Spectral Effects: Chromatic Refraction and Wavelength Interference

Each Wavelength of Light Has a Slightly Different Index of Refraction so that each Wavelength Bends Differently in a Prism

Different colors are seen in different places
Rainbows

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”.

<table>
<thead>
<tr>
<th>Color</th>
<th>$\lambda$ (nm)</th>
<th>$\eta$</th>
<th>$\Theta$</th>
<th>$\cos(\Theta)$</th>
<th>$\Theta(\Theta)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>650</td>
<td>1.510</td>
<td>42°</td>
<td>0.743</td>
<td>50.0°</td>
</tr>
<tr>
<td>Green</td>
<td>500</td>
<td>1.519</td>
<td>41°</td>
<td>0.755</td>
<td>51.5°</td>
</tr>
<tr>
<td>Blue</td>
<td>400</td>
<td>1.528</td>
<td>40°</td>
<td>0.766</td>
<td>53.0°</td>
</tr>
</tbody>
</table>
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 );
vec3 Rainbow(float t)
{
    t = clamp(t, 0., 1.);
    vec3 rgb = vec3(0., 0., 0.);

    // b -> c
    if( t >= 0. )
    {
        rgb.g = 4. * ( t - (0./4.) );
        rgb.b = 1.;
    }

    // c -> g
    if( t >= (1./4.) )
    {
        rgb.r = 0.;
        rgb.g = 1.;
        rgb.b = 1. - 4. * ( t - (1./4.) );
    }

    // g -> y
    if( t >= (2./4.) )
    {
        rgb.r = 4. * ( t - (2./4.) );
        rgb.g = 1.;
        rgb.b = 0.;
    }

    // y -> r
    if( t >= (3./4.) )
    {
        rgb.r = 1.;
        rgb.g = 1. - 4. * ( t - (3./4.) );
        rgb.b = 0.;
    }

    return rgb;
}

Changing the Range [0.,1.] to Rainbow Colors

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

\[ \lambda^* = \frac{2d \eta}{m + \frac{1}{2}} \]
On the way in, Ray A travels \( d \cos(\phi_i) \) less than Ray B does. On the way out, Ray A travels \( d \cos(\phi_r) \) more than Ray B does.

So, wavelengths reinforce when

\[
\text{abs}[d \cos(\phi_i) - d \cos(\phi_r)] \text{ is a multiple of the wavelength } = m \lambda
\]

\[
\lambda^* = d \cdot |\cos(\phi_i) - \cos(\phi_r)| / m
\]
Diffraction Gratings

Call the unit vector from the point to the light ToLight.
Call the unit vector from the point to the eye ToEye.
Call the transformed tangential unit vector Tangent.

Then, \( \cos(\phi_i) \) is ToLight \cdot Tangent
And, \( \cos(\phi_r) \) is ToEye \cdot (-Tangent)
So that \( \cos(\phi_i) - \cos(\phi_r) \) is: Tangent \cdot (ToLight + ToEye)

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