Assignment 5

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The exercises is to build on the `Vector` class (discussed in the class) with an additional `Matrix` class. These classes are then combined into a `LinearSystem` class which has a method for solving systems of the form $Ax = b$ for x. Figure 1 illustrates a typical solution to this exercises with a UML diagram for all the classes produced by this exercise.

Q. 1 Develop a class of matrices called `Matrix` for use with the class of vectors developed in the class. The class of matrices should include the features listed below.

    (a) should have private members `mNumRows` and `mNumCols` that are integers and store the number of rows and columns;

    (b) `mData` that is a pointer to a pointer to a double precision floating point variable, which stores the address of the pointer to the first entry of the first row;

    (c) an over ridden copy constructor that copies the variables `mNumRows` and `mNumCols`, allocates memory for a new matrix, and copies the entries of the original matrix into the new matrix;

    (d) a constructor that accepts two positive integers—`numRows` and `numCols`—as input, assigns these values to the class members `mNumRows` and `mNumCols`, allocates memory for a matrix of size `mNumRows` by `mNumCols`, and initialises all entries to zero.

    (e) An overridden destructor that frees the memory that has been allocated to the matrix.

    (f) Public methods for accessing the number of rows, and the number of columns.

    (g) An overloaded round bracket operator with one-based indexing for accessing the entries of the matrix so that, provided i and j are valid indices for the matrix, `A(i,j)` may be used to access `mData[i-1][j-1]`.

    (h) Overloaded assignment, unary and binary operators to allow addition, subtraction and multiplication of suitably sized matrices, vectors and scalars. You should use `assert` statements to ensure the matrices and vectors are of the correct size.

    (i) A public method that computes the determinant of a given square matrix.

Q. 2 Assuming the system is nonsingular, a linear system is defined by the size of the linear system, a square matrix, and vector (representing the right-hand side), with the matrix and vector being of compatible sizes. Develop a class called `LinearSystem` that may be used to solve linear systems. The class should contain the following features

    (a) the data associated with this class may be specified through an integer variable `mSize` a pointer to a matrix `mpA`,

(b) and a pointer to the vector on the right-hand side of the linear system `mpb`.

(c) You should allow the user to set up a linear system through the use of a constructor that requires specification of the matrix and vector: the member `mSize` may then be determined from these two members. You do not wish to provide a copy constructor, therefore, the automatically generated copy constructor should be overridden and made private to prevent its use.

(d) A public method `Solve` should be used to solve this linear system by Gaussian elimination with pivoting, the code for this method is attached and can be used as it is.
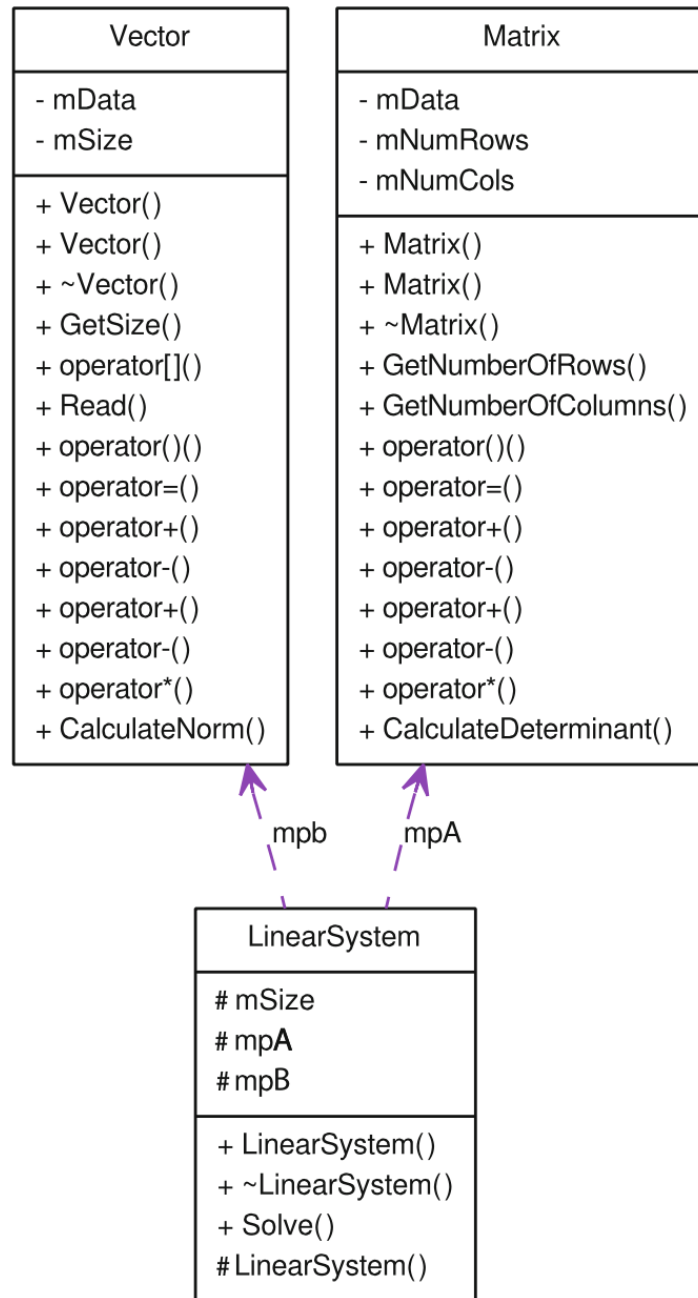
Test your class using suitable examples.

Figure 1: UML diagram for Linear Solver