Computer Graphics	Prof. Brian Curless
CSE 591	Spring 2002

Homework #2

Assigned: Wednesday, June 5, 2002

Animator snapshot and artifact due: 12:00 PM,Wednesday, June 12, 2002

Written assignment due: 6:30 PM, Wednesday, June 12, 2002

Directions:

Please provide short written answers to the questions in the space provided. If you require extra space, you may staple additional pages to the back of your assignment. You should work on the assignments ***individually***. Feel free to contact the instructor for clarifications.

1. Animator artifact (50 points)

For your final artifact, you will use your animation program to animate your model from project #2. The teaching staff will grade this artifact on artistic and technical merit, and the grade counts toward half of your homework grade for this assignment.

You should try to employ the ideas described in John Lasseter's paper on the principles of animation (included in your course reader). Your animation should be no more than 40 seconds in length. In many cases, animations seem to play as though they're in slow motion. It's generally better to make the animation shorter and play faster.

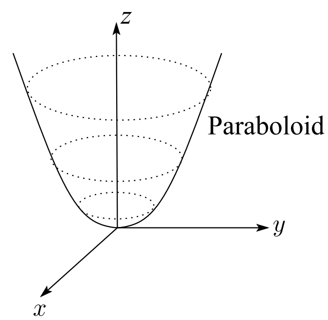
In addition to the staff grading, we will have an in-class voting session during which we will play all the artifacts and decide collectively which are the top five artifacts. Winners will receive cool prizes! To make the in-class voting run as smoothly as possible, we require that you turn in the following by **12:00 PM (Noon) on Wednesday, June 12**:

- You must prepare a single snapshot image of your artifact from some moment in time during your animation. We will compile these images and hand them out with voting ballots. The images will help everyone to keep track of the animations as we play them one after another.

- You must turn in the animation itself, either as an AVI file or as an executable with animation file. If you submit the executable with animation file, please arrange it so that your animation loads at startup. See the project page for more details.

2. Ray Tracing Implicit Surfaces (24 points)

There are many ways to represent a surface. One such way is to define a function of the form $f(x, y, z) = 0$. Such a function is called an *implicit surface* representation. For example, the equation $f(x, y, z) = x^2 + y^2 + z^2 - r^2 = 0$ defines a sphere of radius r. Suppose that you want to ray trace the paraboloid surface defined by the function $z = x^2 + y^2$.



a) Find the implicit function *f* such that the equation $f(x, y, z) = 0$ defines this paraboloid.

b) Now suppose that you are given a ray $\mathbf{p} + t\mathbf{d}$, where **p** is the origin of the ray and **d** is the direction of the ray. Solve for *t* such that the ray intersects the paraboloid. Show your work, and have your answer be in terms of $\mathbf{p} = (p_x, p_y, p_z)$ and $\mathbf{d} = (d_x, d_y, d_z)$.

2. Ray Tracing Implicitly Defined Surfaces (cont'd)

c) Suppose that $\mathbf{p} = (2,4,8)$ and $\mathbf{d} = (-1,-1,-1)$. Where does this ray intersect the surface? If there are multiple intersections, be sure to give all points.

d) The normal N of an implicitly defined surface is given by the gradient of the implicit function. In other words, $\mathrm{N}(x,y,z) = \left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z} \right)$. Give the function N for the paraboloid. What is a *unit* normal at $(1,2,5)$? ***Show your work.***

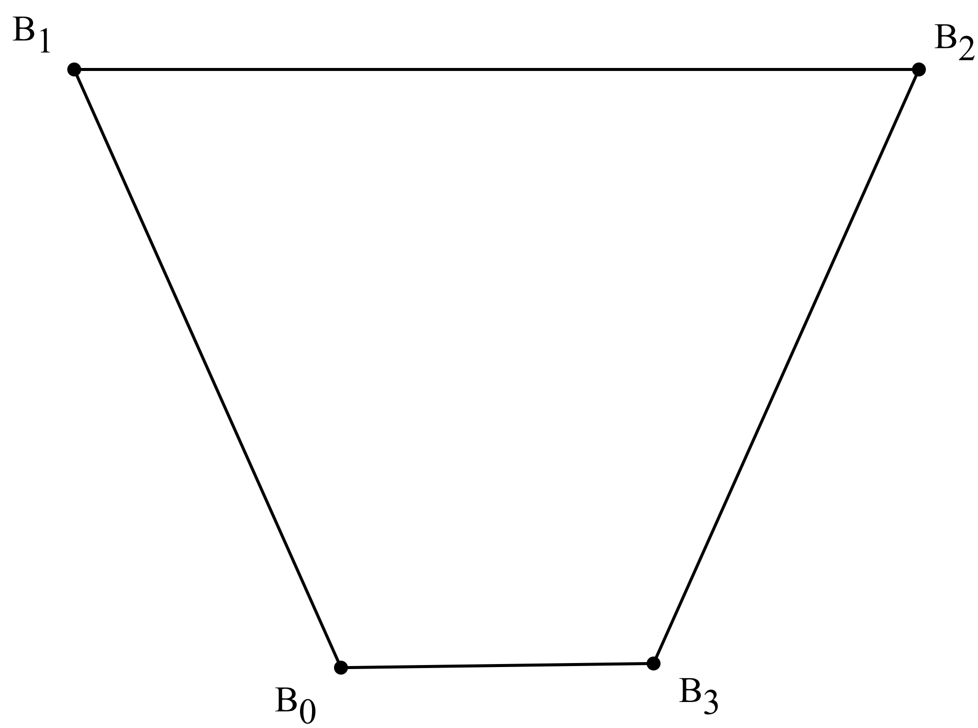
3. Constructing Splines (26 points)

By connecting a sequence of Bézier curves together, we can construct spline curves such as B-splines and Catmull-Rom splines.

In this problem, you will construct Bézier control points and sketch curves. You only need to get the lengths of line segments approximately right, and you need only label the diagrams as requested in the problem statements.

a) Consider a **closed-loop cubic B-spline** curve with control points, B_0, B_1, B_2, and B_3.

- Construct all of the Bézier points generated by these control points, and label them T_0, … T_3, then U_0, … U_3, etc.
- Use the de Casteljau algorithm to generate a point at u=1/3 on the curve segment starting nearest to B_1.
- Sketch the curve (just an approximate sketch that suggests the shape is sufficient).

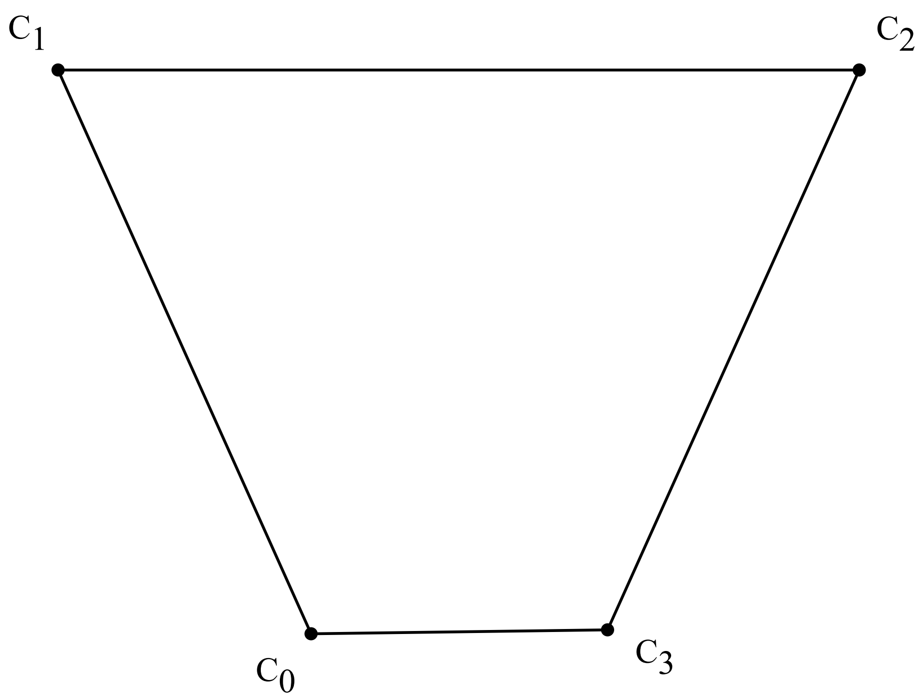


b) If you move one control point in your sketch, will the whole curve change? Justify your answer.

3. Constructing Splines (cont'd)

b) Consider a **closed-loop Catmull-Rom** curve with control points, C_0, C_1, C_2, and C_3 and default tension, $\tau = 1/2$.

- Construct all of the Bézier points generated by these control points, and label them $T_0, \ldots T_3$, then $U_0, \ldots U_3$, etc.
- Use the de Casteljau algorithm to generate a point at u=1/3 on the curve segment starting at C_1.
- Sketch the rest of the curve (just an approximate sketch that suggests the shape is sufficient).



d) If you move one control point in your sketch, will the whole curve change? Justify your answer.