October 14, 2010 Name ___________________

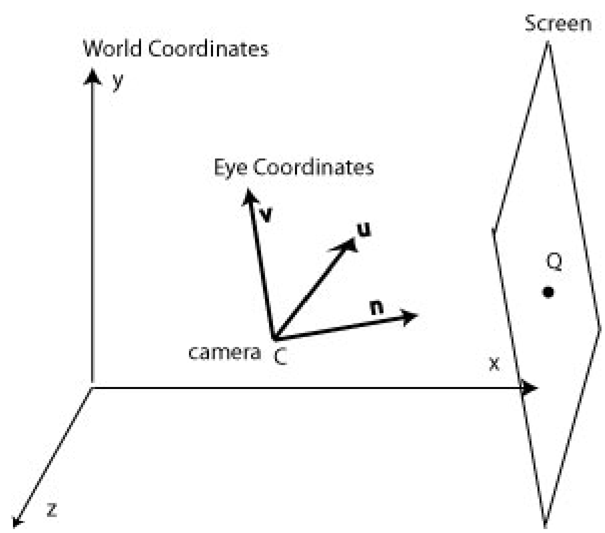
CS445 Midterm

Fall 2010

1.	(max = 10)	5.	(max = 6)
2.	(max = 18)	6.	(max = 12)
3.	(max = 8)	7.	(max = 10)
4.	(max = 16)	8.	(max = 20)
Final Score _________(max=100)			

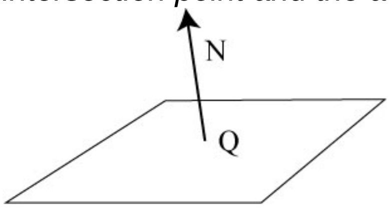
1) (10 pts) Given the following inputs:
   - C = camera location
   - Q = location of the center of the screen (i.e. the camera look-at point)
   - VUP = the up direction vector

   How does one calculate the normalized eye coordinate basis vectors, u,v,n, (see picture). Assume we are using a *right handed* coordinate system as shown. Show your work.



2) (6 pts each, 18 pts total)

a) For a plane defined by a normal N and a point Q, how does one calculate the point of intersection of the plane with a ray defined by $P=P_0 + t\ dir$. That is, what is *both the t value at the intersection point and the actual coordinates of the point p(x,y,z) itself*. Show your work.



t = ____________   p(x,y,z) = _________________________

b) Show the calculation for both t and p(x,y,z) given :

$P_0 = (1,1,2)$, N = (2, -1,1), dir = (-2,1,1), Q = (1,4,3).

t = ____________   p(x,y,z) = _________________________

c) How do you tell if the ray is parallel to the plane but not lying in the plane?

3) (2 pts each, 8 pts total) Given the vectors: v1 = (1, 0, 0), v2 = (-1, 0, 0), v3 = (0,0,1), v4 = (0,1,0) Evaluate the following where the symbol × indicates the cross product. (You do not need to explicitly calculate the cross product, but instead, you just need to reason about it)

a) v1 × v1 = ______________

b) v1 × v2 = ______________

c) v1 × v3 = ______________

d) v1 × v4 = ______________

4) (4 pts each, 16 pts total) 2D Transforms: What is the 3x3 matrix transform (in homogeneous coordinates) for the 2D transformations below. Also give the inverse.

a) Scale by s_x in the x direction:

The transform: The inverse:

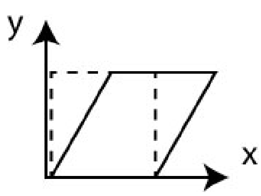
b) A negative rotation of θ degrees:

The transform: The inverse:

c) A reflection about the y-axis.

The transform: The inverse:

d) A shear by α along the x axis



The transform: The inverse:

5) (6 pts total) Determinants:
   a) (2 pts) What does the determinant tell you about the transform?

   b) (4 pts) What is the determinant for the following transformations:
      i) Uniform scale by 3.

      ii) A rotation of 68 degrees:

6) (6 pts each, 12 pts total) *2D Transforms*: Give the *sequence* of matrix transformations (order matters!) that is required to do the following transformations. You do not need to give the actual matrix. Instead, identify each matrix using the syntax $S(s_x, s_y)$ for a scale, $R(\theta)$ for a rotation, $T(t_x, t_y)$ for a translation. For each, also give the *sequence* of transformations needed to obtain the inverse.

   a) Scale uniformly by 5 about the point at (-1,10).

      Inverse:

   b) Scale by 5 along a positive 45 degree angle about the point (4,9)

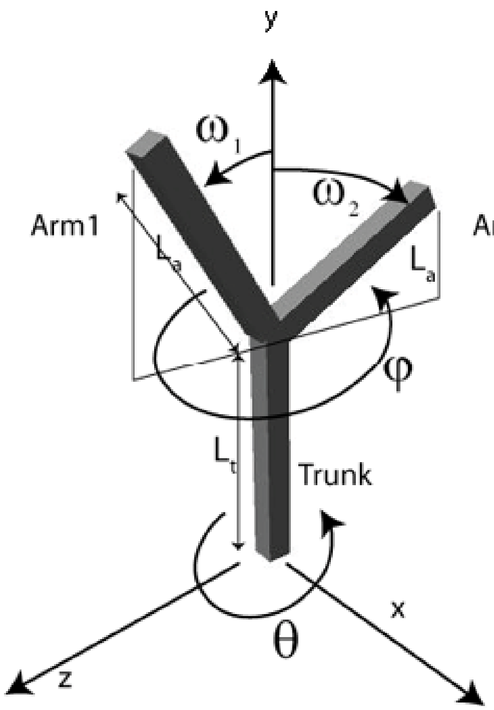
      Inverse:

7) (5 pts each, 10 pts total) In the graphics pipeline:

a) What are Model Coordinates? Why are they used?

b) What are Eye Coordinates? Why are they used?

8) (20 pts total) Below is an adjustable rack used to hang and display items in a store. The trunk can be 1) translated about the floor and 2) rotated about a vertical axis (θ) about its center. Attached to the trunk are two arms which rotate *together* about a vertical axis (φ). However, they can also independently rotate up and down by angles $\omega 1$ and $\omega 2$. The trunk has length L_t and the arms are both of length L_a. Assume the unlabeled dimensions are of length 1.



Draw the <u>scene graph</u> for the rack. Be sure to include all transformations needed to scale, move and place each part properly in the scene.

For the trunk and arms, assume you start with a cube, e.g. the glut cube class which draws a unit cube centered at the origin.

Scale transformations should be indicated as `scale(sx,sy,sz)` where you fill in specific values for `sx`, `sy`, and `sz`.
Similarly, translations and rotations should have the form `translate(tx,ty,tz)` and `rotate(angle, axis)`, respectively.
Indicate push/pops where needed.