3. [20 points] A degree two Bezier curve \( q(u) \) is defined to trace out the right half of the unit circle in \( \mathbb{R}^2 \) centered at the origin, with control points \( p_0 = (0, 1, 1) \), \( p_1 = (1, 0, 0) \) and \( p_2 = (0, -1, 1) \).

Each value \( q(u) \) is equal to the homogeneous representation of a point \( r(u) \) in \( \mathbb{R}^2 \).

What is \( r'(0) \) equal to? (If \( q(u) \) is the homogeneous representation of the position of a point at time \( u \), then \( r'(0) \) is velocity of the point at time 0.)

4. [20 points] Let \( q(u) \) be the same curve as in Problem 3 (right half of the unit circle in \( \mathbb{R}^2 \)).

(a) Express \( q(u) \) as a degree three (order four) Bezier curve by giving its control points.

(b) Express \( q(u) \) as a degree four (order five) Bezier curve by giving its control points.

For these two questions, \( \mathcal{E} \) is the ellipse which is centered at \((1, 2)\), and has a vertical major radius equal to 3 and horizontal minor radius equal to 2. That is, the bottommost and topmost points on \( \mathcal{E} \) are \((1, -1)\) and \((1, 5)\). And the leftmost and rightmost points on \( \mathcal{E} \) are \((-1, 2)\) and \((3, 2)\).

Very briefly justify your answer. For example, if your answers depend on facts you have memorized about Bézier curves for circular arcs, please explain what facts you are using.

1. Express the top half of \( \mathcal{E} \) as a degree 2 Bézier curve by giving its three control points.

2. Express the top half \( \mathcal{E} \) as a degree 3 Bézier curve by giving its four control points.
For these two questions, $\mathcal{E}$ is the ellipse which is centered at $(1, 2)$, and has a vertical major radius equal to 3 and horizontal minor radius equal to 2. That is, the bottommost and topmost points on $\mathcal{E}$ are $(1, -1)$ and $(1, 5)$. And the leftmost and rightmost points on $\mathcal{E}$ are $(-1, 2)$ and $(3, 2)$.

Very briefly justify your answer. For example, if your answers depend on facts you have memorized about Bézier curves for circular arcs, please explain what facts you are using.

1. Express the top half of $\mathcal{E}$ as a degree 2 Bézier curve by giving its three control points.

2. Express the top half $\mathcal{E}$ as a degree 3 Bézier curve by giving its four control points.
6. [18 points] Answer the questions below either "Yes" or "No" or by selecting the appropriate option i.-iv. The questions assume the shader program has only a vertex shader and fragment shader, and also that the shaders does not access any buffers.

a. Can the vertex shader change the position of the vertex?

b. Can the vertex shader determine if the vertex lies in the view volume?

c. When does backface culling occur? (Circle i., ii., or iii.)
   i. Before the vertex shader is called.
   ii. After the vertex shader is called but before the fragment shader is called.
   iii. After the fragment shader is called.

d. When does clipping to the view volume occur? (Circle i., ii., or iii.)
   i. Before the vertex shader is called.
   ii. After the vertex shader is called but before the fragment shader is called.
   iii. After the fragment shader is called.

e. When do calls to draw functions such as `glDrawArrays` and `glDrawElements` occur? (Circle i., ii., or iii.)
   i. Before the vertex shader is called.
   ii. After the vertex shader is called but before the fragment shader is called.
   iii. After the fragment shader is called.

f. Gouraud shading (averaging colors for Phong lighting) is done: (Circle i., ii., iii., iv., or v.)
   i. Before the vertex shader is called.
   ii. By the vertex shader.
   iii. After the vertex shader is called but before the fragment shader is called.
   iv. By the fragment shader.
   v. After the fragment shader is called.