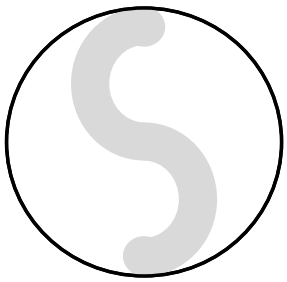
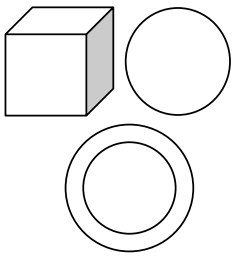
COMPUTER SCIENCE TRIPOS Part II – 2013 – Paper 8

1 Advanced Graphics (NAD)

(*a*) Beginning with a sphere of stone, a sculptor slices the sphere in half and carves a curving path of semi-circular cross-section, tracing the letter S into the flattened face of the sphere as shown at left:





The top and bottom of the S perfectly touch the top and bottom of the hemisphere. The dimensions of the sculpture are as follows:

- Sphere radius: 100cm
- Line width: 20cm
- Radius of the ends of the S: 10cm

Describe how you would build this sculpture using the technique of *Constructive Solid Geometry*. Assume that you have only three primitives, each centred on the origin:

- A *cube*, where each edge is 10cm long.
- A *sphere*, of radius 100cm.
- A *torus*, where the radius of a cross-section of the tube is 2cm and the ring of the tube is a circle of radius 9cm. The torus lies in the xy plane.

For full marks, specify every transformation, in order, for every primitive (e.g., "Translate the cube by 1m up x" or "Rotate this object by 45 degrees around the z-axis") and every binary operation between primitives. [8 marks]

(*b*) (*i*) Given two disks of radius 1, one centered at $(1, 1, 1)$ with normal vector $(0, 0, -1)$ and the other centered at $(1, 1, -1)$ with normal vector $(0, \sqrt{2}, \sqrt{2})$, compute the exact *radiosity* view factor between them. Clearly state the equation you use. Assume there is no occlusion between the two disks. [4 marks]

(*ii*) Briefly describe an efficient mechanism for using modern hardware to compute (approximate) view factors between patches in a radiosity system, including occlusion. [4 marks]

(*iii*) Describe a hybrid method which could produce images which both solve the global illumination problem with a radiosity solution and also correctly portray lighting phenomena such as caustics. [4 marks]