Computer Graphics and Image Processing

(a) We use homogeneous coordinates to represent transformations in 3D space:

\[
\begin{bmatrix}
    x'_H \\
y'_H \\
z'_H \\
w'_H
\end{bmatrix} =
\begin{bmatrix}
a_{11} & a_{12} & a_{13} & b_1 \\
a_{21} & a_{22} & a_{23} & b_2 \\
a_{31} & a_{32} & a_{33} & b_3 \\
c_1 & c_2 & c_3 & d
\end{bmatrix}
\begin{bmatrix}
x_H \\
y_H \\
z_H \\
w_H
\end{bmatrix}
\]

(i) Explain how to convert standard 3D coordinates, \((x, y, z)\), to homogeneous coordinates and how to convert homogeneous coordinates to standard 3D coordinates. [2 marks]

(ii) Describe the types of transformations provided by each of the four blocks of coefficients in the matrix \((a_{11} \cdots a_{33}, b_1 \cdots b_3, c_1 \cdots c_3, \text{ and } d)\). [6 marks]

(iii) Explain what transformation is produced by each of the following matrices:

\[
\begin{bmatrix}
    1 & 0 & 0 & 0 \\
    0 & 1 & 0 & 0 \\
    0 & 0 & 1 & 0 \\
    0 & 0 & 1 & 0
\end{bmatrix}
\]

\[
\begin{bmatrix}
    1 & 0 & p & -p(1 + r) \\
    0 & 1 & q & -q(1 + r) \\
    0 & 0 & 1 + r & -r(1 + r) \\
    0 & 0 & 1 & -r
\end{bmatrix}
\]

[4 marks]

(b) Describe an algorithm (in 2D) which clips an arbitrary polygon against an arbitrary axis-aligned rectangle. [8 marks]