32. Ray Tracing- Barycentric Coordinates

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Source: 1. Ray Tracing Essentials, Part-1 to 7
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2. 3D Computer Graphics Primer: Ray-Tracing as an Example

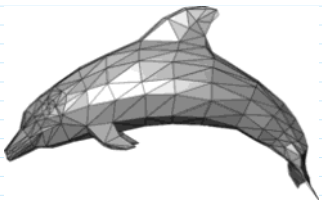
From <https://www.scratchapixel.com/lessons/3d-basic-rendering/introduction-to-ray-tracing/implementing-the-raytracing-algorithm.html>

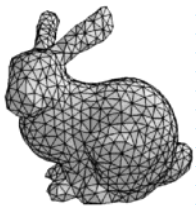
Representation of 3D objects :-

Various geometric primitives :-

1. Circle
2. Polygons.
3. Bezier Surfaces

All these objects are converted into a triangular mesh.



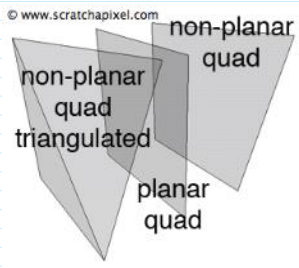


Why triangles ?

Converting a Bezier patch is into a triangle mesh is much simpler than computing ray - Bezier patch intersection. True for all geometric primitives.

Triangles are coplanar :-

Three vertices of a triangle describe a plane, with all three vertices residing in the same plane.



Let polygon is a triangle,

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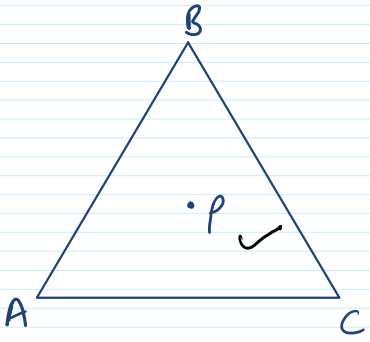


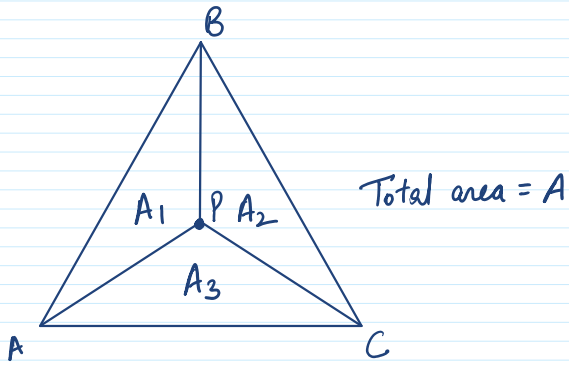
Is point P inside the triangle or outside?

Barycentric Coordinates

$$P = uA + vB + wC$$

A, B, C are the vertices of the triangle.

u, v, w are the barycentric coordinates.



Area Coordinates

$$u = \frac{A_1}{A}, \quad v = \frac{A_2}{A}, \quad w = \frac{A_3}{A}$$

$$u + v + w = 1$$

$$u \geq 0, \quad v \geq 0, \quad w \geq 0$$

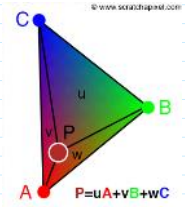
⇒ The point is within the triangle if

$$0 \leq u, v, w \leq 1$$

⇒ If any one of the coordinates is less than zero or greater than one, point is outside.

⇒ If any of them is zero, P is on the lines joining the vertices of the triangle.

Shading using Barycentric Coordinates :-



Let vertex A, B, C as Red, Green, Blue
What is colour at point P?

Barycentric coordinates are used to interpolate vertex data across the triangle's surface.