CMSC425 Fall 2019
Homework 1: Geometric exercises
Assigned Monday, Sept. 16th
Due by midnight on ~~Monday, Sept. 23rd~~ Wednesday, Sept. 25th
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.

1. Given the points p1=(-3,4) and p2=(20,15), give the point-vector from of the ray originating at p1 and going through p2. For what value of t is the point (10.8,10.6) on the line?

2. How far is C=(5,5) from the line through A=(2,5) and B=(4,-1)?

3. Given the two vectors a=<5,4> and b=<3,4>, give u1 and u2 in the orthogonal projection of a onto b.

4. Give the angle between the two vectors u=<-1,1,0> and <-1,0,1>.

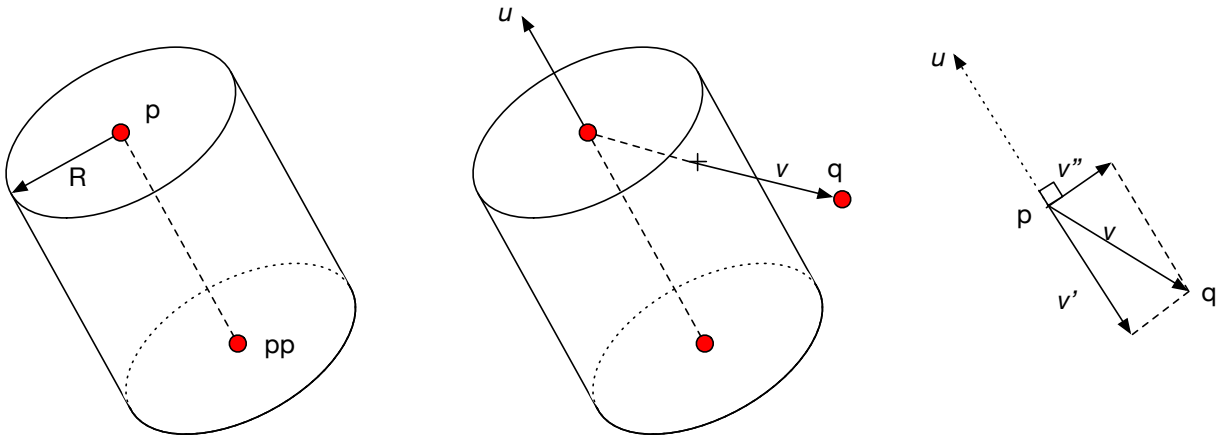
5. Given the three points P1=(1,1,1), P2=(1,2,1), P3=(3,0,4), give a convex combination of the points in the triangle /* any CC is ok */. *** ADDED BUT NOT REQUIRED. What convex combination gives the center?

6. Starting with the points problem (5), compute the distance of the point P4=(0,0,0) to the plane.

7. For a vector v=<x,y>, the 2D perp vector $v^{\perp}$ can be defined as vperp=<-y,x>. Will this vector always be 90 degrees counterclockwise from v?

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

1. **Cylinder collider**. Assume you have a cylinder collider defined by 3D points **p** and **pp**, that give the central axis of the cylinder, and R, which is the radius of the cylinder. The points define a unit vector *u* as shown on the middle diagram. **p**, **pp** and R are enough to define the cylinder.



Now assume you have a point $\boldsymbol{q} = (q_x, q_y, q_z)$, somewhere in 3D space (here $\boldsymbol{q}$ is shown outside the cylinder but could be inside.) We want to compute whether $\boldsymbol{q}$ is inside or outside the cylinder as a boolean flag. Show how to do this in mathematical notation (not code).

(a) Given the points P1 and q, show how to compute the coordinates of the vector $\boldsymbol{v} = \langle v_x, v_y, v_z \rangle$ directed from p to q.
(b) Given (a), show how to decompose $\boldsymbol{v}$ as the sum of two vectors $\boldsymbol{v}'$ and $\boldsymbol{v}''$ such that $\boldsymbol{v}'$ is parallel to $\boldsymbol{u}$ and $\boldsymbol{v}''$ is perpendicular to *u*.
(c) Given your answer to (b), show how to compute the lengths of $\boldsymbol{v}'$ and $\boldsymbol{v}''$

2. **Cylinder collider in code**. Assuming your answer to (1) above is correct, convert the mathematical equations into a Unity C# method that takes p, pp, R and q, and returns a Boolean true if q is in the cylinder, and false if not.

(If you have an error in part (1) we won't take off if part (2) correctly implements your answer.)