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.

May/June 2012

SE3VR11 2011/12 A 001

3 Answer Books
Any programmable calculators permitted
Open Book (Notes and books permitted)

UNIVERSITY OF READING

VIRTUAL REALITY (SE3VR11)

Two hours

Answer **THREE** questions.

Use a separate Answer book for **EACH** Question

1. (a) Does the Cartesian coordinate system in figure 1 use the left or right hand rule? (1 mark)
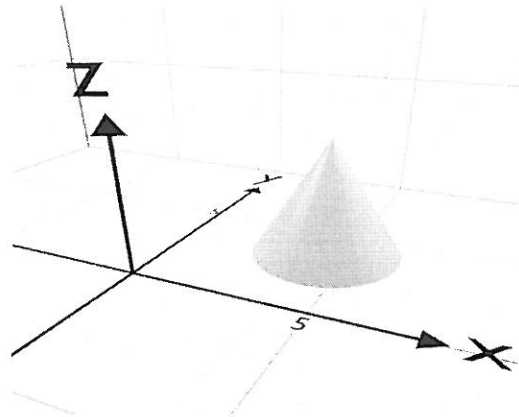

Figure 1.

(b) Given the two vectors $A = \begin{bmatrix} 1 & -2 & 3 \end{bmatrix}$ and $B = \begin{bmatrix} -1 & 3 & 2 \end{bmatrix}$ prove whether or not they are orthogonal with each other. (4 marks)

(c) An object with the centre point $P_0 = \begin{bmatrix} 0 & 0 & 5 \end{bmatrix}$ is moved so that its centre point is now at location $P_1 = \begin{bmatrix} 5 & 1 & 0 \end{bmatrix}$. The object is then rotated around the Y axis by 90 degrees.

  (i) Write the TWO transformation matrices needed for the movements described above. (3 marks)

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

  (iii) What are the coordinates of the object's centre point in its final location? (3 marks)

  (iv) What is the advantage of reducing the transformation matrices into a single matrix like this? (1 mark)

(d) Explain how bounding boxes can be used to optimise the rendering process. (4 marks)

2.   (a)   Explain how flat shading can be very fast to compute compared to other methods.   (2 marks)

(b)   Explain how the Gouraud shading method differs from the flat shading method.   (2 marks)

(c)   The object in figure 2 was created using Constructive Solid Geometry (CSG). Describe how this object could be created by drawing a hierarchy of Boolean operations using the solid geometries in figure 3. Sketch any intermediate objects created by these operations.   (6 marks)
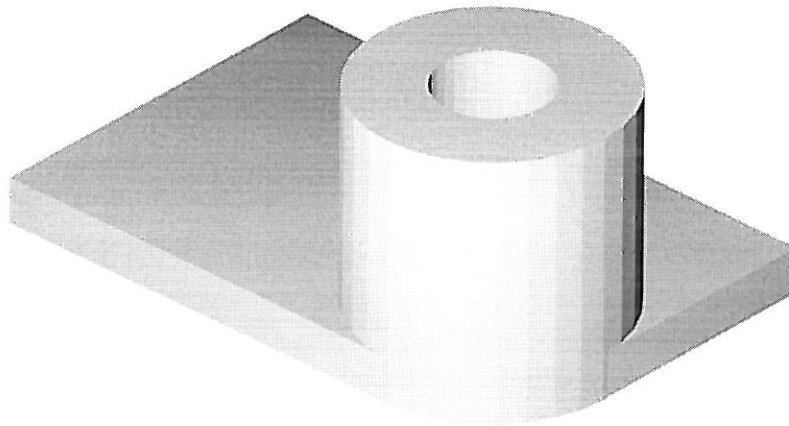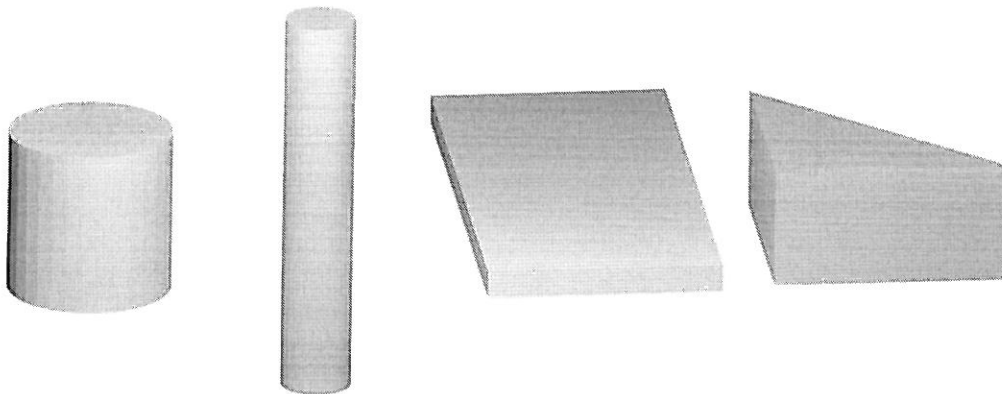

Figure 2.

Figure 3.

(Question continues over page)

Turn over

(d) A surface has specular reflection coefficient $K_s = 0.8$ and specular reflection parameter (hardness) $n = 70$. A point light source is located at $P_{Light} = \begin{bmatrix} 9 & 20 & 5 \end{bmatrix}$ with an intensity $I = 10$, constant fall-off value of $K_c = 0.5$, and linear fall-off value of $K_L = 0.2$. The viewing camera is located at point $P_{View} = \begin{bmatrix} 10 & 18 & 0 \end{bmatrix}$ looking at the surface.

Use the Phong specular-reflection model to calculate the specular intensity of the material at point $P_{Surface} = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$ where the face normal is $V_{Normal} = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}$ $V_{Normal} = 0,1,0$ and the reflection vector is $R = \begin{bmatrix} 0.4 & 0.89 & -0.22 \end{bmatrix}$. Calculate to TWO decimal places.

(10 marks)

3. A bathroom designer is designing a bathroom using the University of Reading's CAVE system. In addition to placing and manipulating objects in the virtual environment, she also needs to annotate objects with text.

    (a) Due to a fault with the projector, the right wall of the CAVE is "off" and hence does not display any image. Discuss the consequent effects on the field of view, field of regard, and level of immersion. (4 marks)

    (b) When the projector gets replaced, why is it important to check for geometric continuity? How does geometric discontinuity manifest itself? (2 marks)

    (c) In this application, a ray-casting technique is used for object selection and manipulation.

        (i) Discuss how well the ray-casting technique works for rotating an object in place. (3 marks)

        (ii) How does the HOMER interaction method differ from traditional ray-casting, and what are HOMER's advantages for rotating an object in place? (3 marks)

    (d) Compare and contrast inertial and acoustic tracking systems in terms of working volume and line-of-sight requirements. Comment on how the inertial and acoustic sensors in a hybrid tracking system complement each other. (4 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)

4.   A virtual reality application has been designed to train archaeologists to plan excavations in grassy fields. In the real world, archaeologists would poke a 1.5m metal rod into the grass at various points in the excavation site. Based on the sound and feel of the rod as it penetrates the ground, the archaeologist is able to get a sense of what lies beneath the grass – e.g. the presence of stone walls. The virtual reality application is intended to simulate this process using a Haptic Master to push the metal rod into the ground and to display haptic feedback, and a head-mounted display with built-in headphones for audio and visual feedback.

(a)   Explain why the Haptic Master arm moves freely when the end-effector is pushed, but does not move when the arm is pushed from elsewhere (e.g. by grabbing hold of the cylindrical arm). (4 marks)

(b)   Explain why the Haptic Master is better than a Phantom device for this application in terms of simulating

(i)   the actual length of the rod and

(ii)   the end of the rod hitting a rock.   (4 marks)

(c)   How do head-mounted displays achieve stereopsis, in contrast with autosterescopic displays?   (4 marks)

(d)   Discuss the human factors that should be considered when working with head-mounted displays.   (4 marks)

(e)   Without headtracking, will the system be using a world-referenced or a head-referenced sound stage? Discuss to what extent the absence of head tracking will affect the user's perception of the audio.   (4 marks)

(End of Question Paper)