Please check one of the following:

☐ I did not collaborate with anyone in the completion of this homework.
☐ I collaborated with people named below in the completion of this problem set:

Name: ___________________________ Student Number: ___________________________

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1. (15 pts) The point coordinate P can be expressed as (4,3); that is, \( P = 4i + 3j \), where \( i \) and \( j \) are basis vectors of unit length along the x and y axes, respectively, with an origin at the lower left of the grid. Describe the point P in terms of the three other coordinate systems given below (A, B, C).

**Update Jan 22: origin of C coordinate frame moved.**

![Coordinate systems](image)

2. (3 pts) Write down the 4x4 matrix for scale an object by 1 in y, 3 in x, and 2 in z.

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 3 & 0 & 0 \\
0 & 0 & 2 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

3. (4 pts) Homogenize the point (6,3,0,3).

\[
(\quad)
\]

4. (16 pts) Give the 4x4 modelview matrix at the four lines A, B, C, and D in the pseudocode below. Assume the matrix stack has been initialized with `LoadIdentity()`. The transformation direction goes left to right.

```c
LoadIdentity();
translation(1,0,0);
A
rotation(90,0,0,1);
B
scale(2,1,3);
C
translation(0,1,2);
D
```
5. (8 pts) Give the pseudocode required to encode \( M \) with left-to-right direction. You may assume the matrix stack has been initialized with \texttt{LoadIdentity}().

\[
M = \begin{bmatrix}
2 & 0 & 0 & 3 \\
0 & 2 & 0 & 1 \\
0 & 0 & 1 & 2 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

6. (54 pts) For each equation below, sketch the new location \( L' \) of the L shape on the grid and provide the pseudocode sequence needed to carry out those operations. You may assume the matrix mode is \texttt{mvMatrix} and that the stack has been initialized with \texttt{LoadIdentity}().

For reference, the pseudocode transformation is \texttt{scale}(x,y,z), \texttt{rotation}(\theta, x,y,z), \texttt{translation}(x,y,z).

Show your partial work, with the position that the L would be drawn after each transformation.

Do these computations in both directions: from left to right (moving coordinate frame), and also from right to left (moving object). You will get different intermediate answers, but the final position of the L should be the same each way; it's a good way to cross-check your work! You don’t need to rewrite the pseudocode from right to left, once is enough.

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

a) \( L' = BC L \)

Left to Right:

Right to Left:
b) L' = CDAC L
Left to Right:

Right to Left:

c) L’ = ADCC L
Left to Right:

Right to Left:

d) L’ = ACBD L
Left to Right:

Right to Left:
e) $L' = ACDB \ L$

Left to Right:

Right to Left:

f) $L' = CCBC \ L$

Left to Right:

Right to Left: