CMSC 401 – Fall 2024

Assignment 4
(due Thu, 12/12 – 11:59pm)

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CMSC 401- Algorithm Analysis with Advanced Data Structures

VCU College of Engineering

Wood Cutting Problem

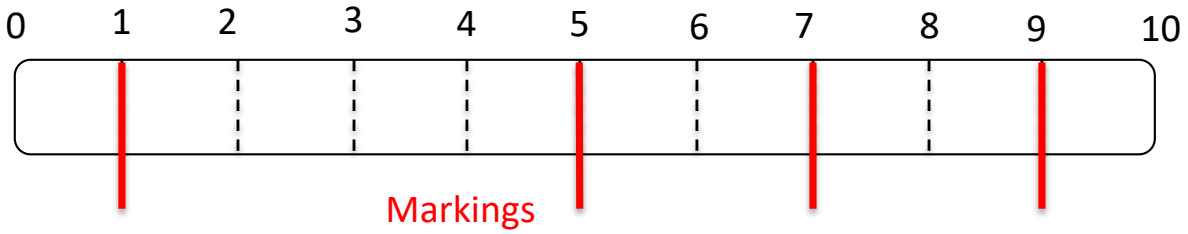
- You are given a wooden piece that has a length of X inches and has M markings on it.
- Each of the M markings shows the cutting points.
- You go to a carpenter, and learn that the carpenter charges a fee depending on the piece sizes obtained after each cut.
- The carpenter uses a flat fee of $1 for every L inch length. That is for pieces in range [1-L] charges $1, for pieces in range [L+1, 2L] charges $2 and so on.
- Your goal is to have the carpenter cut the initial wood piece from all its markings while minimizing the total cost.
- You will to decide the order of cuttings from the marking points and give it to the carpenter.

Assignment 4

- Write a program CMSC401_A4.java that reads the size of the wood piece and marking points in the format below and outputs the minimum cost (single integer):

- The size of the wood piece (integer), X, in the first line. X>=2, X<=1000
- The flat fee length (integer), L, used by the carpenter to charge, in the second line. L>=1, L<=X
- The number of marking points (integer), M, in the third line. M>=1, M<=X-1
- The location of each of M distinct markings (will be >0 and <X)
  - Only integer values (will be given in increasing order)

```
10
1
4
1
5
7
9
```



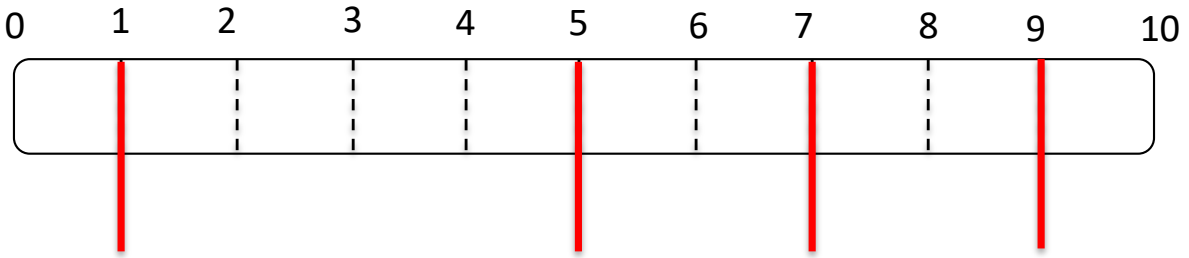
Example 1

Input in correct format

```
10
1
4
1
5
7
9
```

Correct output

```
23
```



Markings

Order	Cost
1) Cutting at 5:	$10
2) Cutting at 1:	$5
3) Cutting at 7:	$5
4) Cutting at 9:	$3
Total Cost:	$23

An order of cutting points that gives the min cost is 5,1,7,9 (there are also others giving the same minimum, e.g., 5,7,9,1)

Bad cut example: Cutting in the order of 1,5,7,9 which has cost 10+9+5+3=27.

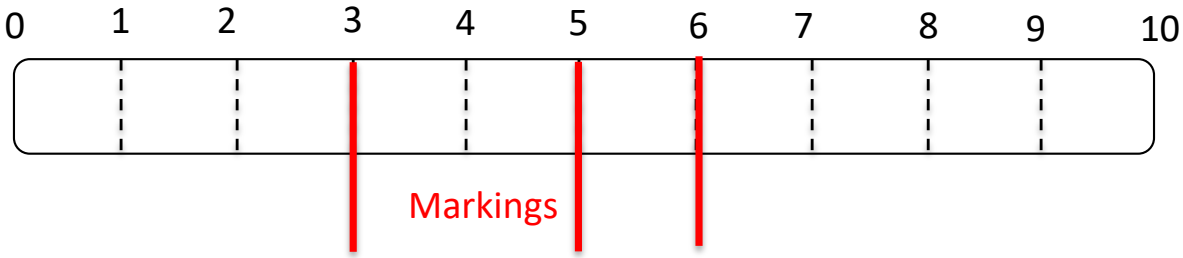
Example 2

Input in correct format

```
10
1
3
3
5
6
```

Correct output

```
19
```



Order	Cost
1) Cutting at 6:	$10 (6+4)
2) Cutting at 3:	$6 (3+3)
3) Cutting at 5:	$3 (2+1)
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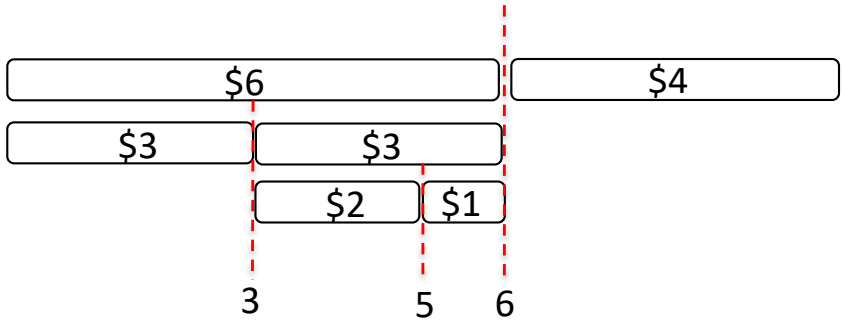
Total Cost:	$19



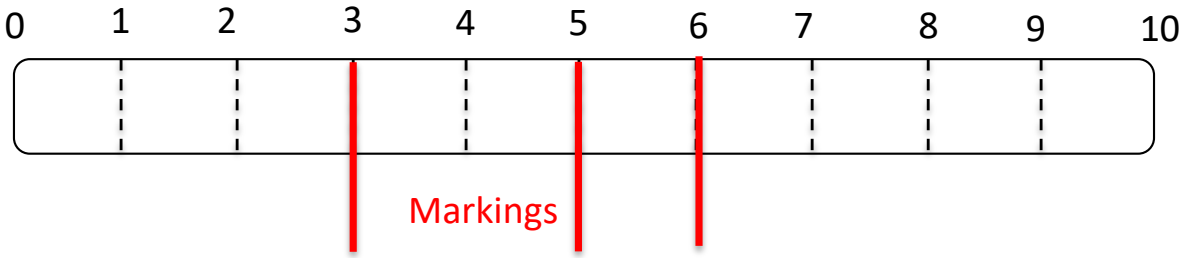
Example 3

Input in correct format

```
10
5
3
3
5
6
```

Correct output

6



Order	Cost
1) Cutting at 5:	$2 (1+1)
2) Cutting at 3:	$2 (1+1)
3) Cutting at 6:	$2 (1+1)
Total Cost:	$6

Note that optimal cutting order changes from L=1 (example 2) to L=5 (example 3). 6,5,3 order would have higher cost as after cutting at 6 first, we have two pieces with a total cost of $3 as 6 inch piece has a cost of $2 i.e., [6/5]

Hint

- Define the (sub)problems in terms of cutting the wood piece from one marking point to another one
  - C(i,j) = cost of cutting the wood from point i to point j
- Find the **recursive formula**
- Apply a dynamic programming method
- Algorithm should have $O(M^3)$ complexity
  - M: number of marking points
  - Complexity should NOT depend on X, the length of wood.
    - You will get lower grade if it does or if you have a larger complexity in general.
  - **Solutions** like proceeding with the point closest to middle of the current wood piece or selecting the median of marking points etc. will not work always (Do not use these!!!).
    - Ex: For example 2, selecting in order of 5,3,6 yields 10+5+5=20 cost, while optimal is obtained with order 6,3,5 which gives 10+6+3=19.

Submission

- Date due: Thu, Dec 12th, 11:59 pm

- Submission through Canvas
  - Just submit the single Java source code file CMSC401_A4.java
    - **No need to zip. Don't worry about "-1", "-2" added to your file by Canvas for new versions.**
    - The file should have *your name* in a comment in the first line
    - Remember: in Java, class name should match the file name, and is case sensitive

- Please do NOT create your own packages
- Use standard I/O to read input (System.in, System.out) and output
- Make sure the **program compiles and WORKS!**
- Late submissions are accepted up to 2 days only with penalties!