Advanced Graphics

(a) State the Jordan curve theorem. [1 mark]

(b) Given point \( V \) and simple convex planar polygon \( P = \{v_0, v_1, \ldots, v_{n-1}\} \) in \( \mathbb{R}^3 \), express:

(i) A test for whether \( V \) is coplanar with \( P \). [1 mark]

(ii) A test for whether \( V \) lies strictly inside \( P \). [2 marks]

(iii) A test for whether \( V \) lies on the border of \( P \). [1 mark]

(c) (i) Describe an algorithm for ray-tracing a complex CSG (Constructive Solid Geometry) shape. How could your algorithm be represented by a state machine? [4 marks]

(ii) Identify three Boolean operations that your algorithm would support between primitives. [1 mark]

(iii) Would your algorithm perform ray-primitive intersections in local, eye, screen, or world co-ordinates? Why? [2 marks]

(d) (i) Show that the closed uniform B-Spline of degree 2 and with knot vector \( \{0,0,0,1,1,1\} \) is a quadratic Bézier curve. [6 marks]

(ii) Sketch the basis functions of the curve’s coefficient polynomials. Accuracy is not critical. [2 marks]