
    print(j)
    if j == 3:
        break
print("done")
```

Jump

```
0
1
2
3
done
```

Break out of loop

```
for j in range(10):
    if j % 2 == 0:
        continue
    print(j)
print("done")
```

Jump

```
1
3
5
7
9
done
```

Continue with next value

Let's play a game

```
>>> guessANum()
I have a number in mind between 0 and 99
Guess a number: 50
Too big
Guess a number: 25
Too big
Guess a number: 12
Too big
Guess a number: 6
Too small
Guess a number: 9
Too big
Guess a number: 7
Bingo!!!
>>>
```

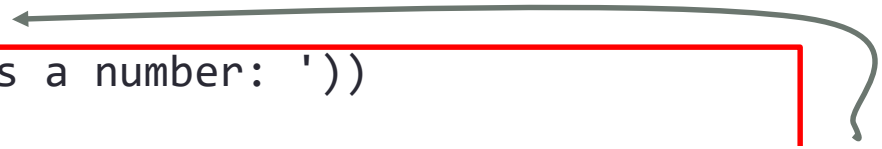
guessANum.py

```
import random

def guessANum():
    secret = random.randint(0,99)    # 0 <= secret <= 99
    guess = -1
    print('I have a number in mind between 0 and 99')
    while guess != secret:
        guess = int(input('Guess a number: '))
        if guess == secret:
            print('Bingo!!! You got it! ')
        elif guess < secret:
            print('Your number is too small')
        else:
            print('Your number is too big')

guessANum()
```

Repeat until the condition is False

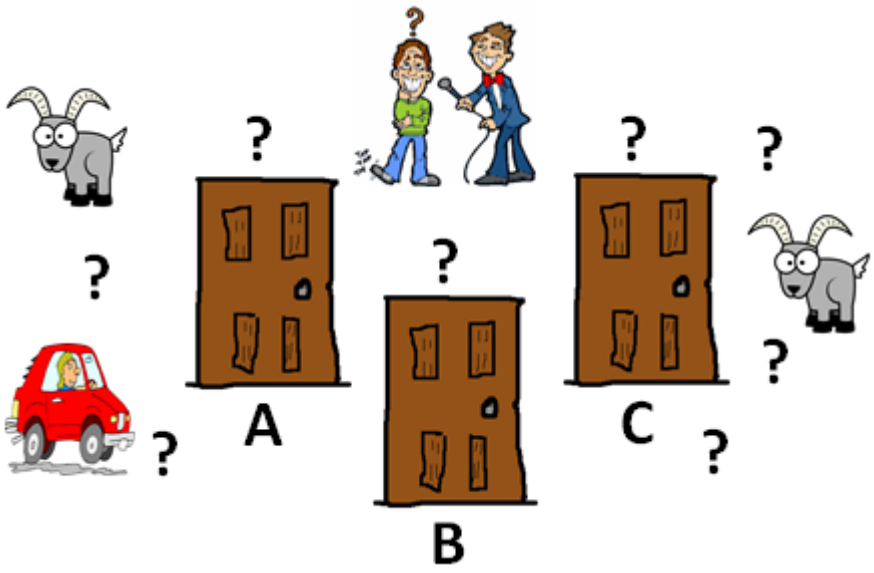
guessANum.py

```
import random

def guessANum():
    secret = random.randint(0,99)    # 0 <= secret <= 99
    guess = -1
    print('I have a number in mind between 0 and 99')
    while guess != secret:
        guess = int(input('Guess a number: '))
        if guess == secret:
            print('Bingo!!! The answer is ' + str(secret)))
        elif guess < secret:
            print('Your number is too small')
        else:
            print('Your number is too big')

guessANum()
```



Repeat until the condition is False

Monty Hall Problem (Again?!!)



How to write a love letter in Python

```
def show_my_love():
    everything = True
    you = everything
    my_mind = you
    while(my_mind == True):
        print('I love you')
```

Tips

- A “while” or “if” block starts with a colon “:”
- Remember
  - When there is a colon, there are indentations
  - When there are indentations, before these there is a colon
- The inclusive/exclusive range is a pain