CS 559: Computer Graphics

Homework 6

This homework must be done individually. Submission date is Tuesday, December 3 in class.

Question 1:

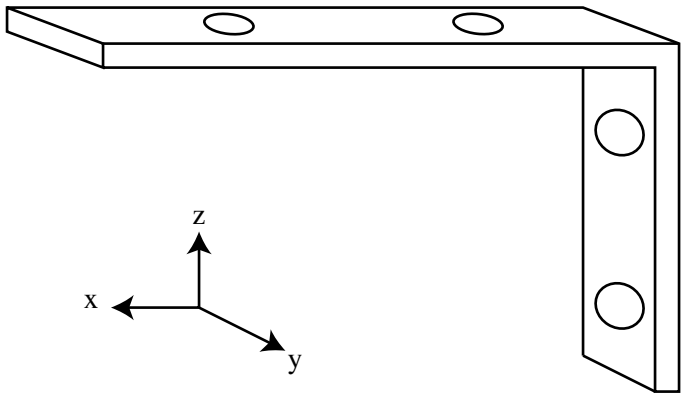
Terrain following algorithms, in which a vehicle drives across terrain, are very important in many graphics applications. Assume the terrain is represented with a polygonal mesh. The simplest algorithms keep track of which polygon the vehicle is in as it drives over the terrain, and set the height of the vehicle appropriately. The information about which polygon the vehicle is in is kept up to date by, on each frame, testing if the vehicle has left its current polygon and, if so, finding out which neighboring polygon it has entered.

Design a polygon mesh data structure for the terrain. Indicate the classes you would use and the member variables. Pay particular attention to which features of the mesh you explicitly store, and which relationships between features. Do not worry about syntax – we care only about the information you choose to store.

Question 2:

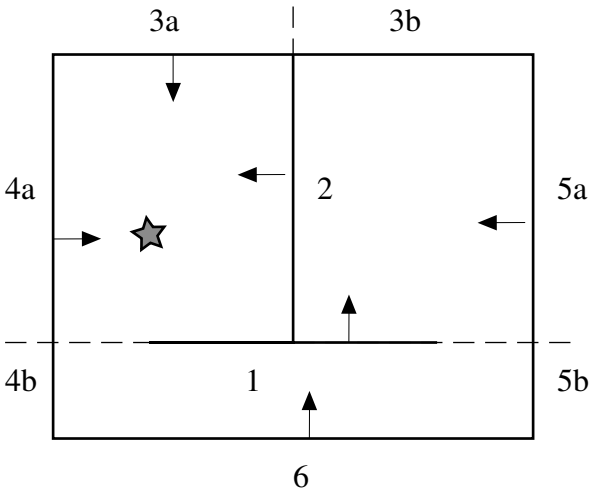
You wish to model the shelf bracket shown below as a CSG object. You have two primitives: a cube of side length 2 with its origin at the center, and a cylinder with radius 1 and height two also centered at the origin with its axis aligned with Z. Give the tree structure, including all of the transformations and the operations to perform at the internal nodes.

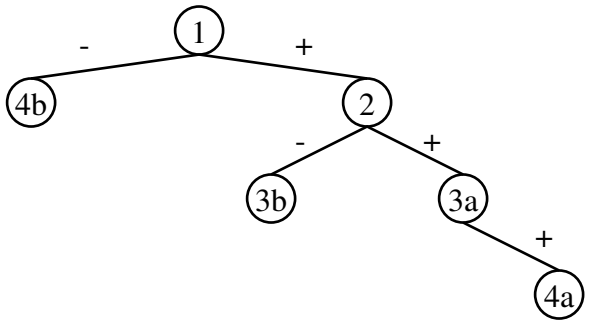
You are free to choose the scale of the picture, and the precise location of the holes. The axes only indicate the orientation, and you are free to put the origin of your bracket anywhere. But be sure that your tree is consistent.



Question 3:

Consider the partially built BSP tree for the scene below. Arrows on the edges point to the "inside."



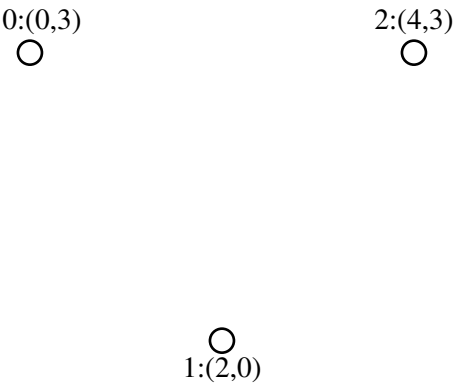


a. Complete the tree by adding nodes for 5a, 5b and 6.

b. Give the rendering order for back-to-front rendering if the viewer is located at the star on the image.

Question 4:

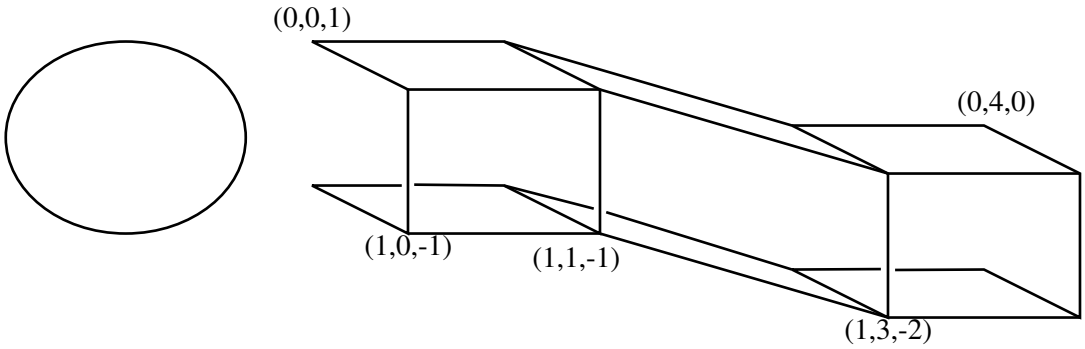
Below is the control polygon for a Bezier curve, with the vertices labeled with their order in the sequence and their 2D location. Use de Casteljau's algorithm to find the point that is at parameter value $t = \frac{2}{3}$. You only need to find the geometric location - do not attempt to find the coordinate values. You must show your working.



Question 5:

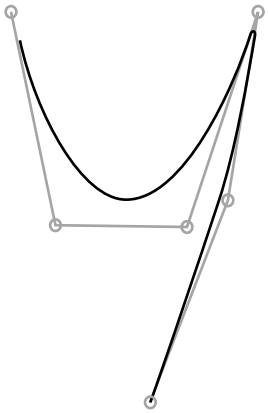
You are required to design a slightly curved pipe using two Bezier patches. The cross section of the pipe is shown on the left, with the control mesh *for one half* of the pipe on the right. Some of the control point locations have been speicifed already.

Fill in the rest of the control point coordinates (in 3D) for the half of the pipe given. You must take into account the continuity conditions for the join with the other half, even though it isn't shown. You must also ensure that the curves around the openings of the pipe are planar. Otherwise, you are free to assign coordinates as you like.



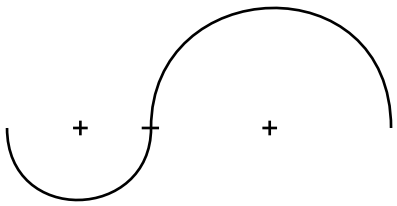
Question 6:

B-spline curves can be forced to be tangent with their control polygons or interpolate vertices by repeating control vertices multiple times. The figure below shows a B-spline curve and its control polygon. Label each vertex of the control polygon (in grey) with the number of times that vertex is being repeated.



Question 7:

The figure below shows two pieces of circular arcs, joined at the point indicated by the small horizontal bar. The center of each circle is also marked, and the centers lie on a straight line through the join point.



a. Each arc is uniformly parameterized such that $t = 0$ is at the left-most point on the arc, $t = 0.5$ is at the midpoint of each arc, and $t = 1$ is at the right-most point. Do the arcs join with C^1 continuity?

b. Do the arcs join with G^1 continuity?