# 2003 Paper 7 Question 4

## Advanced Graphics

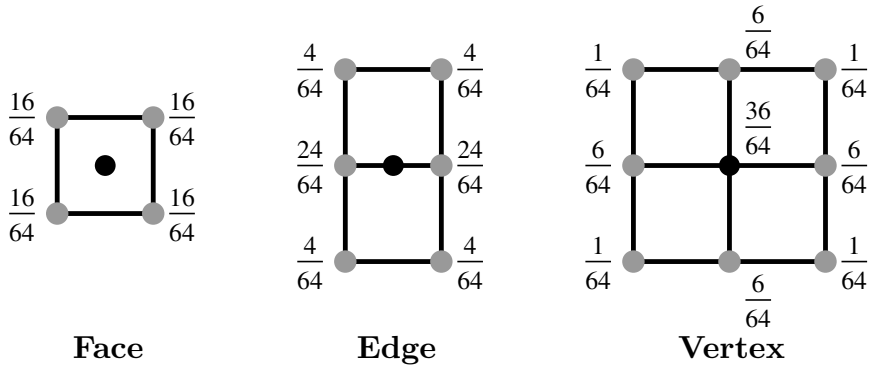
($a$) We want to find the first intersection point between an arbitrary ray and a sphere of arbitrary radius at an arbitrary position in space.

($i$) List and define all of the parameters required to specify the geometry of the ray and the sphere. [2 marks]

($ii$) Give an algorithm which returns the desired intersection point (if it exists) and the appropriate normal vector at the intersection point. [5 marks]

($b$) Describe a method which converts an arbitrary sphere to a triangle mesh at a desired resolution. The desired resolution is specified as a desired number of triangles, $D$. Your method should produce a number of triangles, $N$, which is within an order of magnitude of $D$: $D/10 < N < 10D$. [4 marks]

($c$) The Catmull-Clark bivariate subdivision scheme is a bivariate generalisation of the univariate $\frac{1}{8}[1, 4, 6, 4, 1]$ subdivision scheme. It creates new vertices as blends of old vertices in the following ways:




**Face** **Edge** **Vertex**

($i$) Provide similar diagrams for the bivariate generalisation of the univariate four-point interpolating subdivision scheme $\frac{1}{16}[-1, 0, 9, 16, 9, 0, -1]$. [5 marks]

($ii$) Explain what problems arise around extraordinary vertices (vertices of valency other than four) for this bivariate interpolating scheme and suggest a possible way of handling the creation of new edge vertices when the old vertex at one end of the edge has a valency other than four. [4 marks]