CSEN 102– Introduction to Computer Science

Lecture 4:
Algorithmic Problem Solving
Iterative Operations

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Synopsis – conditional operations

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1 if condition:
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1 if condition:
2         # <operations for the then-part>
3 else
4         # <operations for the else-part>
```

- Execution
  - Evaluate `condition` expression to see whether it is true or false.
  - If true, then execute operations in **`if`**-part
  - Otherwise, execute operations in **`else`**-part

Algorithms: operations

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"Life isn't just one damn thing after another. . . it is the same damn thing over and over again."

—Edna St. Vincent Millay

Iterative Operation – Loops

Repeat a set of steps over and over – also called a looping operation

Iterative Operation – syntax

General Format:

```
1  while <condition>:
2        step 1: <operation>
3        ...
4        step i: <operation>
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Execution

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2. If condition is true, execute steps `1` to `i`, then go back to `1`.

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General Format:

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1  while <condition>:
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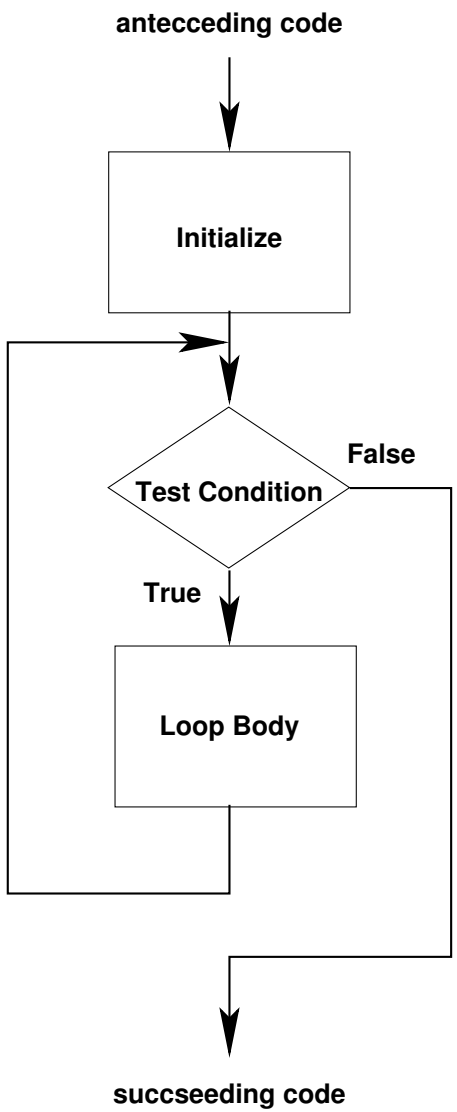
3        ...
4        step i: <operation>
```

Execution

1. Evaluate the condition
2. If condition is true, execute steps `1` to `i`, then go back to `1`.
3. Otherwise, if condition is false continue the execution after the while loop.

Iterative operation – diagram



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count <= 3
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```
print("count is:", count)
count = count + 1 # add one to count
```

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```
count <= 3
```

2. Formulate the actions for the loop body which take you one step closer to termination

```
print("count is:", count)
count = count + 1 # add one to count
```

3. In general, initialization is required before the loop and some postprocessing after the loop

```
count = 1
```

Iterative operations: Example I

Example

Given is a natural number n. Compute the sum of numbers from 1 to n.

Iterative operations: Example I

Example

Given is a natural number *n*. Compute the sum of numbers from 1 to *n*.

```
1  n = eval(input())
2  result = 0
3  i = 1
4  while i <= n:
5      result = (result+i)
6      i = (i+1)
7  print(result)
```

Iterative operations: Example II

Example

Write an algorithm to perform the average of *n* numbers entered by the user.

Iterative operations: Example II

Example

Write an algorithm to perform the average of *n* numbers entered by the user.

```
1  n = eval(input())
2  result = 0
3  i = 1
4  while (i <= n):
5     num = eval(input())
6     result = result + num
7     i = i + 1
8
9  average = result/n
10 print(average)
```

Iterative Operation: Example III

Example

Multiplication of two integers N and M via addition

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- Example: $N = 3$ and $M = 4$ $\rightarrow$

N	M	result

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3	4	0

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3	4	0
3	3	3

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N	M	result
3	4	0
3	3	3
3	2	6

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Multiplication of two integers N and M via addition

- Example: $N = 3$ and $M = 4$ $\rightarrow$

N	M	result
3	4	0
3	3	3
3	2	6
3	1	9

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Multiplication of two integers N and M via addition

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N	M	result
3	4	0
3	3	3
3	2	6
3	1	9
3	0	12

Iterative Operation: Example III

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Multiplication of two integers N and M via addition

- Example: $N = 3$ and $M = 4$ $\rightarrow$

N	M	result
3	4	0
3	3	3
3	2	6
3	1	9
3	0	12

```
1 N, M = eval(input()), eval(input())
2 result = 0
3 while M > 0:
4     result = result + N
5     M = M - 1
6 print(result)
```

Iterative operations: Example IV

Example

Write an algorithm that, given a positive number n, will calculate and print the value of $n! = n \times (n-1) \times (n-2) \times \ldots \times 1$

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Example

Write an algorithm that, given a positive number n, will calculate and print the value of $n! = n \times (n-1) \times (n-2) \times \ldots \times 1$

```
1  n = eval(input())
2  result = 1
3  while n > 1:
4      result = (result * n)
5      n = (n - 1)
6  print(result)
```

Iterative operations: Example V

Example

Write an algorithm to find the largest of 4 numbers (range 0 to 10)

Iterative operations: Example V

Example

Write an algorithm to find the largest of 4 numbers (range 0 to 10)

```
1  max = -1
2  i = 1
3  while (i <= 4):
4     num = eval(input())
5     if (num > max):
6        max = num
7
8     i = i + 1
9
10 print(max)
```

Iterative operations: Example VI

Investment with Compound Interest:

Invest 10000 Euro with 5% interest compounded annually.

Year	Balance
0	10,000.–
1	10,500.–
2	11,025.–
3	11,576.25
4	12,155.06
5	12,762.82

Iterative operations: Example VI

Investment with Compound Interest:

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Year	Balance
0	10,000.–
1	10,500.–
2	11,025.–
3	11,576.25
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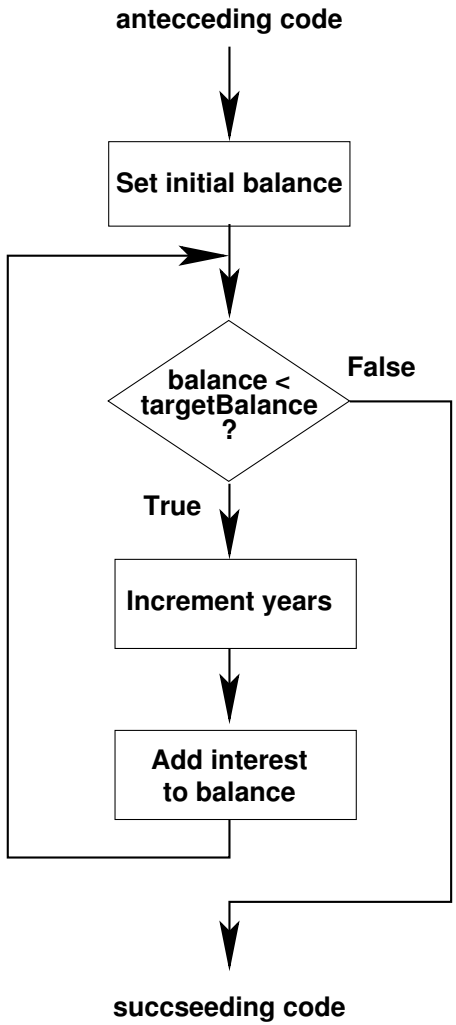
5	12,762.82

Question: When will the balance be at least 20000 Euro?

Iterative operations: Example VI – Flowchart



Iterative operations: Example VI – Python

Compund interest python:

```
1  balance = eval(input())
2  rate = eval(input())
3  targetBalance = 20000
4  year = 0
5  while (balance < targetBalance):
6          year = year + 1
7          interest = balance * rate / 100
8          balance = balance + interest
9  print("The investment doubled after")
10 print(year)
11 print("years")
```

Common errors – infinite loops

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Example 1:

```
while (3 > 2): <operations>
```

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Example 2:

```
while (x <20): y = y + 1
```

Common errors – infinite loops

Infinite loops:

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while (3 > 2): <operations>
```

Example 2:

```
while (x <20): y = y + 1
```

If this loop is entered at all, it will run forever...

Common errors – infinite loops

Why do these two algorithms not terminate?

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Why do these two algorithms not terminate?

```
1  i = 1
2  while i < 10:
3      print(i)
```

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Why do these two algorithms not terminate?

```
1  i = 1
2  while i < 10:
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```

```
1  A = 1
2  while (A % 2 is 1):  # check if A is odd
3      A = A + 2
4      print(A)  # the value of A
```

Common errors – “off by one”

Off-by-one errors

- Occur when loop executes one too many or too few times (often called “± 1-errors”)

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- Example: Add even integers from `2` to `number`, inclusive

```
1  number = eval(input())
2  count = 2
3  result = 0
4  while count < number:
5      result = result + count
6      count = count + 2
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- Produces incorrect result if `number` is assigned an even `number`. Values from `2` to `number - 2` will be added (*i. e.*, `number` is excluded)

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- Produces incorrect result if `number` is assigned an even `number`. Values from `2` to `number - 2` will be added (*i. e.*, `number` is excluded)
- Should be “`while (count <= number)`” in line 4!

Common errors – “missing the target”

Compund interest python:

Find the error in this version!

```
1  balance = eval(input())
2  rate = eval(input())
3  targetBalance = 20000
4  year = 0
5  while not balance == targetBalance:
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Provide for reliable termination of the loop!

Tracing

ALWAYS HAND-SIMULATE first, last and typical case through a loop

- to avoid off-by-one or infinite loop errors and
- to check the correctness of your algorithm.

Sequence, conditional, and iteration in one algorithm

- Remember the Euclidean Algorithm from lecture 1, slide 28 to determine the greatest common divisor (GCD) of two integers.
- Method: To find the GCD of two numbers, repeatedly replace the larger by subtracting the smaller from it until the two numbers are equal.

Sequence, conditional, and iteration in one algorithm

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- Method: To find the GCD of two numbers, repeatedly replace the larger by subtracting the smaller from it until the two numbers are equal.

```
1  A, B = eval(input()), eval(input())
2  while not A == B:
3      if A > B:
4          A = A - B
5      else:
6          B = B - A
7  print("The GCD is ")
8  print(A)
```