CSEN 102– Introduction to Computer Science

Lecture 4:
Algorithmic Problem Solving
Iterative Operations

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Synopsis – conditional operations

- Rationale
  - Determines whether or not a condition is true; and based on whether or not it is true; selects the next step to do
- Notation
  - Use the same primitives as before plus the following:

```
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

Algorithms can be constructed by the following operations:

- Sequential Operation
- Conditional Operation
- Iterative Operation

What is life?

"Life is just one damn thing after another."

—Mark Twain

"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
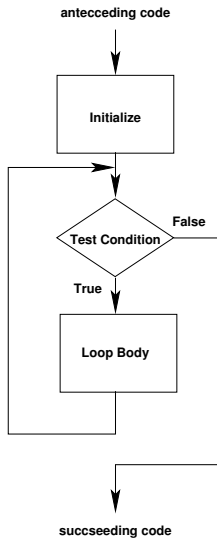
Iterative Operation – syntax

General Format:

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

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

How to write a while-loop?

1. **Formulate the test** which tells you whether the loop needs to be run again

```
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*.

```
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.

```
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

- 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 $n! = n \times (n - 1) \times (n - 2) \times \ldots \times 1$

```
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)

```
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)
```
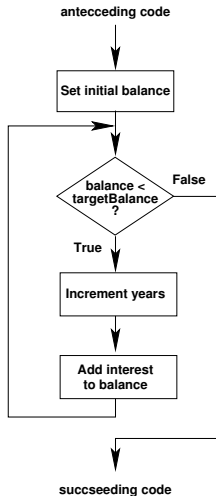
Iterative operations: Example VI

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

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

Iterative operations: Example VI – Flowchart

Iterative operations: Example VI – Python

Compund interest python:

```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")
```

Iteration over Strings: Example VII

Characters in Strings:

Write an algorithm to print the characters in a String one by one

```
1  word = input()
2  n = len(word)      # len() gets the length of the String
3  i = 0              # the first char is at position 0
4  while(i<n):
5    print(word[i])
6    i +=1
```

Iteration over Strings: Example VIII

Reverse a String:

Write an algorithm to reverse a given String

```
1  word = input()
2  n = len(word)    # len() gets the length of the String
3  i = n - 1        # the first char is at position 0
4  result = ""
5  while(i >= 0):
6    result  += word[i]
7    i -=1
8  print(result)
```

Common errors – infinite loops

Infinite loops:

Example 1:
```
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?

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

```
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")
- 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
```

- 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:
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")
```

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 24 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.

```
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)
```