Fundamentals of Computer and Programming

Lecture 2

Structured Programming and Algorithm Design

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What We Will Learn

- Algorithms
- Structured program development
- Pseudo-code and Flowcharts
- Sample algorithms to practice problem-solving steps
- **Input** and **Output** analysis

Recap: Algorithms

- An algorithm is a procedure for solving a problem in terms of
  - the **actions** to execute, and
  - the **order** in which these actions should be executed.
- Specifying the order in which statements should execute in a computer program is called **program control**.

Structured Programming

- All programs could be written in terms of **three control structures:**
  - The **sequence** structure,
  - The **selection** structure, and
  - The **iteration** structure.
- The notion of **structured programming became** almost synonymous with "*goto* elimination."

Recap: Pseudocode

- **Pseudocode** is an informal artificial language similar to everyday English
- **Pseudocode** helps you develop algorithms before converting them to **structured C programs**.
- **Pseudocode** is convenient and user-friendly.
- **Pseudocode** is language-independent.
- Computers **do not execute** pseudocodes.

Recap: Flowcharts

- A **flowchart** is a **graphical representation** of an algorithm or a **portion of** an algorithm.
- You draw flowcharts using certain special-purpose symbols such as *rectangles*, *diamonds*, *rounded rectangles*, and *small circles*, connected by arrows called ***flowlines***.
- Flowcharts clearly show how control structures operate.
  - Pseudocode **is preferred** by most programmers.

Computing the average of three numbers

Algorithm: Average

1. print “Please enter three integers”
2. read x1, x2, x3
3. sum ← x1 + x2 + x3
4. average ← sum / 3
5. print “Average = ” average

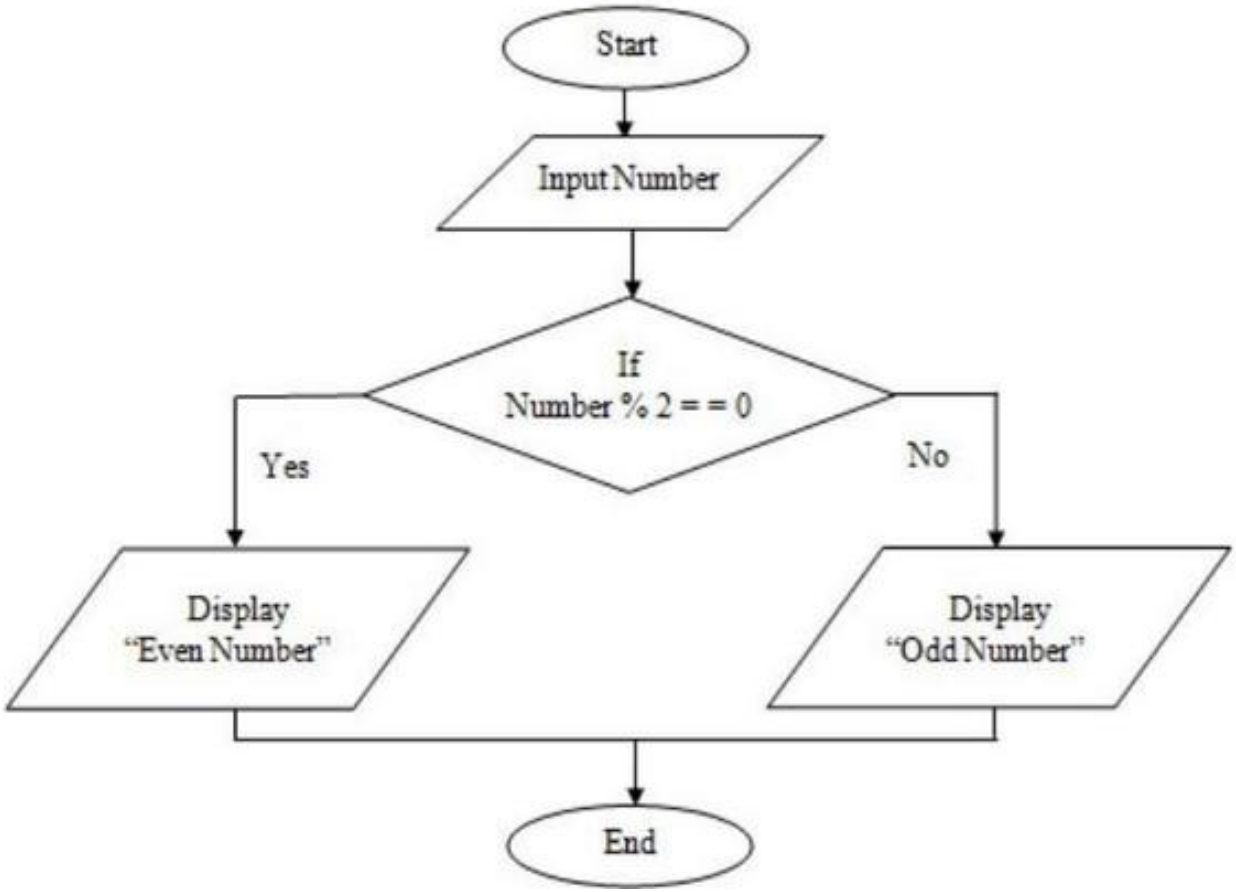
الگوریتم تشخیص زوج یا فرد بودن عدد (شبه کد)

Algorithm: Odd-Even-1

```
1. print "Please enter an integer"
2. read n
3. y ← n mod 2
4. if (y == 0)
        print "Number is even"
   else
        print "Number is odd"
```

الگوریتم تشخیص زوج یا فرد بودن عدد (روندنما)

- Flowchart



الگوریتم تشخیص زوج یا فرد بودن عدد

Algorithm: Odd-Even-2

1. print “Please enter an integer”
2. read n
3. if(n < 0)
   n ← -1 * n
4. while(n >= 2)
   n ← n – 2
5. if(n == 0)
   print “even”
   else
   print “odd”

Verify the Algorithm

الگوریتم تشخیص زوج یا فرد بودن عدد

Algorithm: *Odd-Even-3*

1. print “Please enter an integer”
2. read n
3. while (n >= 2) or (n <= -1)
   n ← n - sign(n) * 2
4. if (n == 1)
   print “odd”
   else
   print “even”

الگوریتمی که یک رشته عدد را که با ۰ تمام می‌شود را می‌گیرد و تعداد اعداد زوج و فرد را چاپ می‌کند

Algorithm: Count Odd-Even

```
odd_cnt ← 0
even_cnt ← 0
print "Please enter an integer"
read n
while (n != 0)
        y ← n mod 2
        if (y == 0)
                even_cnt ← even_cnt + 1
        else
                odd_cnt ← odd_cnt + 1
        print "Please enter an integer"
        read n

print "Odd = " odd_cnt "Even = " even_cnt
```

الگوریتمی که یک عدد صحیح مثبت را بگیرد و مجموع ارقام آن را چاپ کند

Algorithm: Digit-Sum

```
print "Please enter a positive integer"
read n
sum ← 0
m ← n
while (n != 0)
        y ← n mod 10
        sum ← sum + y
        n ← n - y
        n ← n / 10
print "sum of digits of" m " = " sum
```

Verify the Algorithm

الگوریتمی که یک عدد صحیح مثبت را بگیرد و آنرا در مبنای ۸ چاپ کند

Algorithm: Base-8

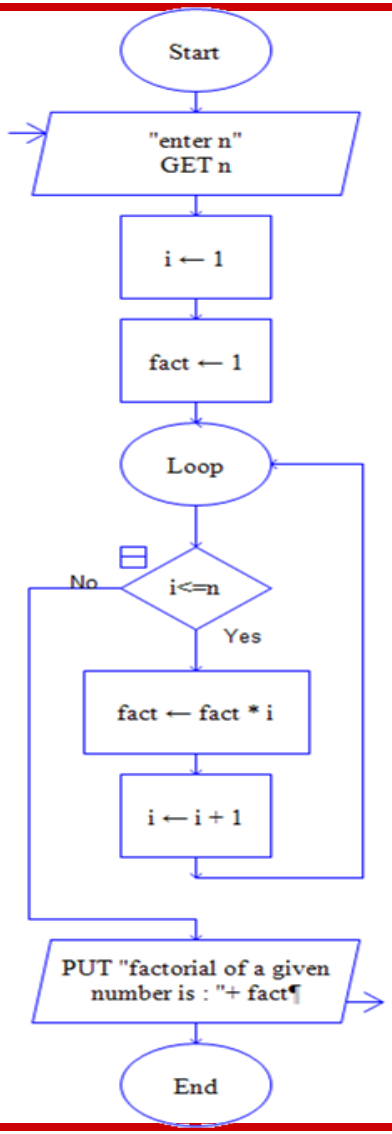
```
print "Please enter a positive integer"
read n
i ← 0
while (n != 0)
        x[i] ← n mod 8
        n ← floor (n / 8)
        i ← i + 1
i ← i - 1
while (i >= 0)
        print x[i]
        i ← i - 1
```

الگوریتمی که یک عدد صحیح مثبت را بگیرد و فاکتوریل آن را تولید کند

Algorithm: Factorial-1

```
print "Please enter a positive integer"
read n
i ← 1
result ← 1
while (i <= n)
        result ← i * result
        i ← i + 1

return  result
```



الگوریتمی که یک عدد صحیح مثبت را بگیرد و فاکتوریل آن را تولید کند

Algorithm: Factorial-2

```
print "Please enter a positive integer"
read n
result ← 1
while (n > 0)
        result ← result * n
        n ← n - 1

return  result
```

الگوریتمی که یک عدد صحیح مثبت را بگیرد و فاکتوریل آنرا تولید کند.

Algorithm: Factorial-Recursive (**n**)

```
if (n <= 1)
    return 1
else
    return n * Factorial-Recursive (n - 1)
```

الگوریتمی که یک رشته عدد را که محل عضو اول آن با **start** و محل عضو آخر آن با **end** مشخص شده است را به صورت صعودی مرتب کند.

Algorithm: sort (**x, start, end**)

```
while (start != end)
        j ← find index of minimum element from start to end
        swap x[j] and x[start]
        start ← start + 1
```

==========

Algorithm find_min(**x, start, end**)

```
y ← start
i ← start + 1
while (i <= end)
        if(x[i] < x[y])
                y ← i
        i ← i + 1
return y
```

	8
	5
	2
	6
	9
	3
	1
	4
	0
	7

Verify the Algorithm

الگوریتمی که یک رشته عدد را که محل عضو اول آن با **start** و محل عضو آخر آن با **end** مشخص شده است را به صورت صعودی مرتب کند.

Algorithm swap(**x, j, i**)

temp ← x[j]
x[j] ← x[i]
x[i] ← temp

Algorithm swap2(**x, j, i**)

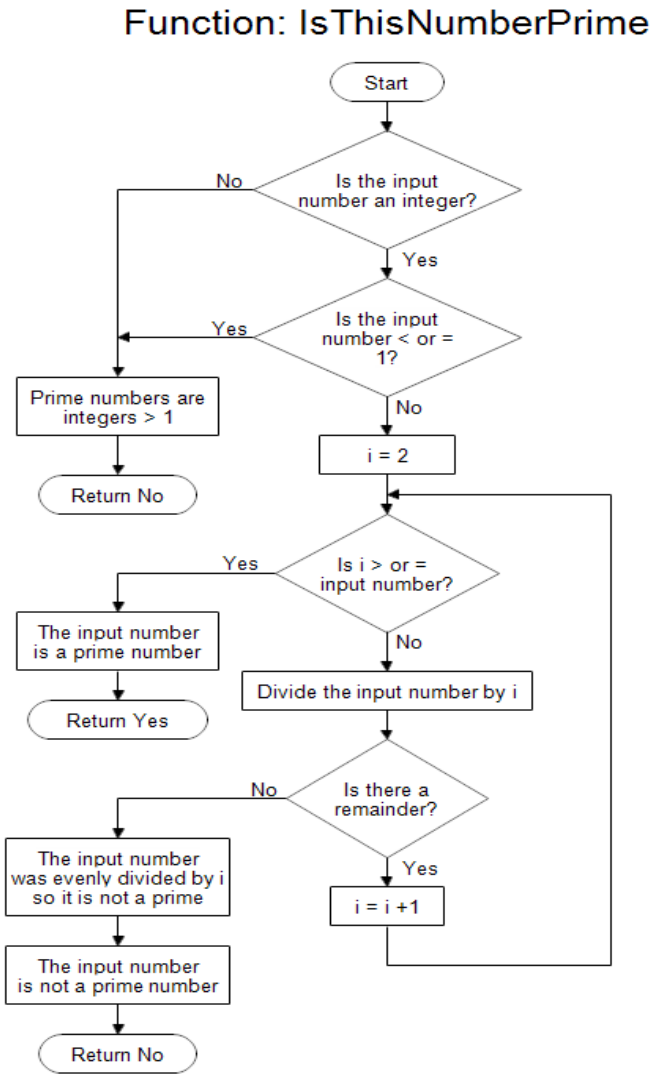
x[j] ← x[j] + x[i]
x[i] ← x[j] – x[i]
x[j] ← x[j] – x[i]

الگوریتمی که آرایه صعودی از اعداد صحیح را بگیرد و آن را به‌صورت درجا (بدون استفاده از آرایه دیگر) تبدیل به آرایه نزولی کند.

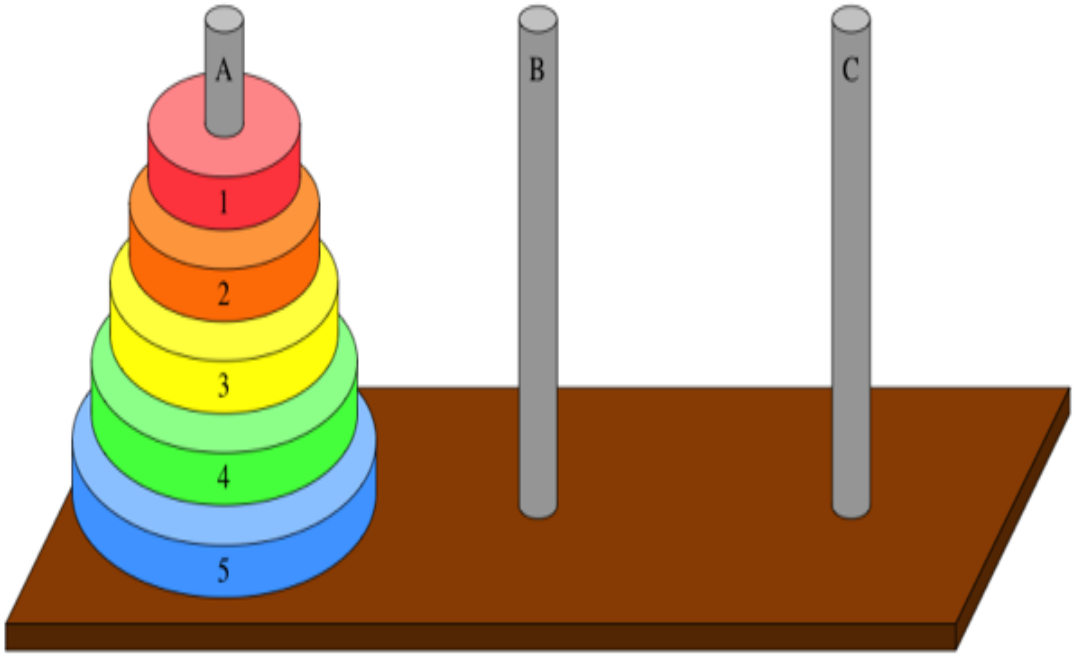
Algorithm reverse(**A, start, end**)

```
if (start >= end)
    return
else
    swap(A, start, end)
    reverse(A, start + 1, end - 1)
```

Flowchart to check whether a number is prime or not

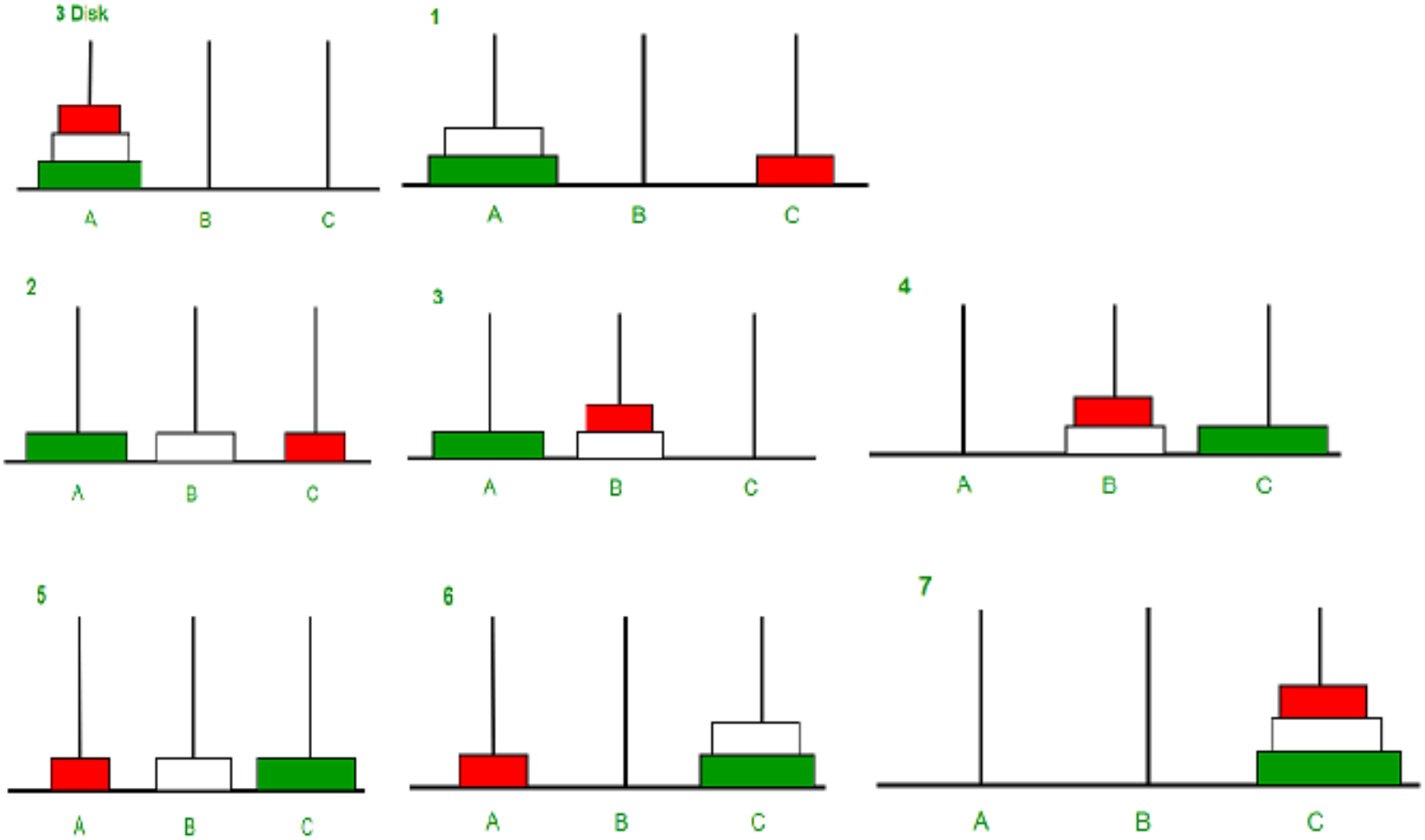


Tower of Hanoi



Tower of Hanoi

- Solution trace for n=3 disks:



Tower of Hanoi

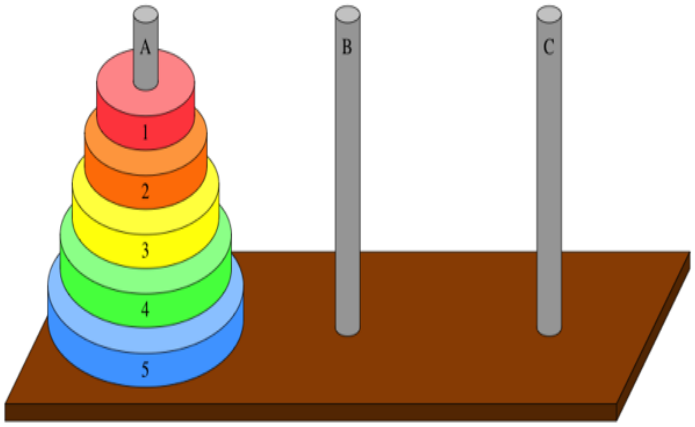
Algorithm Hanoi(n, source, target, auxiliary):

```
if (n <= 0)
    return

# Move n - 1 disks from source to auxiliary
Hanoi(n - 1, source, auxiliary, target)

# Move the nth disk from the source to the target
append the source last disk to the target

# Move the n - 1 disks that we left on the auxiliary onto the target
Hanoi(n - 1, auxiliary, target, source)
```



Tower of Hanoi

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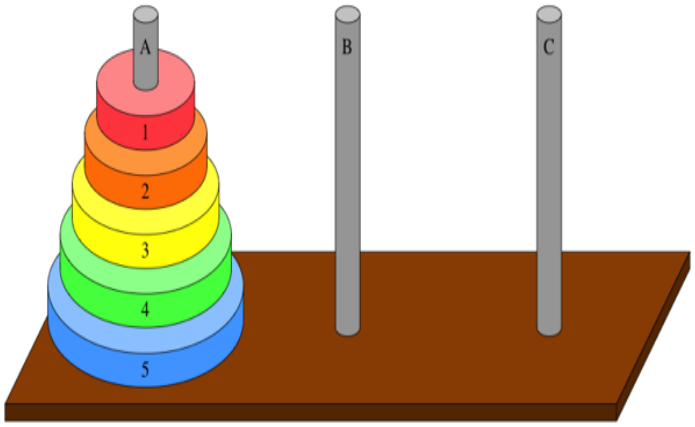

Example run:

A = [3, 2, 1]
B = []
C = []
Hanoi(3, A, C, B)

Tower of Hanoi

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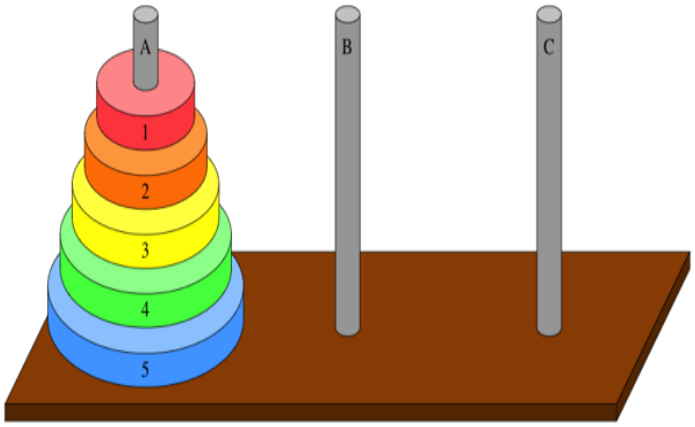
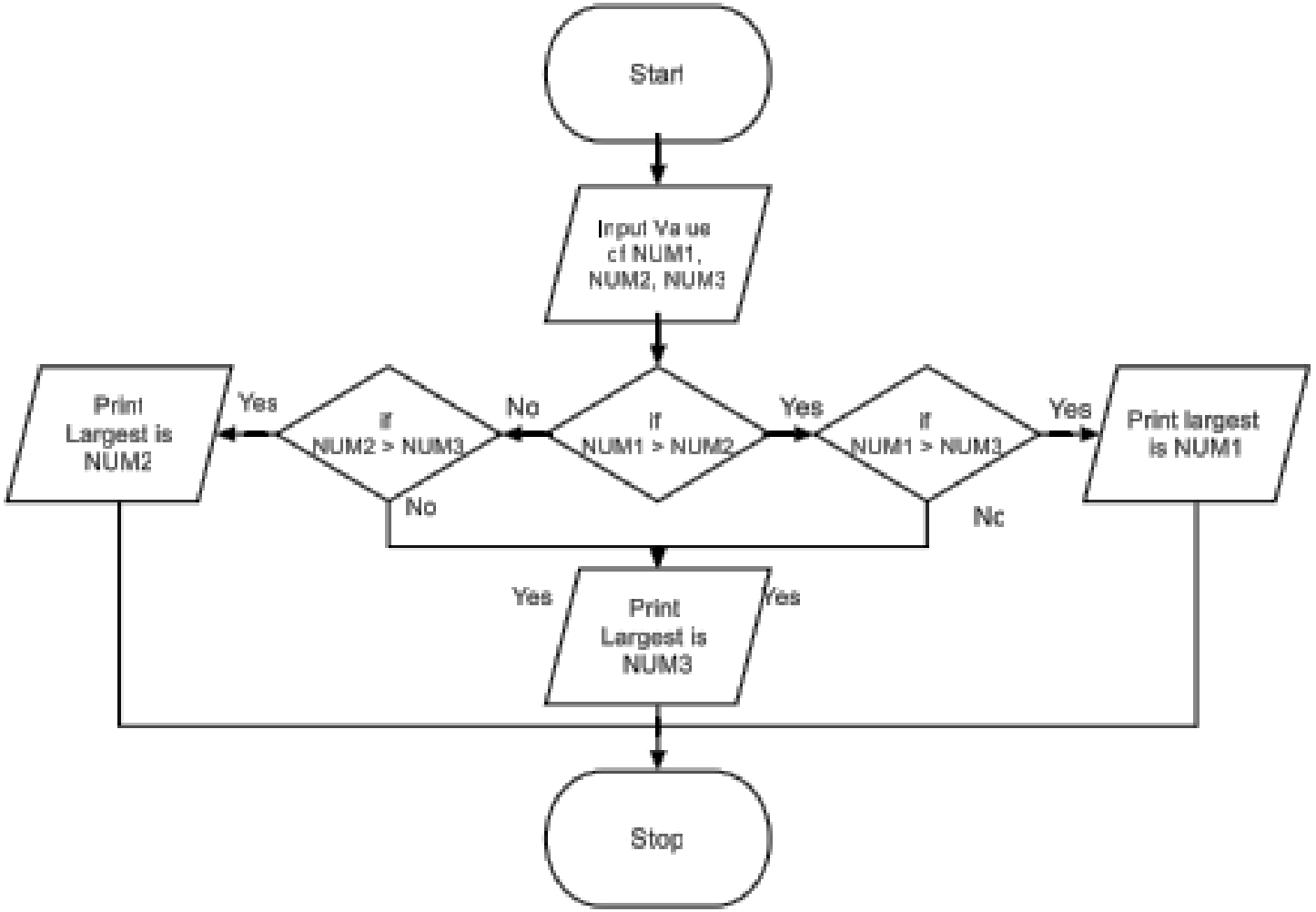


Example run:

A = [3, 2, 1]
B = []
C = []
Hanoi(3, A, C, B)

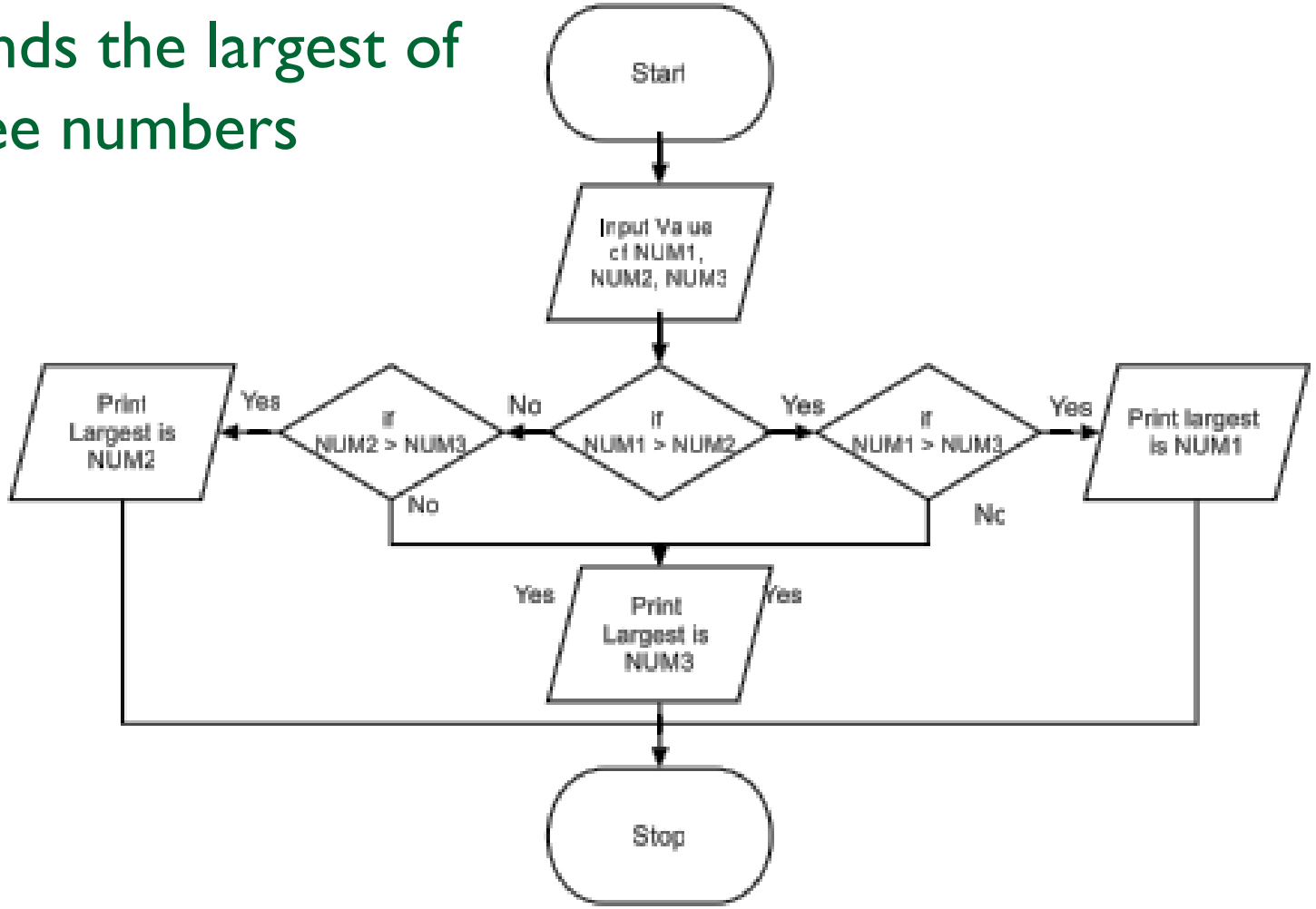
```
Move disk 1 from rod A to rod C
Move disk 2 from rod A to rod B
Move disk 1 from rod C to rod B
Move disk 3 from rod A to rod C
Move disk 1 from rod B to rod A
Move disk 2 from rod B to rod C
Move disk 1 from rod A to rod C
```

What does the following flowchart compute?



What does the following flowchart compute?

It finds the largest of three numbers



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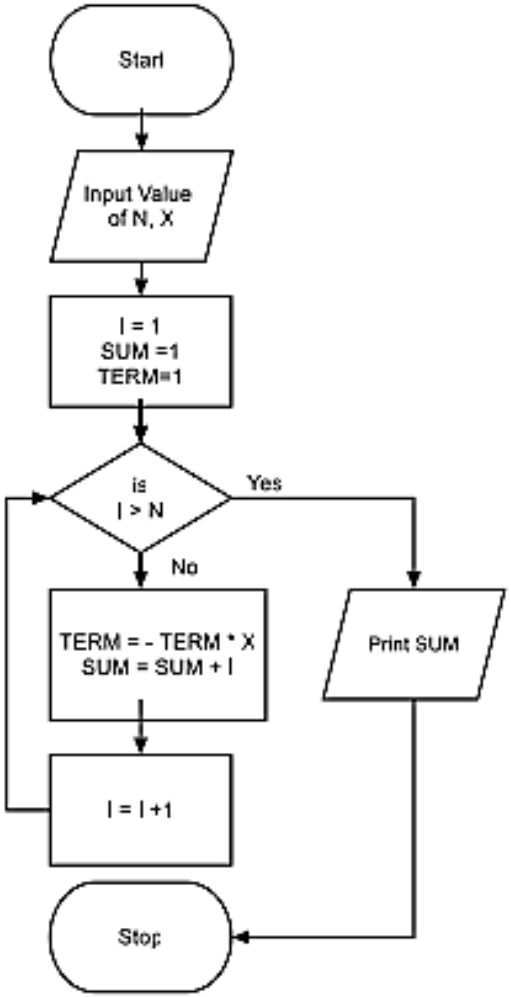
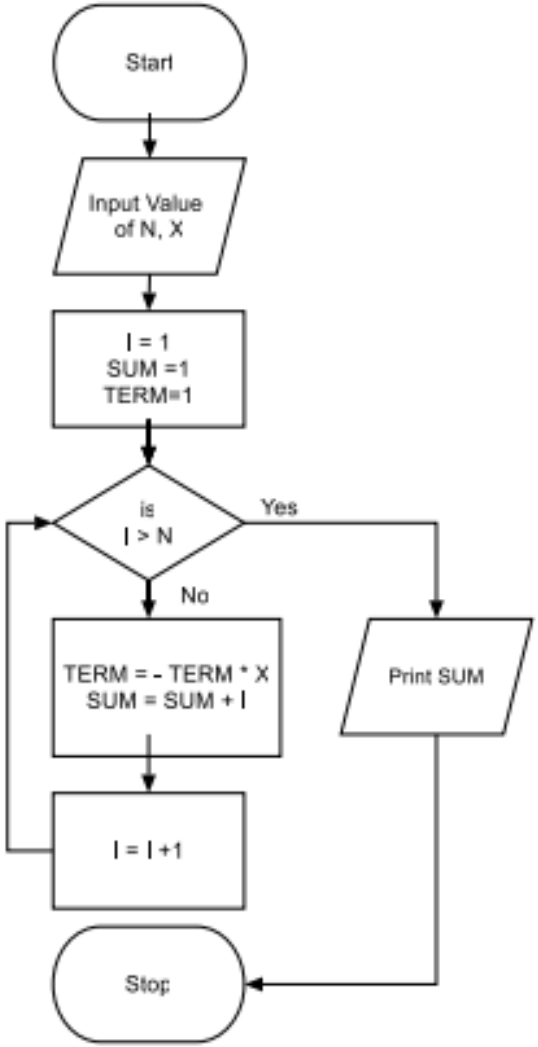


What does the following flowchart compute?

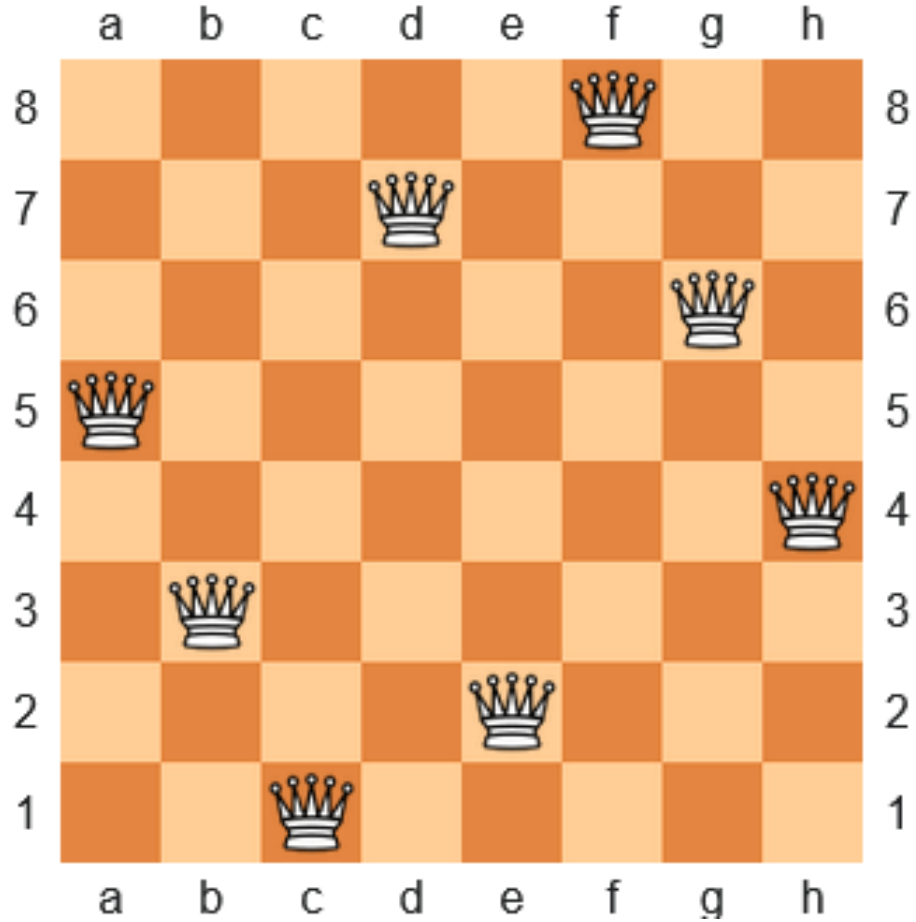
To find sum of the series

$1 - X + X^2 - X^3 \ldots X^N$



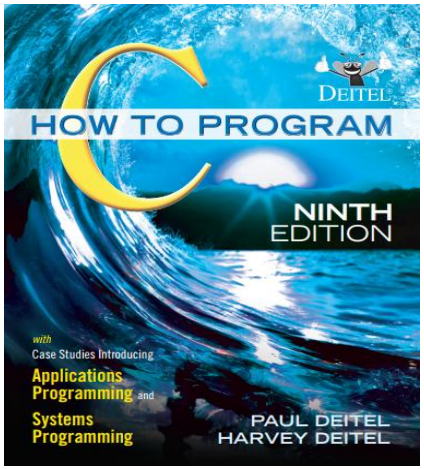
Advanced algorithms: Eight Queens Puzzle

- One possible solution



Summary

- There are **more than one algorithm** for a problem
  - Efficiency, Complexity, Clarity, …
- Algorithm (Programming Language) building blocks
  - Calculations (Lecture 4)
  - Input / Output (Lecture 5)
  - Decision Making (Lecture 6)
  - Repeating (Lecture 7)
  - Modular Programming (Lecture 8)
  - Arrays + Memory Management (Lectures 9 and 10)
  - Others (Complex data types and Files) (Lectures 11 and 12)



Reading Assignment

- Reading Assignment: Sections **3.1** to **3.4** of **Chapter 3** of "C How to Program"
- Read and practice the problems discussed: *https://www.programming9.com/raptor-flowcharts*