

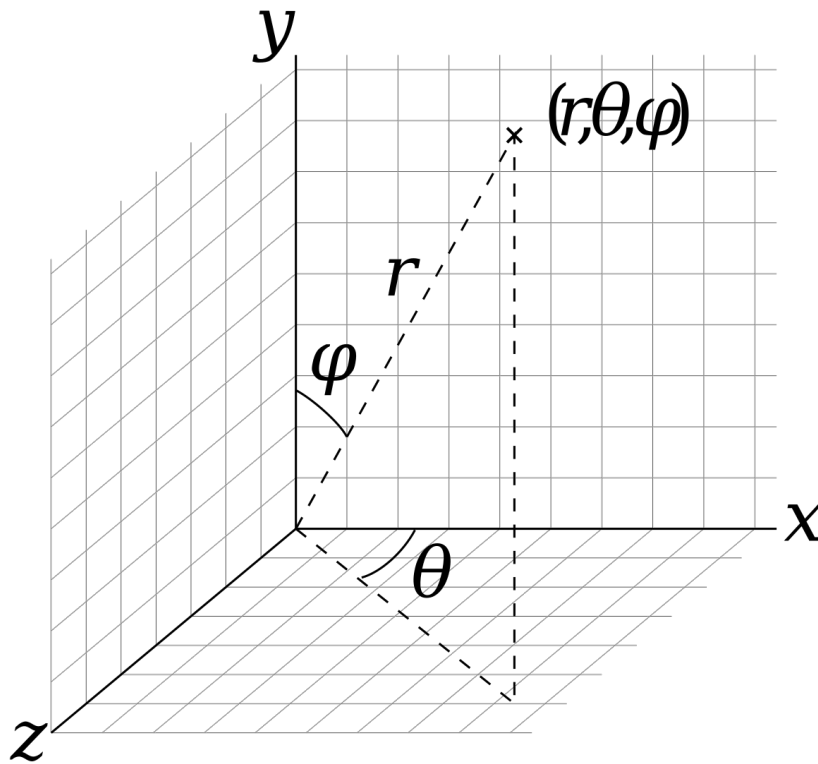
CS3388B, Winter 2023

Problem Set 9

Due: March 26, 2023

Exercise 1.

Let a camera have position $(8, 4, -3)$ in world coordinates. Describe this position in spherical coordinates as a radius r from the world's origin, and two angles θ and φ , where θ is measured from the positive x axis toward the positive z axis, and φ is measured from the positive y axis toward the $x - z$ plane.

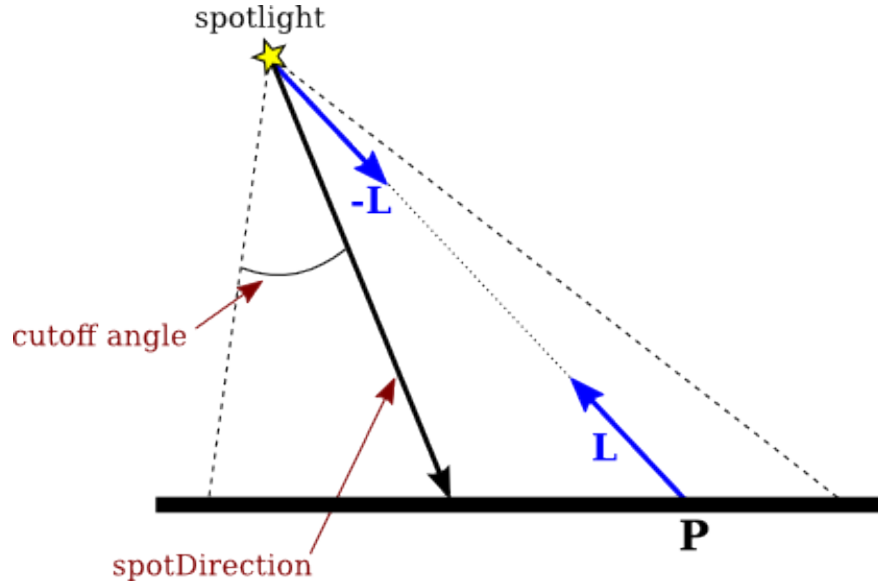


$$r = \sqrt{x^2 + y^2 + z^2} = 9.486$$

$$\theta = \arctan(-3/8) \approx -20.56^\circ = 339.44^\circ$$

$$\varphi = \arccos(y/r) = \arccos(4/9.486) \approx 65^\circ$$

Exercise 2.



Consider a spotlight, as shown in the above diagram. Therein, L is the direction of the light source from the point P . Spot direction refers to the direction the spotlight is pointing, while cutoff angle refers to the **half-angle** of the cone of light produced by the spotlight.

Let a spotlight have position $(5, 10, 2)$, be pointed at $(3, 2, 1)$, and have a cutoff angle of 30° . For a point in space $P = (x_p, y_p, z_p)$ determine a function $f(x, y, z)$ such that $f(x_p, y_p, z_p) > 0$ if P is inside the spotlight's cone of light, and $f(x_p, y_p, z_p) < 0$ if P is outside the spotlight's cone of light.

$$\begin{aligned}\vec{d} &= (3, 2, 1) - (5, 10, 2) = (-2, -8, -1) \\ -\vec{L} &= (x, y, z) - (5, 10, 2) = (x - 5, y - 10, z - 2)\end{aligned}$$

We want $\cos(\theta) > \cos(30)$.

$$\begin{aligned}f(x, y, z) &= \frac{\vec{d} \cdot -\vec{L}}{\|\vec{d}\| \|\vec{L}\|} - \frac{\sqrt{3}}{2} \\ &= \frac{-2x - 8y - z + 92}{\sqrt{69} \sqrt{(x-5)^2 + (y-10)^2 + (z-2)^2}} - \frac{\sqrt{3}}{2}\end{aligned}$$

Exercise 3.

Write a vertex/fragment shader pair which implements the Phong lighting model for two simultaneous directional lights. You can use the `DiffuseShader.vertexshader` and `DiffuseShader.fragmentshader` on OWL as starting points.

Exercise 4.

Write a vertex/fragment shader pair which implements the Phong lighting model with parameterized material colors.

Let the vertex shader have two input vertex attributes: position and normal. Let the vertex shader have four uniforms:

- The MVP matrix
- The View matrix
- The Model matrix
- The position of the light source in world coordinates

In the fragment shader let there be four uniform variables:

- Light color
- Material ambient color
- Material diffuse color
- Material specular color

and three input variables:

- Normal
- Eye direction (camera direction)
- Light direction

Submission.

Submit to OWL:

- Your answers and workings for Exercises 1 and 2.
- Your vertex shader and fragment shader for Exercise 3.
- Your vertex shader and fragment shader for Exercise 4.