**Candidates are admitted to the examination room ten minutes before the start of the examination. On admission to the examination room, you are permitted to acquaint yourself with the instructions below and to read the question paper.**

**Do not write anything until the invigilator informs you that you may start the examination. You will be given five minutes at the end of the examination to complete the front of any answer books used.**

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**May/June 2013** **SE3VR11 2012/13 A 001**

**3 Answer Books**
**Any calculator (including programmable calculator) permitted**
**Open Book (Notes and books permitted)**

**UNIVERSITY OF READING**

# VIRTUAL REALITY (SE3VR11)

Two hours

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Answer any **THREE** out of FOUR questions.

Use a separate Answer Book for **EACH** Question.

**EACH** Question is worth 20 marks.

1. (a) Three points $A = (1, 1, -0.5)$, $B = (-1, 3, -0.5)$ and $C = (0, 2, 4)$ make up the vertices of a polygon.
What is the normal vector from the polygon's face? (5 marks)

(b) The polygon shown in figure 1 is defined by the points:
$P_0 = (0.2, 0.4, 0)$ and $P_1 = (1.5, 1.55, 0)$.
The polygon needs to be scaled to half its current size, but $P_0$ must remain in the same location.

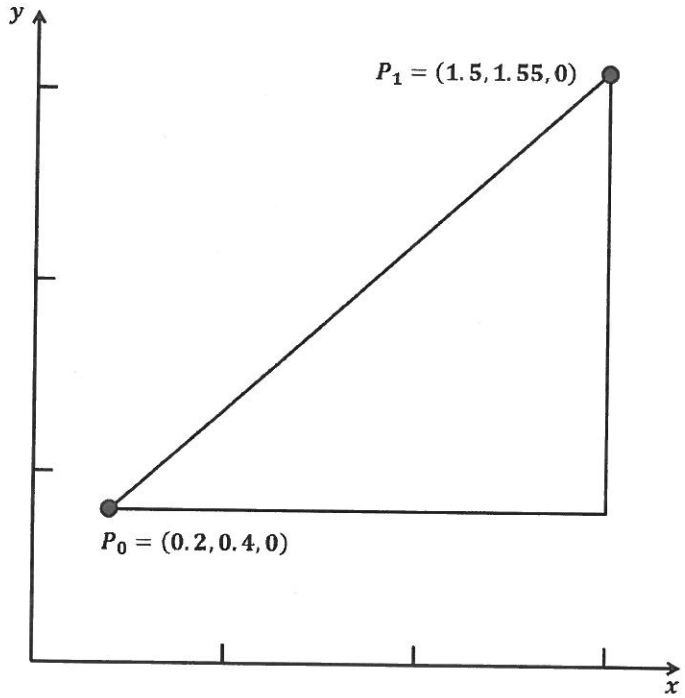


Figure 1

(i) Write down EACH of the matrices needed to perform this operation. (2 marks)

(ii) Calculate a single matrix that would perform the same transformation of the object. (4 marks)

(iii) What is the new coordinate of point $P_1$ after the transformation? (2 marks)

(iv) Calculate a single matrix that will rotate the polygon 90 degrees around the direction of the y-axis about the point $P_0$. (5 marks)

(c) What is a scene graph? Give ONE advantage of using a scene graph in a Virtual Reality application. (2 marks)

2. (a) One of the methods for rendering a 3D environment, which contains objects and light sources, is ray casting.

(i) Basing your answer on the environment shown in Figure 2, describe the ray casting process and sketch what you would expect to see displayed on the computer screen when the scene is rendered. (3 marks)

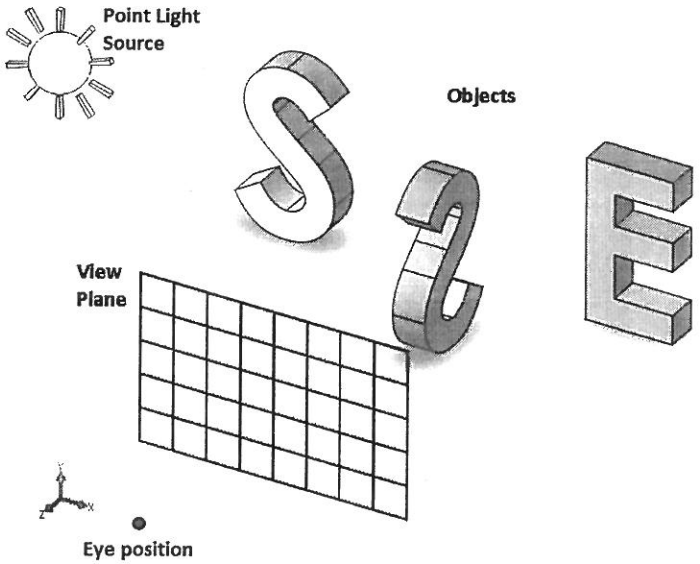


Figure 2

(ii) 3D objects with complex surfaces can take a long time to calculate 3D ray collisions for.
Describe and sketch an approach to increase the rendering speed of a complex 3D object that is illuminated by a point light source. (3 marks)

(b) Name and describe the most common camera model used in computer graphics. Explain TWO advantages of using this model and TWO limitations of this model. (4 marks)

(c) The following questions are based on Constructive Solid Geometry.

(i) How can complex objects be represented using a binary tree? Describe the THREE operations that are used to create Constructive Solid Geometry shapes. (4 marks)

(Question continues over page)

(ii) The object in figure 3 was created using Constructive Solid Geometry.
Describe how this object could be created by drawing a hierarchy of Boolean operations, using the Solid Geometries shown in figure 4, noting any intermediate objects created by these operations. (6 marks)

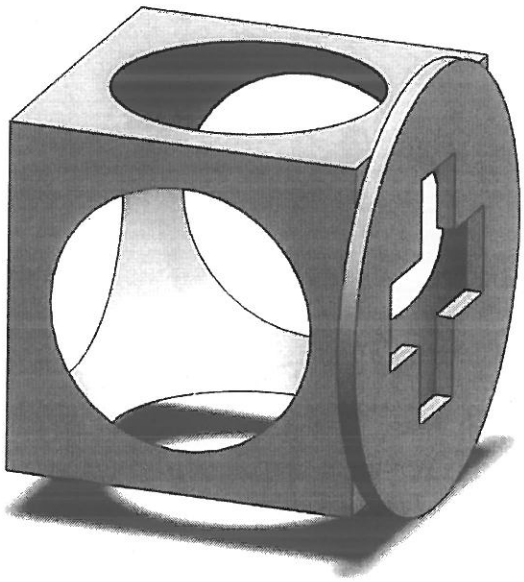

Figure 3

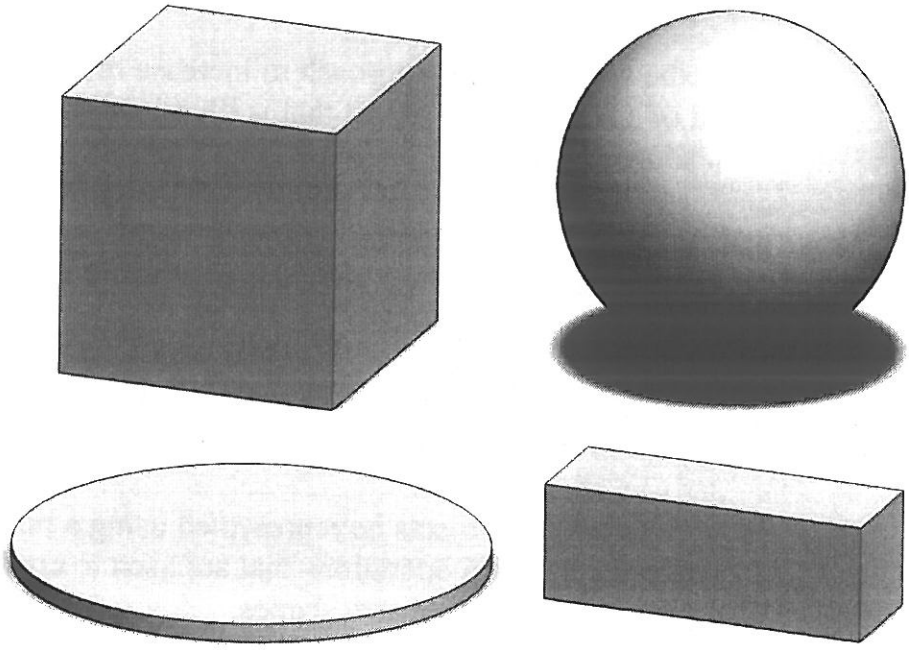

Figure 4

3. Consider a virtual supermarket application. A typical scenario is that the user would enter a virtual supermarket, look for the cereal aisle, move to that aisle, and pick up a box of cereal to read the list of ingredients. While he is reading, the user hears the noise from a virtual box of cereal falling to the ground on his left.

(a) For the different types of interactions involved in this application, discuss the field-of-view and resolution requirements of the visual display. (4 marks)

(b) Suppose the audio display is a set of headphones. Explain how you would spatialise the sound of the noise of the falling box, as described above. (4 marks)

(c) What additional information would you need, to implement spatialised sound, using a world-referenced sound stage as opposed to a head-referenced sound stage? (2 marks)

(d) Ray casting generally has some limitations as a method of manipulation. Discuss these limitations in the context of manipulating the cereal box in this scenario. Suggest an alternative for overcoming any issues. (6 marks)

(e) Discuss the extent to which this scenario qualifies as virtual reality. (4 marks)

4. Consider a virtual supermarket application in which users can shop for bread rolls. Users typically like to feel the rolls to know if they are still warm, to check how hard they are, and to assess how heavy they are. At the virtual supermarket self-checkout, they must type "bread rolls" into a search box.

(a) Explain the haptic exploratory procedures that this application should aim to support, and discuss the feasibility of carrying out EACH of these procedures using a Phantom robot arm. (6 marks)

(b) Explain why a grounded haptic device would be more appropriate for this application, as opposed to a non-grounded device. (2 marks)

(c) For tracking the user's hand position, compare and contrast the suitability of using a Phantom robot arm versus an Intersense wand for this application, in terms of (i) encumbrance, (ii) working volume, and (iii) latency. (6 marks)

(d) Explain why having a lot of metal in the environment is problematic for magnetic sensors. (2 marks)

(e) Explain the basic principle of chording keyboards. Discuss ONE advantage AND ONE disadvantage of a chording keyboard over a traditional keyboard for entering text in this application. (4 marks)

(End of Question Paper)