Spectral Effects:
Chromatic Refraction and Wavelength Interference

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All You *Pink Floyd* Fans Already Understand Spectral Behavior . . . 😊

Certain processes result in a different light color being seen in a different place
Rainbows

Red: \approx 650 \text{ nm}, 1.510, 42^\circ, 0.743, 50.0^\circ
Green: \approx 500 \text{ nm}, 1.519, 41^\circ, 0.755, 51.5^\circ
Blue: \approx 400 \text{ nm}, 1.528, 40^\circ, 0.766, 53.0^\circ
Rainbow Strategy

1. Draw one big quadrilateral across the scene
2. Anywhere that \(0.7400 \leq \cos(\Theta) \leq 0.7700\), paint a color
3. Otherwise, discard.

Or anything else, really. You just need a large “fragment-generator”.

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Spectral Colors

float
Pulse( float min, float max, float tol, float t )
{
    float a = min - tol;
    float b = min + tol;
    float c = max - tol;
    float d = max + tol;

    return smoothstep(a,b,t) - smoothstep(c,d,t);
}

vec3 SunDirection = vec3( 0., SunY, 10. );
vec3 PtToSun = normalize( SunDirection );
vec3 PtToEye = normalize( vec3(0.,0.,0.) - ECposition );
float costheta = dot( PtToEye, PtToSun );
float R = Pulse( .7400, .7490, Tol, costheta );
float G = Pulse( .7490, .7605, Tol, costheta );
float B = Pulse( .7605, .7700, Tol, costheta );
Spectral Colors

float t = (λ - 400.) / (600. - 400.);
vec3 rgb = Rainbow(t);
Oil Slicks

No phase change

Air

Oil

Water

Cancels when $2d = \lambda_n \cdot (m)$

Reinforces when $2d = \lambda_n \cdot (m + \frac{1}{2})$

$\lambda^* = \frac{2d \eta}{m + \frac{1}{2}}$

$\lambda_n = \frac{\lambda}{\eta}$

$\eta \approx 1.4$

$\lambda = \frac{\lambda}{\eta} \cdot (m + \frac{1}{2})$

Phase change
On the way in, A travels $d \cos(\phi_i)$ less than B. On the way out, A travels $d \cos(\phi_r)$ more than B.

So, wavelengths reinforce when $\text{abs}[d \cos(\phi_i) - d \cos(\phi_r)]$ is a multiple of the wavelength $= m \lambda$

$$\lambda^* = d \times |\cos(\phi_i) - \cos(\phi_r)| / m$$
Diffraction Gratings

Call the unit vector from the point to the light \( \text{ToLight} \).
Call the unit vector from the point to the eye \( \text{ToEye} \).
Call the transformed tangential unit vector \( \text{Tangent} \).

Then, \( \cos(\phi_i) \) is \( \text{ToLight} \cdot \text{Tangent} \)
And, \( \cos(\phi_r) \) is \( \text{ToEye} \cdot (-\text{Tangent}) \)

So that \( \cos(\phi_i) - \cos(\phi_r) \) is: \( \text{Tangent} \cdot (\text{ToLight} + \text{ToEye}) \)

\[
\lambda^* = d \times | \cos(\phi_i) - \cos(\phi_r) | \div m
\]