

3 Computer Graphics and Image Processing (PR)

Consider the transformations used in the construction and rendering of a three-dimensional model on a screen.

- (a) List the three principal transformations in the processing pipeline and explain their rôles. [6 marks]
- (b) Why is it convenient to represent the transformations as matrices? [2 marks]
- (c) What are homogeneous coordinates? Explain how they are used in modelling these transformations as matrices. [2 marks]
- (d) Derive the matrix to represent a perspective transformation for a viewer at the origin of a point in three dimensions to a point on a screen in the plane $z = d$. [5 marks]
- (e) Perspective in classical art has *vanishing points* towards which parallel lines converge. Explain mathematically why this is the case and show how to calculate the location on the screen of the vanishing point for lines in a particular direction. [5 marks]

[*Hint:* It may be helpful to represent lines parametrically in vector form as $\mathbf{P}(s) = \mathbf{A} + s\mathbf{V}$ where \mathbf{V} is a direction and \mathbf{A} is any point on the line.]