1. Light and shading
   
   (a) Given a scene with two non specular objects, one yellow ($k_a = k_d = (1, 1, 0)$) and one red ($k_a = k_d = (1, 0, 0)$), classify the following statement as true or false. Explain.
   
   i. (1 point) Given a single point light source with intensity $I_p = (1, 0, 0)$ the objects will have the same shading.

   ii. (1 point) Given a single ambient light source with intensity $I_a = (1, 0, 0)$ the objects will have the same shading.

   (b) (1 point) Write the openGL code for defining the following lighting scenario with three light sources: ambient light source with intensity $I_a = (0.3, 0, 0)$; directional light with direction $(1, 0, 0)$ and intensity $(0.6, 0.6, 0.6)$; point light at $(10, 0, 0)$.

   (c) (1 point) In openGL define the material properties for a triangle with $k_a = (1, .5, .5)$, $k_d = (1, .5, .5)$, $k_s = (.5, .5, .5)$ and specularity coefficient $n = 16$. 
(d) In the scene below there is one directional light source at infinity \((\infty, 0, 0)\) with direction \((-1, 0, 0)\). The view direction is the same as light direction \((-1, 0, 0)\). The shading coefficients for the triangle are \(k_a = k_d = (1, 0, 0), \ k_s = (0, 1, 0)\) and the specularity coefficient is \(n = \infty\).

Compute the color at point \(P\) on the triangle using the following shading algorithms (use per-face or per-vertex normals as necessary):

i. (2 points) Flat shading,

ii. (2 points) Gourard shading,

iii. (2 points) Phong shading.
2. Ray-Tracing

(a) (3 points) Draw the ray tree for the ray \( R \) shown below. Assume index of refraction \( c_1 \) for air is 1 and index of refraction for all the transparent objects in the scene is \( c_2 = \frac{1}{\sqrt{2}} \). Use Snell’s law to obtain refraction angles.

(b) (2 points) Assume the transparency coefficient \( \alpha \) for the transparent objects is .5, the light intensity is \( I_p = (1, 1, 1) \) (no other lights), and the diffuse/specular coefficients for the objects are \( k_{d1} = (1, 0, 0), k_{s1} = (0, 0, 0), k_{d2} = (0, 0, 0), k_{s2} = (1, 1, 1), k_{d3} = (0, 0, 0), k_{s3} = (1, 1, 1), k_{d4} = (0, 1, 0), k_{s4} = (0, 0, 0) \). What is the color returned by the ray tracing algorithm for ray \( R \)?
3. Texture Mapping.

(a) (3 points) The following texture is stored in the array image of size $imgx \times imgy$ ($256 \times 256$).

Draw the textured triangle produced by the following code:

```cpp
    glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_S, GL_REPEAT);
    glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_WRAP_T, GL_REPEAT);
    glTexImage2D(GL_TEXTURE_2D, 0, GL_RGBA, imgx, imgy, 0,
                 GL_RGBA, GL_UNSIGNED_BYTE, image);
    glEnable(GL_TEXTURE_2D);
    glBegin(GL_POLYGON);
    glVertex3d( 0, 0, 0 );
    glVertex3d( 1, 0, 0 );
    glVertex3d( 1, 1, 0 );
    glVertex3d( 0, 1, 0 );
    glEnd();
```

(b) (2 points) The texture below is stored in a 4 $\times$ 4 “texel” array.

How will this texture look when mapped to a square of 3 $\times$ 3 pixels? Draw and explain.