

7 Further Graphics (aco41)

- (a) State the best geometry representation for the following tasks. Briefly explain.
- (i) Testing if a line segment intersects a surface. [1 mark]
 - (ii) Tracking the surface of a fluid undergoing geometry and topology (connectivity) changes. [1 mark]
 - (iii) Aligning and merging surfaces acquired from different views. [1 mark]
 - (iv) Rendering the surface of a cube. [1 mark]
 - (v) Look up the colour of each point on a surface from a texture. [1 mark]
- (b) Assume constant minimum κ_{min} and maximum κ_{max} curvature for a surface. Which of the following could be a closed surface?
- (i) $\kappa_{min} = \kappa_{max}$. [1 mark]
 - (ii) $2H^2 - K = 0$ for mean curvature H and Gaussian curvature K . [2 marks]
- (c) A heightfield is a surface in 3D defined by a function $h(x, y)$ over the xy -plane. Assuming we define points with $z > h(x, y)$ as outside this surface, provide an expression for the surface normal in terms of the derivatives of h without using the cross product. [4 marks]
- (d) Given a surface in both parametric $\mathbf{p}(u, v)$ and implicit $f(\mathbf{p}) = 0$ forms,
- (i) prove that the surface normal of the parametric form is parallel to the normal of the implicit form.
 $[Hint: Chain rule: \frac{\partial f(a(x), b(x), c(x))}{\partial x} = \frac{\partial f}{\partial a} \frac{\partial a}{\partial x} + \frac{\partial f}{\partial b} \frac{\partial b}{\partial x} + \frac{\partial f}{\partial c} \frac{\partial c}{\partial x}]$ [6 marks]
 - (ii) Will the normals remain parallel if the implicit function is also a signed distance function? [1 mark]
 - (iii) Why is the sign ambiguous? [1 mark]