1. In the figure below, the 3D segment \( AB \) is projected by a standard perspective camera to the image segment \( ab \). The point \( C \) on \( AB \) bisects \( AB \) in a ratio of \( t:(1-t) \), and its projection \( c \) bisects \( ab \) in a ratio of \( s:(1-s) \). Denote by \( Z_A, Z_B, Z_C \) the depths of \( A, B \) and \( C \).
   
   A. Express \( t \) as a function of \( s, Z_A, Z_B \) (in particular show it is independent of the focal length).
   
   B. Express \( Z_C \) as a function of \( s, Z_A, Z_B \) (simplify the result).

![Diagram showing perspective projection and bisecting points]

2. In this question we explore recovering information from the perspective projection of a rectangle.
   Assume the camera is a standard perspective camera, i.e. the focal point is at the origin and the \( X \) and \( Y \) axes of the world coordinate system are aligned with the \( x \) and \( y \) axes of the camera.
   A rectangle (on some tilted plane) is projected by the perspective camera into a quadrilateral.
   The vertices of the quadrilateral in the image are at \( p_1=(0,0.2828) \), \( p_2=(0.1818,0.5143) \), \( p_3=(0.0952,0.6734) \) and \( p_4=(-0.1053,0.4466) \).
   
   A. The edges of the rectangle define two directions in 3D. Find their vanishing points.
   
   B. Find the vanishing line of the 3D plane of the rectangle.
   
   C. Let \( r_1 \) be a ray from the focal point of the camera through one vanishing point on the screen, and \( r_2 \) a ray from the focal point through the second vanishing point. Are \( r_1, r_2 \) orthogonal?
   
   D. Compute the focal length.
   
   E. Find the normal to the plane of the rectangle.
3. A corner of a box (with three orthogonal faces) is imaged under orthographic projection as shown below, where \( p_0=(0,0), p_1=(-2,1), p_2=(0,2) \) and \( p_3=(3,1) \).
   A. Compute \( Z_1-Z_0, Z_2-Z_0, Z_3-Z_0 \), where \( Z_i \) is the depth of \( p_i \).
   B. Compute the normals to the box faces.

4. Read chapters 1-5 in the OpenGL programming guide (the “red book”). An online version is at [http://www.glprogramming.com/red/index.html](http://www.glprogramming.com/red/index.html). This reading is intended to prepare you for the next programming assignments.