Project 3

CS 557 - COMPUTER GRAPHICS SHADERS

Name: Tianle Yuan (933-946-576)

Project Number: 3

Project Name: Displacement Mapping, Bump Mapping, and Lighting

Video Link: https://media.oregonstate.edu/media/t/1_apn2ykyf

Email: yuant@oregonstate.edu

Time: January 26, 2020

- **What you did and explaining why it worked this way**

There are four steps I worked for this project.

The first step is geometry model construction. This step is finished in the vertex shader, which means for each vertex, I get the new coordinate of Z axis direction by recalculating the equation: z = K * (Y0-y) * sin(2.*PI*x/P) according to the original coordinates of X axis and Y axis.

The second step is calculating the normal of the surface. This step is finished in the vertex shader. Normal means the vector that is perpendicular to any vectors on the surface. By considering 2D surface only has 2 degree of freedom, vectors in X axis and Y axis is enough for normal vector's calculation. The theory of the normal calculation is calculating cross product on each vertex, which means after gotten tangent value from both x and y direction we can get the normal vector in X axis direction.

The third step is Lighting, which has been finished in the fragment shader. The reason that we implement this step in the fragment shader is that we can have smoother curved highlights. After passed normal and eye position value from vertex shader to rasterizer, in the fragment shader, final lighted result is blend of three light effect: ambient light, diffuse light and specular light.

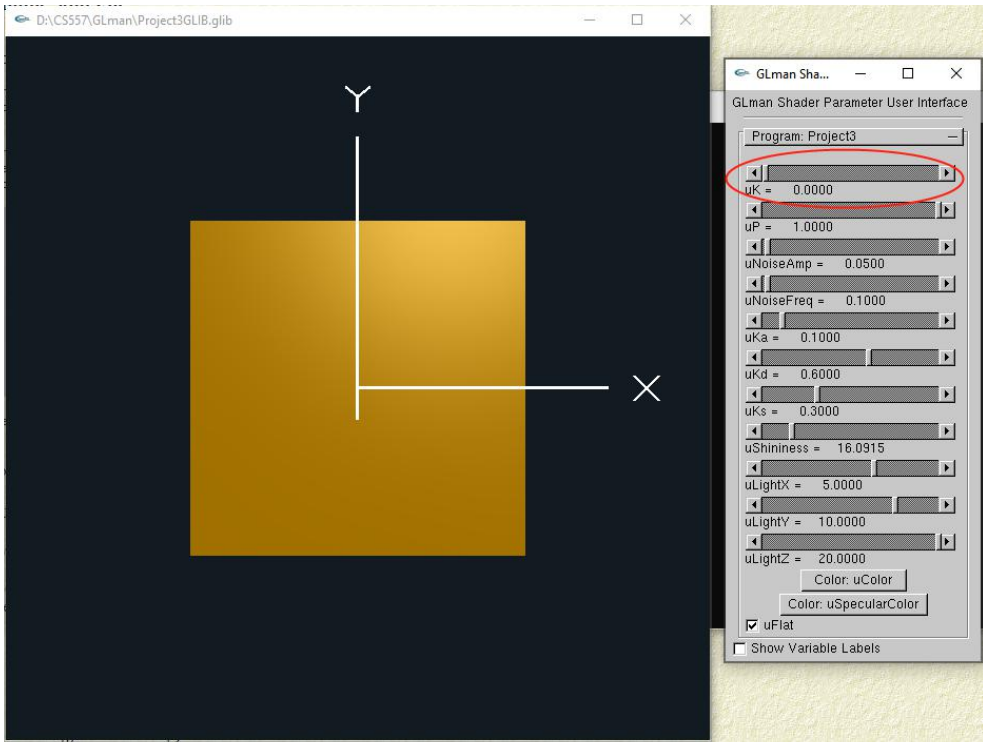
The final step is Bump-Mapping. In the project, I used the 3D noise to recalculate the normal of original 3D surface normal by using normal rotation matrix. The result of the rotation is the new normal that can show the effect that lighting is based on the "eroded geometry". The reason that I used the quotation mark is that the erosion effect is not because of real shape deformation but only the changed surface normal.

- **Side-by-side images showing different values for the input parameters**

There are several major input uniform parameters used in the project. They are: uK, uP, uNoiseAmp, uNoiseFreq, uKa, uKd, uKs, uShininess, uLightX, uLightY, uLightZ, uColor, and uSpecularColor.

uK is the parameter control the amplitude of ripple:

When uK = 0.0:


D:\CS557\GLman\Project3GLIB.glib

GLman Shader Parameter User Interface

Program: Project3

```
uK =          0.0000
uP =          1.0000
uNoiseAmp =   0.0500
uNoiseFreq =  0.1000
uKa =         0.1000
uKd =         0.6000
uKs =         0.3000
uShininess =  16.0915
uLightX =     5.0000
uLightY =     10.0000
uLightZ =     20.0000
```

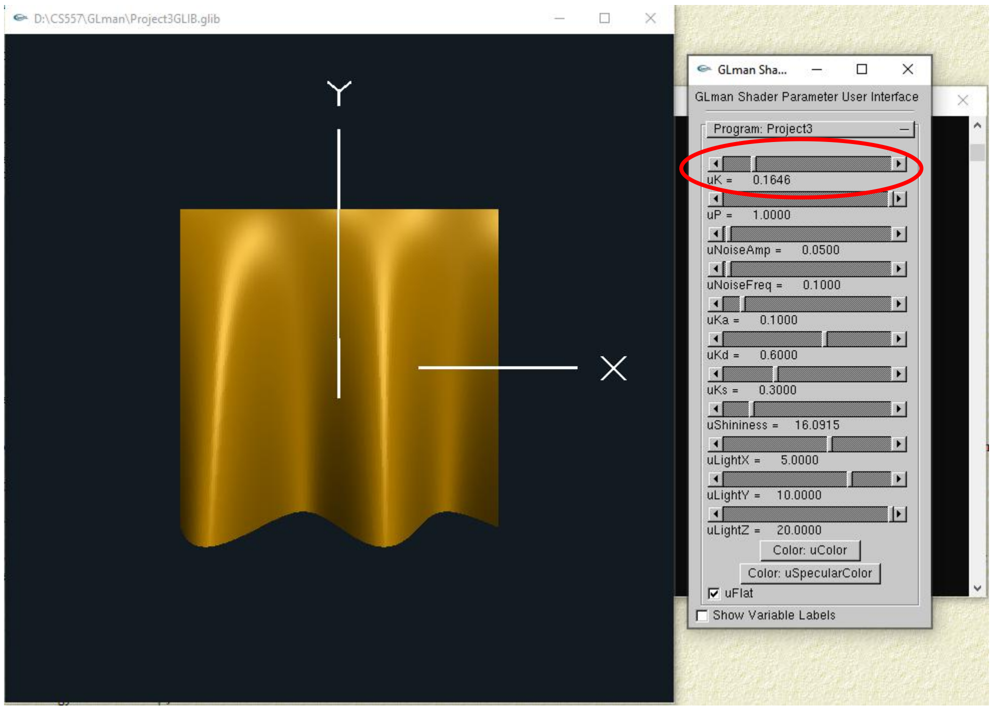
Color: uColor

Color: uSpecularColor

☑ uFlat

☐ Show Variable Labels

When uK > 0.0:


D:\CS557\GLman\Project3GLIB.glib

GLman Shader Parameter User Interface

Program: Project3

```
uK =          0.1646
uP =          1.0000
uNoiseAmp =   0.0500
uNoiseFreq =  0.1000
uKa =         0.1000
uKd =         0.6000
uKs =         0.3000
uShininess =  16.0915
uLightX =     5.0000
uLightY =     10.0000
uLightZ =     20.0000
```

Color: uColor

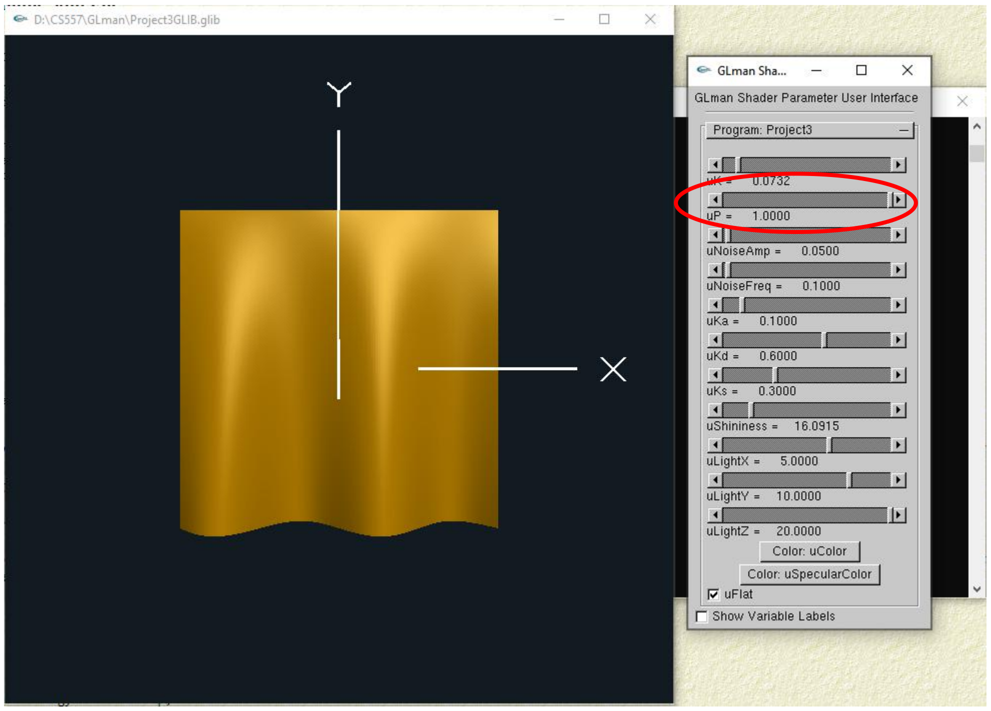
Color: uSpecularColor

☑ uFlat

☐ Show Variable Labels

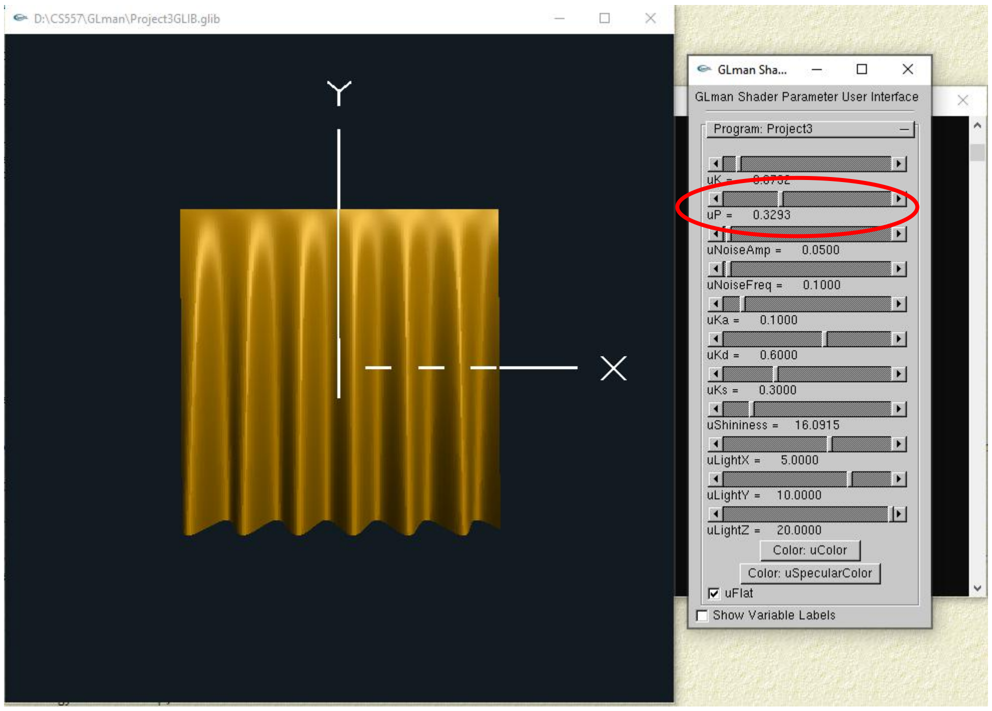
uP is the parameter control the frequency of ripple:

When uP = 1.0:



```
GLman Shader Parameter User Interface
Program: Project3
uK =  0.0732
uP =  1.0000
uNoiseAmp =  0.0500
uNoiseFreq =  0.1000
uKa =  0.1000
uKd =  0.6000
uKs =  0.3000
uShininess =  16.0915
uLightX =  5.0000
uLightY =  10.0000
uLightZ =  20.0000
Color: uColor
Color: uSpecularColor
[✓] uFlat
[ ] Show Variable Labels
```

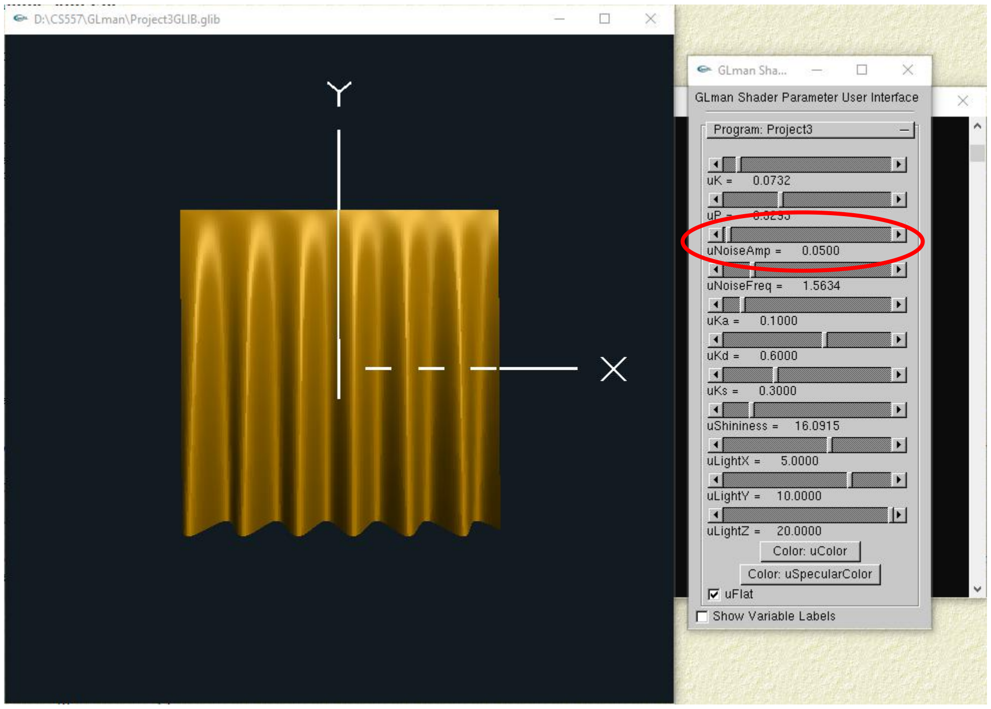
When uP < 1.0:



```
GLman Shader Parameter User Interface
Program: Project3
uK =  0.0732
uP =  0.3293
uNoiseAmp =  0.0500
uNoiseFreq =  0.1000
uKa =  0.1000
uKd =  0.6000
uKs =  0.3000
uShininess =  16.0915
uLightX =  5.0000
uLightY =  10.0000
uLightZ =  20.0000
Color: uColor
Color: uSpecularColor
[✓] uFlat
[ ] Show Variable Labels
```

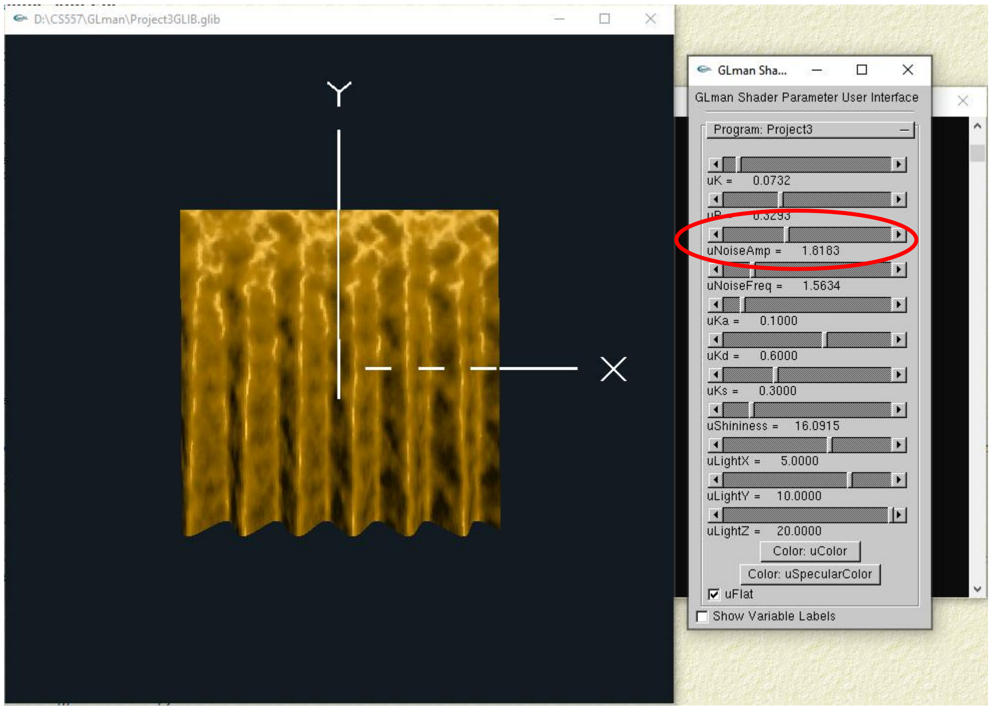
uNoiseAmp is the parameter control the degree of noise Bump-Mapping:

When uNoiseAmp = 0.0:



uK = 0.0732
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 1.5634
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 16.0915
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000
☑ uFlat

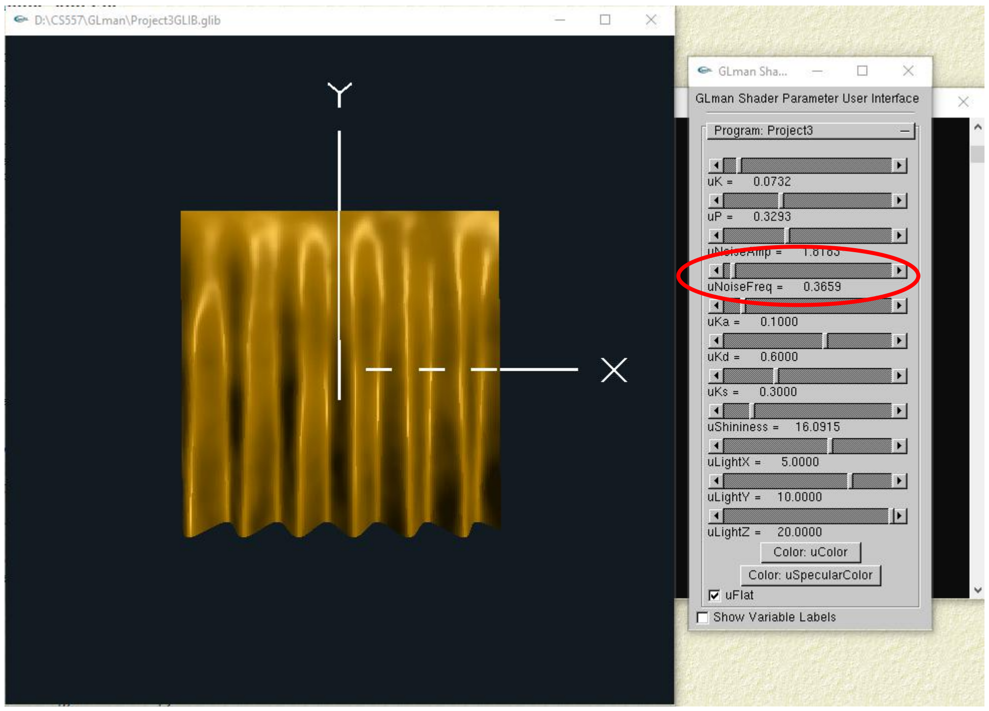
When uNoiseAmp > 0.0:



uK = 0.0732
uP = 0.3293
uNoiseAmp = 1.8183
uNoiseFreq = 1.5634
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 16.0915
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000
☑ uFlat

uNoiseFreq is the parameter control the frequency of noise Bump-Mapping:

When uNoiseFreq near 0.0:



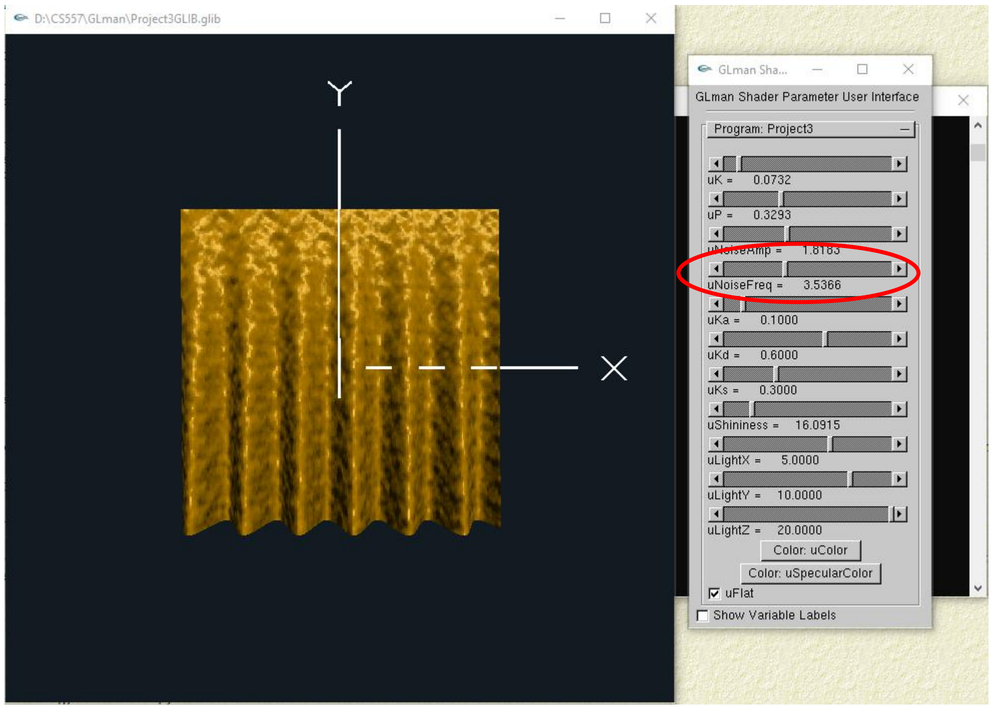
GLman Shader Parameter User Interface

Program: Project3

uK = 0.0732
uP = 0.3293
uNoiseAmp = 1.8183
uNoiseFreq = 0.3659
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 16.0915
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000

☑ uFlat
☐ Show Variable Labels

When uNoiseFreq farther larger than 0.0:



GLman Shader Parameter User Interface

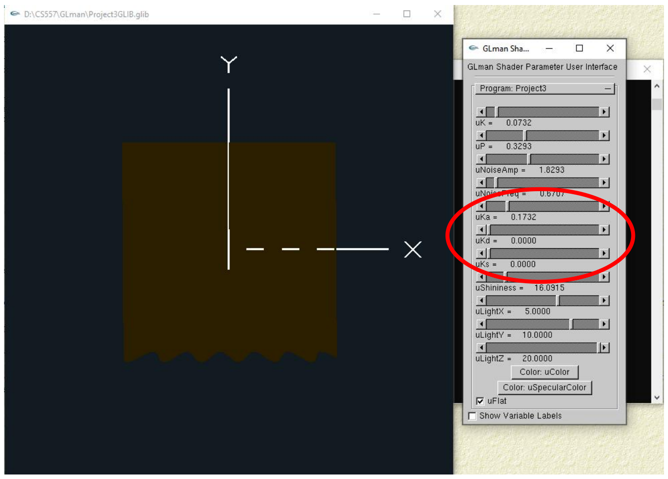
Program: Project3

uK = 0.0732
uP = 0.3293
uNoiseAmp = 1.8183
uNoiseFreq = 3.5366
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 16.0915
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000

☑ uFlat
☐ Show Variable Labels

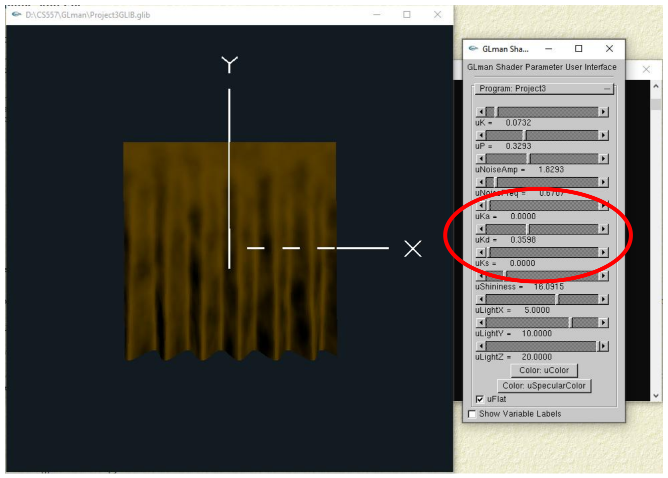
uKa, uKd, uKs are the parameter show the light effect of ambient, diffuse and specular:

When there is only uKa, there is only color of the curtain:



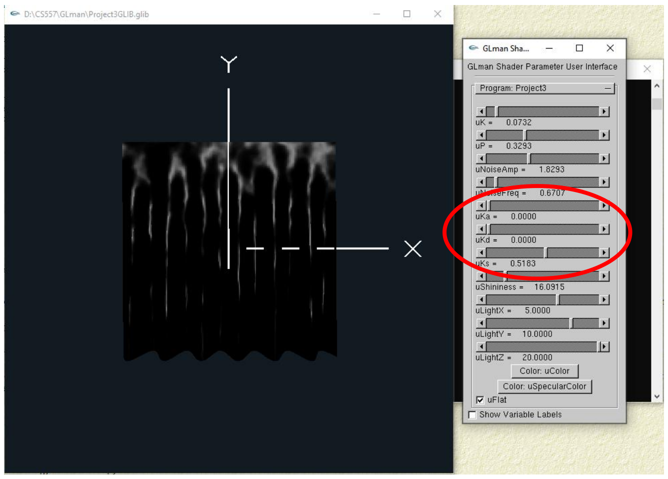
```
uK =  0.0732
uP =  0.3293
uNoiseAmp =  1.8293
uNoiseFreq =  0.6707
uKa =  0.1732
uKd =  0.0000
uKs =  0.0000
uShininess =  16.0915
uLightX =  5.0000
uLightY =  10.0000
uLightZ =  20.0000
[✓] uFlat
[ ] Show Variable Labels
```

When there is only uKd, there is only shadow and part color of the curtain:



```
uK =  0.0732
uP =  0.3293
uNoiseAmp =  1.8293
uNoiseFreq =  0.6707
uKa =  0.0000
uKd =  0.3598
uKs =  0.0000
uShininess =  16.0915
uLightX =  5.0000
uLightY =  10.0000
uLightZ =  20.0000
[✓] uFlat
[ ] Show Variable Labels
```

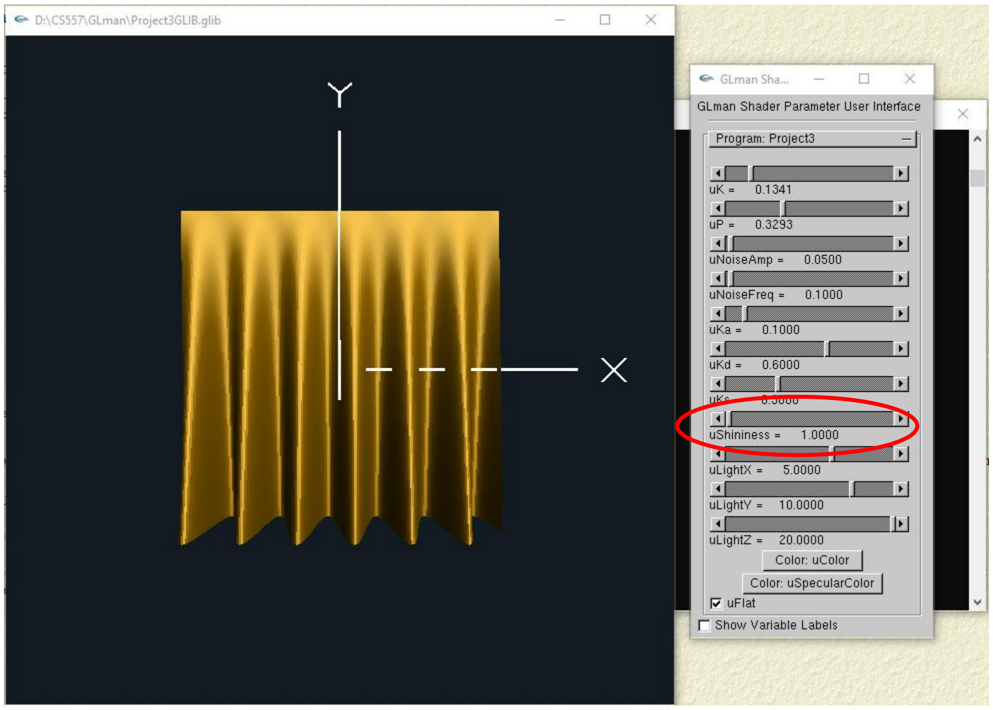
When there is only uKs, there is only highlight of the curtain:



```
uK =  0.0732
uP =  0.3293
uNoiseAmp =  1.8293
uNoiseFreq =  0.6707
uKa =  0.0000
uKd =  0.0000
uKs =  0.5183
uShininess =  16.0915
uLightX =  5.0000
uLightY =  10.0000
uLightZ =  20.0000
[✓] uFlat
[ ] Show Variable Labels
```

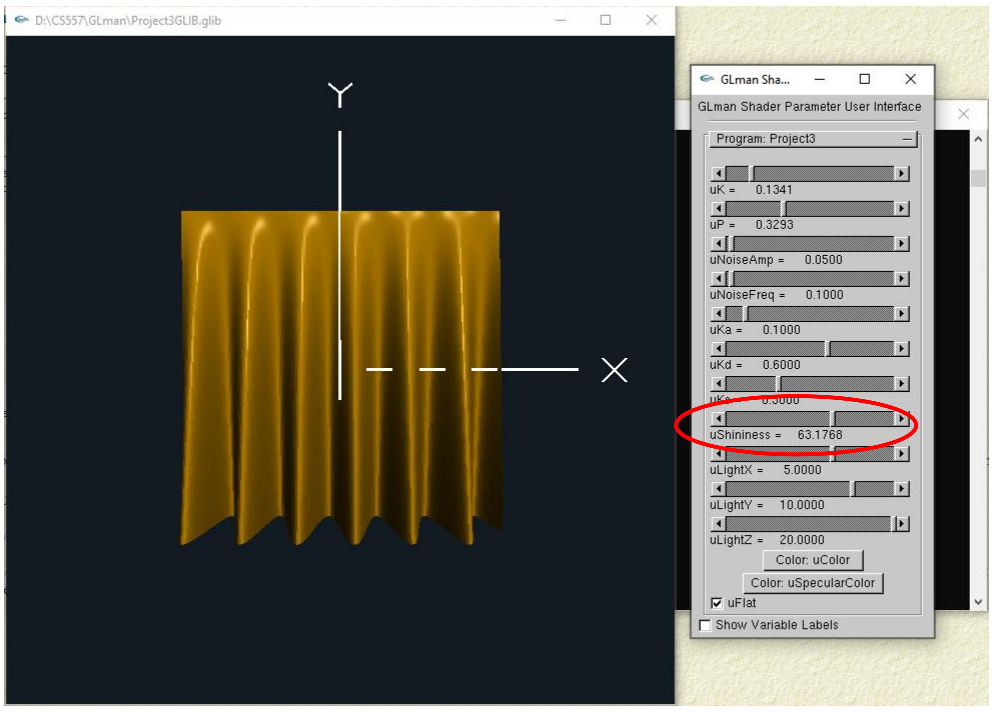
uShininess is the parameter that used to control how shiny the surface is:

When uShininess = 1:


D:\CS557\GLman\Project3GLIB.glib
Y
X
GLman Sha...
GLman Shader Parameter User Interface
Program: Project3
Color: uColor
Color: uSpecularColor

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.5000
uShininess = 1.0000
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000
☑ uFlat
☐ Show Variable Labels

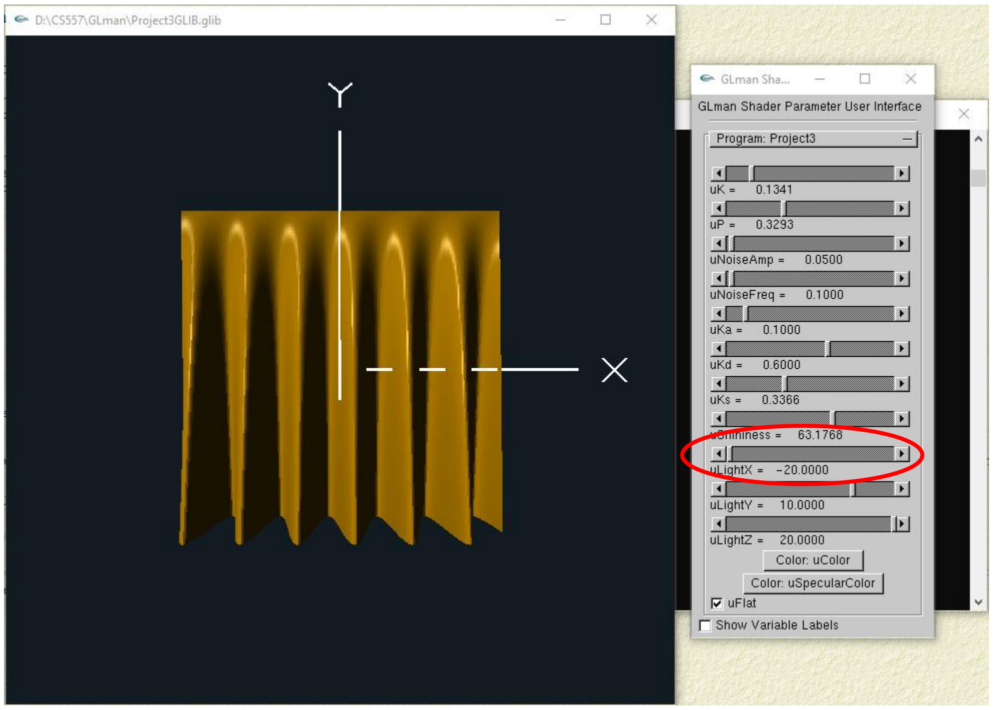
When uShininess > 1:


D:\CS557\GLman\Project3GLIB.glib
Y
X
GLman Sha...
GLman Shader Parameter User Interface
Program: Project3
Color: uColor
Color: uSpecularColor

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.5000
uShininess = 63.1768
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000
☑ uFlat
☐ Show Variable Labels

uLightX is the parameter that used to control the light source on X axis direction:

When uLightX = -20.0:



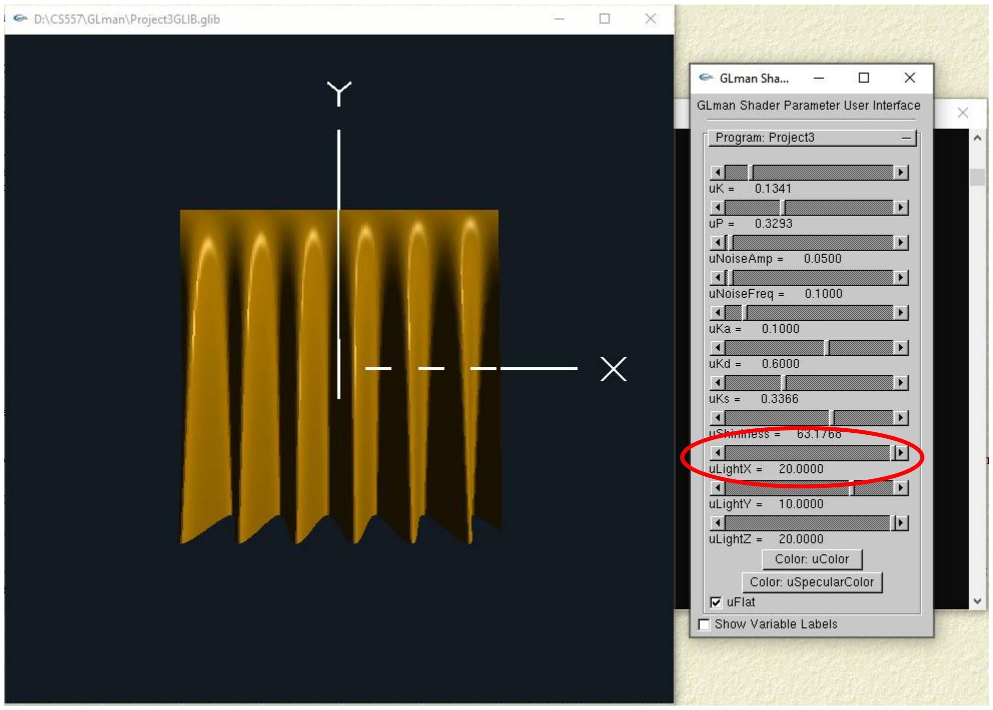
GLman Shader Parameter User Interface

Program: Project3

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3366
uShininess = 63.1768
uLightX = -20.0000
uLightY = 10.0000
uLightZ = 20.0000

[✓] uFlat
[ ] Show Variable Labels

When uLightX = 20.0:



GLman Shader Parameter User Interface

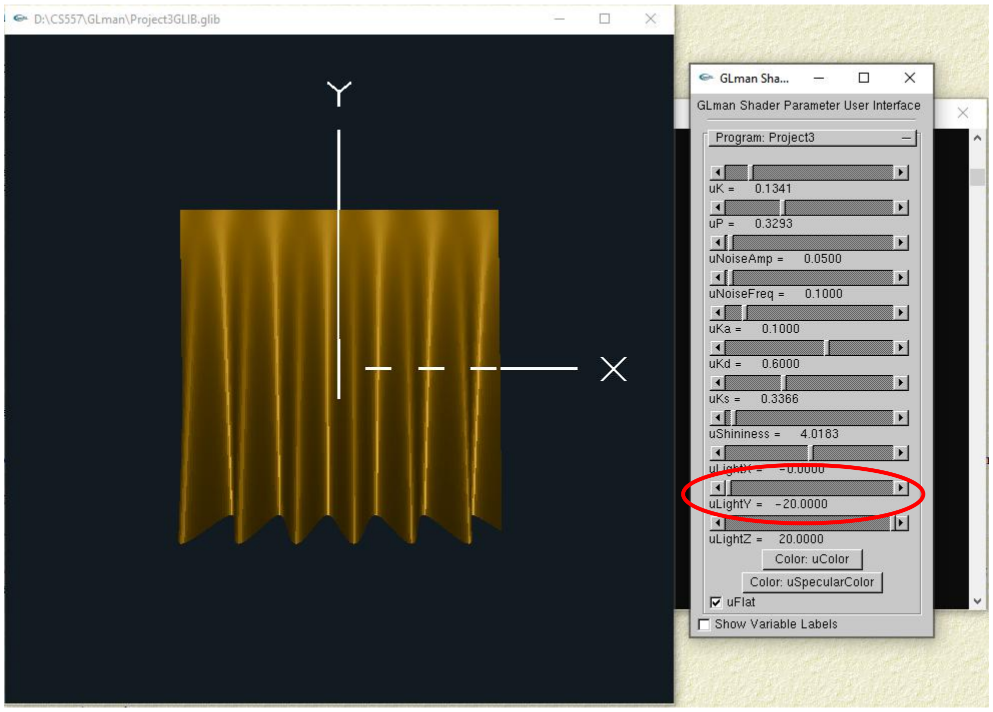
Program: Project3

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3366
uShininess = 63.1768
uLightX = 20.0000
uLightY = 10.0000
uLightZ = 20.0000

[✓] uFlat
[ ] Show Variable Labels

uLightY is the parameter that used to control the light source on X axis direction:

When uLightY = -20.00:



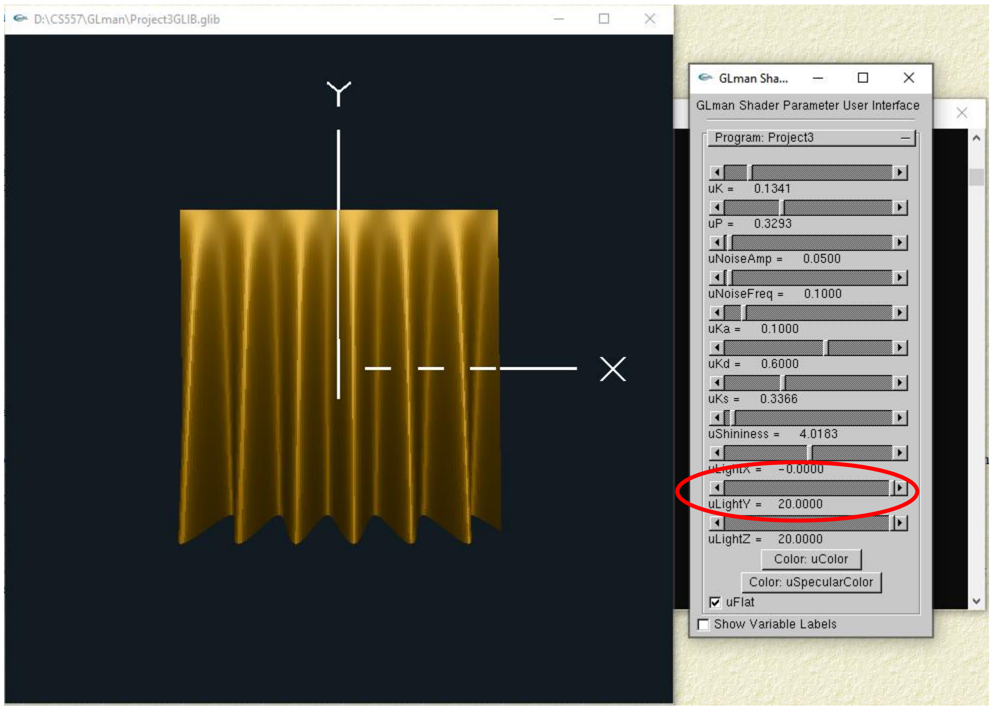
GLman Shader Parameter User Interface

Program: Project3

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3366
uShininess = 4.0183
uLightX = -0.0000
uLightY = -20.0000
uLightZ = 20.0000

Color: uColor
Color: uSpecularColor
☑ uFlat
☐ Show Variable Labels

When uLightY = 11.95:



GLman Shader Parameter User Interface

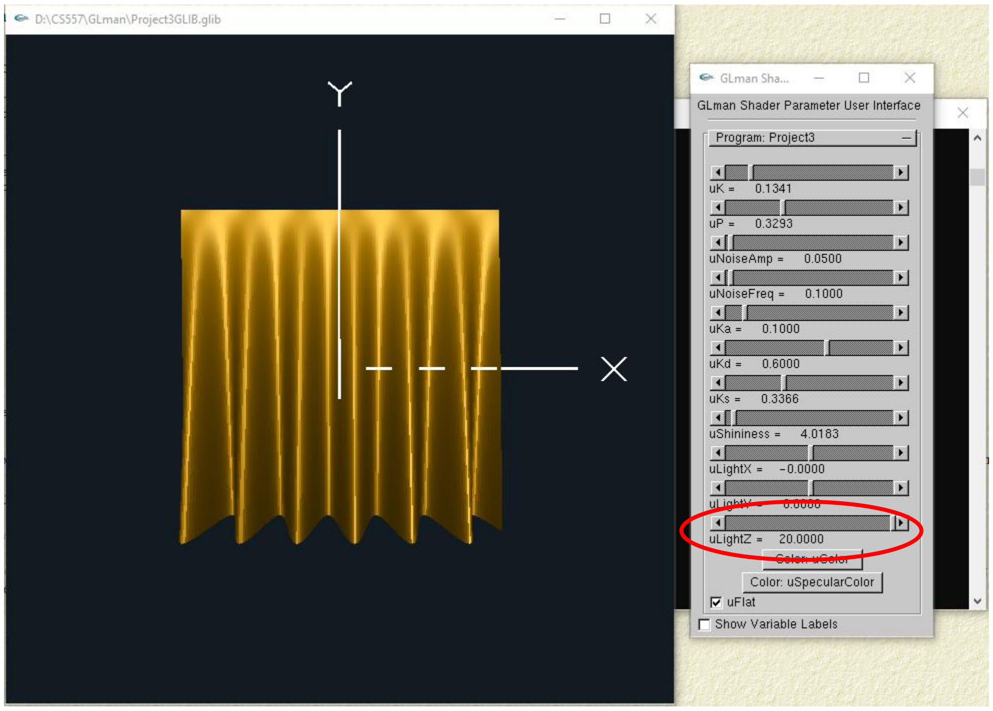
Program: Project3

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3366
uShininess = 4.0183
uLightX = -0.0000
uLightY = 20.0000
uLightZ = 20.0000

Color: uColor
Color: uSpecularColor
☑ uFlat
☐ Show Variable Labels

uLightZ is the parameter that used to control the light source on X axis direction:

When uLightZ = 20.00:

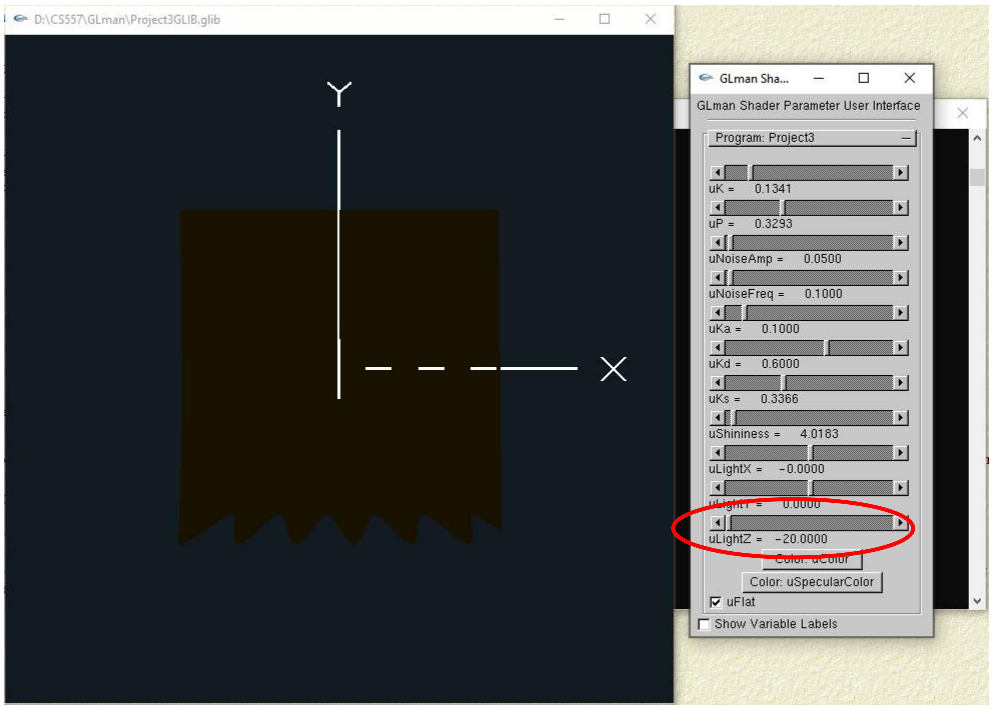


GLman Shader Parameter User Interface

Program: Project3

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3366
uShininess = 4.0183
uLightX = -0.0000
uLightY = 0.0000
uLightZ = 20.0000
Color: uColor
Color: uSpecularColor
☑ uFlat
☐ Show Variable Labels

When uLightZ = 0.00: (At this time, the light is lighting the back of the curtain)



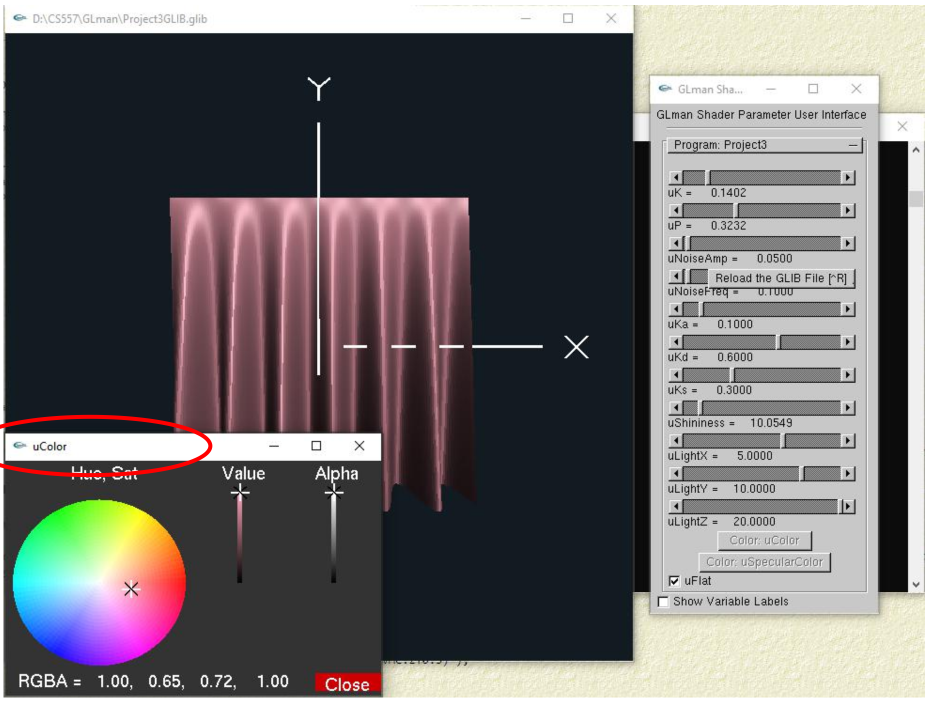
GLman Shader Parameter User Interface

Program: Project3

uK = 0.1341
uP = 0.3293
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3366
uShininess = 4.0183
uLightX = -0.0000
uLightY = 0.0000
uLightZ = -20.0000
Color: uColor
Color: uSpecularColor
☑ uFlat
☐ Show Variable Labels

uColor, and uSpecularColor are primitives used to change colors of the curtain and color of high light:

When we want to change the color of the curtain, we click uColor bottom:


D:\CS557\GLman\Project3GLIB.glib

GLman Sha...

GLman Shader Parameter User Interface

Program: Project3

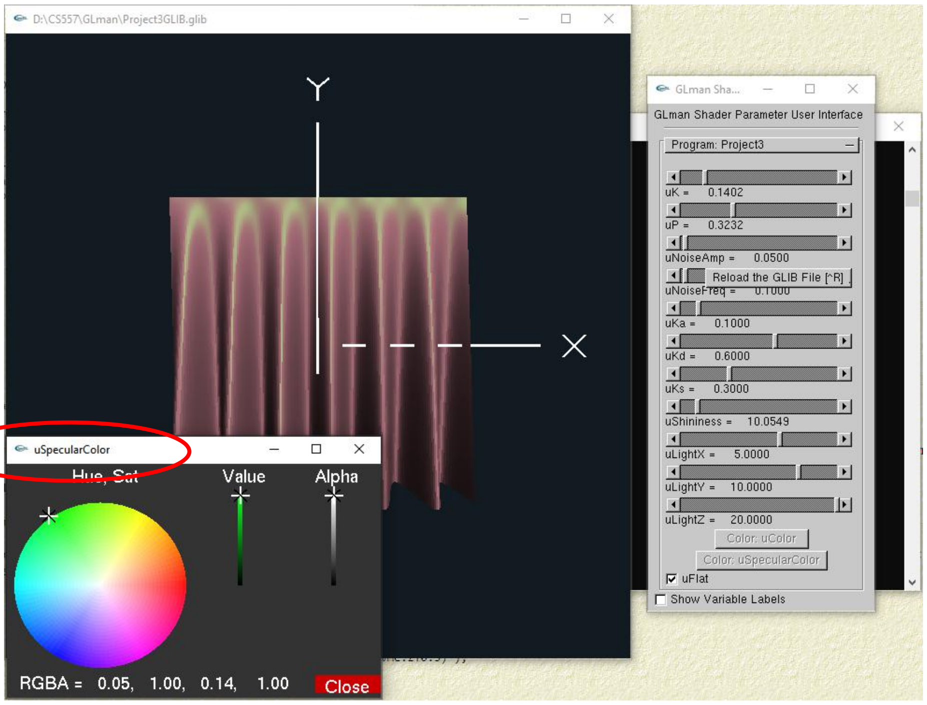
uK = 0.1402
uP = 0.3232
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 10.0549
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000

[✓] uFlat
[ ] Show Variable Labels

uColor

RGBA = 1.00, 0.65, 0.72, 1.00

When we want to change the color of the curtain, we click uSpecularColor bottom:


D:\CS557\GLman\Project3GLIB.glib

GLman Sha...

GLman Shader Parameter User Interface

Program: Project3

uK = 0.1402
uP = 0.3232
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 10.0549
uLightX = 5.0000
uLightY = 10.0000
uLightZ = 20.0000

[✓] uFlat
[ ] Show Variable Labels

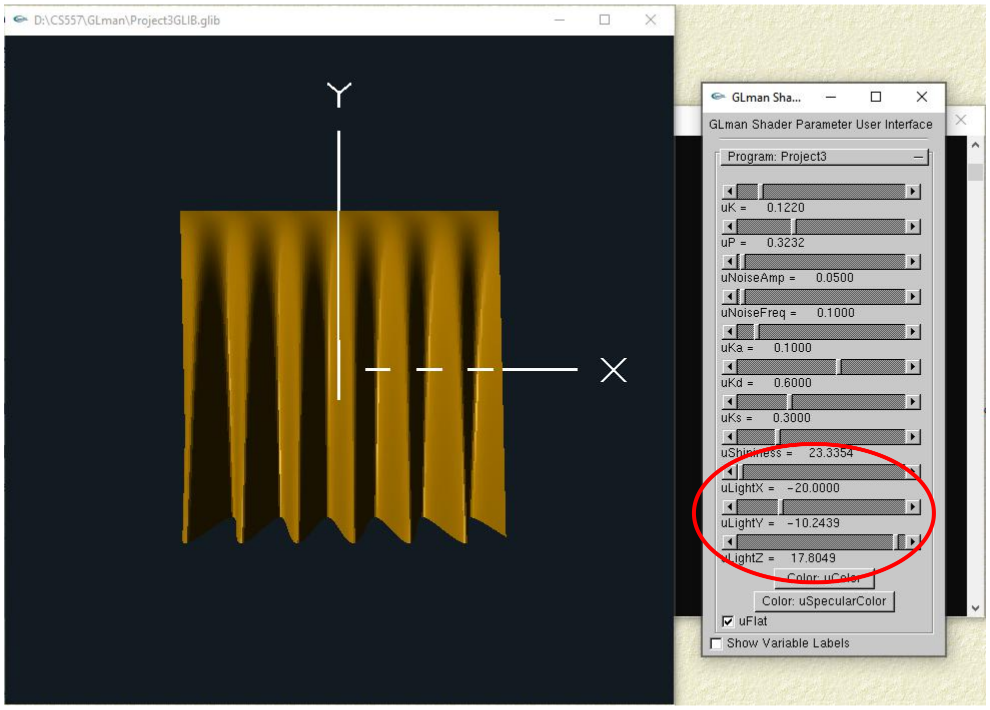
uSpecularColor

RGBA = 0.05, 1.00, 0.14, 1.00

- **Per-fragment lighted image(s) showing that your normal computation is correct.**

To prove the normal computation is correct, we only need to check the high light and shadows are correct when we change the location of light source:

Moving light from left to right, when light is at the bottom position:



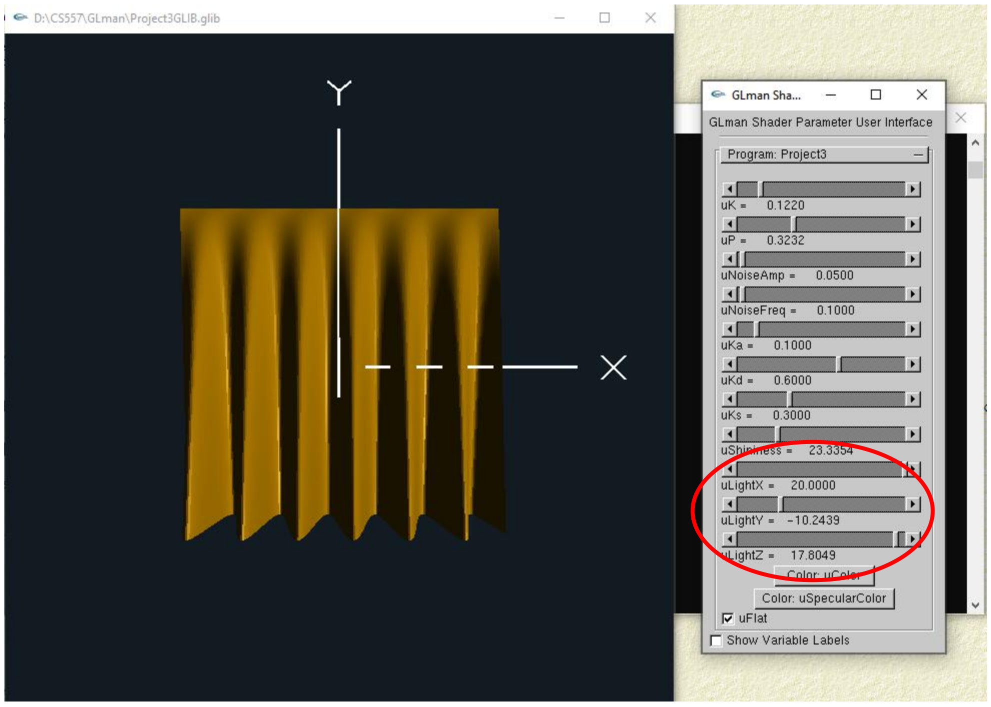
D:\CS557\GLman\Project3GLIB.glib

GLman Sha...

GLman Shader Parameter User Interface

Program: Project3

uK = 0.1220
uP = 0.3232
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 23.3354
uLightX = −20.0000
uLightY = −10.2439
uLightZ = 17.8049
Color: uColor
Color: uSpecularColor
☑ uFlat
☐ Show Variable Labels



D:\CS557\GLman\Project3GLIB.glib

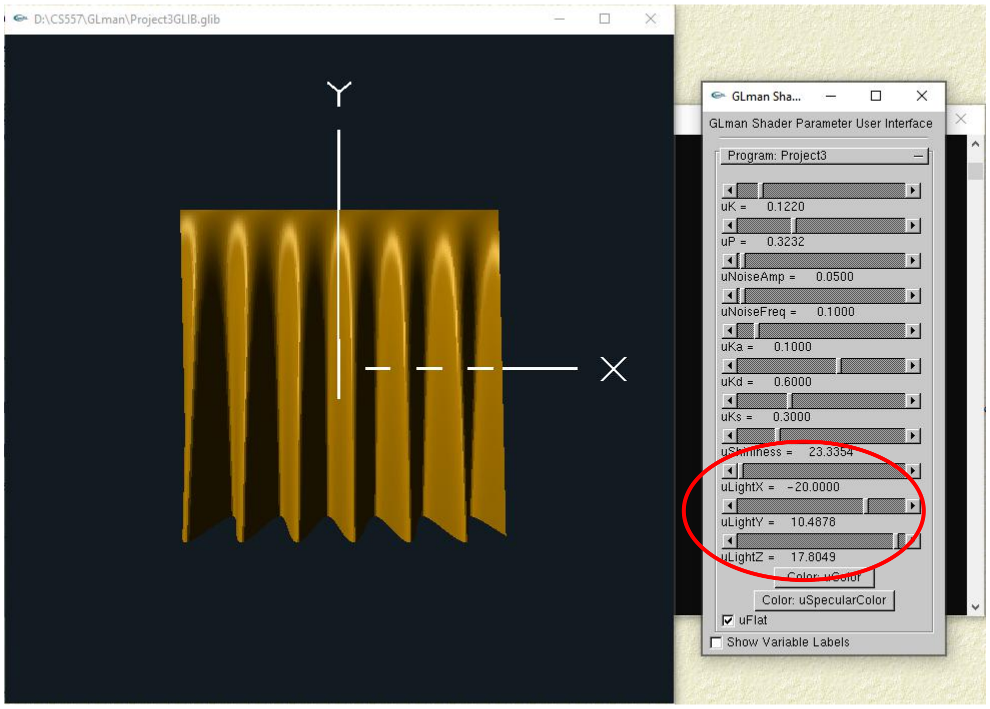
GLman Sha...

GLman Shader Parameter User Interface

Program: Project3

uK = 0.1220
uP = 0.3232
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 23.3354
uLightX = 20.0000
uLightY = −10.2439
uLightZ = 17.8049
Color: uColor
Color: uSpecularColor
☑ uFlat
☐ Show Variable Labels

Moving light from left to right, when light is at the top position:



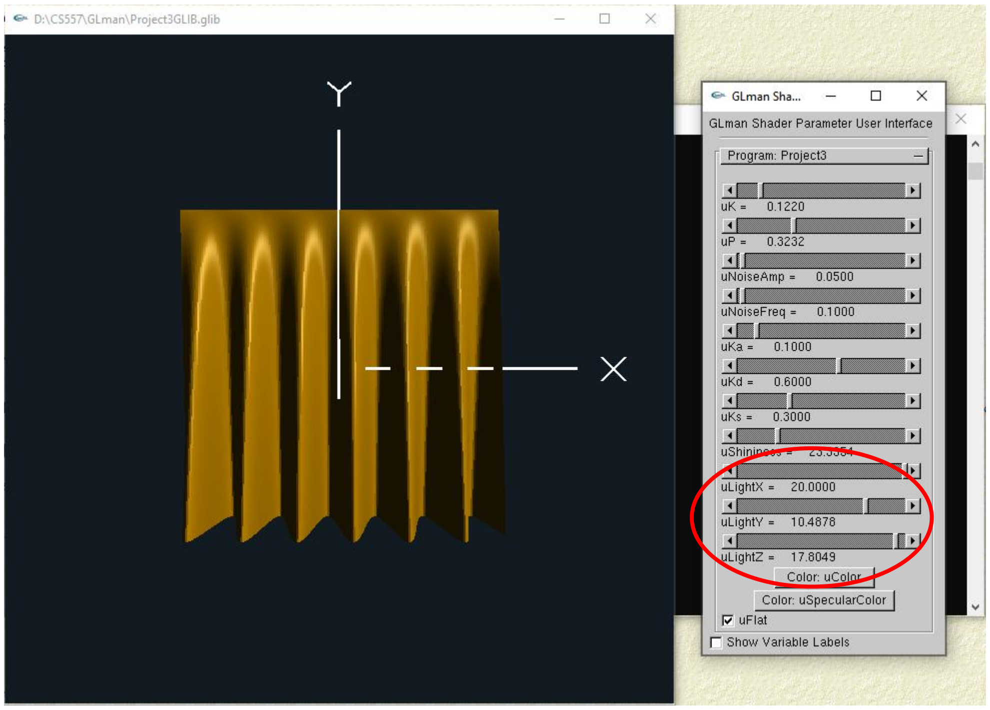
D:\CS557\GLman\Project3GLIB.glib

GLman Shader Parameter User Interface

Program: Project3

uK = 0.1220
uP = 0.3232
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 23.3354
uLightX = -20.0000
uLightY = 10.4878
uLightZ = 17.8049

☑ uFlat
☐ Show Variable Labels



D:\CS557\GLman\Project3GLIB.glib

GLman Shader Parameter User Interface

Program: Project3

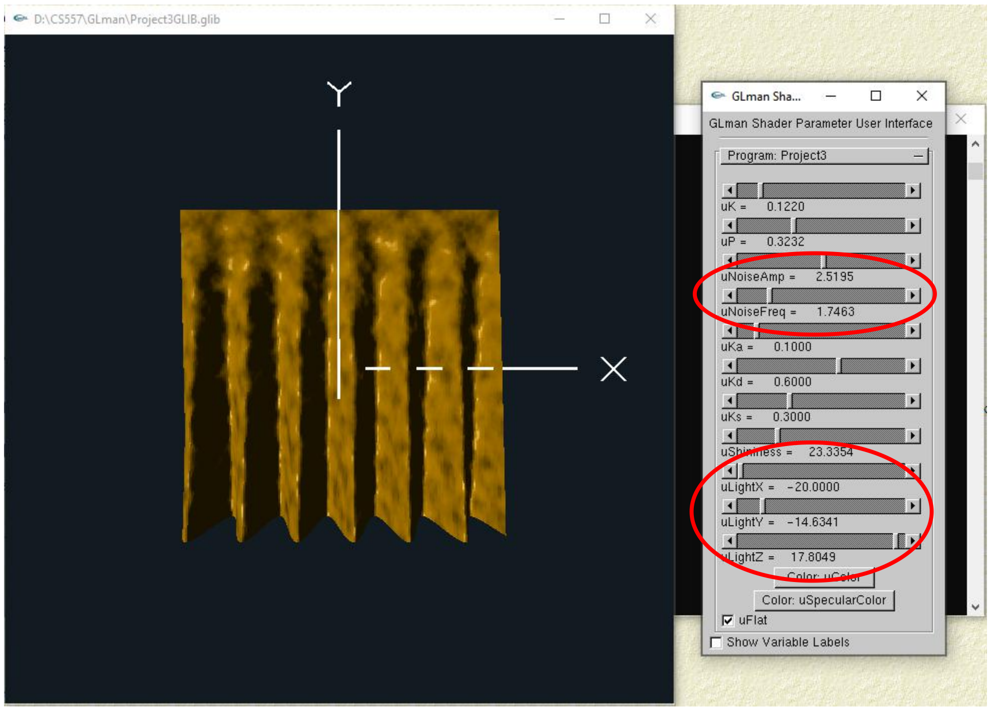
uK = 0.1220
uP = 0.3232
uNoiseAmp = 0.0500
uNoiseFreq = 0.1000
uKa = 0.1000
uKd = 0.6000
uKs = 0.3000
uShininess = 23.3354
uLightX = 20.0000
uLightY = 10.4878
uLightZ = 17.8049

☑ uFlat
☐ Show Variable Labels

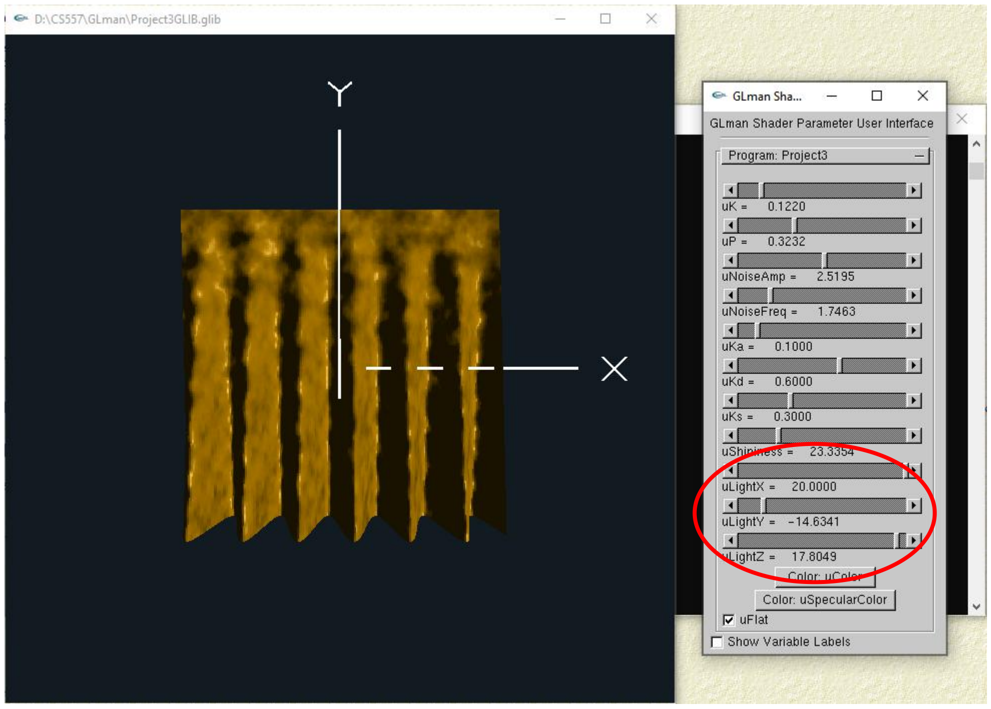
- Per-fragment lighted image(s) showing that your bump-mapping is correct.

To prove the bump-mapping is correct, we only need to check the high light and shadows (the new normals) are correct when we change the location of light source after we open the noise mapping:

Open the noise mapping, moving light from left to right, when light is at the bottom position:

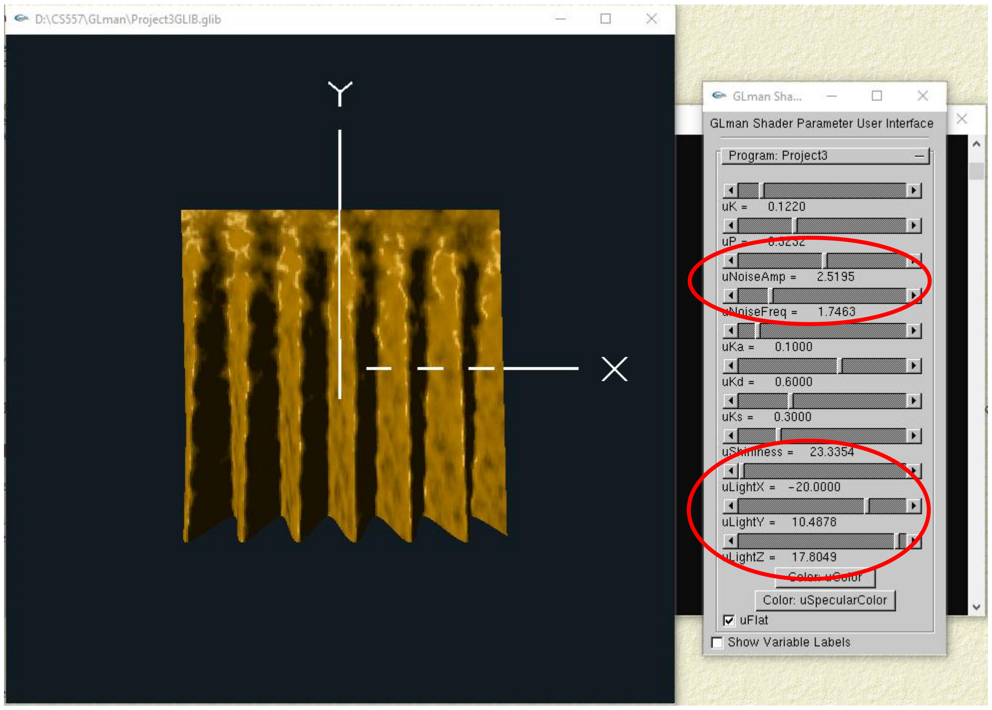


```
GLman Shader Parameter User Interface
Program: Project3
uK =        0.1220
uP =        0.3232
uNoiseAmp =      2.5195
uNoiseFreq =     1.7463
uKa =       0.1000
uKd =       0.6000
uKs =       0.3000
uShininess =     23.3354
uLightX =   -20.0000
uLightY =   -14.6341
uLightZ =    17.8049
Color: uColor
Color: uSpecularColor
[✓] uFlat
[ ] Show Variable Labels
```

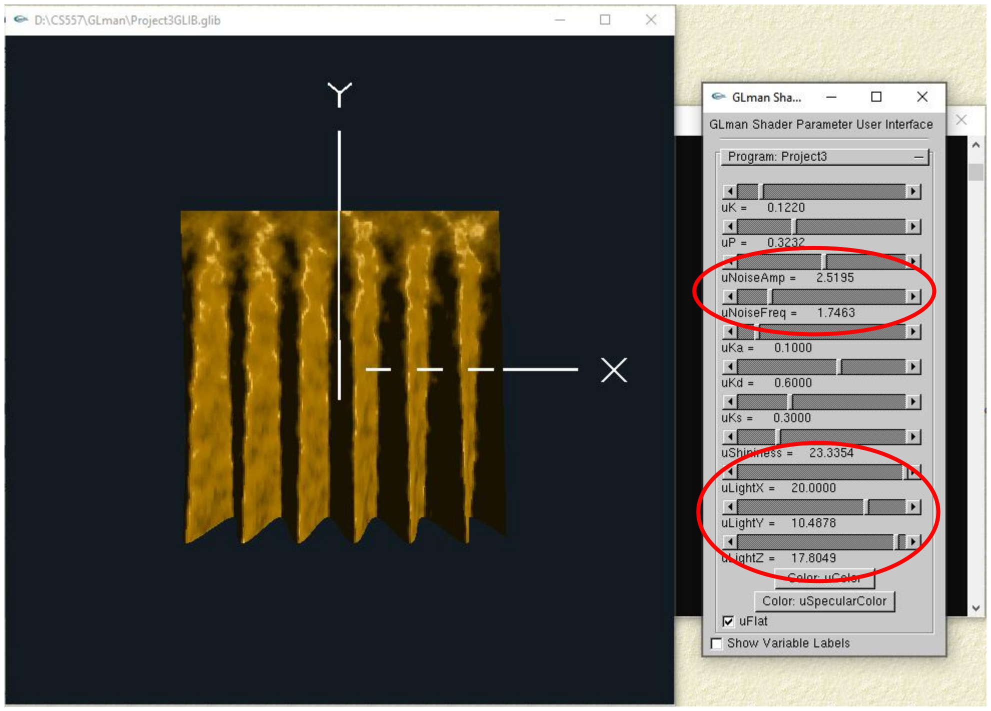


```
GLman Shader Parameter User Interface
Program: Project3
uK =        0.1220
uP =        0.3232
uNoiseAmp =      2.5195
uNoiseFreq =     1.7463
uKa =       0.1000
uKd =       0.6000
uKs =       0.3000
uShininess =     23.3354
uLightX =    20.0000
uLightY =   -14.6341
uLightZ =    17.8049
Color: uColor
Color: uSpecularColor
[✓] uFlat
[ ] Show Variable Labels
```

Open the noise mapping, moving light from left to right, when light is at the top position:



```
uK =  0.1220
uP =  0.3232
uNoiseAmp =  2.5195
uNoiseFreq =  1.7463
uKa =  0.1000
uKd =  0.6000
uKs =  0.3000
uShininess =  23.3354
uLightX =  -20.0000
uLightY =  10.4878
uLightZ =  17.8049
[✓] uFlat
```



```
uK =  0.1220
uP =  0.3232
uNoiseAmp =  2.5195
uNoiseFreq =  1.7463
uKa =  0.1000
uKd =  0.6000
uKs =  0.3000
uShininess =  23.3354
uLightX =  20.0000
uLightY =  10.4878
uLightZ =  17.8049
[✓] uFlat
```