NOTE: All code can be emailed to the TA by 10PM on the due date.

Problem 1

Suppose a 3D triangle has the following vertices with (x,y,z) coordinates: (-0.6, -0.7, 1.2), (0.6, -0.3, 1.5), (-0.3, 0.6, 0.5), as well as the following values at each vertex respectively: 1, 8, -3. Therefore each vertex has a value (a.k.a. *mass*) associated with it. Write a small program that determines if a 3D point lies in the triangle.

Hint: In barycentric coordinates, triangles have the following property: For a triangle $\top$ with vertices $\vec{r_1}$, $\vec{r_2}$, $\vec{r_3}$, any point $\vec{r}$ on the triangle may be written as the weighted sum of three vertices $\vec{r} = \lambda_1\vec{r_1} + \lambda_2\vec{r_2} + \lambda\vec{r_3}$. This is subject to the constraint $\lambda_1 + \lambda_2 + \lambda_3 = 1$.

An example of a test input file is the following. Each **tab-delimited** line is the (x,y,z) coordinate of a point in 3D space.

-0.15	0.05	0.925
-0.18	0.16	0.84
0.075	-0.175	1.175
0	-0.02	1.04
-0.05	0.0833333	0.95
0.18	-0.2	1.24
0.1	-0.0666667	1.11667
0.0428571	0.0285714	1.02857
-0.225	-0.275	1.1
-0.24	-0.1	0.98
-0.25	0.0166667	0.9
0.81	-0.84	2.46
-0.06	-0.28	1.18
-0.128571	-0.0285714	0.985714
0.05	-0.283333	1.23333
$-1.49012e-08$	-0.157143	1.12857
-0.0375	-0.0625	1.05
-0.69	-0.72	1.89
-0.3	-0.36	1.12
-0.3	-0.2	1.01667
-0.3	-0.0857143	0.942857
-0.15	-0.35	1.18333
-0.171429	-0.214286	1.08571
-0.1875	-0.1125	1.0125
-0.0428571	-0.342857	1.22857
-0.075	-0.225	1.1375

For each test point, your program must output (using cout or printf) to console a line containing the linearly interpolated value at that location in the triangle **only** if the point is on the same plane as the triangle **and** it is within the bounds of the triangle. Hint: This value is the result of a combination of the Barycentric coordinates. Each line should contain only one number, so for example your output may look like:

```
0.4153
3.1253
```

Please save your code in a .ZIP file and name it:

```
[last name]_[first name]_Written3_Problem1.zip
```

Problem 2

Write and turn in a small program that uses the QMatrix4x4 and QVector4D classes to implement Cramer's rule for solving for **x** in the equation $\mathbf{Ax} = \mathbf{b}$.

As before your program must take as input a matrix **A** specified by a line of 16 numbers in column-major order. The second line of the file is 4 numbers, that specify the 4x1 vector **b** in the above equation. For example, the input file for the following equation:

$$\underbrace{\begin{pmatrix} -18 & 14 & -5 & -5 \\ 10 & -2 & -7 & 7 \\ 4 & 16 & -8 & 5 \\ 1 & 4 & 2 & 3 \end{pmatrix}}_{A} \underbrace{\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix}}_{x} = \underbrace{\begin{pmatrix} 1 \\ -2 \\ -1 \\ 0 \end{pmatrix}}_{b}$$

would be represented as the following **tab-delimited** input:

```
-18  10   4   1  14  -2  16  4  -5  -7  -8  2  -5  7  5  3
 1   -2  -1  0
```

Your program must output the vector **x** in column-major order, **tab-delimited**:

x_1 x_2 x_3 x_4

Please save your code in a .ZIP file and name it:

```
[last name]_[first name]_Written3_Problem2.zip
```

Problem 3

Write and turn in a small program that computes the inverse of a 3x3 matrix using the QMatrix3x3 class (e.g. using determinants). Hint: see **http://mathworld.wolfram.com/MatrixInverse.html**. You may also use **http://www.bluebit.gr/matrix-calculator** to come up with your own matrix and check its solution against the output of your program.

The input file will have 9 numbers which specify a 3x3 matrix in column-major order. For example, the following matrix:

$$\begin{pmatrix} -8 & 5 & -8 \\ -28 & -25 & -7 \\ -2 & -10 & -8 \end{pmatrix}$$

would be represented by the following tab-delimited input:

```
-8  -28  -2  5  -25  -10  -8  -7  -8
```

Your program must output the inverse matrix in column-major order to standard out (printf or cout) where each row is tab-delimited. **Round all numbers to 4 decimal places.**

```
-0.0331  0.0534  -0.0585  -0.0305  -0.0122  0.0229  0.0598  -0.0427  -0.0865
```

Please save your code in a .ZIP file and name it:

`[last name]_[first name]_Written3_Problem3.zip`