ESC101: Fundamentals of Computing
Lab 10 (March 24 - March 27, 2014)

Duration: 3 hours **Total Marks: 60**

1. **Largest product in 2D matrix**(15 marks)
   Write a program to take as input a 2D matrix and calculate the largest product of 4 elements of the matrix such that all four elements lie consecutively along a row/column/diagonal of the matrix(Assume that neither the number of rows nor the number of columns exceed 100, and the elements are non-negative. Also assume that the matrix has at least 4 rows and 4 columns.)

   For example, in the following matrices:

1	3	4	10
2	5	9	11
6	8	12	15
7	13	14	16

   the largest product is 26400(across the last column)

22	4	11	9	14
2	1	24	8	17
25	6	7	18	20
13	19	15	10	3
12	21	5	23	16

   the largest product is 96390(across the diagonal 21, 15, 18, 17)

   Here are a few sample interactions of the program:

```
$./a.out
Enter the dimensions of the matrix(row column): 4 4
Enter the matrix:
1 2 3 4
8 7 6 5
9 10 11 12
16 15 14 13
43680

$./a.out
Enter the dimensions of the matrix(row column): 12 17
Enter the matrix:
8 23 15 20 11 10 11 20 15 13 11 19 14 20 1 2 20
4 4 23 5 16 17 17 17 5 19 19 20 9 20 10 3 12
8 13 5 16 19 13 3 19 8 10 7 19 16 19 2 22 15
14 9 23 22 7 3 1 10 22 20 3 19 21 8 8 15 3
7 17 10 10 23 19 23 2 4 5 18 7 10 3 10 14 15
3 1 23 22 22 22 14 19 18 2 2 17 22 14 23 5 10
3 20 20 8 15 5 3 20 10 21 15 4 20 15 20 6 8
4 4 3 13 17 6 4 6 4 20 20 9 19 6 1 14 2
9 23 1 17 19 5 23 11 21 15 20 16 18 4 1 5 13
22 10 23 4 23 14 6 9 5 6 21 13 5 23 12 5 1
6 5 1 15 11 23 19 22 2 19 16 3 5 18 6 14 11
5 17 13 10 13 10 11 5 9 22 17 20 8 17 20 5 21
244904
```

2. **Bomb placement**(15 marks)
Country J is planning a revenge bomb attack on country A. Let us take a simplified model of country A: it is represented as a single row of N cities each with some population. Country J wants to drop a bomb in such a way that the range of the bomb(K) covers the maximum population possible. Help country J in its mission.

Write a program to take as input:

(a) N and K. Assume that $N < 1000$ and $K < 10,000$

(b) N lines, with line i containing two integers L_i and P_i. L_i is the location of city i and P_i is the population of city i. Assume that $0 < L_i < 10,000$

and output a single integer, which represents one of the optimal location of the bomb, such that it inflicts maximum damage. **Note:** A bomb placed at the coordinate X destroys cities in the range $[X - K, X + K]$

Here are some sample interactions of the program:

```
$./a.out
Enter N and K: 4 3
Enter location and population of city 1: 7 4
Enter location and population of city 2: 15 10
Enter location and population of city 3: 2 2
Enter location and population of city 4: 1 5
Optimal bomb location: 4
```

```
$./a.out
Enter N and K: 10 5
Enter location and population of city 1: 15 1
Enter location and population of city 2: 2 5
Enter location and population of city 3: 9 2
Enter location and population of city 4: 16 9
Enter location and population of city 5: 20 3
Enter location and population of city 6: 4 1
Enter location and population of city 7: 14 5
Enter location and population of city 8: 18 6
Enter location and population of city 9: 11 5
Enter location and population of city 10: 8 2
Optimal bomb location: 13
```

3. **Product of two matrices**(15 marks)
Write a program to take two matrices M_1 and M_2 from the user as input, and print the product $M_1.M_2$. Recall that the product of two matrices

$$\text{A} = \begin{matrix} A_{11} & A_{12} & A_{13} & A_{14} & \dots & A_{1m} \\ A_{21} & A_{22} & A_{23} & A_{24} & \dots & A_{2m} \\ A_{31} & A_{32} & A_{33} & A_{34} & \dots & A_{3m} \\ \vdots & & & & & \\ A_{n1} & A_{n2} & A_{n3} & A_{n4} & \dots & A_{nm} \end{matrix}$$

and

$$\text{B} = \begin{matrix} B_{11} & B_{12} & B_{13} & B_{14} & \dots & B_{1p} \\ B_{21} & B_{22} & B_{23} & B_{24} & \dots & B_{2p} \\ B_{31} & B_{32} & B_{33} & B_{34} & \dots & B_{3p} \\ \vdots & & & & & \\ B_{m1} & B_{m2} & B_{m3} & B_{m4} & \dots & B_{mp} \end{matrix}$$

is defined as $C_{ij} = \sum_{x=1}^{x=m} A_{ix}.B_{xj}$. Note that if the dimensions of A and B are nxm and mxp respectively, then the dimensions of C are nxp

For example, the product of

1	2	3
4	5	6

and

7	8	9	10
11	12	13	14
15	16	17	18

is

74	80	86	92
173	188	203	218

Note: You should allocate the memory for the matrices dynamically

Here are some sample interactions of the program:

```
$./a.out
Enter the dimensions of the matrices(n m p): 4 5 6
Enter matrix 1:
1 5 9 13 17
2 6 10 14 18
3 7 11 15 19
4 8 12 16 20
Enter matrix 2:
21 26 31 36 41 46
22 27 32 37 42 47
23 28 33 38 43 48
24 29 34 39 44 49
25 30 35 40 45 50
Product:
1075 1300 1525 1750 1975 2200
1190 1440 1690 1940 2190 2440
1305 1580 1855 2130 2405 2680
1420 1720 2020 2320 2620 2920
```

```
$./a.out
Enter the dimensions of the matrices(n m p): 10 15 20
Enter matrix 1:
1 0 1 5 3 3 3 2 7 2 3 2 5 3 3
8 3 1 0 8 4 5 3 4 6 2 0 9 0 0
5 0 4 9 3 5 1 1 4 9 5 6 2 9 3
6 3 8 8 6 9 3 8 3 8 1 2 5 5 8
5 0 9 4 6 5 9 2 0 9 4 0 4 9 0
2 5 2 4 2 4 4 5 0 3 7 5 3 3 4
8 6 4 7 2 6 9 8 0 3 9 0 7 5 6
8 0 6 4 1 7 0 4 5 5 8 4 0 6 1
9 3 2 9 6 2 0 2 0 2 4 3 9 5 7
3 8 4 1 2 4 5 3 8 6 2 1 2 5 4
Enter matrix 2:
7 7 8 9 4 1 0 9 7 3 7 2 7 7 7 5 5 5 4 5
2 9 3 5 5 4 7 5 1 5 2 1 3 7 8 7 5 1 9 3
6 3 9 6 9 8 1 8 0 4 8 1 5 2 0 8 5 1 6 0
0 7 0 2 9 3 3 1 0 2 7 4 7 2 4 3 5 7 8 1
4 4 1 5 7 3 4 5 7 7 5 4 4 7 8 2 4 3 9 7
0 9 4 3 2 9 6 5 0 6 6 3 0 8 3 9 3 2 5 5
1 3 3 9 4 3 9 4 0 2 5 3 1 3 9 0 7 4 9 6
3 6 0 2 8 8 8 6 7 1 2 1 3 7 7 9 8 9 5 5
8 3 6 2 6 7 2 4 7 6 4 6 4 8 2 9 8 2 2 2
3 4 6 1 9 7 7 4 0 6 3 2 6 0 7 9 6 2 5 5
4 1 0 2 9 4 1 2 6 8 3 9 4 3 4 0 3 6 8 6
3 7 5 3 4 2 5 3 2 9 2 4 9 0 8 6 2 0 3 9
9 3 5 4 8 3 6 0 3 1 5 1 4 3 0 8 0 7 6 2
5 1 1 4 9 9 6 9 7 0 5 5 9 0 0 3 3 6 7 1
2 9 9 1 6 1 3 2 0 9 2 9 8 0 4 4 9 3 2 5
Product:
180 196 160 143 293 209 187 157 149 192 195 183 209 167 169 233 210 184 240 162
253 252 226 250 332 232 253 237 203 221 250 145 212 268 280 310 237 218 325 238
241 313 256 220 469 342 271 303 202 304 313 266 391 185 277 352 299 257 374 256
291 459 358 303 559 431 379 389 224 360 392 276 409 316 370 502 427 334 470 317
252 259 257 306 471 367 317 349 190 241 348 206 314 208 288 324 301 268 440 246
165 281 176 191 350 243 258 215 150 256 210 207 256 184 274 264 247 219 329 243
278 409 283 340 532 365 376 352 242 311 364 288 359 313 384 387 392 382 511 321
239 279 242 218 398 331 208 312 224 278 286 234 310 231 242 337 276 234 319 236
262 341 253 248 437 231 240 257 214 267 302 240 367 217 273 308 269 295 375 244
227 293 257 227 372 314 283 284 175 265 242 205 264 245 273 352 318 191 334 215
```

4. **Reordering students**(15 marks)
Campus School, IIT Kanpur is organizing the annual function. In one of the dance acts, the students will stand in a straight line and dance in a pattern. A few days before the function, someone tells the students that they have to stand height-wise, since they will have to March right after the dance. Now the students have to be reordered. The reordering process will divide the students into groups, such that the groups can be reordered independently. Each group will have to meet later on so that the students know their new dance moves. For example, if there are 5 students

1 2 3 4 5

who have to be reordered as

5 1 4 3 2

i.e. student 5 will come to position 1, student 1 to position 2 and so on
then there are two groups: 1, 2, 5 and 3, 4

Write a program which takes as input:

(a) The number of students N. Assume that $N < 100$
(b) The new ordering of the students

and prints

(a) The number of groups in the reordering process
(b) The maximum size of a group

Here are a few sample interactions of the program:

```
$./a.out
Enter N: 3
Enter the new order: 2 1 3
Groups: 2
Biggest group: 2
```

```
$./a.out
Enter N: 5
Enter the new order: 5 1 4 3 2
Groups: 2
Biggest group: 3
```

```
$./a.out
Enter N: 15
Enter the new order: 9 5 6 10 2 3 13 7 4 8 14 12 1 15 11
Groups: 5
Biggest group: 7
```

```
$./a.out
Enter N: 24
Enter the new order: 20 10 7 9 3 15 8 12 23 21 22 14 19 1 17 5 24 11 13 16 6 2 18 4
Groups: 3
Biggest group: 13
```