a) What is the difference between Phong shading and Phong lighting (the Phong reflection model)?

Phong reflection calculates the surface color at each vertex in the vertex shader, which is then linearly interpolated between the vertices (Like Gouraud), to achieve a smoother shading in appearance over flat shading. This means, that specular highlights diminish and look less appealing with low poly objects.

Phong shading takes a slightly different approach and interpolates the normals for each fragment, and then uses these to calculate the surface appearance within the fragment shader, which can produce much better specular highlights for low poly objects, because these are calculated at a finer level (fragments over pixels).

b) What is the difference between flat shading, Gouraud shading, and Phong shading? List pros and cons of each. Is Gouraud or Phong shading the best method for simulating highlights? Explain.

Flat shading calculates the surface appearance for each triangle as a single color using the surface normals, which makes each surface look flat.

Gouraud uses the vertex normals and calculates the color at each vertex, which is then linearly interpolated for each fragment. Due to this linear interpolation, the edges of each triangle are still somewhat noticeable in some lower poly cases.

As mentioned earlier, Phong shading uses linearly interpolated normals, which are renormalized for each fragment in a surface. This renormalization is non-linear and can produce smoother looking surfaces but is heavier on computational resources.

As mentioned in the first question, Phong reflection with linear interpolation like Gouraud produces unappealing specular highlights with low poly objects, which look unrealistic, whereas Phong shading is finer grained. Therefore, Phong shading can produce better results.

c) What is the difference between a directional light and a point light?

With directional light, the light rays are parallel which means, objects will be lit from the same direction regardless of placement. This is ideal for simulating sunlit scenes.

A point light has a position, and sends light in all directions, which means, objects on opposite sides of the light are lit on opposite sides. This could be a lamp in your home.

d) Does the eye position influence the shading of an object in any way?

The eye position affects the specular highlights, because this is a mirror-like reflection. Just like what you see in a mirror depends on your viewing angle and position in relation to the light of the reflected objects.

e) What is the effect of setting the specular term to (0, 0, 0)?

This would eliminate the specular highlighting term from the Phong model, as we have zero multiplication, which results in 0, only leaving the diffuse and ambient terms in the model.

f) What is the effect of increasing the shininess exponent (α)?

The specular highlight depends on the angle between the light reflection in the object, and the direction of the eye to fragment vector, or rather the dot product of the two with a lower bound of 0. This means, that number will be in the range [1, 0], with 1 being a small angle between the two vectors, meaning the light source is reflected directly into the eye at that fragment, and 0 is a 90° angle, so the specular term will have no effect on the color of such fragments. When a number in the range]1, 0[is raised to another number (here the shininess), it will become a smaller number. This means, that increasing the shininess, the specular highlight will be more focused on the middle of the highlight and be less noticeable the further away from the middle of the highlight.

g) In what coordinate space did you compute the lighting?

Directional lights can be computed in local space, whereas positional lights are computed in world space. The specular is computed in eye space, as this term is relative to the camera.