1. (21 pts) The point coordinate \( P \) can be expressed as \( P = 3i + 0j \), where \( i \) and \( j \) are basis vectors of unit length along the \( x \) and \( y \) axes, respectively. Describe the point \( P \) in terms of the 3 other coordinate systems given below.

\[
\begin{array}{cccc}
Ai & Aj & Cj & Ci \\
\hline
Bi & Bj & & \\
\end{array}
\]

2. (3 pts) Write down the 4x4 matrix for scaling an object by 2 in \( y \) and 3 in \( Z \).

3. (10 pts) Give the OpenGL commands required to encode \( M \). You may assume the matrix stack has been initialized with \( \text{glLoadIdentity()} \).

\[
\begin{bmatrix}
1 & 0 & 0 & 1 \\
0 & 1 & 0 & 1 \\
0 & 0 & 2 & 1 \\
0 & 0 & 0 & 1 \\
\end{bmatrix}
\]

4. (6 pts) Homogenize the point \((2,10,8,4)\).

5. (20 pts) Give the 4x4 OpenGL modelview matrix at the four lines A, B, C, and D below.

```cpp
glLoadIdentity();
glTranslate(2,3,0);  // A
glRotate(90, 0,1,0); // B
glPushMatrix();
glScale(1,.5,1);     // C
glTranslate(1,1,0);
glPopMatrix();
glScale(2,1,1);     // D
```
6. (40 pts) For each equation below, sketch the new location $L'$ of the L shape on the grid and provide the OpenGL sequence needed to carry out those operations. Use the function `drawL()`, which draws an L shape with the lower left corner at the current origin as shown below. You may assume the matrix mode is `GL_MODELVIEW` and that the stack has been initialized with `glLoadIdentity()`. For reference, the OpenGL command syntax is `glRotatef(angle, x, y, z)`, `glTranslatef(x, y, z)`, `glScalef(x, y, z)`.

$$A = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad \B = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad \C = \begin{bmatrix} 1 & 0 & 0 & -1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad \D = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

a) $L' = ABC L$

b) $L' = ACD L$

c) $L' = BAB L$

d) $L' = CBA L$

```
drawL();
```