CS315 – Introduction to Computer Graphics
Winter, 2021

Assignment 2

Assigned Date: Wednesday, February 9, 2022
Due Date: Friday, February 25, 2022

1. (15 marks) Modified Exercise 4.3 (page 212)

   Give two 3D vectors, *v1*[3] and *v2*[3] of float type. Suppose you are to write a library of functions that do the following computations.

   (a) A (C++ or C) function that returns the dot-product of the two vectors with the following function heading:

   float DotProduct(vec3 v1, vec3 v2);

   (b) A (C++ or C) function that returns the angle (in degree) between the two vectors with the following function heading:

   float FindAngle(vec3 v1, vec3 v2);

   [**Hint**: There are two definitions for calculating the dot-product:

   $v1 \bullet v2 = v1_x * v2_x + v1_y * v2_y + v1_z * v2_z$

   or

   $v1 \bullet v2 = |v1||v2|cos(\alpha)$ where α is the angle between the two vectors.]

   (c) A (C++ or C) function that returns the cross-product between the two vectors with the following function heading:

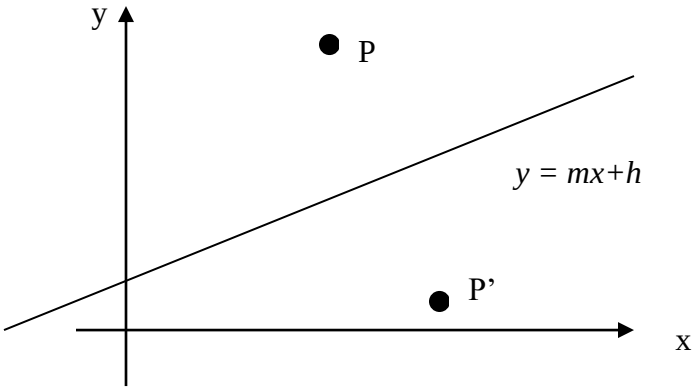
   vec3 CrossProduct(vec3 v1, vec3 v2);

   [Calculation of cross-product can be found in Appendix c.6, page 657 of the textbook, or in calculus textbooks.]

Write a testing main program to test each of these functions with at least two different inputs for each function. Your submission should include well-documented source programs and screenshots of testing results.

2. (10 marks) *Derivation of Compound Transformation* (Non-programming)

In two dimensions, we can specify a line by the equation $y = mx + h$. Find an affine transformation to reflect two dimensional points about this line. That is, given a point $P = (x, y)$, and let M be the transformation matrix you will derive, then $P' = M * P$ will be the reflection point.



[Hint:

Assume the input parameters are m and h of a line, and the location of a point P = (x, y).

(1) Find a sequence of elementary transformations (such as translation and rotation, etc.) in proper order that will move the line on the x-axis;
(2) Do flipping with respect to x-axis;
(3) Find the inverse sequence of step (1) to put the line back to its original location; and
(4) Concatenate all the elementary transformations (in 4x4 matrix form) from steps 1, 2, and 3 together to obtain the final matrix M.

]

3. (8 marks) *Parametric Line Representation* (Non-programming)

Given two points in 2D, $P_1 = (x_1, y_1)$ and $P_2 = (x_2, y_2)$, that define a line:

(a) Write the parametric line expression in vector form:

$P(\alpha)$ =

(b) Write the parametric line expression in individual coordinates:

$x(\alpha)$ =
$y(\alpha)$ =

(c) Give another pair of points in 2D, $P_3 = (x_3, y_3)$ and $P_4 = (x_4, y_4)$, defining another line, compute the intersection point between the two lines using the parametric representation.

(d) The intersection point may or may not be between P_1 and P_2. How do you determine if the intersection point is between P_1 and P_2 on the first line?

4. (10 marks) *(Problem 4.20, page 213)* (Non-programming)

Three vertices determine a triangle if they do not lie in the same line. Devise a test for co-linearity of three vertices.

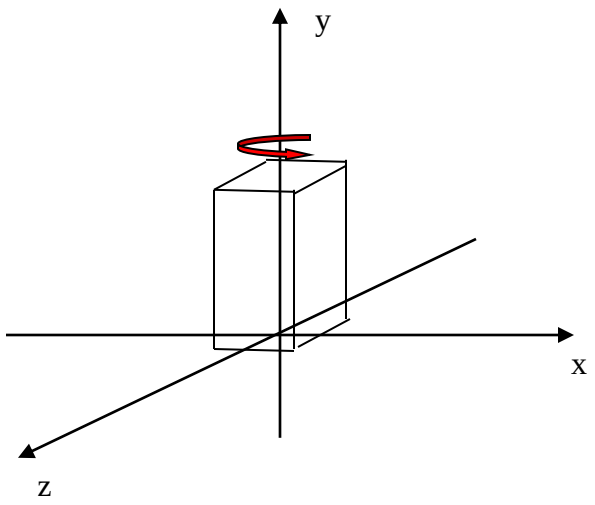
[Hint:
Let the three vertices to be:
$v1 = (v1_x, v1_y, v1_z)$
$v2 = (v2_x, v2_y, v2_z)$
$v3 = (v3_x, v3_y, v3_z)$
Derive an expression that can be used for the test.
]

5. (7 marks) *(Problem 4.19, page 213)* (Non-programming)

We have used vertices in three dimensions to define objects such as polygons. However, given a set of vertices, they are not necessarily lying on the same plane. Find a test to determine whether a polygon specified by a set of vertices is co-planar.

6. (50 marks) (Programming Question)

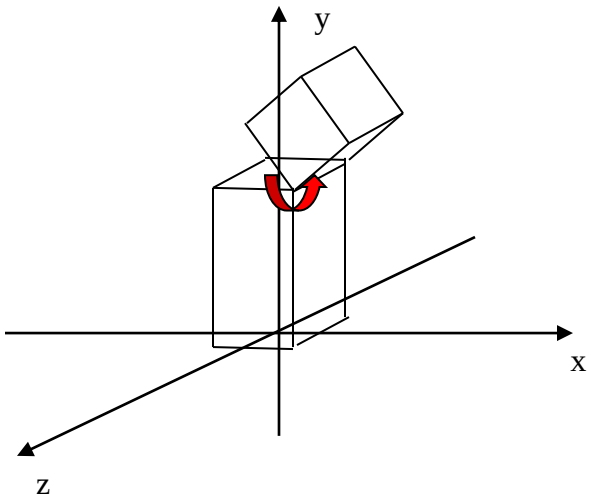
a. A rectangular object with size 1x1x2 is placed on the z-x plane, with the center of the base at the origin.



Write a WebGL program, using proper transformations, to generate this object and rotate it around y-axis.

b. Connect another rectangular object with size 1x1x1 to the first object by a "hinge" as shown in the diagram, such that the second object can rotate around the "hinge" up-and-down

Write a WebGL program, using proper transformations, to generate both objects, and keep the first object stationary but rotate the second object around the "hinge" between -45° and +45° back and forth.



c. Write another WebGL program to generate both objects, and rotate the first object around the y-axis, at the same time, rotate the second object around the "hinge" between -45° and +45° back and forth.

General Rules for the Assignments:

1. Discussion among the students is encouraged for effective learning. However, sharing answers (including program codes in this case) is strictly prohibited.
2. Assignments should be submitted in electronic form to the UR Courses – CS 315 before the closing time on the due day. Any extension must have the instructor's permission in advance.
3. All programs must be well-documented. A general rule is that, the marker should be able to understand your program by reading only the comments. Any non-trivial statements must have in-line comments.
4. Your submission should include the source programs and the generated pictures.

5. Written questions can be submitted in either a typed Microsoft Word document, or a PDF document scanned from or a picture taken from a hand-written hardcopy,.
6. All documents should be zipped into a single file for submission. Please use the basic zip, and try to avoid 7-zip or rar formats because markers had problem to open them.