In this homework you will write 2 programs to solve a "Production planning problem", the first will use dynamic programming, and the second will use linear programming.

You are expected to work in teams of upto 4. Fewer are discouraged, but acceptable.

The submission deadlines are revised: Both programs and the report are to be submitted on the midnight of Wednesday Nov 11.

1 The production planning problem

The problem is a slight modification of the production problem from DPV 7.1.2.

We are given the (integer) demand $D[m]$ for carpets for the next M months, numbered $m = 0..M - 1$. Assume that the carpets demanded in each month are to be delivered at the end of each month. At the beginning of month 0, we have E employees. In addition we can hire and fire employees at the beginning of each month as necessary, at a cost $Hcost, Fcost$ per employee respectively. Retaining a previously hired employee for the next month has no cost. Each employee is paid a salary S per month and will make C carpets each month, in regular working hours. However an employee can also be expected to produce upto OTC carpets in addition as overtime, and for this a charge $OTPrice$ has to be paid per carpet produced during overtime.

The carpets that remain after satisfying the demand at the end of each month (and the demand must be satisfied) must be put into a warehouse at a charge of W per carpet per month.

One day 1 of month M we may hire or fire employees if necessary so that we have E employees with which we started. On day 1 of month M it is OK if we have undelivered carpets; assume that we give these away with no additional cost or income from them.

The goal is to plan the production so that the total cost (salary, hiring, firing, overtime, storage) is minimized.

1.1 Input and output

The input is given in the following format.

M
$D[0], \ldots, D[M - 1]$
$E, Hcost, Fcost$
S, C
$OTC, OTPrice$
W

There are no commas in the input, they have been given above only for readability. In C++, only the order matters since you will read input using `cin`.

As output, please print two numbers (without commas):

Total Cost, Execution time

2 Dynamic programming based program:

This is expected to be in C++. There are no specified limits on how many employees you can hire, how many carpets you can put in storage. You should allow whatever is needed to minimize cost. Explain this in your program through comments.

The program should contain comments that explain your recurrence and also the analysis of running time. In general put everything that helps understanding as comments in the program.

3 Integer Linear Programming based program:

This is expected to be in Python, using the Pulp library. You can start working on this if you know Python. However, soon we will give a sample program that solves an LP using Pulp. It might be adequate to modify that to suit our problem.

Do put comments.

4 Evaluation 1:

The basic evaluation will be for correctness; but you will lose marks if your running time is too large. This will be decided as per some general judgement by the TAs.

Here are two data sets and the answers expected for them.

This is is data set 1.

```
2
5 4
1 32 40
200 2
1 180
6
```

The cost expected for this is 1052 (for both programs).

Here is another data set

```
3
50 40 70
5 32 40
200 8
3 35
6
```

The cost for this should be 4272.

We will also execute your programs on test sets that we ourselves create.

5   Evaluation 2:

We would like you to tell us which of the 2 programs is faster. For this you should create your own data sets. It is possible that for some types of instances one is faster, while for others the other is faster. If you can give any explanations (e.g. "for large data sets, or for data sets with these characteristics, this program is faster") it will obviously count more.

Submit a report detailing the test cases you used (if you generated them randomly explain how) and explain your conclusions.

6   Viva:

There will be a viva, in which you will be quizzed about your contribution to the effort and also your understanding of the effort. The marks will be different for the team members if it is found that the effort put in is different.

Some sharing of work is fine, but everyone must be ready to answer all questions.