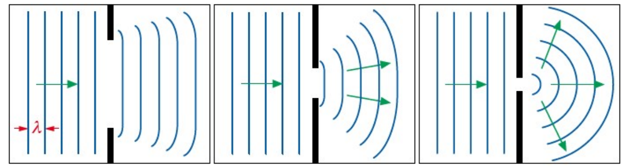
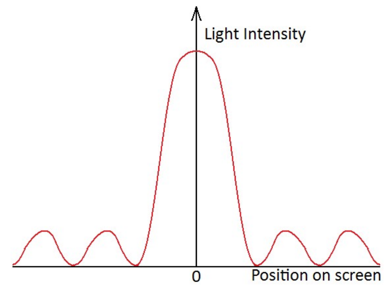
Diffraction



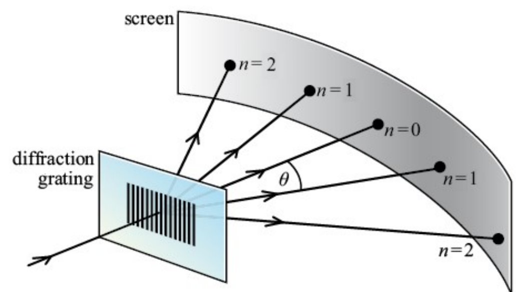
Diffraction is when waves pass through a gap and spread out. The amount of diffraction depends on the size of the wavelength compared to the size of the gap.
In the first diagram the gap is several times wider than the wavelength, so the wave only spreads out a little.
In the second diagram the gap is closer to the wavelength, so it begins to spread out more.
In the third diagram the gap is now roughly the same size as the wavelength, so it spreads out the most.

Diffraction Patterns

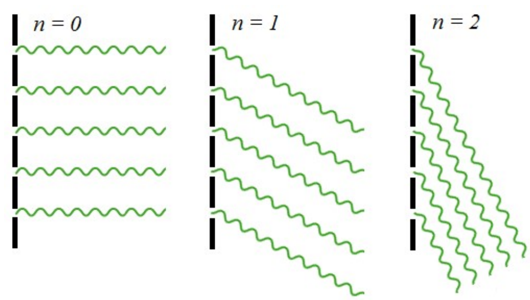


Here is the diffraction pattern from light being shone through a single slit.
There is a central maximum that is twice as wide as the others and by far the brightest. The outer fringes are dimmer and of equal width.
If we use three, four or more slits the interference maxima become brighter, narrower and further apart.

Diffraction Grating

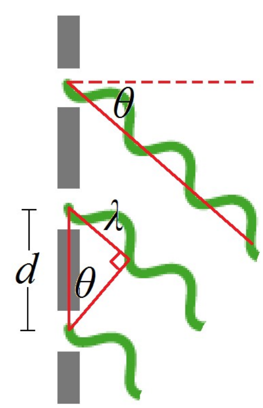


A diffraction grating is a series of narrow, parallel slits. They usually have around 500 slits per mm.
When light shines on the diffraction grating several bright sharp lines can be seen as shown in the diagram to the right.
The first bright line (or interference maximum) lies directly behind where the light shines on the grating. We call this the zero-order maximum. At an angle of θ from this lies the next bright line called the first-order maximum and so forth.



The zero-order maximum ($n=0$)
There is no path difference between neighbouring waves. They arrive in phase and interfere constructively.
The first-order maximum ($n=1$)
There is a path difference of 1 wavelength between neighbouring waves. They arrive in phase and interfere constructively.
The second-order maximum ($n=2$)
There is a path difference of 2 wavelengths between neighbouring waves. They arrive in phase and interfere constructively.
Between the maxima
The path difference is not a whole number of wavelengths so the waves arrive out of phase and interfere destructively.

Derivation



The angle to the maxima depends on the wavelength of the light and the separation of the slits. We can derive an equation that links them by taking a closer look at two neighbouring waves going to the first-order maximum.
The distance to the screen is so much bigger than the distance between two slits that emerging waves appear to be parallel and can be treated that way.
Consider the triangle to the right.

$$\sin\theta = \frac{Opposite}{Hypotenuse} \rightarrow \sin\theta = \frac{\lambda}{d} \rightarrow d\sin\theta = \lambda$$

For the nth order the opposite side of the triangle becomes $n\lambda$, making the equation:

$$\boxed{d\sin\theta = n\lambda}$$