15-462 Homework 2

Due Date: Thursday, December 3, 2009, at the beginning of lecture

1. **Image Processing**
   
   What does the following kernel do when convolved with an image?
   
   \[
   \begin{bmatrix}
   0 & 1 & 0 \\
   0 & 0 & 0 \\
   0 & -1 & 0 \\
   \end{bmatrix}
   \]

2. **Differential Equation**
   
   Solve the following system analytically
   
   \[
   x' = -x \\
   x(0) = 1
   \]
   
   Pick a time step and integrate the system numerically for three iterations using Euler method. What behavior do you expect from \( x \)?

3. **Shadow**
   
   Imagine a vertical pole illuminated by the sun and the sky. Which parts of the shadow will be sharp, and which blurry? Why?

4. **Rendering**
   
   Choose the best algorithms to render the following types of scenes: (a) object with diffuse surfaces, (b) transparent and specular objects, and (c) glasses with caustics.

5. **Intersection**
   
   Intersect the ray starting at \((x_p, y_p, z_p)\) going in direction \((x_d, y_d, z_d)\) with the quadratic surface \( z = x^2 + y^2 \). Note that the solution will be of the form:
   
   \[
   \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
   \]
   
   and it is sufficient to give expressions for \( a, b, \) and \( c \).