Spectral Effects: Chromatic Refraction and Wavelength Interference

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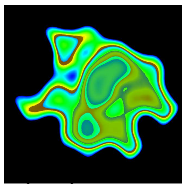
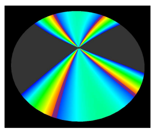
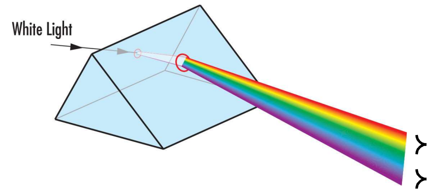



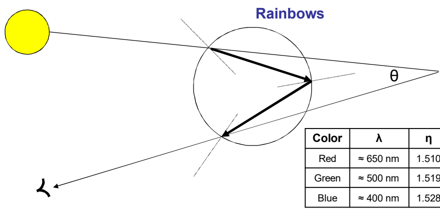

Each Wavelength of Light Has a Slightly Different Index of Refraction so that each Wavelength Bends Differently in a Prism



http://www.edmundoptics.com

Different colors are seen in different places

Rainbows



Primary Rainbow | Secondary Rainbow

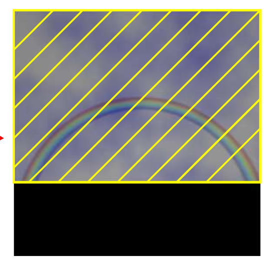
Color	λ	η	Θ	cosΘ	ΘΘ
Red	≈ 650 nm	1.510	42°	0.743	50.0°
Green	≈ 500 nm	1.519	41°	0.755	51.5°
Blue	≈ 400 nm	1.528	40°	0.766	53.0°



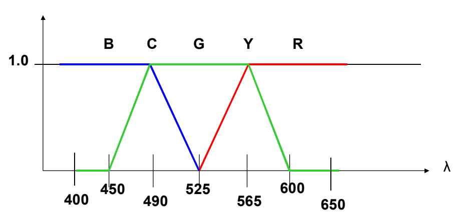
Rainbow Strategy

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

1. Draw one big quadrilateral across the scene
2. Anywhere that .7400 ≤ cos(Θ) ≤ .7700, paint a color
3. Otherwise, discard.



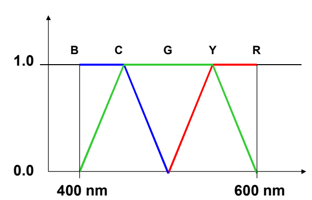
Spectral Colors




```
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 );
```

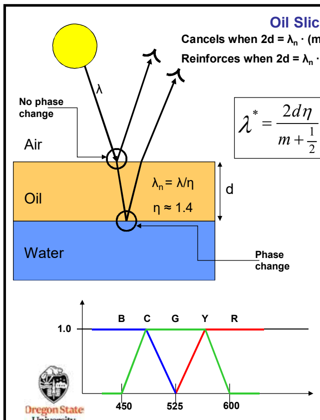
Changing the Range [0.,1.] to Rainbow Colors


```
vec3
Rainbow( float t )
{
	t = clamp( t, 0., 1. );
	vec3 rgb = vec3( 0., 0., 0. );

	// b -> c
	if( t >= 0. )
	{
		// rgb.r = 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;
}
```

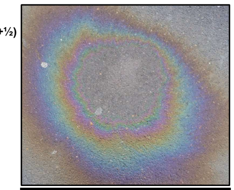

Oil Slicks

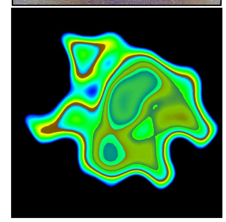
Cancels when $2d = \lambda_n \cdot (m)$

Reinforces when $2d = \lambda_n \cdot (m+½)$



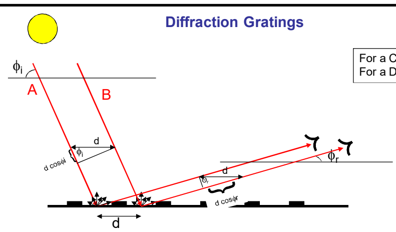
$$\lambda^* = \frac{2d\eta}{m+\frac{1}{2}}$$

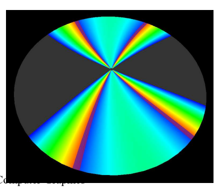




Diffraction Gratings

For a CD, d = 1600 nm
For a DVD, d = 740 nm

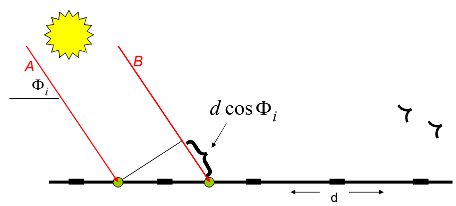


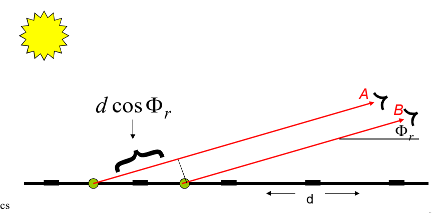


On the way in, Ray A travels *dcos(ϕi)* less than Ray B does. On the way out, Ray A travels *dcos(ϕr)* more than Ray B does.

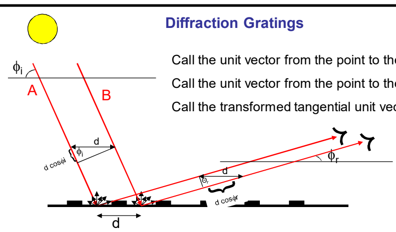
So, wavelengths reinforce when abs[$d\cos(\phi_i) - d\cos(\phi_r)$] is a multiple of the wavelength = mλ

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





Diffraction Gratings



Call the unit vector from the point to the light **ToLight**.

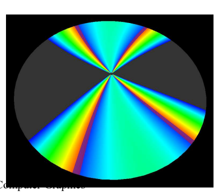
Call the unit vector from the point to the eye **ToEye.**

Call the transformed tangential unit vector **Tangent.**

Then, $\cos(\phi_i)$ is *ToLight•Tangent*

And, $\cos(\phi_r)$ is *ToEye•(-Tangent)*

So that cos(ϕi) - cos(ϕr) is: *Tangent•(ToLight + ToEye)*



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