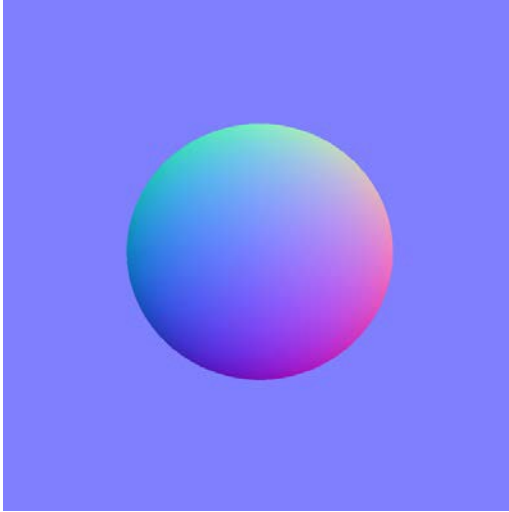


## Normal Maps

### 1. Encoding Normals



Normal maps encode unit-length vectors in images as colors.

**a. Decode it**

Suppose you sample a normal map and get a color value of  $(0.5, 0, 0.75)$ . What is the decoded normal?

**b. Why so blue?**

Normal maps, like the one shown above, typically have a lot of blue. Why is this? What is the minimum possible value the blue channel of the RGB encoding assuming the normal is expressed in relation to the tangent plane at a point on the surface?

## 2. Implementing Normal Mapping in the Shader Program

There's more than one correct way to do this, but....

Describe in words what data are passed to the Vertex Shader?

What data are passed to the Fragment Shader?

## 3. Normals from a Height Map

Suppose you are given a height map for a terrain in which  $h(i, j) \in [0, 1]$  is a function that represents the height at texel  $(i, j)$ . Based on intuition from the image below, can you discover two vectors whose cross product can be used to determine a normal for the texel  $(i, j)$ ? Hint: your answer should make use of finite differences in the height map...

