Slide 2: What the experiment shows

“This experiment demonstrates one core idea. Light behaves like a wave.
In the early eighteen hundreds, it was still debated whether light was a particle or a wave. Young showed that when light passes through two slits it produces a clear pattern of bright and dark fringes exactly like any other wave.
This behavior became the foundation for wave particle duality.
Whenever a wave goes through two openings, the waves overlap and interfere. Peaks add, dips cancel, and the screen records this structure.”

Slide 3: Setup and experiment

“Our setup uses a six hundred seventy nanometer red laser. The photodiode converts the incoming light into a voltage and the multimeter reads that voltage which is proportional to intensity.
The detector moves using micrometers with a ten micrometer resolution.
We use a single slit, a double slit, and a five hundred millimeter distance to reach the Fraunhofer regime where the pattern depends only on angles.
The data collected is simple. Position in millimeters versus intensity in millivolts.”

**Fraunhofer regime where the pattern depends only on angles*

Slide 4: What happens with one slit

“With one slit the light does not travel straight. The entire width of the slit acts like many small wave sources that interfere with each other.
This produces a wide central bright region and weaker side lobes on both sides.
Mathematically the pattern follows a sinc squared shape. The phase difference across the slit appears as the parameter beta, which depends on the slit width, wavelength, and the detector position.
This diffraction envelope becomes important later because it multiplies the two slit interference pattern.”

Slide 5: What happens with two slits

“With two slits each slit generates its own wave. These two waves travel different distances before they reach the detector which creates a phase difference.
If they arrive in phase they add and form a bright fringe. If they arrive out of phase they cancel and form a dark fringe.
The result is a series of narrow bright and dark lines. The spacing depends on the slit separation S.
This is the classic interference pattern Young observed.”

Slide 6: Double slit intensity

“In the real double slit the intensity is the product of two effects. The diffraction envelope from each slit and the interference fringes created by the separation between the slits.
The diffraction envelope is wide and smooth, and the interference fringes are narrow and periodic inside that envelope.
This is why the double slit pattern has a central bright region with many thin fringes inside.”

Slide 7: Where bright and dark fringes appear

“Bright fringes appear when the path difference between the slits equals whole multiples of the wavelength. Dark fringes occur when the difference equals half odd multiples.
Geometrically the path difference comes from simple trigonometry. The slit separation creates a small angle and that angle controls where constructive and destructive interference appear on the screen.”

Slide 8: Slit geometry and Fourier transformation

**“In the Fraunhofer regime the pattern on the screen is the Fourier transform of the aperture.
A rectangular slit has a Fourier transform that is a sinc function which is exactly the shape of the single slit diffraction pattern.
If there are two slits the aperture is two rectangles shifted apart. In Fourier space that shift produces a cosine term which creates the interference fringes.
So the full double slit pattern is a sinc squared envelope multiplied by a cosine squared fringe structure.”**

**Adding waves from different positions is exactly what a Fourier transform does*

Slide 9: Data measurements and normalization

“To analyze the data we first recorded raw voltages from the photodiode. The baseline with the laser off was eight point five millivolts, so we subtracted that offset.
Then we normalized the data by dividing by the peak value so the maximum becomes one. This allows direct comparison between theory and experiment.
Finally we converted positions in millimeters to angles using theta equals x over L with L equal to five hundred millimeters.”

Slide 10: Fitting process

“The single slit data was fitted to the Fraunhofer model. The key parameter extracted from each fit is the slit width D. The fitting also determines the position shift x zero and the amplitude I zero.
For the double slit pattern we used the full combined model that includes both the diffraction envelope and the interference term.
This fit gives us both D and the slit separation S which determines the fringe spacing. The **position offset x zero is again included to center the pattern**.”

Slide 11: Results

“From the fits the left slit width was about seventy two point nine micrometers and the right slit was about sixty seven point one micrometers.
For the double slit the separation S was approximately four hundred eight micrometers which matches the sixteen mil reference value for that slit card.
The fitted x zero values allowed us to center all patterns correctly.
Using the known wavelength of six hundred seventy nanometers we verified that the theoretical fringe spacing matched the measured spacing.”

**How D and S come from fits*
D (slit width) controls the width of the diffraction envelope. Making D larger narrows the envelope.

S (slit separation) controls the spacing of the interference fringes. A larger S produces more closely spaced fringes.
By adjusting D and S while fitting the theoretical curve to the measured data, the best match gives the values of the physical slit width and separation.

Slide 12: Fit quality and physics checks

"To evaluate how well the models matched the data we used chi squared values. The right slit showed the best agreement. The left slit had alignment issues but still produced a usable estimate. The double slit fit was good enough to reliably extract the geometry.
We also checked the number of fringes and the predicted spacing using delta x equals lambda times L divided by S. The measured spacing of zero point eight two millimeters was consistent with theory."

Slide 13: Uncertainties

"When we fit the data, the computer adjusts the parameters D, S, x_0, and I_0 until the theoretical curve matches the measured intensity pattern as closely as possible.

The fitting algorithm then gives us a covariance matrix. This matrix tells us how sensitive the fit is to noise in the data.

If a parameter changes the curve a lot, its uncertainty is very small.

If a parameter barely affects the curve, its uncertainty is larger.

So, the uncertainties come directly from how the fit reacts to noise and how sharply the model is defined."

Closing

"In summary this experiment demonstrated the wave nature of light, reproduced the classic diffraction and interference patterns, and used fitting techniques to determine the slit width and separation directly from the observed intensity.
Thank you."