International Institute of Information Technology, Hyderabad
CSE 251:Spring-2015: Graphics
Mid Term 1

Max. Points: 100 [Time: 90 Mins]

Answer the following questions briefly and precisely. Avoid verbosity. [$5 \times 20 = 100$]

1. Consider the following sequence of transformations applied to an object in 2 dimensions: The object is first scaled by 2.0 along both axes, then rotated by -60 degrees (clockwise), then translated by the vector $(4, 5)$. All transformations are applied with respect to the world co-ordinate frame.
   (a) Derive the composite transformation matrix for the above transformation.
   (b) If the order of translation and rotation are interchanged, will the resultant transformation be different? Why or why not?

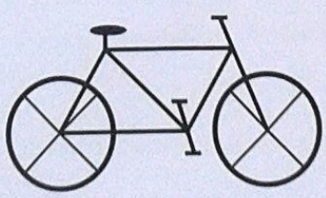
2. Consider an arbitrary $3D$ rotation matrix (not in homogeneous co-ordinates) shown below. Note that this is could be rotation about an arbitrary axis, not just about one of the co-ordinate axes.

$$\begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}$$

   (a) What can you say about the nature of the rows (or columns) if this matrix?
   (b) Prove that: *"The co-ordinate axes will be aligned with the first, second and third columns of the matrix after rotation"*

3. Prove or give a counter example for the following statements regarding commutativity of transformations. You may use examples in 2D.
   (a) Two translations is commutative. i.e., $T_1T_2 = T_2T_1$.
   (b) Two rotations is commutative. i.e., $R_1R_2 = R_2R_1$.
   (c) Scaling and translation are commutative. i.e., $ST = TS$.
   (d) Rotation and translation are commutative. i.e., $RT = TR$.

4. Assume that you have three classes: a cube, a cylinder and a sphere, available to you. You can create instances of cubes, cylinders, and spheres by declaring: *Ring* $r1(radius, x, y)$; *Cylinder* $c1(start_x, start_y, angle, length)$; and *Seat* $s1(size, x, y)$;. These classes contain draw functions that will draw the instance of the shape when you make a call such as $r1.draw()$.



(a) Draw a simple bicycle (as shown above) using the above objects (draw on paper), and mark the co-ordinates of the wheels (rings), etc.

(b) Construct the above bicycle hierarchically using OpenGL-like commands for modeling. For each transformation that you write, give a comment as to what you are doing with respect to your figure. Note that you only need to give the modeling and drawing calls and not the window setup, projection, etc. Write your assumptions about the draw functions of the objects.

5. In the previous question, assume that the cycle wheels rotate at the same speed as the pedal (one rotation of pedal equals one rotation of wheel).

(a) Describe how you will draw the cycle at time t if the pedal is rotated at a rate of 1 cycle per second.

(b) Give the OpenGL commands to draw the cycle at time t.