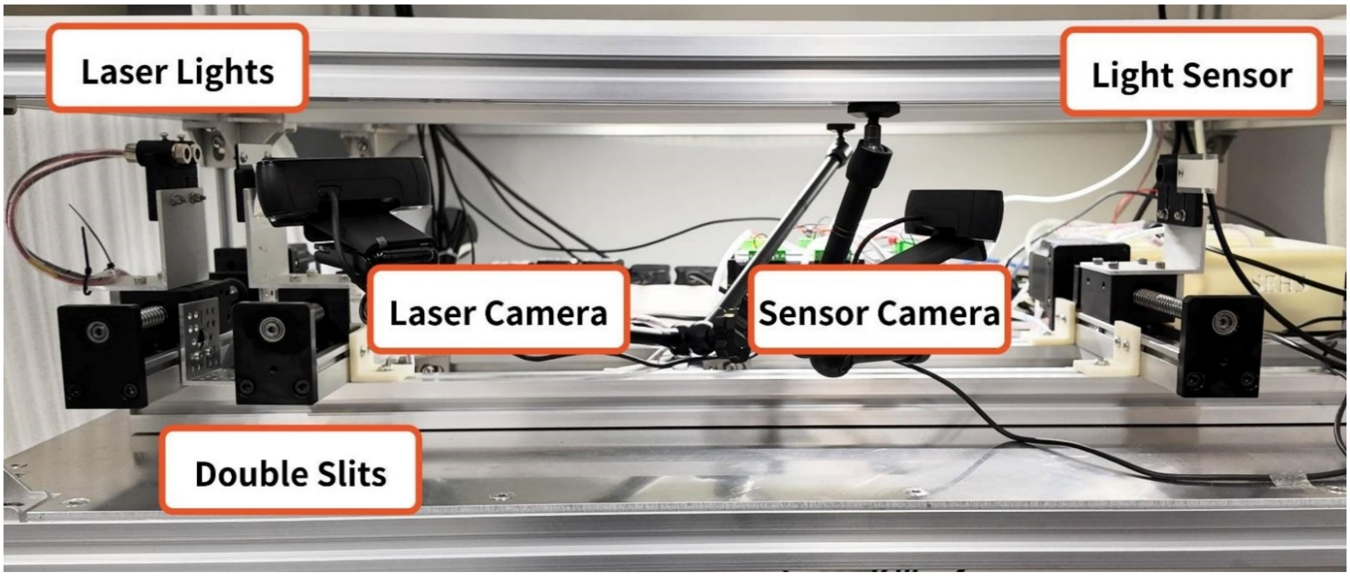
The Hong Kong Polytechnic University
College of Professional and Continuing Education
Hong Kong Community College

HKCC Remote Laboratory System*
Optics Experiment: Interference and Diffraction Laboratory Worksheet



*HKCC Remote Laboratory is a web-based service to enable remote off-campus access to experimental sets for science and engineering students. The Remote Lab was financially supported by the Quality Enhancement Support Scheme of the Hong Kong Special Administrative Region Government (QESS, HKSAR) and Hong Kong Community College of The Hong Kong Polytechnic University (PolyU HKCC), under the project title, "Development of a Web-based Remote Laboratory for Science and Engineering Education", and project no.: 04/QESS/2021.

Objective

In this experiment, you will investigate the double-slit patterns formed by laser light passing through slits. You will carry out an experiment by using laser light with different colours (i.e. wavelengths) and slits with different separations.

Theory

Interference occurs when waves emerging from double-slit superimpose to form a resultant wave that has greater or lower amplitude if two waves are in phase or out of phase respectively, as shown in Figure 1 below. The phase difference between two waves will change if the waves travel paths of different lengths, i.e. path length difference, $L = d\sin\theta$. Hence, for bright fringes, $d\sin\theta = m\lambda$, $m = 0, 1, 2, 3, ...$, where m is integer, and d is the slit separation.

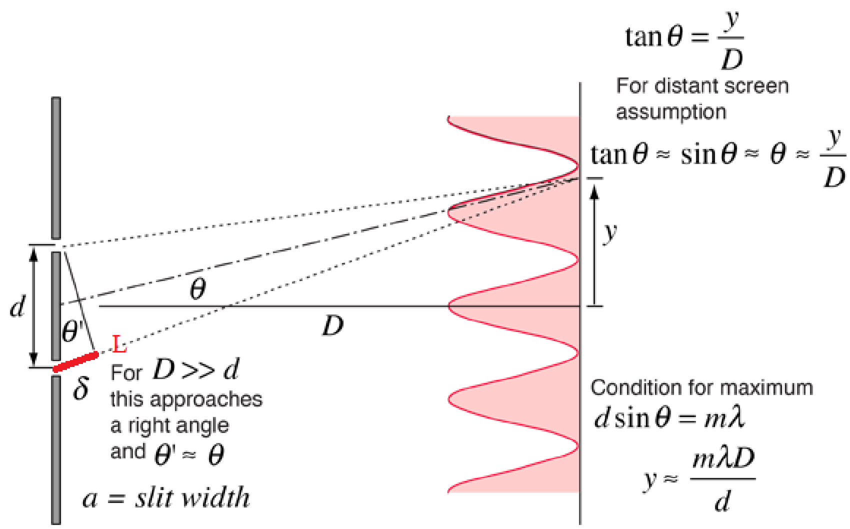


Figure 1. Interference Pattern (http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/slits.html)

The distance of mth bright fringe to the central line (y_m) is,

$$\tan\theta = \frac{y_m}{D},$$

and the angle, θ, of mth bright fringe will be,

$$\sin\theta = \frac{m\lambda}{d}.$$

Since $D >> a$, we have $\sin\theta \approx \theta \approx \tan\theta$. Then, we have

$$\frac{y_m}{D} = \frac{m\lambda}{d}$$

Hence, the distance of mth bright fringe to the central can be calculated by,

$$y_m = \frac{m\lambda D}{d}$$

<u>Diffraction</u> occurs when a wave is spreading out by passing through a single slit (Figure 2). Similarly, the phase difference between adjacent fringes depends on the path length difference, L. Hence, for <u>dark fringes</u>, we have

$$\frac{a}{2}\sin\theta = m\frac{\lambda}{2}$$

$a\sin\theta = m\lambda, m = 1, 2, 3, \ldots$, where m is integer, and a is the slit width.

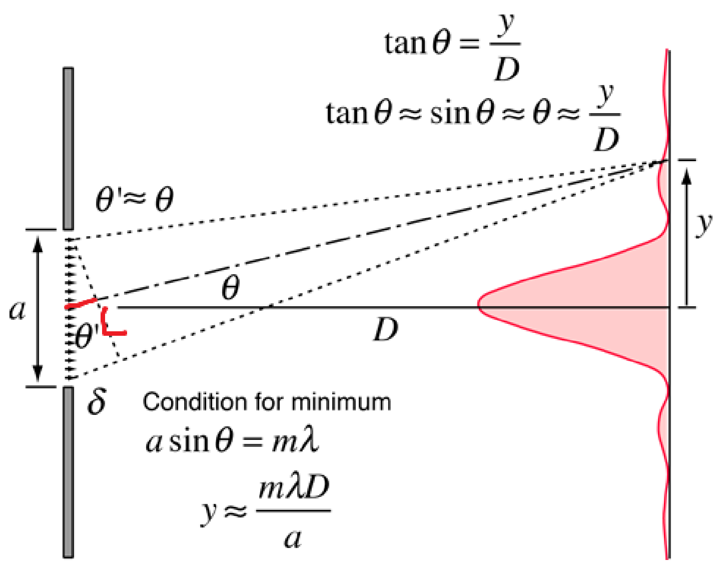


Figure 2. Diffraction Pattern (http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/slits.html)

<u>Procedure</u>

1. Select a laser light (red or green) and double-slit under the "Controls" tab. Then, click "Start" button to begin the experiment.

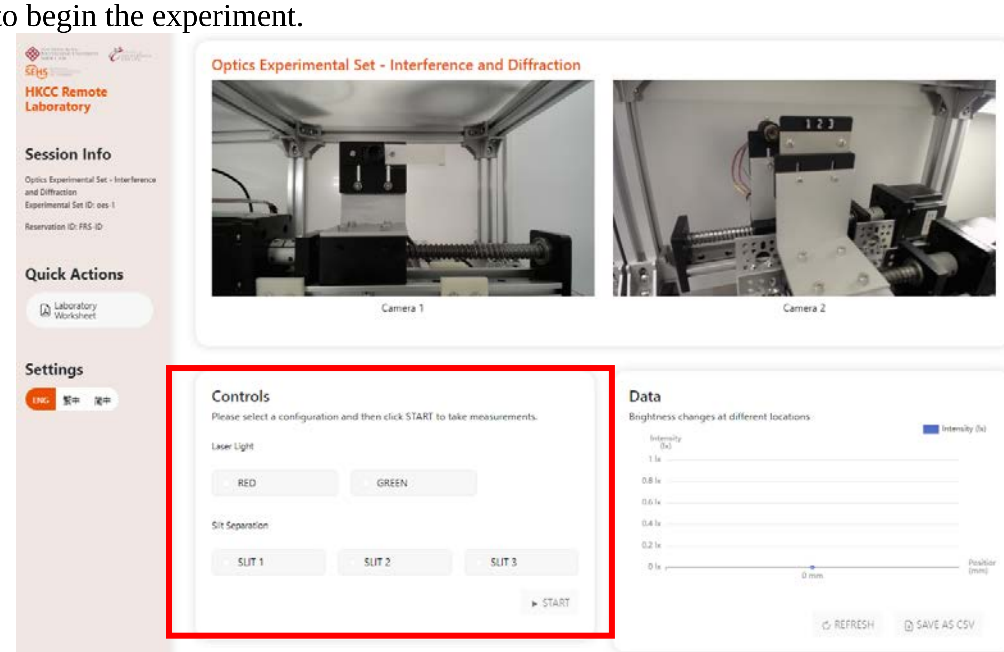


Figure 3. Select a laser light and slit separation for starting the experiment.

2. Observe your selected laser light will turn on and the selected double-slit will move to the corresponding position. You can click on the live Camera 2 to enlarge the view.

3. The double-slit pattern can now be observed on the white screen on Camera 1 (Figure 4), and the light sensor will then move from left to right. You can click on the live Camera 1 to enlarge the view.

Figure 4. Enlarge view of camera 1 (double-slit pattern shows on the white screen).

4. The double-slit pattern will then be plotted in the "Data" tab as shown in Figure 5.

5. The result can be downloaded in .CSV format for further analysis (Figure 5).

6. You may start a new trial of the experiment with same or other settings.

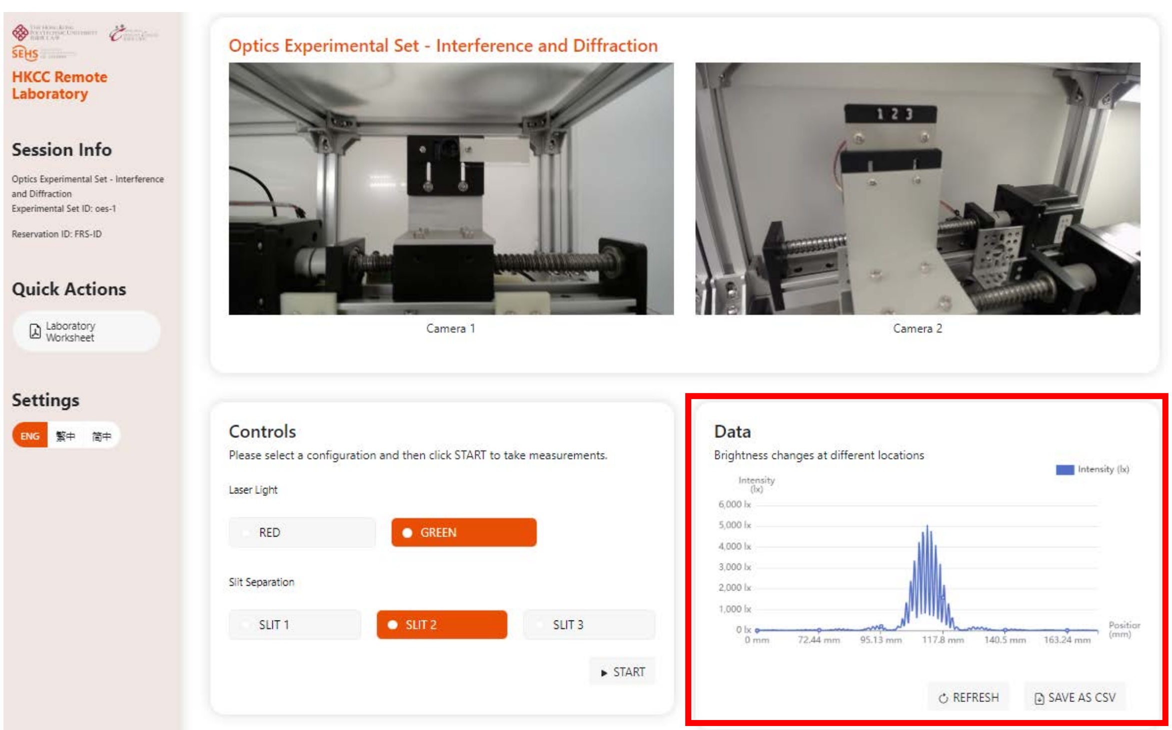


Figure 5. The experimental result.

Data

Trial	Laser Light (Red or Green)	Slit Number	No. of Bright Fringes in the Central Diffraction Envelope
1			
2			
3			
4			

Analysis and Discussion

7. There are 3 kinds of slit separation, e.g. 0.2 mm, 0.4 mm, and 0,6 mm, used in the experiment. Match the slit number with its corresponding slit separation.

Slit Number	Slit Separation (in mm)
1	
2	
3	

Given the **slit width is 0.05 mm** and the **distance** between double-slit and screen is **60 cm**.

8. How does the double-slit pattern change as you select different laser lights from red to green with the same 0.2 mm double-slit? You may draw the patterns and/ or show by calculation to supplement your answer.

9. How does the double-slit pattern change as you increase the slit separation from 0.2 mm to 0.4 mm? You may draw the patterns and/ or show by calculation to supplement for your answer.

10. Calculate the wavelengths of red and green laser lights.

End of Laboratory Worksheet

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