Apply algorithm design and analysis methods

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Contents of the presentation

01

Review

02

Computional Thinking

03

Experiments

01

Review

Review

Quiz

- Everyone will answer 10 questions. Your group's score will be the total score of the two of you

Active

- Every time our group asks a question, after thinking and discussing it.
  Top 3 will get 5, 4, 3 points respectively. The remaining groups get 1 point.

Prize Pool

Plus 5 points

Plus 4 points

Plus 3 points

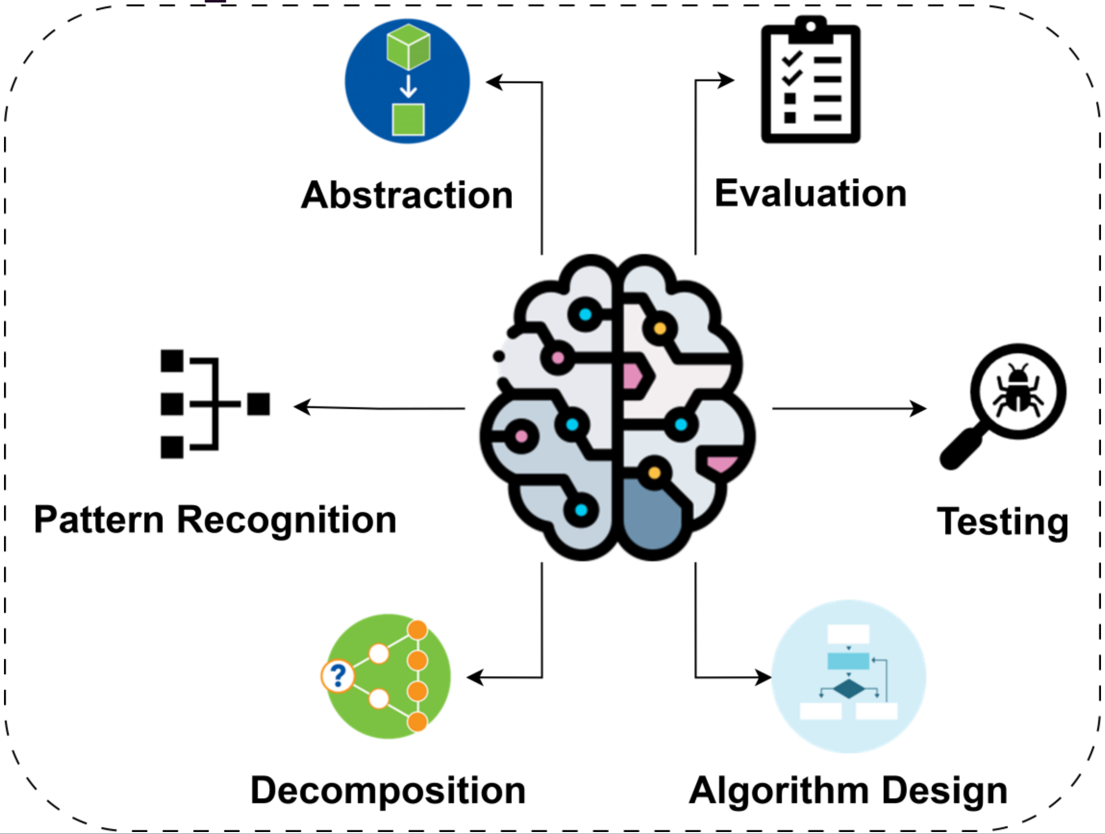
Code: 350 752

Nickname: ***Gx_YourName***

02

Computional Thinking

Computational Thinking



Abstraction thingking

Abstraction is "identifying and extracting relevant information to define main idea(s)".

The key to abstraction is to be able to identify and filter out or ignore the details not necessary to solve the problem

____?____ + ____?____ = ____?____

Abstraction thingking

She eat Pie

Subject (person or thing)	+	Action/ Occurence/ State of Being	+	Object (person or thing)
Noun	+	Verb	+	Noun

Abstraction thingking

Listening English test

First you take your ___icicle___ then add a layer of ___dinosaur___ before you pour on a hearty dose of ___maple syrup___.

Next, press some ___tulips___ down into the ___noun___ before covering with a sprinkle of ___noun___ .

That's how we make a ___noun___ !

Decompositional thinking

"If you can't solve a problem, then there is an easier problem you can solve: find it."

George Pólya

Smaller subproblem + Smaller subproblem + Smaller subproblem = **Big Complex Problem**

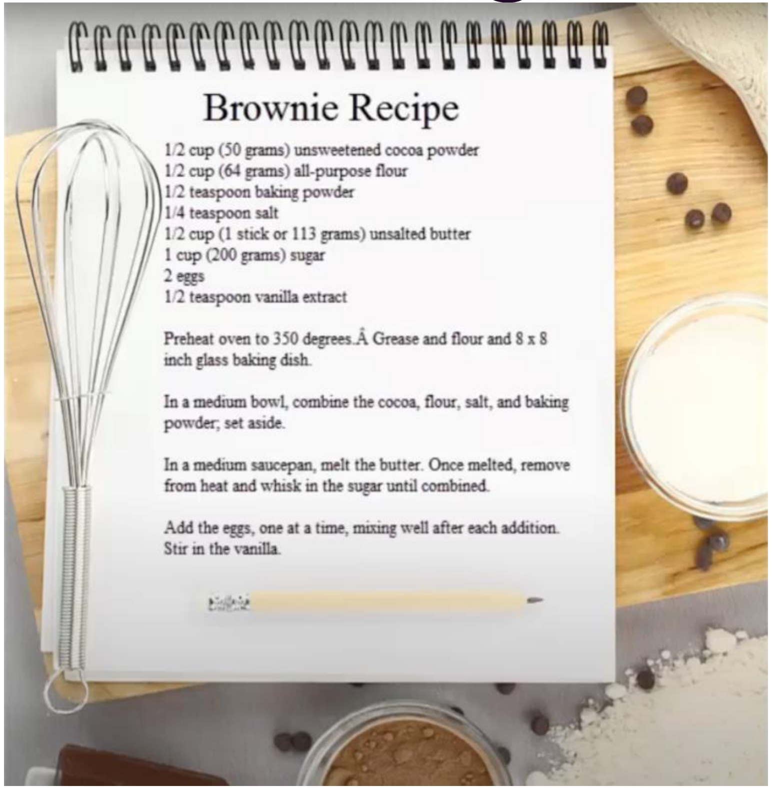
Example

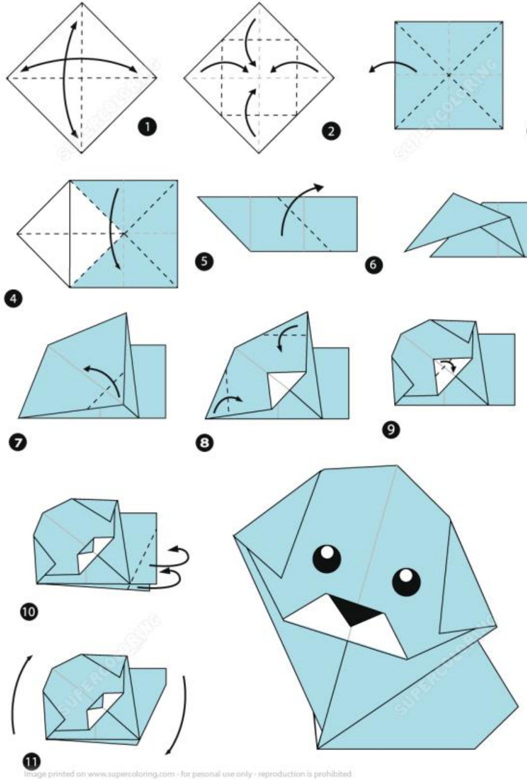
- Take the example of criminal investigation by the police, how can the police apprehend criminals?.

Smaller subproblem + Smaller subproblem + Smaller subproblem = Big Complex Problem

Decomposition

Algorithm Design

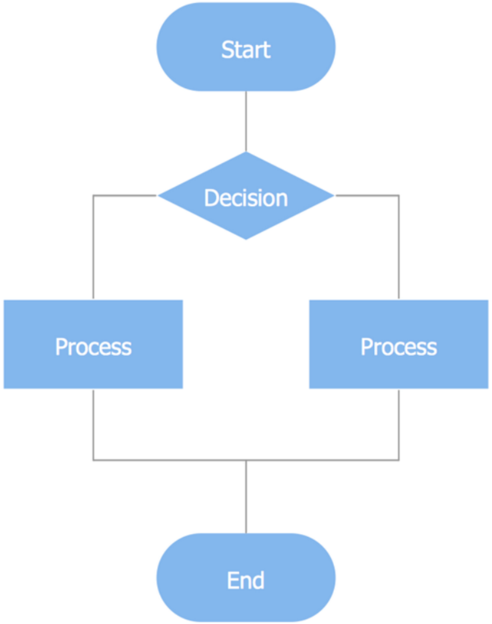




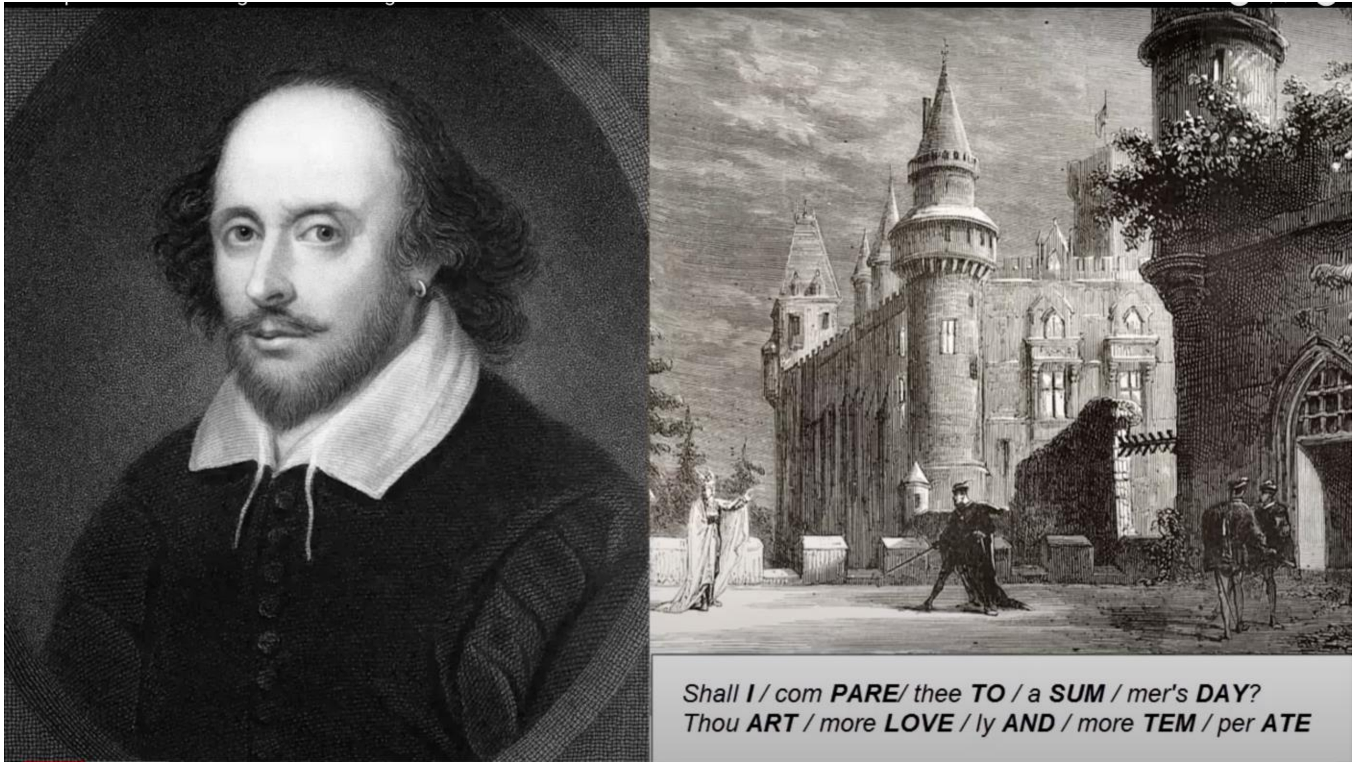
Algorithmic Thinking

Algorithmic thinking is about

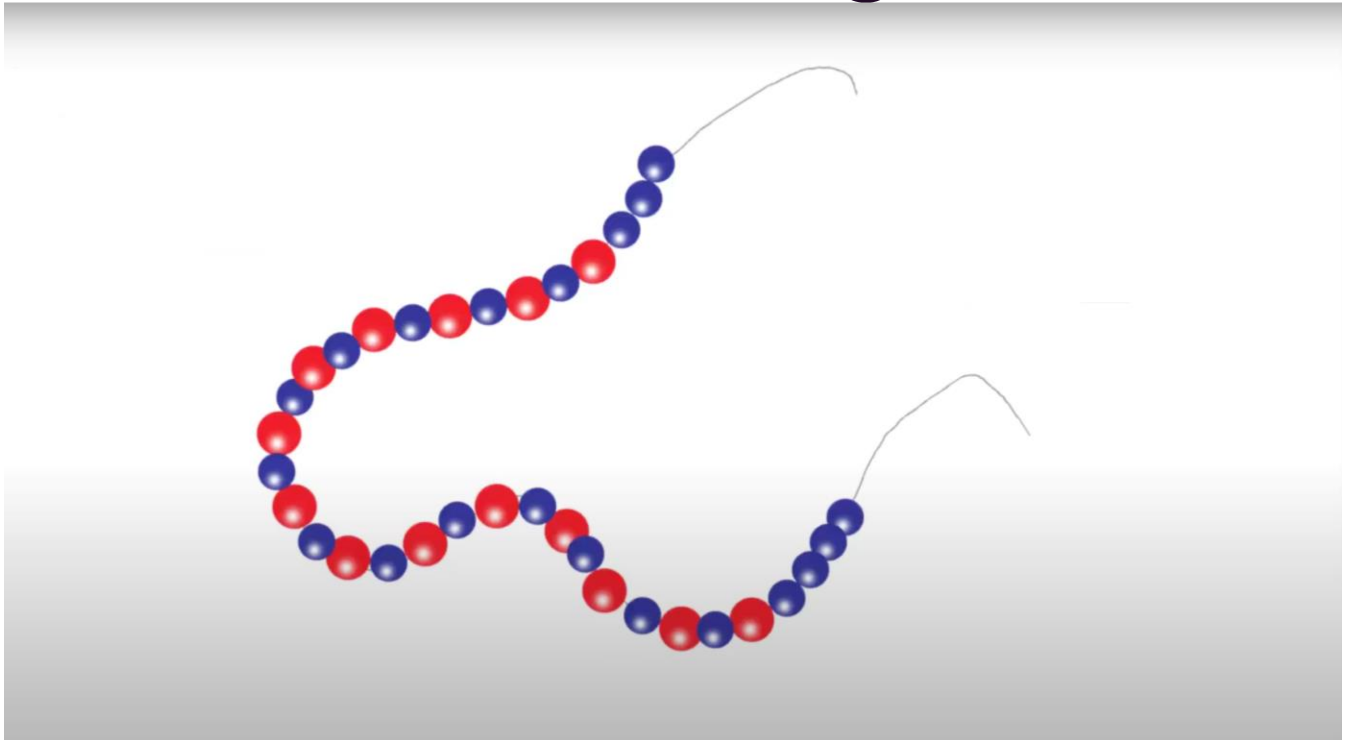
- Planning,
- Detailing each step
- Creating a process
- Creating a flowchart,...



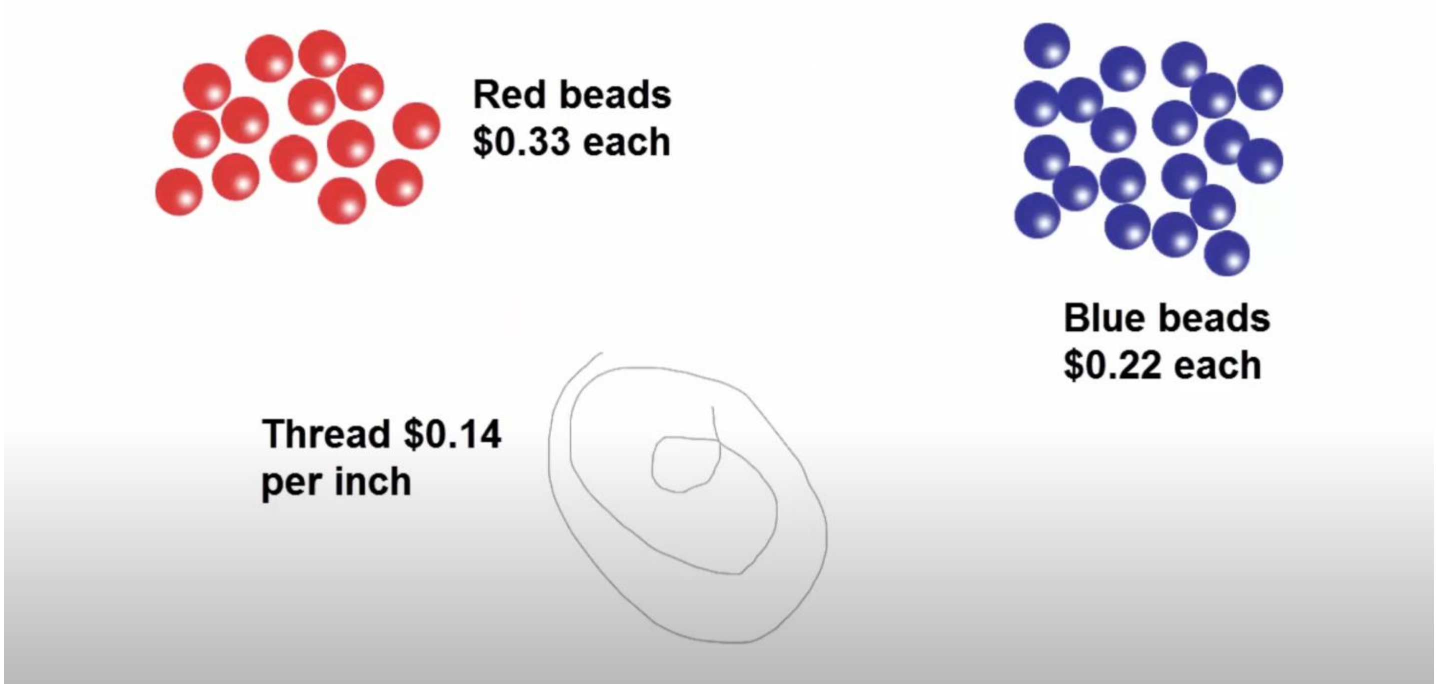
Pattern Recognition



Pattern Recognition



Pattern Recognition

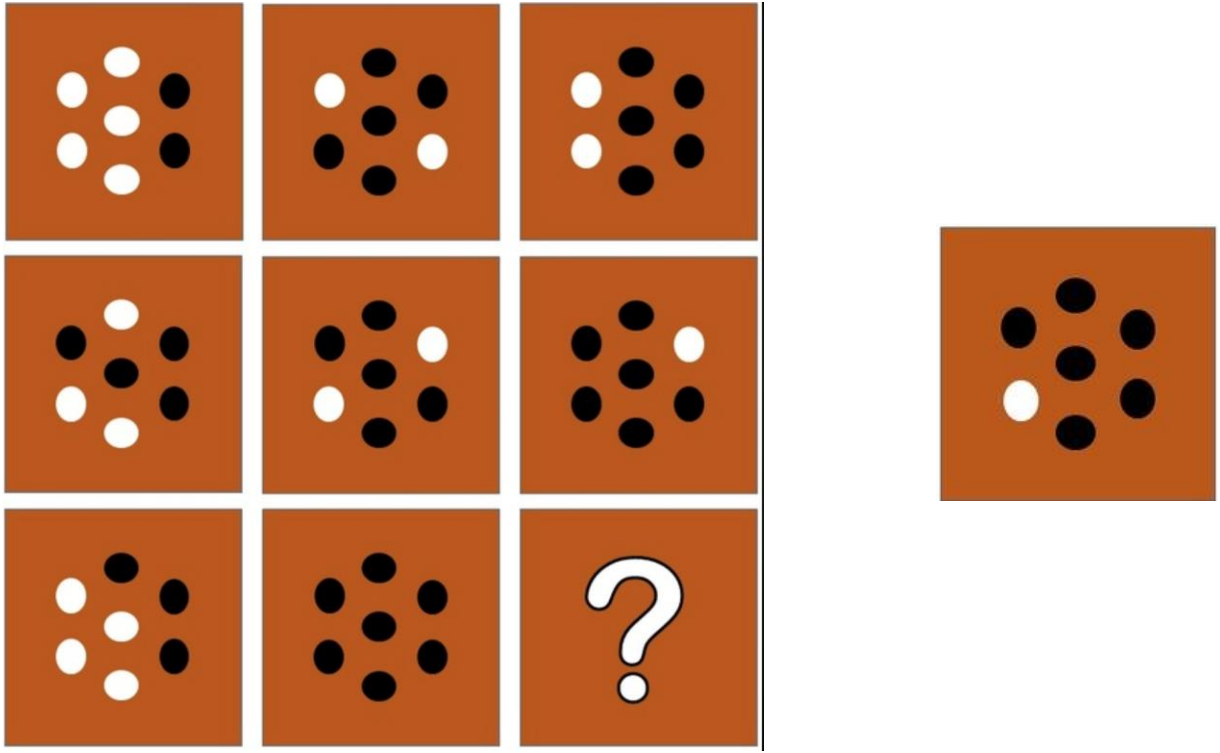


Pattern Recognition

a	. —	k	— . —	u	. . —
b	— . . .	l	. — . .	v	. . . —
c	— . — .	m	— —	w	. — —
d	— . .	n	— .	x	— . . —
e	.	o	— — —	y	— . — —
f	. . — .	p	. — — .	z	— — . .
g	— — .	q	— — . —	ch	— — — —
h	. . . .	r	. — .	â æ	. — . —
i	. .	s	. . .	ö œ	— — — .
j	. — — —	t	—	ü	. . — —

1	. — — — —	6	— . . . .
2	. . — — —	7	— — . . .
3	. . . — —	8	— — — . .
4	. . . . —	9	— — — — .
5	. . . . .	10	— — — — —

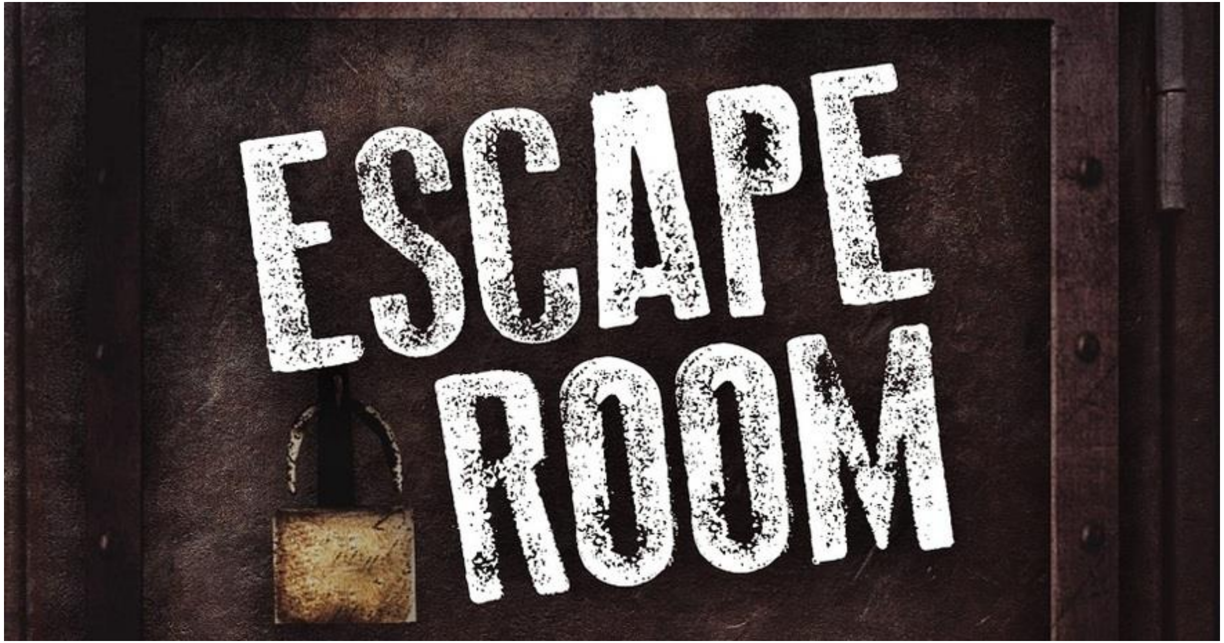
Pattern Recognition



03

Experiments

Problem 1



Problem 1

In an escape puzzle game, you are trapped in a locked room with a keyhole. Inside the room, there is only a table, a piece of paper, a pen, and sequences of numbers and characters written all over the room. On the wall, you discover an important clue for your escape:

3
6 3 1 2 5
The password is 4

To escape, you need to write the password on the piece of paper. As a super sharp detective, you immediately recognize the pattern of the characters. The first line contains only one number, N, and the second line contains 2N - 1 positive integers. The password is the smallest number that, when added to the sequence, allows for at least one way to pair the numbers so that the sum of each pair is equal.

Problem 1

In the given example, there exists [6, 3, 1, 2, 5]. You can separate it into [6, 1], [5, 2], [3, x]. You need to fill in the number 4 so that 6+1=5+2=3+4. If you cannot find such a number, write -1 on the piece of paper, and you will be set free.

Input format:
1 <= K <= 70.
1 <= N <= 3*10^5.
1 <= Ai <= 10^9 (Ai is any number).

Solution

- ## Abstraction

To find the smallest number 'a' ($a >= 1$) to add to an array of size 2N-1 such that the sum of the array (S/2N) is a positive integer

- ## Decomposition & Pattern Recognition

We divide it into three cases: adding at the beginning of the array, in the middle of the array, and at the end of the array.
S1 = a[0] + a[n-2] if inserted at the beginning of the array,
S2 = a[0] + a[n-1] if inserted in the middle of the array,
S3 = a[1] + a[n-1] if inserted at the end of the array.

Solution

- **Algorithm Design**

Sort the array
Sort the cases Si (S1, S2, S3) in ascending order
Perform the loop
Taking (Si - the corresponding array element) = Result.

- **Evaluation**

To sort the array with a time complexity of O(n log n) and perform the O(n) loop, resulting in a total time complexity of O(n log n)

Problem 2 – Cashier Problem

Problem 1: Coin Problems: Minimum.
Given a set of coin values coins {c1,c2,...,ck} and a target sum of money m, what's the minimum number of coins that form the sum m?

Constraints :

1<=k<=10

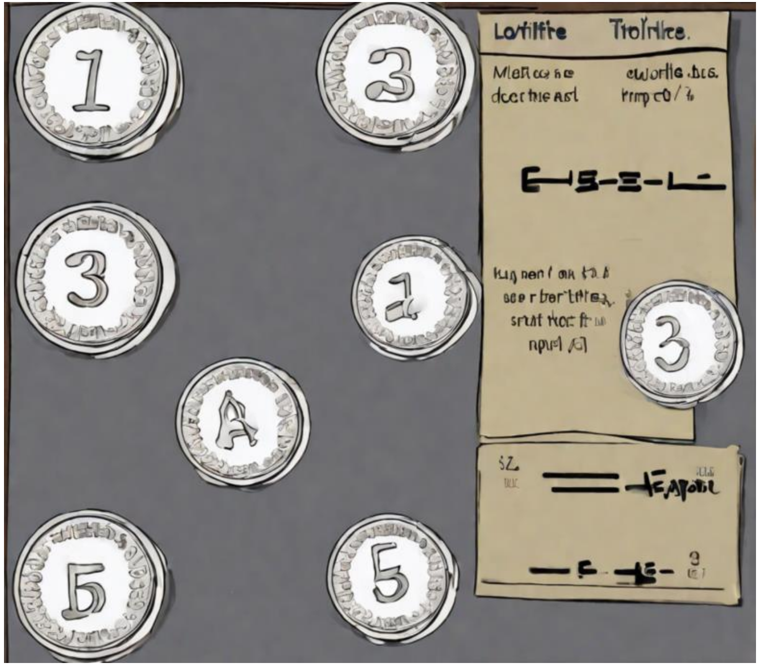
1<=m<=10^5

1<=ci<=500

Example:

Coins={200,100,50,20,10,5,2,1}

Target: 734



Problem 2

- Greedy Solution: 3{200} + 1{100} +1{20} + 1{10} + 2{2}. Sum=8 .

- Recursion Solution:

We will try calling minimum_coins(coins, m) as the function that returns the desired result.
minimum_coins(coins, 0) = 0 is the base case.
minimum_coins(coins, m) = ? is the problem that needs to be solved.

Recursion Solution

We will solve the subproblem

Coins = {1, 4, 5} and target = 13.

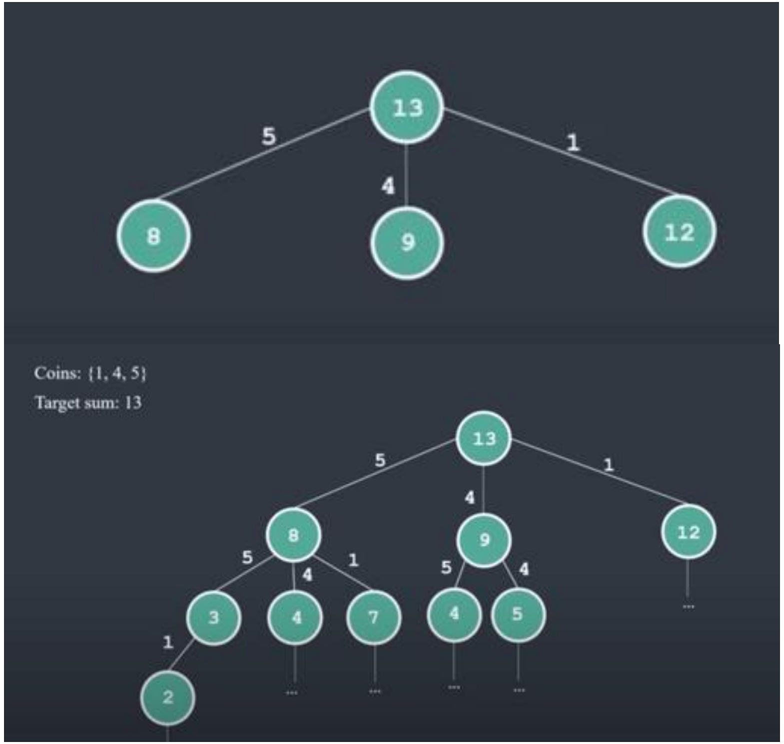
First, let's consider the brute force approach:
With the brute force approach, we can choose any coin.
If we choose 5, we will need to solve the subproblem with

Coins = {1, 4, 5} and target = 8.

If we choose 4, we will need to solve the subproblem with

Coins = {1, 4, 5} and target = 9.

If we choose 1, we will need to solve the same problem with target = 12.



Solution

1. Abstraction

Minimum_coins(coins,m) = ?

2. Decomposition

Minimum_coins(coins,0) = 0

Minimum_coins(coins,x) = ? (0<=x<=m)

3. Pattern Regconition

Recursion solution

Solution

4. Algorithm Design

```
def min_ignore_none(a, b):
    if a is None:
        return b
    if b is None:
        return a
    return min(a, b)

def minimum_coins(m, coins):
    if m == 0:
        answer = 0
    else:
        answer = None
        for coin in coins:
            subproblem = m - coin
            if subproblem < 0:
                # Skip solutions where we try to reach [m]
                # from a negative subproblem.
                continue
            answer = min_ignore_none(
                answer,
                minimum_coins(subproblem, coins) + 1)
    return answer
```

```
print(minimum_coins(13, [1, 4, 5]))
Output: 3
```

Solution

5. Evalution : O(k^m)

```
print(minimum_coins(150, [1, 4, 5]))
Output: 30
```

6. Update ?

```
memo = {}

def minimum_coins(m, coins):
    if m in memo:
        return memo[m]

    if m == 0:
        answer = 0
    else:
        answer = None
        for coin in coins:
            subproblem = m - coin
            if subproblem < 0:
                # Skip solutions where we try to reach [m]
                # from a negative subproblem.
                continue
            answer = min_ignore_none(
                answer,
                minimum_coins(subproblem, coins) + 1)
    memo[m] = answer
    return answer
```

```
print(minimum_coins(13, [1, 4, 5]))
Output: 3

print(minimum_coins(150, [1, 4, 5]))
Output: 30
```

ReSolution

1. Abstraction

Minimum_coins(coins,m) = ?

2. Decomposition

Minimum_coins(coins,0) = 0

Minimum_coins(coins,x) = ?
(0<=x<=m)

3. Pattern Regconition

Dynamic Programing

ReSolution

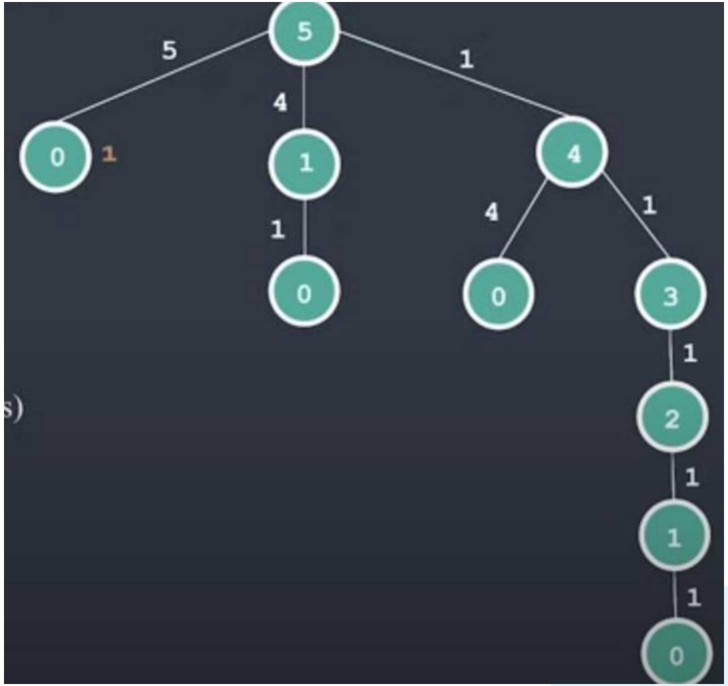
4. Algorithms Design

```
def minimum_coins(m, coins):
    memo = {}

    memo[0] = 0
    for i in range(1, m + 1):
        for coin in coins:
            subproblem = i - coin
            if subproblem < 0:
                continue

            memo[i] = min_ignore_none(memo.get(i), memo.get(subproblem) + 1)

    return memo[m]
```

5. Evalution O(K*M)

Problem 3

Given a set of coin values coins
{c1,c2,...,ck} and a target sum of money m.
But how many ways can we form the
sum
m using these coins?
Coins: {1,4,5}
Target sum: 5
There are 4 ways in total:
1+1+1+1+1   1+4   4+1   5
Constraints :
1<=k<=10 (number
1<=m<=10^5
1<=ci<=500



Solution

Given a set of coin values coins={c1, c2, …, ck} and a target sum of money m, in how many ways can we form the sum m using these coins?

```python
from collections import defaultdict


def how_many_ways(m, coins):
    memo = defaultdict(lambda _: 0)

    memo[0] = 1
    for i in range(1, m + 1):
        memo[i] = 0

        for coin in coins:
            subproblem = i - coin
            if subproblem < 0:
                continue

            memo[i] = memo[i] + memo[subproblem]

    return memo[m]


print(how_many_ways(5, [1, 4, 5]))
print(how_many_ways(87, [1, 4, 5, 8]))
```

$$solution(0) = 1$$

$$solution(m) = \sum_{c \in coins} solution(m - c)$$

Output: 4

Output: 3306149332861088

Thank You