COMP108
Data Structures and Algorithms

Pseudo code (Part I)

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Outline

Describing algorithms using pseudo code

- Algorithm vs Program
- Pseudo code
  - Trace pseudo code
  - Develop simple pseudo code

Learning outcome:

- Able to use pseudo code to describe algorithm

What is an algorithm

- A sequence of precise and concise instructions that guide you (or a computer) to solve a specific problem in a finite amount of time

- Daily life examples: cooking recipe, furniture assembly manual
  - What are input / output in each case?

Algorithm vs Program

An algorithm is a sequence of precise and concise instructions that guide a person/computer to solve a specific problem

Algorithms are free from grammatical rules

- Content is more important than form
- Acceptable as long as it tells people how to perform a task

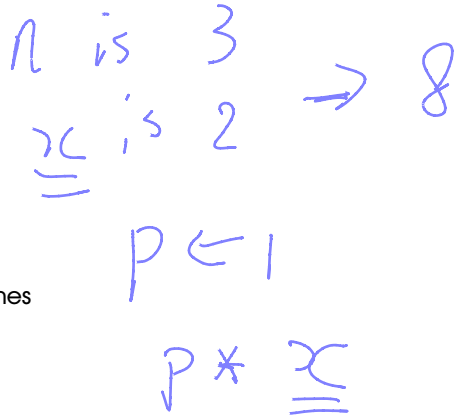
Programs must follow some syntax rules

- Form is important
- Even if the idea is correct, it is still not acceptable if there is syntax error

Compute the n-th power

Input: a number x & a non-negative integer n
Output: the n-th power of x
Algorithm:

1. Set a temporary variable p to 1
2. Repeat the multiplication $p \leftarrow p * x$ for n times
3. Output the result p.



Pseudo code

Pseudo code:

```
p ← 1
for i ← 1 to n
  p ← p * x
output p
```

C:

```
p = 1;
for (i=1; i<=n; i++)
  p = p * x;
printf("%d\n", p);
```

Pascal:

```
p := 1;
for i := 1 to n
  p := p * x;
writeln(p);
```

Python:

```
p = 1
for i in range(n):
  p = p * x
print p
```

C++:

```
p = 1;
for (i=1; i<=n; i++)
  p = p * x;
cout < < p < < endl;
```

Java

```
p = 1;
for (i=1; i<=n; i++)
  p = p * x;
System.out.println(p);
```

Pseudo Code

One way to describe algorithm is by pseudo code

```
p ← 1
for i ← 1 to n
  p ← p * x
output p
```

more like English

similar to programming language

Pseudo code uses combination of both

Control flow

Expectations (refer to COMP101 / COMP122)

- if-then-else

```
if <condition> then
    <statement>
else
    <statement>
```

```
index variable
i
```

- for-loop

```
for <variable> ← <value1> to <value2> do
    <statement>
```

- while-loop

```
while <condition> do
    <statement>
```

Control flow

Expectations (refer to COMP101 / COMP122)

- if-then-else

```
if <condition> then
    <statement>
else
    <statement>
```

- for-loop

```
for <variable> ← <value1> to <value2> do
    <statement>
```

- while-loop

```
while <condition> do
    <statement>
```

- block of statements

```
begin
    <statement1>
    <statement2>
    ⋮
end
```

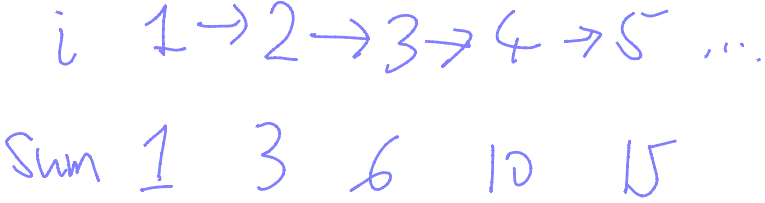
OR

```
{
    <statement1>
    <statement2>
    ⋮
}
```

Loops

- Sum of first n +ve integers

```
sum ← 0
i ← 1
while i ≤ n do
begin
   sum ← sum + i
   i ← i + 1
end
output sum
```



Loops

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Trace table - how variables change

- suppose n = 4

iteration	i before	sum	i after
before loop	1	0	1
1	1	1	2
2	2	3	3
3	3	6	4
4	4	**10**	5

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- suppose n = 6

iteration	i before	sum	i after
before loop	1	0	1
1	1	1	2
2	2	3	3
3	3	6	4
4	4	10	5
5	5	15	6
6	6	**21**	7

Loops

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How to find product?

Trace table - how variables change

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Loops

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i ← 1
while i ≤ n do
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```

How to find product?

(i) 0 change to 1 (ii) + i change to * i

Trace table - how variables change

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Example — What is being computed?

Trace table

Suppose 0 < x < y & both are +ve integers

```
i ← 1
while i ≤ x do
begin
   if x%i == 0 AND y%i ==0 then
      output i
   i ← i + 1
end
```

- Operator % finds remainder:
  a%b gives remainder of a divided by b

mod

6 % 4 = 2

6 % 3 = 0

Example — What is being computed?

Suppose 0 < x < y & both are +ve integers

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i ← 1
while i ≤ x do
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   if x%i == 0 AND y%i ==0 then
      output i
   i ← i + 1
end
```

Trace table

- suppose x = 4, y = 12

iteration	i before	output	i after
	1	-	1
1	1	**1**	2
2	2	**2**	3
3	3	-	4
4	4	**4**	5

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- suppose x = 6, y = 15

iteration	i before	output	i after
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1	1	**1**	2
2	2	-	3
3	3	**3**	4
4	4	-	5
5	5	-	6
6	6	-	7

Example — What is being computed? common factors

Suppose 0 < x < y & both are +ve integers

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   if x%i == 0 AND y%i ==0 then
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4	4	-	5
5	5	-	6
6	6	-	7

What happen if we change to ``else i ← i+1''?

Example 2 — What is being computed?

HCF
GCD

highest common factors
greatest common divisors

Suppose 0 < x < y & both are +ve integers

```
i ← x
found ← false
while i ≥ 1 AND found ≠ true do
begin
   if x%i == 0 AND y%i == 0 then
      found ← true
   else
      i ← i - 1
end
output i
```

- `found` is a flag variable
- What value is output?
- Questions:
  - What value of found makes the loop stop?
  - When does found change to such value?

Example 2 — What is being computed? HCF/GCD

Suppose 0 < x < y & both are +ve integers

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      found ← true
   else
      i ← i - 1
end
output i
```

- `found` is a flag variable
- What value is output?
- Questions:
  - What value of found makes the loop stop?
  - When does found change to such value?
  - What happens if we change the relational operator of the if-then-else from AND to OR? only x will be output

removing else => HCF-1 will be ouput

Example 3

Consider the following algorithm.

```
// Assume x < y are two integers
r ← y
q ← 0
while r ≥ x do
begin
    r ← r - x
    q ← q + 1
end
output r and q
```

What is computed?

Trace table

Example 3

Consider the following algorithm.

```
// Assume x < y are two integers
r ← y
q ← 0
while r ≥ x do
begin
    r ← r - x
    q ← q + 1
end
output r and q
```

What is computed?

Trace table

- Suppose x=4, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	10	1
2	6	2
3	2	3

Example 3

Consider the following algorithm.

```
// Assume x < y are two integers
r ← y
q ← 0
while r ≥ x do
begin
    r ← r - x
    q ← q + 1
end
output r and q
```

What is computed?

Trace table

- Suppose x=4, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	10	1
2	6	2
3	2	3

- Suppose x=5, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	9	1
2	4	2

Example 3

Consider the following algorithm.

```
// Assume x < y are two integers
r ← y
q ← 0
while r ≥ x do
begin
    r ← r - x
    q ← q + 1
end
output r and q
```

What is computed?

Trace table

- Suppose x=4, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	10	1
2	6	2
3	2	3

- Suppose x=5, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	9	1
2	4	2

- Suppose x=7, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	7	1
2	0	2

Example 3

Consider the following algorithm.

```
// Assume x < y are two integers
r ← y
q ← 0
while r ≥ x do
begin
    r ← r - x
    q ← q + 1
end
output r and q
```

What is computed?

remainder & quotient

Trace table

- Suppose x=4, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	10	1
2	6	2
3	2	3

- Suppose x=5, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	9	1
2	4	2

- Suppose x=7, y=14

(@ end of) **iteration**	**r**	**q**
	14	0
1	7	1
2	0	2

Summary

Summary: Understanding and tracing pseudo code

Next: Developing pseudo code

For note taking