CS2010 PS8 - Bundle of Joy 2012

Released: Thursday, 01 November 2012
Due: Saturday, 10 November 2012, 8am

Collaboration Policy. You are encouraged to work with other students or teaching staffs (inside or outside this module) on solving this problem set. However, you **must** write the Java code **by yourself**. In addition, when you write your Java code, you **must** list the names of every collaborator, that is, every other person that you talked to about the problem (even if you only discussed it briefly). This list may include certain posts from fellow students in CS2010 IVLE discussion forum. Any deviation from this policy will be considered cheating, and will be punished severely, including referral to the NUS Board of Discipline. It is not worth it to cheat just to get 15% when you will lose out in the other 85%.

R-option. There is no R-option in this PS.

Last Year's Story – still relevant until now. Last year, Steven received his *'Bundle of Joy'*, a term that is usually associated with the arrival of 'a new baby'. It is a happy term. Steven and CS2010 students have another reason to be happy as PS8 is the last PS for this semester :D. Therefore, to share happiness, let's conclude this semester with a final exam preparation.

The Actual Problem. Cut the List

NOTE: This is a copy paste from CS2010 Final Exam S1 AY2011/2012. Sub-question A). to F). are guiding questions with the answers already given. For PS8, you need to submit a working code `CutTheList.java` (skeleton file is given).

There is a little girl by the name of Esther who likes to play a particular game. She would start with a list L of N numbers ($1 \leq N \leq 400$, each number is a positive number less than 1000, the numbers in L are not necessarily pairwise distinct) and cut the list up into K sub-list ($1 \leq K \leq N$). Cutting a list is formally defined as follows: Suppose $L = \{l_1, l_2, \ldots, l_i, l_{i+1}, \ldots, l_N\}$. Then, cutting the list L at index i will split L into two *non-empty* sub-lists $L_1 = \{l_1, l_2, \ldots, l_i\}$ and $L_2 = \{l_{i+1}, l_{i+2}, \ldots, l_N\}$. Esther will keep cutting the list until she has K sub-lists in total.

For example, if she starts with the list $L = \{1, 2, 3, 4\}$ with $N = 4$ numbers, then it is possible to cut up L into $K = 3$ sub-lists: $\{1, 2\}, \{3\}, \{4\}$. However, it is **not** possible to cut up L into $\{1, 3\}, \{2\}, \{4\}$ as it is **impossible** to cut out $\{1, 3\}$ from L.

A). Is it possible to cut $L = \{8, 1, 5, 4, 7\}$ into $K = 3$ sub-lists: $\{8\}$, $\{1, 4, 7\}$, and $\{5\}$?

Select either (Yes) or (No)! The answer is no, not contiguous.

B). Show *all* possible ways to cut $L = \{8, 1, 5, 4, 7\}$ into $K = 2$ sub-lists!
One of the way is already shown below!
1). $L_1 = \{8, 1\}$, $L_2 = \{5, 4, 7\}$.

There are 3 other ways, total 4 ways:
2). {8}, {1,5,4,7}
3). {8,1,5}, {4,7}
4). {8,1,5,4}, {7}

Then for each of the sub-list L_i, she would find out the difference between the maximum value (M_i) and minimum value (m_i) of L_i and call it d_i, i.e. $d_i = (M_i - m_i)$. Then she will sum out all the d_i. Her goal in this game is to *minimize* the sum i.e. $\sum_{i=1}^{K} d_i$.

For example, let the initial list $L = \{7, 2, 1, 5, 3\}$ and $K = 3$. She can cut it up into $\{7\}$, $\{2, 1\}$, and $\{5, 3\}$. So, $\sum d_i = (7 - 7) + (2 - 1) + (5 - 3) = 0 + 1 + 2 = 3$. This so happens to be the minimum possible value of $\sum d_i$ and is the answer she is looking for.

C). If Esther cuts $L = \{8, 1, 5, 4, 7\}$ into $K = 2$ sub-lists: $\{8, 1\}$, and $\{5, 4, 7\}$,
what is the value of $\sum_{i=1}^{K} d_i$? Answer: (8-1) + (7-4) = 7 + 3 = 10.

Esther heard that you have taken CS2010 - Data Structures and Algorithms II and have learned 'Dynamic Programming'. She seeks your help to solve this problem. So, given the initial list L with N numbers and an integer K, please answer Esther's query as explained above, i.e. implement:

```
int Query(int[] L, int N, int K)
```

D). What is the minimum $\sum_{i=1}^{K} d_i$ that Esther can get with $L = \{8, 1, 5, 4, 7\}$ and $K = 2$?
Hint: Look at your answers for sub-question B). and C). above.

The answer is 6; Split L into {8} and {1,5,4,7}
$\sum d_i$ = (8-8) + (7-1) = 0 + 6 = 6.

E). Important sub-question: What is the minimum $\sum_{i=1}^{K} d_i$ that Esther can get with $L = \{8, 1, 5, 4, 7\}$ and $K = 3$ instead?

The answer is 3; Split L into {8}, {1}, and {5,4,7}
$\sum d_i$ = (8-8) + (1-1) + (7-4) = 0 + 0 + 3 = 3.

F). Important sub-question: What is the minimum $\sum_{i=1}^{K} d_i$ that Esther can get with $L = \{8, 1, 5, 4, 7\}$ and $K = 4$ instead?

The answer is 1; Split L into {8}, {1}, {5,4}, and {7}
$\sum d_i$ = (8-8) + (1-1) + (5-4) + (7-7) = 0 + 0 + 1 + 0 = 1.

Subtask 1 (5 points). $1 \leq N \leq 100$, K is always N.
That is, you will only be asked to output the value of `Query(L, N, N)`

Subtask 2 (Additional 10 points). $1 \leq N \leq 100$, K is always 1.
That is, you will only be asked to output the value of `Query(L, N, 1)`

Subtask 3 (Additional 50 points). $1 \leq N \leq 100$, $1 \leq K \leq N$.

Subtask 4 (Additional 35 points). $1 \leq N \leq 400$, $1 \leq K \leq N$.

Note: You are only given `Sample.txt` and `Sample-ans.txt`. You are not given any other official test data. You are allowed to check your program's output with your friend's. You are encouraged to generate and post additional test data in IVLE discussion forum. Credits to Victor Loh Bo Huai (NUS alumni), the author of the original version of this problem.