

On admission to the examination room, you should acquaint yourself with the instructions below. You must listen carefully to all instructions given by the invigilators. You may read the question paper, but must 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 2015

SE3VR11 2014/15 A 001

3 Answer Books & Treasury Tag
Any calculator (including programmable calculator) permitted
Open Book (Notes and books permitted)

UNIVERSITY OF READING

VIRTUAL REALITY (SE3VR11)

Two hours

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

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

EACH Question is 20 marks.

1. (a) Three points; $A = (2, -5, -1.5)$, $B = (4, -3, 2.5)$ and $C = (-1, 1, -2.5)$ make up the vertices of a polygon. Assuming a clockwise winding, calculate the normal vector for the front face of the polygon. (6 marks)
- (b) The polygon shown in Figure 1 is defined by the points: $P_0 = (0.4, 1.2, 0)$ and $P_1 = (2.2, 0.4, 0)$. The polygon needs to be scaled to quarter of its current size, but P_0 must remain in the same location.

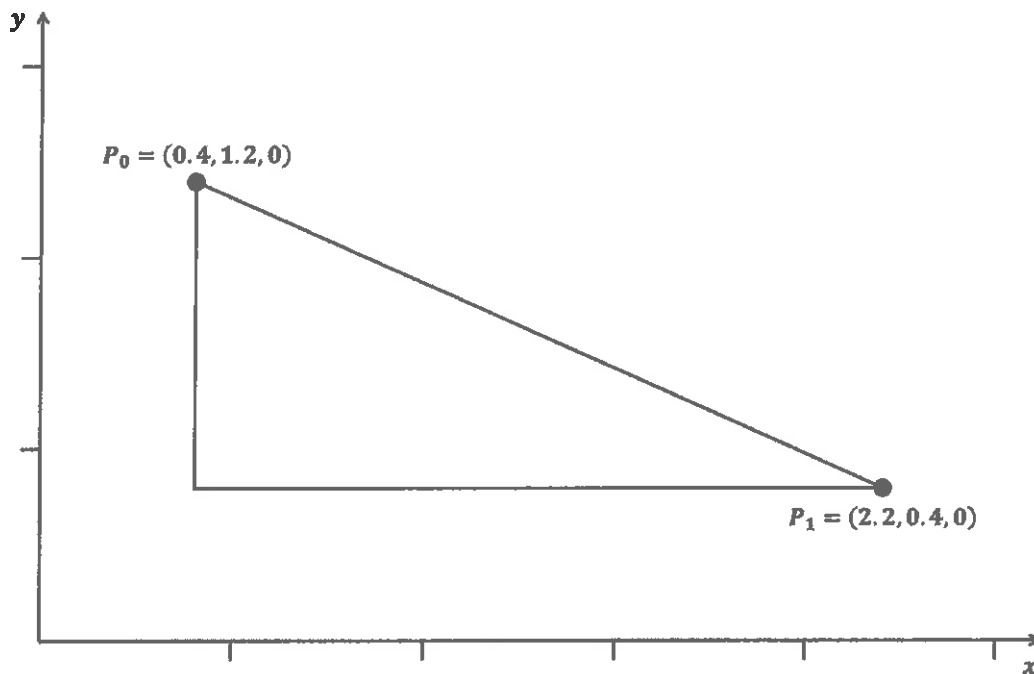


Figure Q1

- (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 60 degrees around the direction of the x-axis about the point P_0 to 3 decimal places. (6 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 Q2-1, would the rendered image using the view plane contain enough visual detail for the letters to be read, assuming one ray per cell? Explain your answer.

(1 mark)

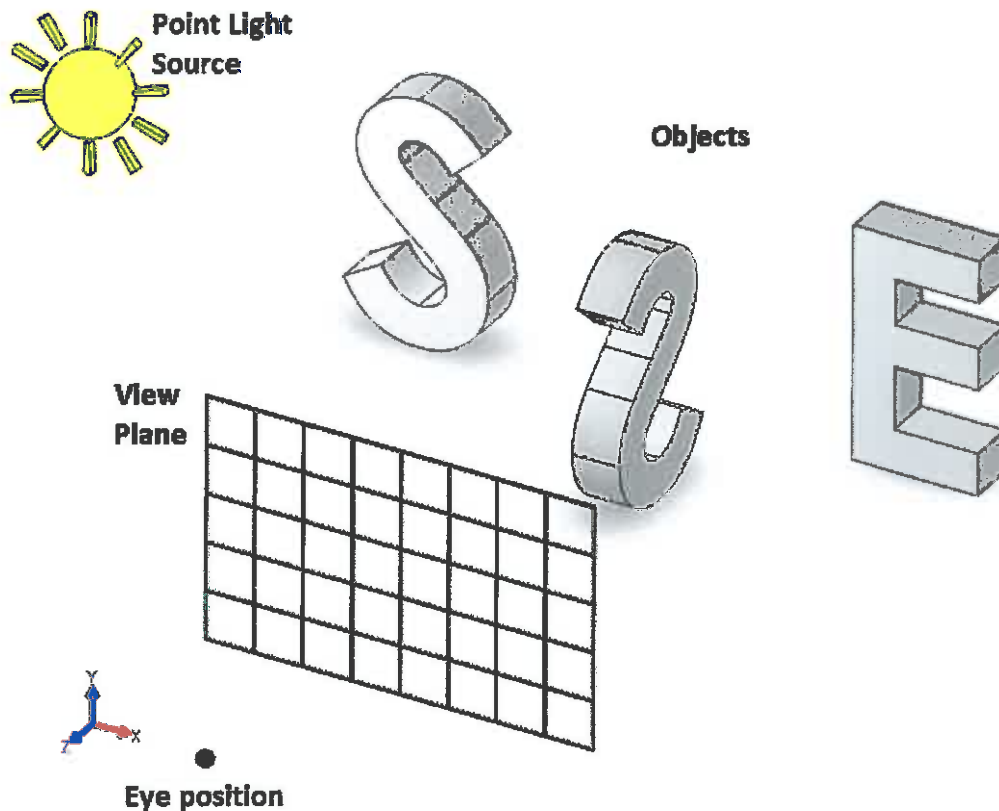


Figure Q2-1

- (ii) The render settings include a ray bouncing value. If set to 'three', describe how a ray would interact with objects in the environment during the render process. What properties would the ray 'pick-up' during each bounce? (3 marks)
- (iii) Describe THREE common systems of lighting. Include detail of how they differ from each other. (4 marks)
- (iv) Describe how the OpenGL Phong reflectance model is built from multiple sub-models. Detail the differences between these sub-models. (4 marks)

(Question continues over page)

- (b) The following questions are based on Constructive Solid Geometry.
- (i) Describe three situations that can result in invalid geometry when described by two objects in CSG. (2 marks)
 - (ii) The object in Figure Q2-2 was created using Constructive Solid Geometry. Detail how this object could be created by drawing and describing the hierarchy of Boolean operations, using the Solid Geometries shown in Figure Q2-3, sketching intermediate objects created by these operations. (6 marks)



Figure Q2-2

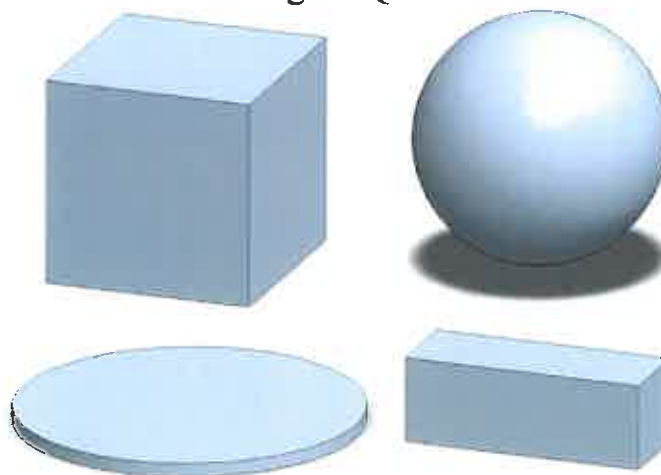


Figure Q2-3

3. You have been asked to consult on a large infrastructure project for a company that wishes to implement immersive visualisation in their design office. Please answer the following questions with this in mind.
- (a) Considering the project needs to visualise large infrastructure, such as buildings, why might a CAVE type system be suitable. Describe your thoughts detailing THREE advantages of using a CAVE type system for this application. (4 marks)
 - (b) A rival company is trying to use personal head mounted display (HMD) systems to visualise the same data. In terms of computing performance and user interaction argue both for and against utilising HMDs for this application. (4 marks)
 - (c) Embedded within the building model there are sound cues, including street noise, machinery (such as drills and jack-hammers), wind noise and virtual conversations. Answer the following sub-questions with this in mind.
 - (i) What is required to produce an audio display within a CAVE system, such that users can easily localise sounds? Detail the hardware and software required, including the number and positioning of speakers. (3 marks)
 - (ii) Imagine you are stood outside a virtual room with an open door, and inside the room there is a conversation. Describe how audio is affected by environmental cues. (3 marks)
 - (iii) The ambient sound outside the building simulation is a combination of street noise, wind sound and the noise coming from a jack hammer. This noise however is not meant to be heard when inside the building simulation. Describe TWO approaches to ensure the noise does not follow a user into the building. (3 marks)
 - (iv) How can local environmental noise break a user's perception whilst using virtual reality? Would you want to block out local sound entirely? Give your reasoning. (3 marks)

4. (a) For each of the following, explain if there are any conditions where it might be considered a haptic interface.
- (i) A standard computer mouse (2 marks)
 - (ii) Nociceptor and Nociception (1 mark)
 - (iii) Haptic Bandwidth (2 marks)
 - (iv) Force Feedback (1 mark)
 - (v) Degrees of Freedom (2 marks)
- (b) You have been asked by a drugs company to develop a haptic device to train new clinical staff how to administer vaccinations. Answer the following sub-questions with this in mind:
- (i) Describe THREE potential benefits of using haptics for this application. (3 marks)
 - (ii) Describe key components required to immerse the user in the task of administering a vaccination, detailing essential requirements of those components. (4 marks)
- (c) You have been given a force feedback data-glove to use inside a fully immersive virtual environment, such as a CAVE. Answer the following sub-questions with this in mind:
- (i) Describe TWO advantages and TWO disadvantages of using the data-glove inside the CAVE. (3 marks)
 - (ii) To expand the data-gloves functionality it can be 'grounded' using another haptic system. Which system would you choose and why? (2 marks)

(End of Question Paper)