# CS 4300: Introduction to Computer Graphics
## Sample Exam

Name: _____

ULID  : _____

**Duration: 100 minutes**                                                    **Total: 100 points**

**Closed book, closed notes. No laptops or cell phones. One cheat sheet allowed.**

Instructions:

1.  There are four questions in this midterm. Please make sure there are 5 sheets in this test, including this page.
2.  **Do not start until directed.**
3.  **Do not write in red ink.**
4.  Read each question carefully before writing your answer.
5.  Please write your answers only on this test. Use the back side of every page if you run out of space.

Question 1: (10 points)

(a) In general, transformations are not commutative (i.e. AB ≠BA). Give an example of two rotations R and P that are commutative (i.e. RP = PR). Both rotations must have non-zero angles and must not cancel each other. (5 points)

(b) What is the difference between a Vertex Array Object (VAO) and a Vertex Buffer Object (VBO)? (5 points)

Question 2: (30 points)

You are provided an ObjectInstance obj "quad" that contains a polygon mesh of a quad: (-0.5,-0,5,0), (0.5,-0.5,0), (0.5,0.5,0), (-0.5,0.5,0). That is, a square of side 1 in the X-Y plane centered at the origin.

You have to create a "tray" that looks like:
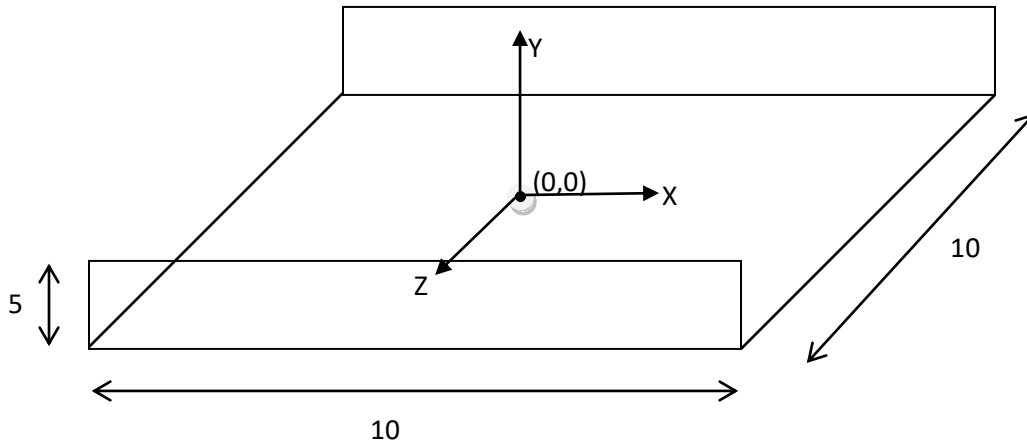


The tray is "sitting" on the X-Z plane with all the vertical sides parallel to the X-Y plane. The base of the tray is centered at the origin as shown. For each part above, write transformations that will convert the quad to that part. You do not have to write code: just provide the transformations in terms of R(angle, axis-x,axis-y,axis-z), T($t_x$,ty,$t_z$), S(sx,$s_y$,$s_z$) for rotate, translate and scale respectively but with the correct parameters.

Question 3: (20 points)

You are given a scene graph as illustrated below. Each node 'i' stores a transformation from its coordinate system to that of its parent, as $M_i$.

$M_1$

$M_2$

$M_3$

$M_5$

$M_4$
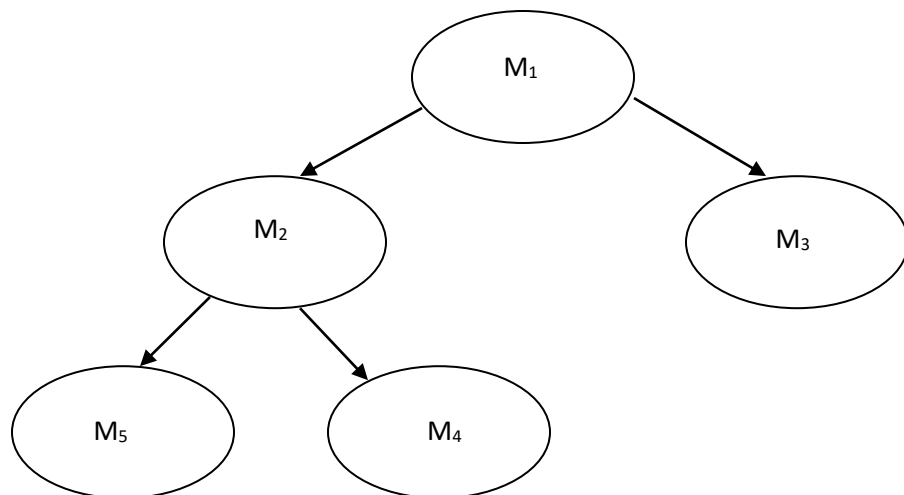
Given any two nodes 'a' and 'b', provide an algorithm for how you would compute the transformation from a's coordinate system to b's coordinate system.

Question 4: (40 points)

You are given a point A (x,y) on a circle of unit radius centered at the origin.

(a) You must draw the path traced by A (using lines) as this circle rolls on the +X axis (i.e. its rim is always on the +X axis and it is headed in that direction) after being scaled by (100,100,100).

Given that the center of the circle should advance by a distance 'p' in a single step, write the code for the function "create" that will return a list of vertex positions for the lines to draw its path, as the circle completes 't' steps. Assume 'x' and 'y' and the number of steps are available to you as member variables. Remember that (x,y) are in terms of the original circle (unit radius, centered at origin). (20 points)
**Hint:** The arc length of a sector of the circle of radius 'r' with angle θ is rθ. Think about the relationship between how the circle must move and rotate so that it appears to "roll".

(b) Instead of the +X axis, your circle must now roll along the inner edge of a bigger circle with outer radius 250 and inner radius 200. Write the modified "create" function that will draw A's path in this case, assuming that the inner circle must move by the same distance 'p' in a single step as above, but this time on the inner rim of the larger circle instead of a straight line. (20 points)
Note: As kids most of us have used those "drawing kits", called spirographs, that draw nice shapes using circles with geared rims. This program is doing just that!