CSC418/2504F Fall 2005: Midterm Test:
Wednesday, Oct. 26, 2005, 7:00 PM
Evening Section

Family Name:_____

First Name: _____

Student ID: _____

Instructions:
   Attempt **all** questions.
   There are four questions.
   The total mark is 30.

   You have 50 minutes to complete the test.

   Aids allowed: Brain, writing implements.
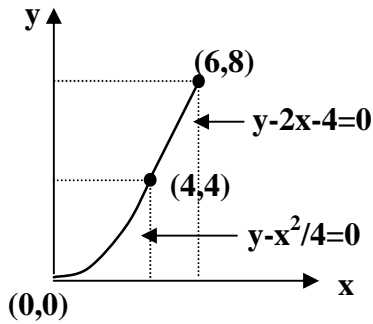   Textbooks, calculators and notes are NOT allowed.

         1:       /12

         2:       /6

         3:       /6

         4:       /6

   _____

     Total: /30

1. **Vectors and line/curve drawing - 12 marks**: We would like to develop a Bresenham-like algorithm using only integer arithmetic to draw the shape shown. The shape is parabolic defined by the equation $y-x^2/4=0$ between the points **(0,0)** and **(4,4)** and a straight line between the point **(4,4)** and **(6,8)**, $y-2x-4=0$.

a. **3 marks**: What pixels are turned on for the line between **(4,4)** and **(6,8)?**

b. **2 marks**: What is the unit normal vector to the parabola at a point **(a,b)**?

c. **3 marks**: A Bresenham-like algorithm iterates over one coordinate to generate a line or curve segment between two points with integer coordinates. Define the segments (using pairs of points) that the overall shape would need to be broken into and explain why?

d. **4 marks**: Does the point **(1,1/2)** lie above or below the parabola? How is this useful in determining the pixel adjacent to **(0,0)** that should be turned on?

2. **Transformation – 6 marks:** A 2D bead necklace is constructed below by placing beads angularly equi-spaced around an ellipse. The ellipse is a unit circle at the origin that is scaled non-uniformly into an 8x5 ellipse (in **x** and **y** respectively) and then rotated counterclockwise by 30 degrees. Prior to placing the bead each bead is uniformly scaled to twice its size. What is the overall 3x3 transformation matrix for the ith bead if the first bead is placed along the positive semi-major axis as shown.

Note: Indicate the individual transformation matrices for each step and leave the final result as a composition of matrices in symbolic form.
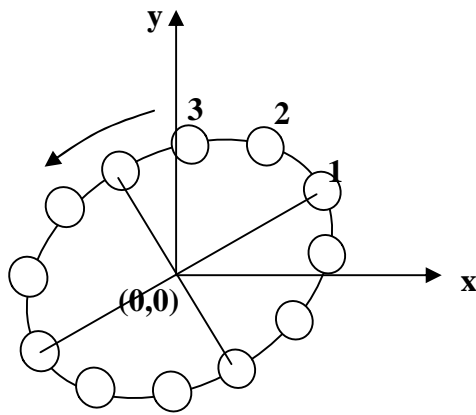
3. **Projection - 6 marks**

    a. **2 marks**: Explain with an illustrated example why an object thrice as far from the viewpoint as another object a third its size appears to be of the same size as the smaller object, under perspective projection.

b. **4 marks**: Parallel lines typically converge to a point in the image plane under perspective projection. Is this always true? If not, given a family of parallel lines defined by a direction vector **l** and a viewing direction vector **v**, how can one determine if the family of lines will converge to a single point under perspective projection.

4. **Visibility and the graphics pipeline - 6 marks** (True or False with reason, 1.5 marks each, **NO marks** without the correct reason).

   a. Polygons can be clipped to the 3D canonical view volume after a perspective divide.

   b. For a single object in a scene removing back-faces completely resolves visibility, i.e. all the remaining faces are visible.

   c. Resolving the visibility of **n** objects with an object space algorithm can have time complexity $O(\mathbf{n}^2)$ in the worst case.

   d. If the centroid of a triangle A is closer to the eye than the centroid of triangle B, visibility is resolved by rendering A after B.