

Exercises for Alex Benton's lectures

All work must be submitted by email no less than 48 hours before supervision.

These exercises are drawn from past exam questions.

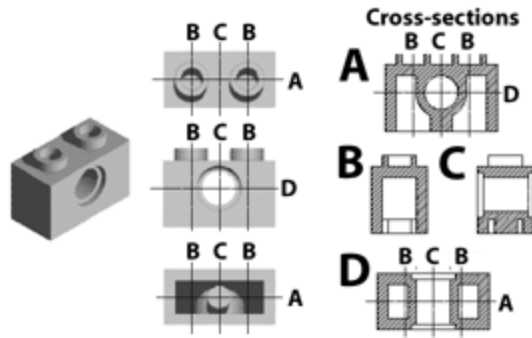
1. Ray / Cone

- a. Show how to find the first intersection between a ray and a finite-length, open-ended (right circular) cone, centred at the origin, aligned along the x-axis, for which both ends of the finite-length are on the positive x-axis (i.e. $0 < x_{\min} < x_{\max}$).
- b. Extend this to cope with a closed cone (i.e. the same cone, but truncated to a frustum with end caps). Take care to consider any special cases.
- c. Extend this further to give the normal vector at the intersection point.

2. Curvature - The *one-ring* of a vertex is the (usually ordered) set of vertices which lie exactly one edge away from a given vertex on a polyhedral surface. Given a vertex V with one-ring $\{v_0, \dots, v_{n-1}\}$, give a formula for the discrete curvature of the surface at V .

3. Constructive Solid Geometry

- a. List the three ways of combining objects using constructive solid geometry (CSG).
- b. Describe how an object built using CSG can be represented using a binary tree.
- c. Given the intersection points of a ray with each primitive in the tree, explain how these points are passed up the tree by each type of combination node to produce a list of intersection points for the whole CSG object.
- d. Show how the Lego™ brick below can be constructed using Constructive Solid Geometry (CSG). You may assume the following primitives: sphere, cylinder, cone, torus, box. [You are expected to describe which primitives are needed and how they are combined but you are not expected to specify accurately all of the parameters of the primitives.]



4. **Radiosity** – Explain form factors and view factors in radiosity. Outline an implementable method of calculating view factors. Describe how your method might leverage existing hardware acceleration.
5. **Photon mapping**
 - a. Explain photon mapping, highlighting the two portions of the algorithm which show *Monte Carlo* integration.
 - b. Explain how photon mapping produces *caustics*.
6. **Implicit Surfaces**
 - a. Explain the special cases in the polygonalization of an octree, and how you might address them.
 - b. Summarize the *marching cubes* algorithm.
7. **Shaders**
 - a. Describe the inputs, outputs, and usage of *vertex shaders*
 - b. Describe the inputs, outputs, and usage of *fragment shaders*
8. **Ray tracing** – A perfectly reflective mirrored sphere, S , is centered at the origin $(0, 0, 0)$. Directly above it is a bright red $2 \times 2 \times 2$ cube, C , centred at $(0, 5, 0)$ and axis-aligned. The default background colour of the scene is blue. A ray-tracing ray R is fired from $(0, 1, 10)$ with direction $(0, 0, -1)$. The scene is lit by an ambient light source and there are no other objects in the scene. What is the maximum radius of S such that the colour calculated for R is red?