"You can’t trust your eyes it is your imagination that is out of focus."
--Mark Twain
The diffraction grating consists of many equally spaced parallel slits. A typical grating contains several thousand lines per centimeter.

You will again get a diffraction pattern that consists of bright and dark spots. The bright spots will be sharper than the double slit case.
Diffraction Grating

The condition for maxima is:

$$d \sin \theta_{bright} = m \lambda$$

where $m$ is 0, 1, 2, ... .

A central maximum is defined and the angle $\theta$ is still measured with respect to the centerline.

The dark spots will be wider than the double slit case.
Polarization of Light

- Light from the sun is produced by the vibrations of multitude of atoms located there.
- Each atom produces a wave with its own orientation of the electric field.
- All directions of the electric field vector are equally possible and are in a plane perpendicular to the direction of propagation.
- This type of wave is known as an unpolarized wave.
Polarization of Light

- A wave is said to be linearly polarized if the resultant electric field vibrates in the same direction at all times at a particular point.
- It is possible to polarize an unpolarized beam. The most common technique for polarizing light is called polarization by selective absorption.
Polarization of Light

In this technique, you use a material that transmits waves whose electric field vectors in that plane are parallel to a certain direction.

This material also absorbs waves whose electric field vectors are perpendicular to that direction.

This device is known as a polarizer.

The material is known as a Polaroid.
Polarization of Light

When you place a second polarizing sheet (called the analyzer) behind the polarizer, the intensity of the polarized beam that is transmitted will vary as:

\[ I = I_o \cos^2 \theta \]

where \( I_o \) is the intensity of the polarized wave incident on the analyzer.

The angle \( \theta \) is the angle between the transmission axes of the two polarizing.

This is Malus’ Law.
Polarization of Light

- For angles of incidence between 0° and 90°, there is some degree of polarization.
- For one particular angle, the beam will be completely polarized. This angle is known as the polarizing angle, $\theta_p$ (also called Brewster’s Angle).
- Brewster’s Law relates the polarizing angle to the index of refraction for the material:

$$n = \frac{\sin \theta_p}{\cos \theta_p} = \tan \theta_p$$
Clicker Question 25A-1

Light of wavelength $\lambda_1$ illuminates a double slit, and interference fringes are observed on a screen behind the slits. When the wavelength is changed to $\lambda_2$, the fringes are closer together. How large is $\lambda_2$ relative to $\lambda_1$?

A) $\lambda_2$ is smaller than $\lambda_1$.
B) $\lambda_1$ is smaller than $\lambda_2$.
C) $\lambda_1$ and $\lambda_2$ are equal.
D) There is no way to tell how $\lambda_1$ and $\lambda_2$ compare with this experiment as changing the wavelength will never affect distance between the resulting interference fringes.
Optical Instruments

- Optical instruments use reflection and refraction to alter the light rays diverging from an object to make an image.
- A single-lens camera is an example of an optical instrument.
- A converging lens placed in a light-tight box produces a real image on film.
- The shutter is a mechanical device that is opened for a selected time interval.
Optical Instruments

- A camera focuses by changing the distance from the lens to the film screen, \( q \).
- This proper focusing leads to sharp images on the film.
- The f-number of a camera is the ratio of the focal length to its diameter.

\[
 f \text{-number} = \frac{f}{D}
\]

- The f-number is often given as the description of the lens “speed.”
- A lens with a low f-number is a “fast” lens.
The Eye

The normal eye focuses light diverging from an object and produces a sharp, real image.

- The cornea is a transparent section where the light passes through.
- Light then passes through the aqueous humor and a crystalline lens.
The Eye

- The pupil is a variable aperture that allows light to enter the lens.
- The iris is the colored portion of the eye which controls the size of the pupil.
- In low light conditions, the iris dilates the pupil to allow more light to enter.
Most of the refraction takes place at the outer surface of the eye. The cornea-lens system focuses light on the back surface of the eye known as the retina. The retina contains receptors called rods and cones that send impulses to the brain.
The Eye

The eye can focus on objects at different distances by varying the shape of the lens, this is known as accommodation.

The ciliary muscle helps to control the shape of the lens. When the muscle is relaxed the lens flattens. When the muscle tenses the lens bulges.
The Eye

- For a very distant object (say an object at infinity), the eye flattens the lens in order to increase the focal length.

- In this situation, the focal length, \( f \), will equal the fixed distance between the lens and retina (the image distance, \( q \)).

- This image distance has a nominal value of 1.7cm.

- For a very near object, the eye curves the lens in order to decrease the focal length.

- The near point of the eye is the closest distance for which the eye can focus light on the retina.
The Eye

- When you are young this is a small distance (<25cm) but it increases as you get older.
- We say that a person with normal vision has a near point of 25cm.
- The far point of the eye is the largest distance for which the eye can focus light on the retina.
- We say that a person with normal vision has a far point of infinity.
- This means that the eye can take parallel light rays and focus them on the retina.
Nearsighted

But some eyes may have trouble focusing these parallel light rays, this is known as being nearsighted.

Nearsightedness, also known as myopia, means the person can focus on nearby objects but not those far away.
Nearsighted

- A diverging lens can be used to correct the condition.
- The lens refracts the rays away from the principle axis before they enter the eye.
- This makes it appear to the eye that the object originated in front of the far point and allows the rays to focus on the retina.
Farsighted

- Some eyes may have trouble focusing light rays that originate from close objects, this is known as being farsighted.

- Farsightedness, also known as hyperopia, means the person can focus on far away objects but not those nearby.

Light rays reach the retina before they converge to form an image.
Farsighted

- A converging lens can be used to correct the condition.
- The lens refracts the rays more towards the principle axis before they enter the eye.
- This makes it appear to the eye that the object originated behind the far point and allows the rays to focus on the retina.
The Eye

As you get older, your eye loses the ability to accommodate. This is known as presbyopia.

This condition is similar to hyperopia and can be corrected with converging lenses.

When optometrists prescribe lenses to correct these vision problems they measure the value in diopters [= 1/meter].

\[ \phi = \frac{1}{f} \]

The power of a lens in diopters equals the inverse of the focal length in meters.
For Next Time (FNT)

- Keep reading Chapter 25

- Start working on the homework for Chapter 24