Algorithms Laboratory (CS29203)
Assignment 0: PDS brush-up (not to be graded)
Department of CSE, IIT Kharagpur

10th August 2023

Question-1

Consider a text file having the following format, which is typically used in computer graphics applications to store 3D point and geometry:

```
# This is a file for geometric data
# Version 2.3.1
# VCGLib generated
Points 4
Triangles 3
12.5  3.36  10.2
7.3  20.91  9.9
11.2  14.02  8.9
23.1  0.56  4.5
1 2 3
1 2 4
2 3 4
```

In the file, the lines beginning with '#' are comment lines, which should be ignored for processing. Next, the line starting with *'Points'* denotes the number of 3D points, which is written as an integer number next to it separated by a space. The next line starting with *'Triangles'* denotes the number of triangles that are formed from the points, and the integer number is written next to it separated by a space. Then the 3D points are listed in the preceding lines as x, y and z coordinates separated by spaces. For example in this file, there are 4 points, which are written in the next 4 lines. After the points, triangle vertices are stored as numbers denoting the indices of the declared points. For example, this file has 3 triangles where the first triangle has the first, second, and third declared points as the three vertices. That means, the vertices of the first triangle are $(12.5, 3.36, 10.2), (7.3, 20.91, 9.9), (11.2, 14.02, 8.9)$. Similarly the vertices for the second triangle are $(12.5, 3.36, 10.2), (7.3, 20.91, 9.9), (23.1, 0.56, 4.5)$, and so on.

Your task is to read a given text file of the same format as described before, read the points and triangles, and compute the *surface normal* for each triangle. The surface normal of a triangle is computed as the cross product of two sides of the triangle. That is, if a triangle has vertices $P_1(x_1, y_1, z_1), P_2(x_2, y_2, z_2), P_3(x_3, y_3, z_3)$, then the following vectors are computed: $U = P_2 - P_1$, $V = P_3 - P_1$. Then the x, y, and z components of the normal are computed as:

$$N_x = U_y V_z - U_z V_y$$
$$N_y = U_z V_x - U_x V_z$$
$$N_z = U_x V_y - U_y V_x,$$

where U_x, U_y, U_z represents the x, y, and z component of the vecotor U (and same for V as well).

After computing the surface normal for each triangle, you have to create a new text file, and write the surface normal information in the file as $N_x N_y N_z$ format, as well as display the file content in the output window.

Example:

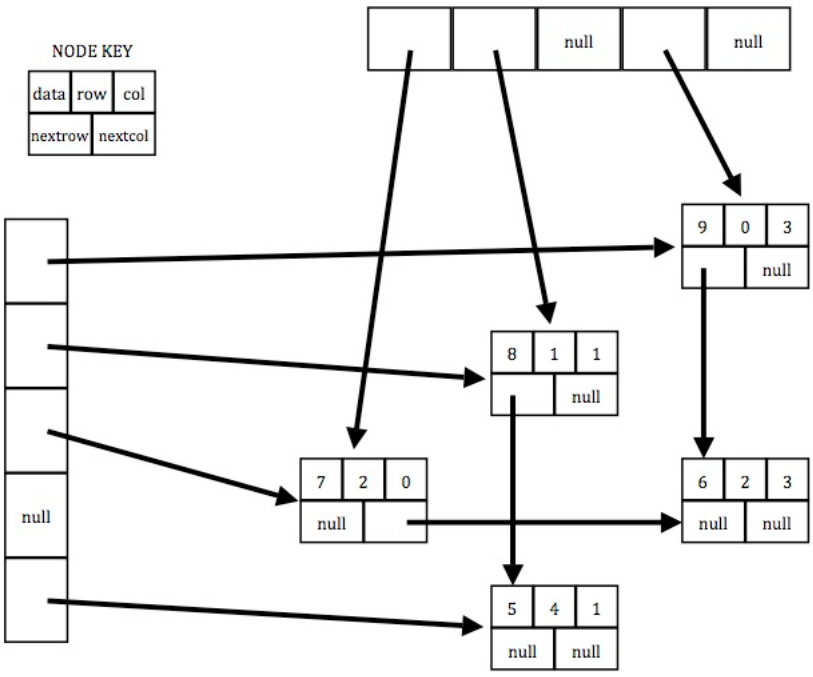
```
Enter the file name to be read: myGeometryPoints.txt
Enter the output file name: mySurfaceNormals.txt

Number of points in the file: 10
Number of triangles in the file: 15

Computing the surface normals...

Surface normals have been computed and written to the file mySurfaceNormals.txt

List of surface normals:
-0.34  0.45  3.67
1.25  4.21  -1.33
7.32  2.11  9.76
.
.
.
```

Question-2

A sparse matrix is a matrix in which most of the elements are zero. For example, the following is an example of a 5×5 integer matrix which is sparse:

```
0 0 0 9 0
0 8 0 0 0
7 0 0 6 0
0 0 0 0 0
0 5 0 0 0
```

Although matrices are usually stored in a 2D array, we will store a sparse matrix using inked lists where we only store nodes for the locations that have non-zero values. In our representation to store a sparse matrix, we will create two arrays of references to the heads of the lists of nodes for rows and columns. Each node key will contain the following fields: data, row, column, pointer to next row, pointer to next column. The sparse matrix above would be stored as shown in the picture below:



Your task is to take a sparse matrix from the user input, store using the linked list representation showed above, and display the same matrix as output from the stored representation.