CMSC425 Spring 2019
Homework 2: More geometric exercises
Assigned Thursday, Oct. 3rd
Due by midnight on Thursday, Oct. 10th
Submit PDF on Elms (no paper required)

Part a. Warm up problems
These are intended as straightforward use of basic formulas to review and debug your understandings of the concepts. You may use Octave or another vector calculator, but should show the steps you use. Notice that the problems mix ordinary text (p=(1,2)) and MS Word equation mode ($v^{\perp}$). You can use either mode, or Latex, if the answer is clear.

Useful notes on homogenous coordinates:
https://prateekvjoshi.com/2014/06/13/the-concept-of-homogeneous-coordinates/

1. Something we did not do in class, but is fairly straightforward. A homogenous point is represented by a four-tuple <x,y,z,w>, with w=1. Under most operations we keep w at 1. But, in some operations we do multiply w by a number. Eg, we might get p=<2,1,1,1> multiplied by 2 to get p2=<4,2,2,2>. But we do a special normalization of homogeneous points, dividing by w, which means that p2=<4,2,2,2>= <4/2,2/2,2/2,2/2>=<2,1,1,1>=p. In effect, multiplying a homogenous point by a scalar has no effect, and we always return w back to 1. (ADDED: A quick reading on homogenous coordinates and why we use them:
https://prateekvjoshi.com/2014/06/13/the-concept-of-homogeneous-coordinates/)

Given this idea, show the value of q after multiplication, and then after normalization.

$$q = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 1 & 0 \\ 2 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 3 \\ 2 \\ 1 \end{bmatrix}$$

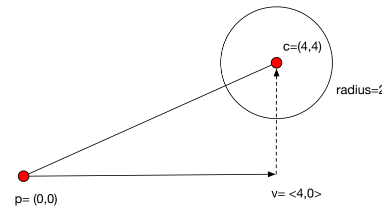
2. Assuming we have a 2 by 2 by 2 cube centered at the 3D homogenous point p=(1,3,1,1), give a sequence of homogeneous matrices to rotate the square 45 degrees clockwise around the X axis first, and then 60 degrees around the Z axis, both rotations around the center of the object.

3. Do similar actions for a box in 3D centered at p=(1,3,1,1), but this time do the following. Scale the box by 2 in the y direction, so it has a preferred direction, and rotate it by 45 degrees around the x-axis and then 30 degrees around the z-axis.

4. Give Unity Vector3 methods to carry out problem (4).

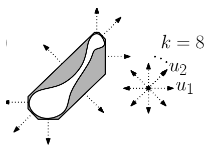
5. Give a Unity command to rotate 60 degrees around the vector <2,2,1,0>. Just one line …

6. Consider the problem of ray circle intersection (see the handout on the web page). Describe how you might simplify the problem by rotating the data so one of the vectors involved aligns with an axis.



Part b. Application
These are intended as applications of the formulas to game design problems.

1. **8-DOP 2D collider**. A 4-DOP 2 collider is just an AABB box. An 8-DOP collider adds four more diagonal sides with slopes of -1 and 1, as below.



(e)

Assume an 8-DOP is represented by the polygon of 4 to 8 points (4 would be a square). We'll have the convention that the first point is the lower left most, and the polygon points go counterclockwise (see below).

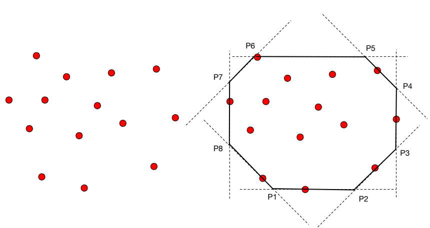
a) Draw three examples of degenerate 8-DOPs – where they don't have 8 points. Use this an opportunity to explore the space of possible 8-DOPs.

b) Related to the Cohen Sutherland algorithm, given two lines, one horizontal or vertical, and the other with +1 or -1 slope, how would you compute the intersection?

c) Given a set of n points, how would you generate an 8-DOP? (This is a simplified version of convex hull). Consider the following issues:

How to find the extreme (eg, maximal) points in the 8 directions.
How to find the intersection points between the line segments in each direction.
How to determine if the 8-DOP is degenerate in any direction so that line is length 0.

You may assume from (a) you have method to find the intersection between any two.



d) Finally, sketch how you'd intersect two 8-DOPs – what comparisons and computations would you make in which order? Again, you can assume a method to intersect two lines.