Aim of the experiment:

To study the diffraction pattern of a slit using a laser source and a photo-diode based detection system on an optical bench. To measure the intensity distribution due to the single slit and measure the slit width. To observe the diffraction pattern from an obstacle(thin wire).

Apparatus:

Optical bench, red semiconductor laser, photo cell, multimeter, single slit with adjustable

width, optical mounts for wire, screen to observe pattern.

Theory:

Different from Fresnel diffraction, *a diffraction pattern for which the phase of the light at the point of observation is a linear function of the position, for all points in the diffracting aperture is Fraunhofer diffraction.*1This diffraction occurs when source and screen are at an infinite distance from the slit.

Mathematically, W2/Lλ << 1 where W = aperture size, Wavelength of incident light, L = distance of slit from aperture.

According to the Huygens principle, the line source of light can be understood as a collection of point source of light that give rise to secondary wavelets. If the distance between consecutive points is ∆, and if n is the number of point sources:

a = (n − 1)∆

Now the experimenter should keep in mind two assumptions while doing the experiment:

1. D >> a
2. ∆ << λ

Here D is the distance between the slit and the source of light, 'a' is the aperture of the slit. Our objective is to find for each point on the screen, sum of amplitudes arriving from each point source of light in the limit that n tends to infinity, ∆ tends to 0 and n∆ tends to a. At a point P on the screen, because of slightly different path lengths, the field produced by a point source at A1 will differ in phase from the field produced by a point source at A2 with the phase difference being ∆β = 2π∆ sin θ/λ. This can be seen from the fact that phase difference between the rays is ∆ sin θ. Furthermore, the amplitude of the wave emerging from each point source is given by ∆E0 = E0/n

where E is the amplitude of the wave incident on the single slit.

The total amplitude on the screen for the angle θ will be the coherent sum of the n waves

Eθ = Eθ0 sin (ωt + φ).

The resultant field at the point P from n sources adds upto:

E0[sin ωt + sin (ωt + ∆β) + sin (ωt + 2∆β) + ... + sin (ωt + (N − 1)∆β)]/n in the limit n goes to ∞, and ∆ goes to 0.

The field thus becomes:

Eθ = E0 sin (ωt + β/2)sin(β/2)/ (β/2)

It can be shown that intensity of light is zero when a sinθ = mλ

Procedure:

1. The laser was left switched on for 15 minutes so that light intensity from laser did not flicker.
2. The slit was mounted on the bench so that the diffraction pattern could be seen on the white screen.
3. The slit size and distance from laser were varied and observations were noted.
4. The photocell was mounted onto the stand between the slit and the white screen.
5. A graph between the photo-current and position of the diode was plotted.
6. The distance *D* between the slit and photocell was measured.
7. The distance *x* from the center of diffraction pattern to the first minimum was obtained and the slit width was calculated (as explained in the theory)
8. The expected theoretical values and the observed values were compared.
9. Lastly, a wire was mounted on the optical bench. The wire and laser sources were moved until the diffraction pattern was visible through the wire. The aperture dimensions were measured by a traveling microscope and the thickness of the wire was found.

The observations/calculations and results are as shown on the following pages.

Precautions:

1. The laser should not looked into directly.
2. The photo cell should be kept far away from the screen