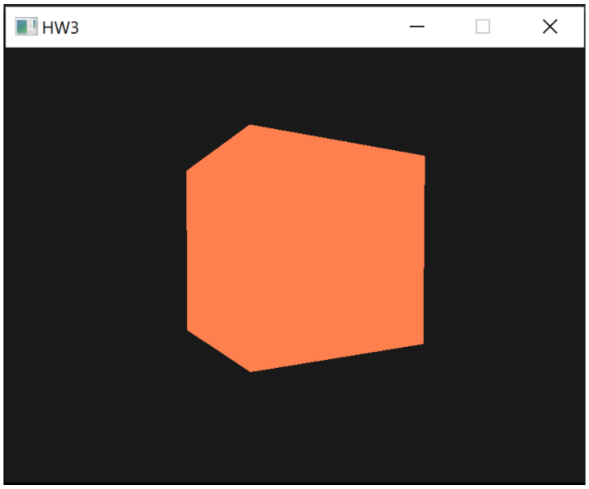
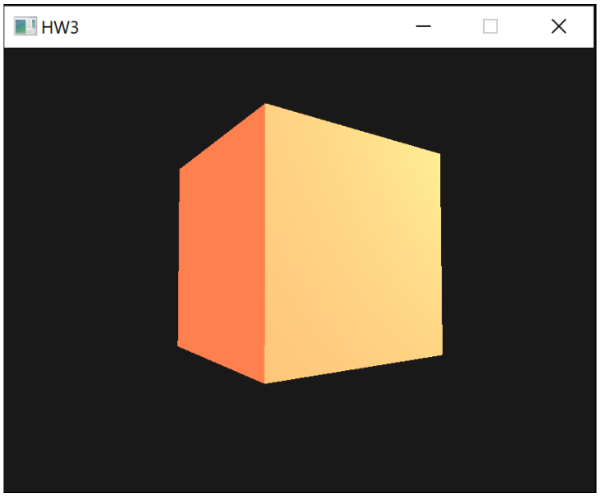
For assignment 3 I was given the task of create lighting on a cube using the Phong shader model. The model is the combination of three versions of light: ambient, diffuse, and specular light. Ambient light is the color of the cube with no real light source. The diffuse light is is the lighting with directional light source. Diffuse light allows there to be a shaded side and different shades depending on the location of the source light and the cube. Specular light is the simulation of the reflection of the light source on the object. To complete this assignment, I used the website “learnopengl”. They have a very good explanation and tutorial for the Phong shader model.

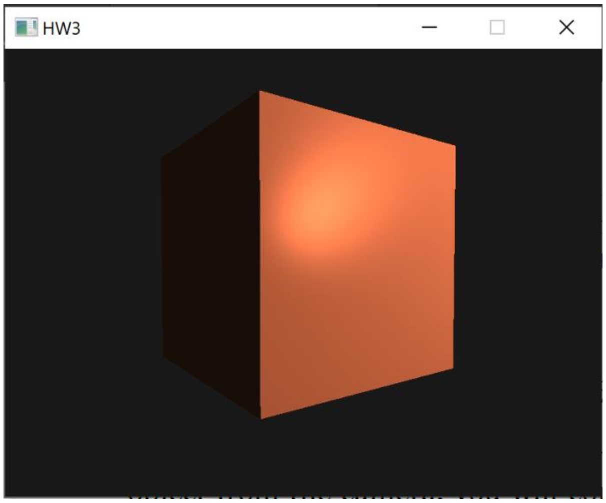
For the assignments code itself, I had to edit the camera.h, phong.vs, phong.frag, and main.cpp. To start with the cpp file I had to set up the projection matrix which uses perspective projection because of the camera in the given code. After that I needed to complete the GetViewMatrix function in the camera header file. After that the code would produce a black window when ran, so now we need to use the phong files to make the cube visible in the window. To do this I started with the ambient light. In the pong.frag file I create the an vec3 variable named “ambient” which is the multiplication of the lightColor variable and the strength of the ambient light which I found to be 1.0 (changed to 0.1 after fully implementing phong model to correct the colors to match the output in the homework pdf). I then had to create a variable named phong which was the multiplication of the ambient variable with the objectColor. I also had Changed the given code for Color at the end of phong.frag to `color = vec4(vec3(phong), 1.0f);`. To see the effects of the ambient code I had to set the gl_Position correctly. After all that I was able to see a red cube in the window after running.



Next I Moved onto diffused light. To do this I had to create 4 new variables, normal, lightDir, diff, diffuse. To find the light direction I had to normalize the difference between lightPos and FragPos. The diff variable is the dot component of the new normal and lightDir variables. after I got diff to find the diffuse variable I simply multiplied diff and lightColor. I then had to add diffuse to the phong variable (`vec3 phong = (ambient + diffuse) * objectColor;`). The ersult of this addition to the phong.frag file is:



Now that I have successfully implemented ambient lighting and diffused lighting all I had left to do is add specular lighting. This was the most complicated of the three, but over all not to bad. I had to create four variable viewDir, reflectDir, spec, and specular. for viewDir we do a similar calculation to the lightDir when implementing the diffused lighting. Then for reflectDir we reflect the negative lightDir so that the reflection is a realistic direction. Now for the spec variable I calculated the dot component of viewDir and reflectDir then raised it to the power of 10. 10 was the value of the highlight that I felt best fit the output example in the pdf. For the final variable specular I calculated it by multiplying the strength of the specular light(in this case I used 0.5), spec, and lightColor. Now that specular light variable is finished we can add it to the phong variable with ambient and diffuse (`vec3 phong = (ambient + diffuse + specular) * objectColor;`). To get the correct colors for the final output I had to change the ambient strength to 0.1. after all that the final output is:



The output is as close as I could get to the example output and I'm happy with it. during this assignment I used the learnopengl (https://learnopengl.com/Lighting/Basic-Lighting). This assignment was very fun to implement and debug since most adjustments were visible when running. It was also interesting to look the code for the camera movement.