CPSC 314
Assignment 1

due: Wednesday, October 11, 2006, 4pm
Worth 9% of your final grade.

Purpose: (a) to test your understanding of geometric transformations; (b) to apply this towards building a hierarchical articulated figure animation.

Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

Name: _____

Student Number: _____

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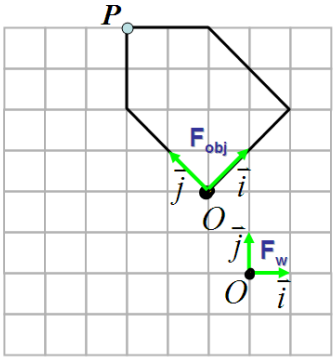
1. Composing Transformations



$$\begin{bmatrix} \\ 1 \end{bmatrix}_{w} = \begin{bmatrix} \end{bmatrix} \begin{bmatrix} \\ 1 \end{bmatrix}_{obj}$$

(a) (4 points) Express point P in world coordinates, i.e., F_w. Express point P in object coordinates, i.e., F_{obj}. Assume $z = 0$ for all points on the house in F_w and F_{obj}. Give the 4×4 transformation matrix M that should be used to draw the house, i.e., that takes a point in known object coordinates and transforms it to world coordinates. Verify that you get the correct answer for point P.

(b) (2 points) Given $M = Trans(a, b, 0)Rot(z, \theta_1)Scale(c, c, c)$, provide the values of a, b, c, θ_1 that would implement the given transformation.

(c) (2 points) Given $M = Rot(z, \theta_2)Trans(d, e, 0)Scale(f, f, f)$, provide the values of d, e, f, θ_2 that would implement the given transformation.

2. (3 points) Give the 4×4 modeling transformation matrix that results from the following OpenGL commands. Show the reasoning or steps used to arrived at your answer.

```
glLoadIdentity();
glTranslate(1,-3,0);
glRotatef(-90,0,0,1);
glPushMatrix();
  glScale(3,3,3);
  glTranslate(0,1,0);
glPopMatrix();
glRotatef(-90,0,0,-1);
```

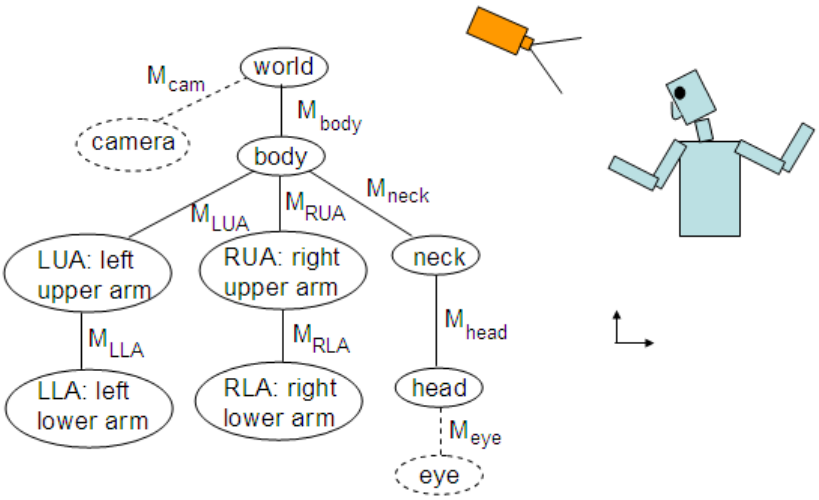
3. (5 points) A rotation matrix has a number of distinct properties, and should represent a rotation that a real physical object can undergo, i.e., without any scaling, stretching, etc. The columns of a rotation matrix should all have magnitude 1, and they should all be orthogonal to each other, i.e., have a zero dot product. In addition, there is one other more minor constraint. Are each of the following 4×4 matrices a valid rotation matrix ? Why or why not? Can you think of what the extra constraint should be ?

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad B = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$C = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad D = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. (3 points) Determine the viewing transformation, M_{view}, that takes points from WCS (world coordinates) to VCS (viewing or camera coordinates) for the following camera parameters: $P_{eye} = (-20, 10, 10), P_{ref} = (0, 10, 10), V_{up} = (0, 0, 1)$. Do not bother with numerically inverting any matrices.

5. Consider the scene graph of a simple character and a camera. The transformation matrices associated with each link take a point from the child's coordinate frame (lower end of the link) to the parent's coordinate frame (upper end of the link). Note that M_{cam} takes a point from the camera coordinate frame to the world coordinate frame. There is geometry associated with each node in the scene graph, except the eye and the camera. Assume all the given transformations are known.



(a) (1 point) Give an expression for the transformation matrix that would be used when drawing the left lower arm, as seen from the camera's point of view. I.e., give the transformation matrix that takes a point from left-lower-arm coordinates to camera coordinates.

(b) (3 points) Using the following calls, give the code that would be used to draw the character from the camera's point of view.

```
glLoadIdentity();    // T = I
glMultMatrix(M);     // T = T*M
```

```
glPushMatrix();     // push copy of matrix onto top of stack
glPopMatrix();      // remove top of stack
DrawObj(RUA);       // draws geometry associated with RUA frame
DrawObj(world);     // draws geometry associated world frame
...
```

(c) (1 point) Suppose that we now want to see the scene from the point of view of our character, i.e., the camera is now placed at the eye of our character. Give an expression for the transformation matrix that would be used when drawing the left lower arm. I.e., give the transformation matrix that takes a point from left-lower-arm coordinates to eye coordinates.

(d) (3 points) Using the same function calls as above, give the code that would be used to draw the character and objects in the world from the eye's point of view.