3D Geometry and Mesh Data Structures

1. Draw a picture of a triangulated polygon that can be drawn using a single triangle fan but not a single triangle strip. No degenerate triangles can be used.

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3. Suppose a triangle has a normal vector of \((1,1,0)\) and that the vector for the view direction is \((1,-2,0)\). Is the triangle front-facing or back-facing?
4. The following vertex buffer is suitable for drawing 3 triangles using `gl.TRIANGLES` and `gl.DRAW_ARRAYS`. Convert the buffer to one suitable for drawing the same triangles using `gl.TRIANGLE_STRIP` and `gl.DRAW_ARRAYS`. Assume we are using a CCW winding order.

| V1 | V2 | V3 | V3 | V4 | V1 | V4 | V3 | V5 |

5. The Euler Characteristic

The Euler Characteristic states the following relationship for the elements of a closed and connected surface mesh:

\[ V - E + F = 2(1 - G) \]

- \( V \) is the number of vertices
- \( E \) is the number of edges
- \( F \) is the number of faces
- \( G \) is the genus of the surface (how holes/handles it has)

Show that for a triangle mesh with no holes we have \( F \approx 2V \). Hint: each face has 3 edges and each edge is shared by 2 faces.

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**Memory Requirements**

Using the fact that \( F \approx 2V \), compare the storage requirements for an indexed face mesh and a triangle soup (in WebGL this corresponds to using `gl.drawElements` versus `gl.drawArrays`). Assume the mesh has \( V \) vertices and a number requires 4 bytes of space. Derive functions for the number of bytes the mesh will require as a function of \( V \).