GMV - VIVE

Electronic calculators are permitted.

Note : where an algorithm is asked for, you may write in any suitable pseudo-code. Correct syntax for any computer language is not expected.

Answer *three* questions, at least one from each of Part A and Part B

PART A

1. a) Explain the use of Homogeneous Coordinates in Computer Graphics for representing transformations in three-dimensional space. Include in your answer a definition of *identity transformations*, *inverse transformations* and *concatenation* of transforms.
[8 marks]

b) What is the relationship between a transformation of an object in a fixed coordinate system, and the transformation of a coordinate system around a fixed object ?
[4 marks]

c) The equation of an infinite plane is $ax + by + cz + d = 0$. What is the surface normal of this plane? What is the significance of its direction ?
[3 marks]

d) Derive the transformation that reflects in this plane by taking the following steps :

i) Find the position of a point on this plane by considering the intersection of one of the coordinate axes with the plane. Show how to ensure that such an intersection does exist.
[3 marks]

ii) Give the transformation that translates this point to the origin.
[2 marks]

iii) Show how a combination of rotations around two of the principle axes can be used to align the surface normal with the z-axis.
[6 marks]

iv) Give the transformation for a reflection in the xy plane.
[2 marks]

v) Combine the answers to ii)-iv) above to derive the transformation that reflects in the required plane. (You may leave your answer as a sequence of transformations without explicitly concatenating them).
[5 marks]

[**TURN OVER**]

2. a) How does half-toning help to convey the impression of different intensity levels on a bi-level output device ?

[5 marks]

b) How many intensity levels may be simulated by using a 4 x 4 pattern of binary pixels to represent one grey pixel ?

[2 marks]

c) An image has been calculated for display on an eight-bit display device. What is the maximum range of values in the pixels representing this image ?

[2 marks]

d) The image is to be displayed on a bi-level device using the dither matrix shown :

$$D^{(4)} = \begin{matrix} 1 & 9 & 3 & 11 \\ 13 & 5 & 15 & 7 \\ 4 & 12 & 2 & 10 \\ 16 & 8 & 14 & 6 \end{matrix}$$

Show how to divide up the original greyscale range into the range that may be simulated using this dither matrix. Give the half-tone patterns that represent original greyscale values i) 15, ii) 74, iii) 150, iv) 239.

[8 marks]

e) The image was originally calculated at 256 x 256 resolution. How would the dither matrix be used to generate the image on the bi-level device at a resolution of i) 1024 x 1024, ii) 256 x 256 ?

[8 marks]

f) Briefly explain how error diffusion may be used as an alternative to dithering. Give examples where each method might perform badly.

[8 marks]

3. a) The 3D viewing transformation may be considered as an Object-to-Image Space transformation **Q**, followed by a projection transformation, **P**. Explain the meaning of the terms *Object Space* and *Image Space* in this process.

[6 marks]

b) **Q** can be derived by considering a camera model specified by only three vectors : a *Camera position vector, a View Direction*, and *a View Up direction*. Explain the meaning of these terms, and indicate how **Q** is derived using them. (Note : you are not required to derive explicit forms for the transformations)

[12 marks]

c) Explain the difference between parallel and perspective projection transformations, **P**. What extra piece of information is required for the second of these two processes ?

[6 marks]

d) What subsequent transformations must be applied to transform the object scene into a viewport area on a 2D output device ? Explain the advantages of using a 3D normalised viewing volume.

[9 marks]