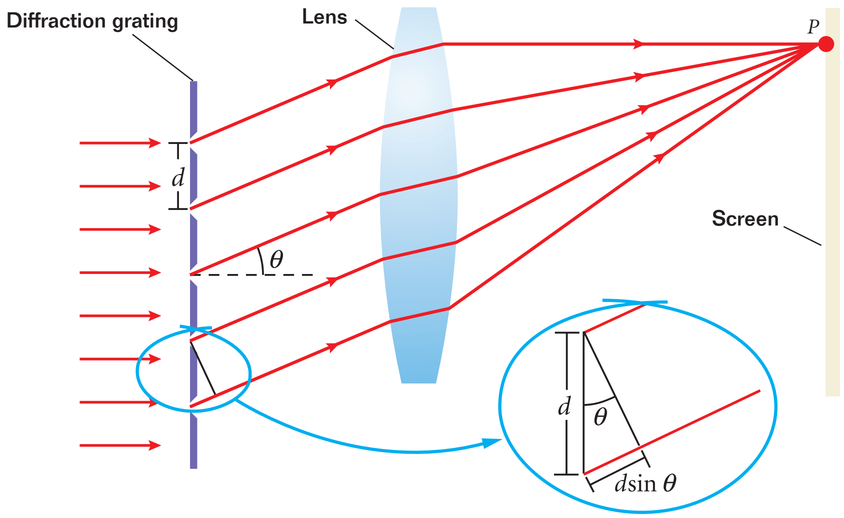

Figure 16
Light of a single wavelength passes through each of the slits of a diffraction grating to constructively interfere at a particular angle θ.

This phenomenon has been put to practical use in a device called a *diffraction grating.* A diffraction grating, which can be constructed to either transmit or reflect light, uses diffraction and interference to disperse light into its component colors with an effect similar to that of a glass prism. A transmission grating consists of many equally spaced parallel slits. Gratings are made by ruling equally spaced lines on a piece of glass using a diamond cutting point driven by an elaborate machine called a *ruling engine.* Replicas are then made by pouring liquid plastic on the grating and then peeling it off once it has set. This plastic grating is then fastened to a flat piece of glass or plastic for support.

Figure 16 shows a schematic diagram of a section of a diffraction grating. A monochromatic plane wave is incoming from the left, normal to the plane of the grating. The waves that emerge nearly parallel from the grating are brought together at a point P on the screen by the lens. The intensity of the pattern on the screen is the result of the combined effects of interference and diffraction. Each slit produces diffraction, and the diffracted beams in turn interfere with one another to produce the pattern.

For some arbitrary angle, θ, measured from the original direction of travel of the wave, the waves must travel *different* path lengths before reaching point P on the screen. Note that the path difference between waves from any two adjacent slits is $d\sin\theta$. If this path difference equals one wavelength or some integral multiple of a wavelength, waves from all slits will be in phase at P, and a bright line will be observed. The condition for bright line formation at angle θ is therefore given by the equation for constructive interference:

$$d\sin\theta = \pm m\lambda \qquad m = 0, 1, 2, 3, \ldots$$

This equation can be used to calculate the wavelength of light if you know the grating spacing and the angle of deviation. The integer m is the order number for the bright lines of a given wavelength. If the incident radiation contains several wavelengths, each wavelength deviates by a specific angle, which can be determined from the equation.

Why it Matters

Conceptual Challenge

1. Spiked Stars

Photographs of stars always show spikes extending from the stars. Given that the aperture of a camera's rectangular shutter has straight edges, explain how diffraction accounts for the spikes.

2. Radio Diffraction

Visible light waves are not observed diffracting around buildings or other obstacles. However, radio waves can be detected around buildings or mountains, even when the transmitter is not visible. Explain why diffraction is more evident for radio waves than for visible light.