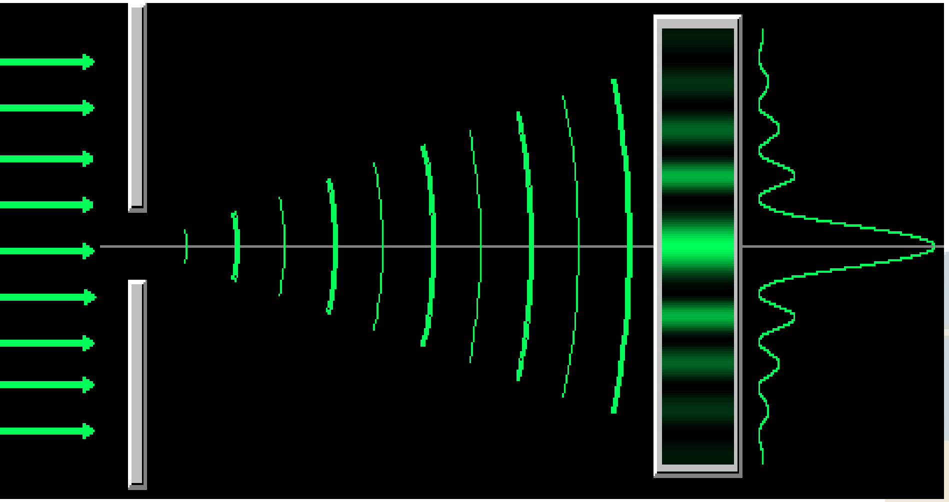
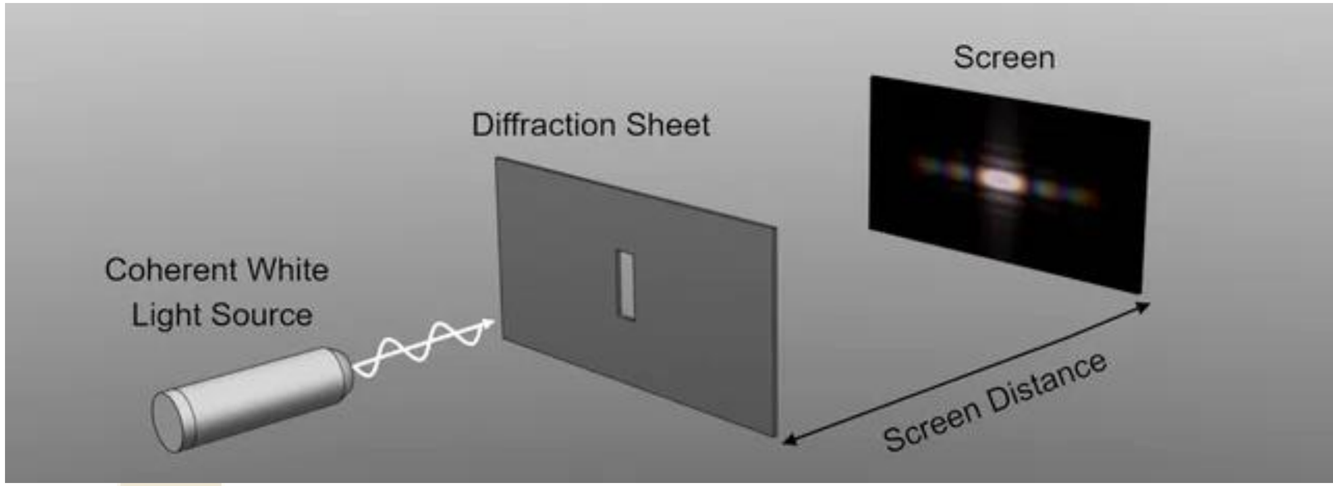




Unit III

Chapter 13

Wave Aspect of Light - Diffraction

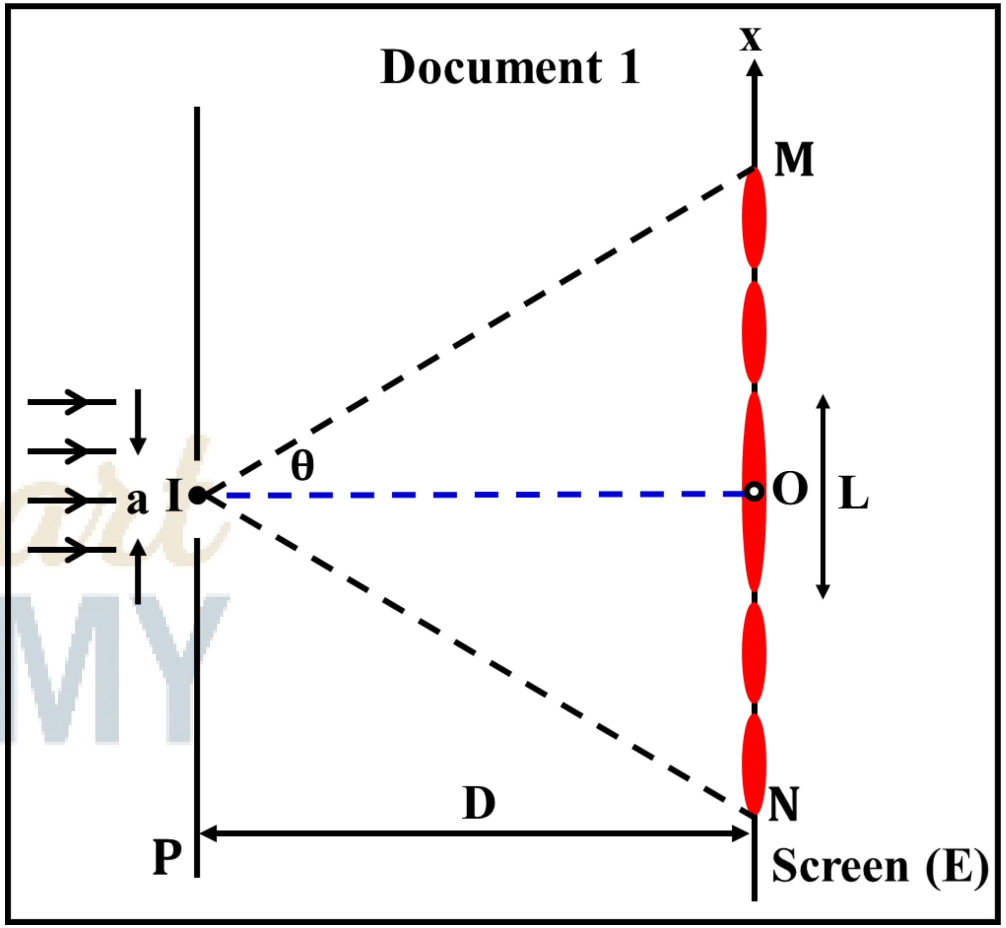
Prepared and Presented by: Mr. Mohamad Seif


Quiz
Time

A laser beam (S) of blue light, of wavelength in vacuum is λ_1, falls normally on a vertical slit of width $a = 0.45mm$.

The diffraction pattern is observed on a screen (E) placed perpendicularly to the laser beam at a distance $D = 2\ m$ from the axis (P) of the slit.

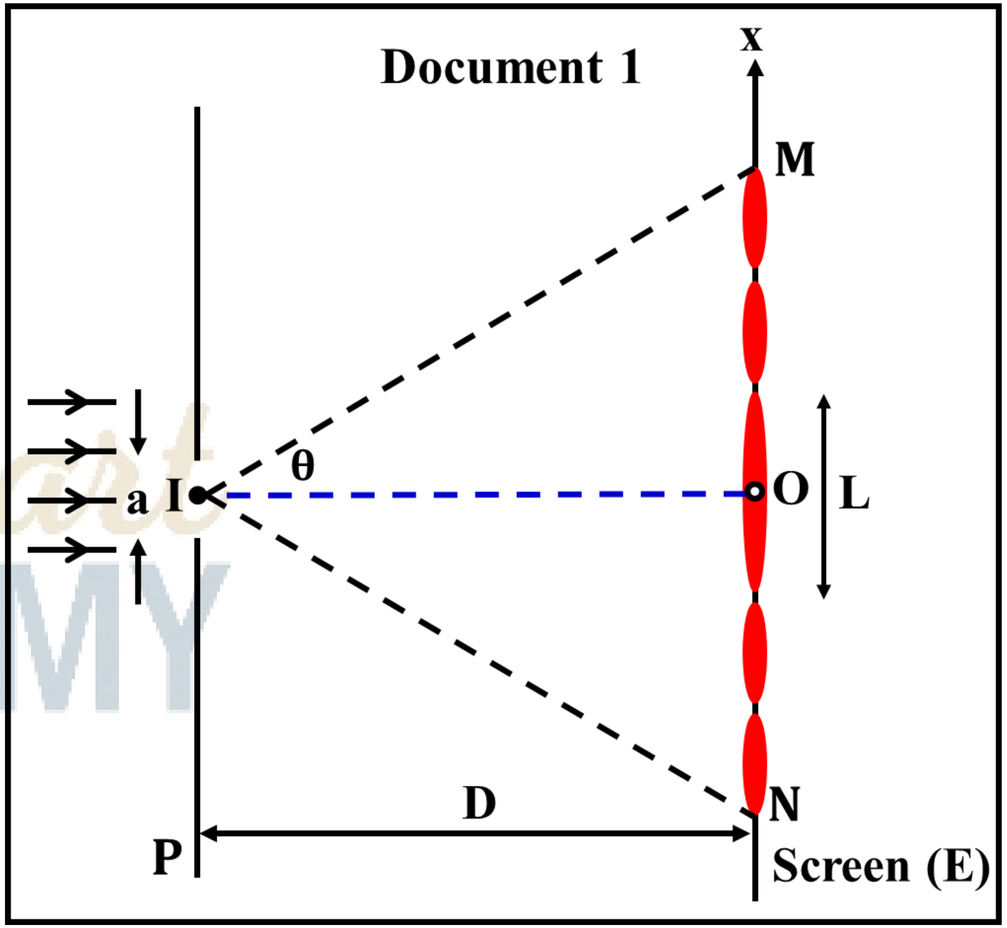
I is the center of the slit and O is the center of central bright fringe whose linear width is L. (Doc. 1).



The angle of diffraction corresponding to a dark fringe of order n is given by $\theta_n = \frac{n\lambda}{a}$, where n is an integer ($n > 0$).

The aim of this exercise is to identify the wavelength of this light

Let M be the center of the third dark fringe of abscissa $X_M = \overline{OM}$ in the positive side and N be the center of the third dark fringe of abscissa $X_N = \overline{ON}$ in the negative side.



1) Characteristics of Diffraction pattern:

1.1) Diffraction shows evidence of a certain aspect of light. What is this aspect?

1.2) blue light is monochromatic and belongs to a visible range.

a) Why blue light is visible?

b) What does monochromatic light mean?

1.3) Describe the observed diffraction pattern.

1.1) Diffraction shows evidence of a certain aspect of light. What is this aspect?

This experiment shows the wave aspect of light.

1.2) blue light is monochromatic and belongs to a visible range.

a) Why blue light is visible?

Blue light is visible because its wavelength is between $400nm$ and $800nm$

$$400nm \le \lambda_{blue} \le 800nm$$

b)What does monochromatic light mean?

Monochromatic light means the light beam is of one color (blue).

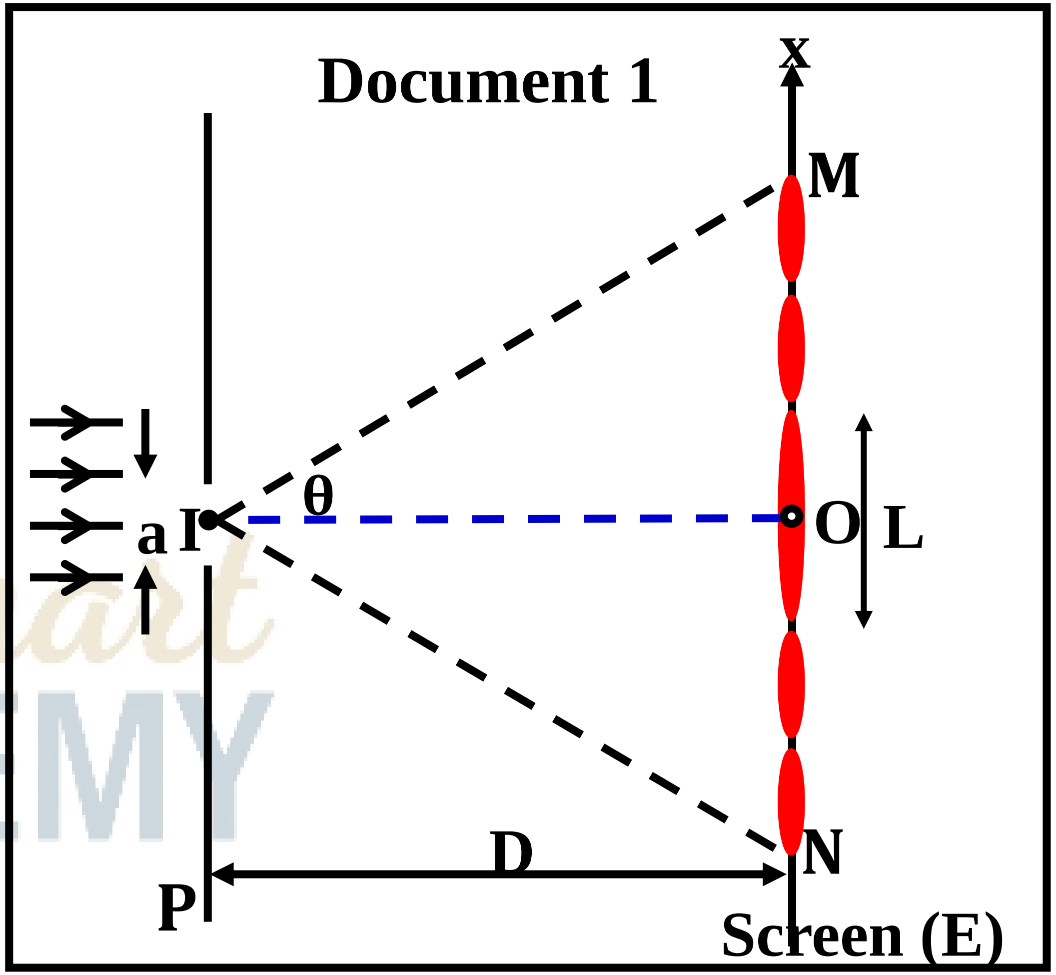
1.3) Describe the observed diffraction pattern.

- **Alternative bright and dark fringes.**
- **The size of the central bright fringe is double the width of any other bright fringe.**
- **The direction of the pattern of fringes is perpendicular to that of the slit.**
- **Central bright fringe of maximum intensity.**

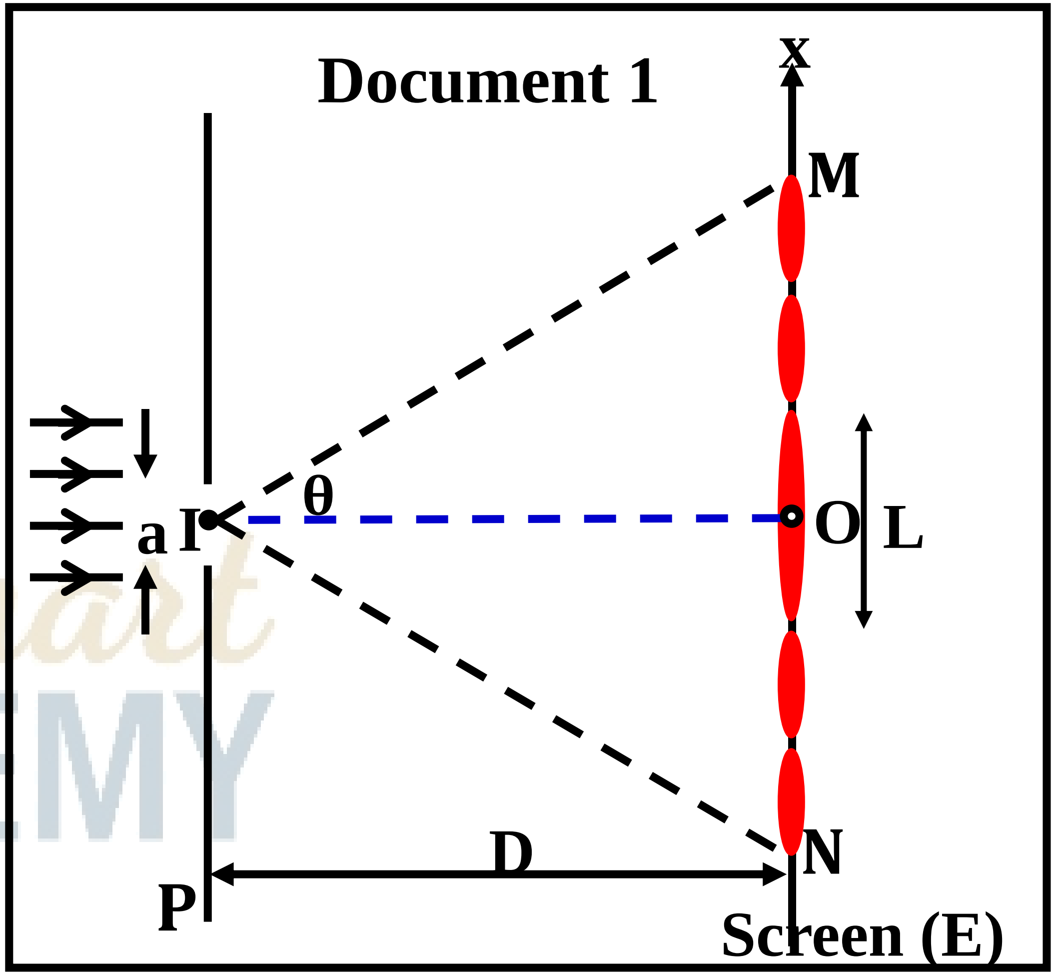
2)Determination of the wavelength of blue light:

2.1) Write the expression of the linear width L of the central bright fringe obtained, in terms λ_1, D and a.

2.2) Show that $X_M = \frac{3\lambda_1 D}{a}$ then determine the expression of X_N.



2.1) Write the expression of the linear width L of the central bright fringe obtained, in terms λ_1, D and a.

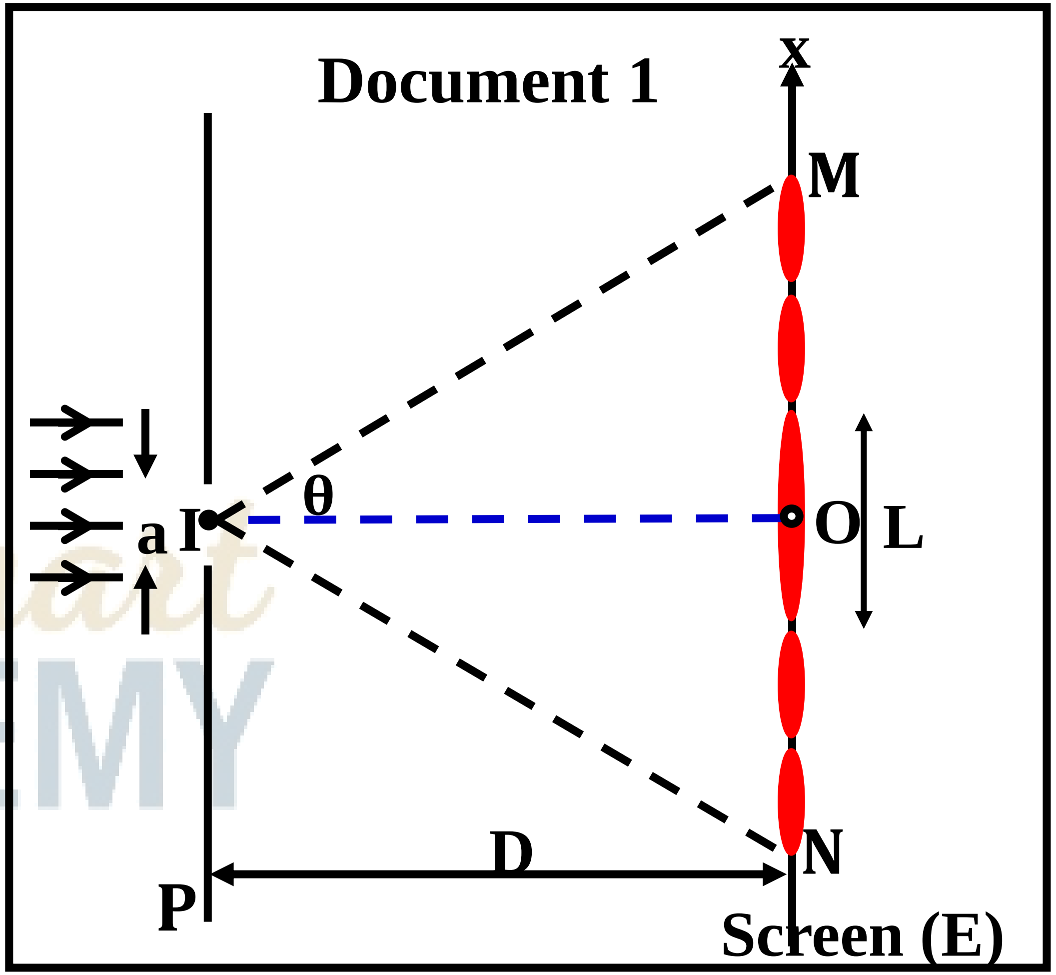


$$\theta = \frac{n\lambda_1}{a} \Rightarrow \theta_1 = \frac{\lambda_1}{a}$$

$$\tan\theta_1 = \frac{opp}{adj} = \frac{L/2}{D} \Rightarrow \theta_1 = \frac{L}{2D}$$

$$\frac{\lambda_1}{a} = \frac{L}{2D} \Rightarrow L = \frac{2\lambda_1 D}{a}$$

2.2) Show that $X_M = \frac{3\lambda_1 D}{a}$ then determine the expression of X_N.



$$\tan\theta_n = \frac{opp}{adj} = \frac{x}{D} \Rightarrow \theta_n = \frac{x}{D}$$

$$\theta_n = \frac{n\lambda_1}{a}$$

$$\frac{x}{D} = \frac{n\lambda_1}{a}$$

$$x = \frac{n\lambda_1 D}{a}$$

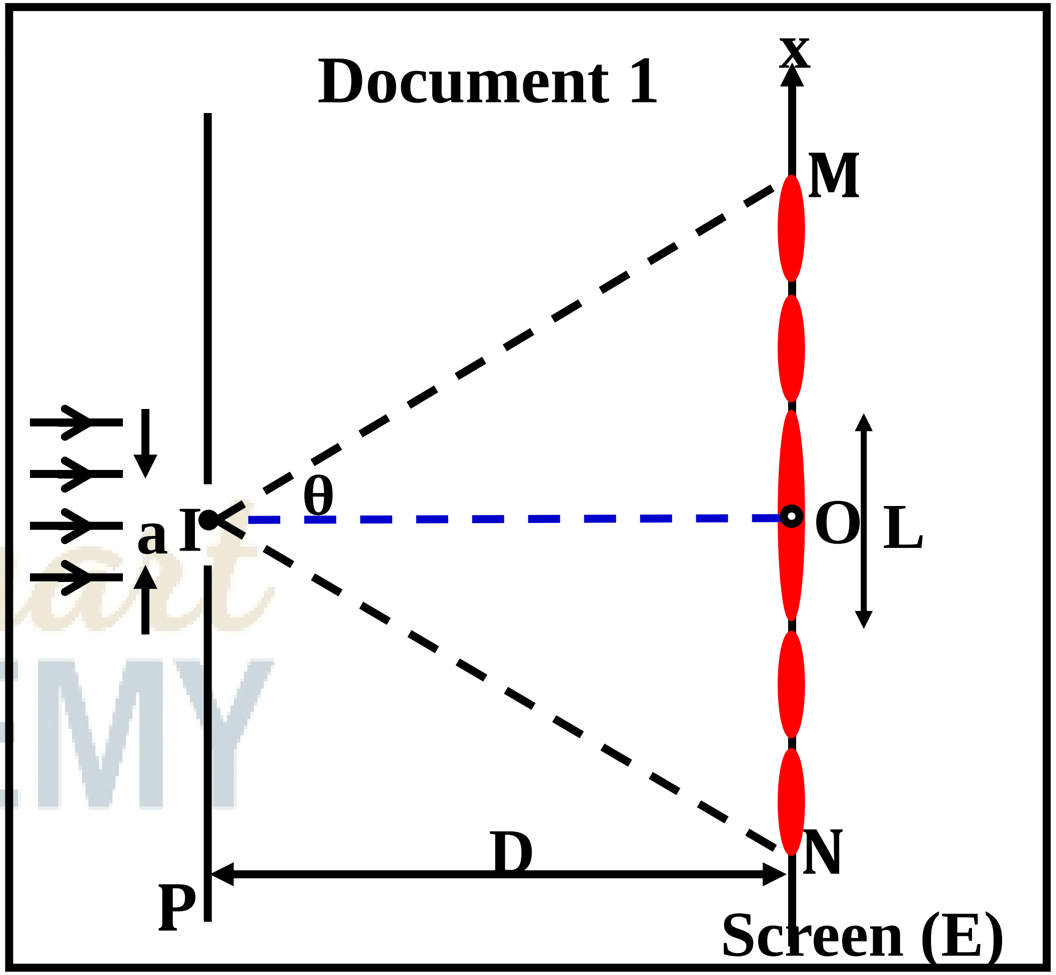
2.2) Show that $X_M = \frac{3\lambda_1 D}{a}$ then determine the expression of X_N.

For point M; 3rd dark fringe in the positive direction, $n = +3$

$$x_M = \frac{3\lambda_1 D}{a}$$

For point N; 3rd dark fringe in the negative direction, $n = -3$

$$x_N = \frac{-3\lambda_1 D}{a}$$



2)Determination of the wavelength of blue light:

3) The pattern observed in (Doc. 2) shows the distance between M and N.

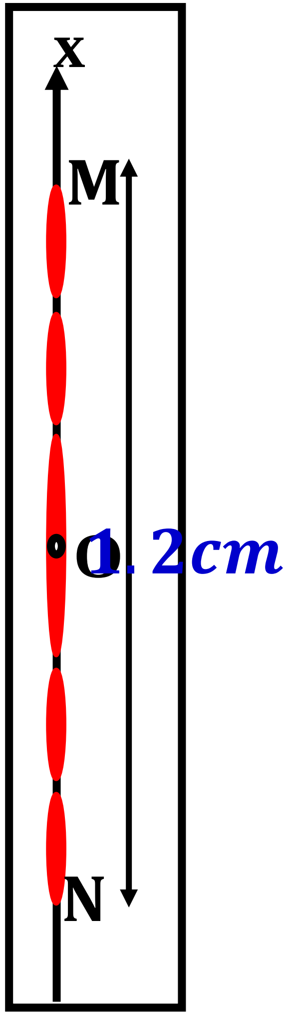
3.1) Show that MN = 3L then deduce the value of L.

3.2) Calculate the value of the wavelength.

3) The pattern observed in (Doc. 2) shows the distance between M and N.

3.1) Show that MN = 3L then deduce the value of L.

Document 2



Screen (E)

$$MN = x_M - x_N \Rightarrow MN = \left[\frac{3\lambda_1 D}{a}\right] - \left[\frac{-3\lambda_1 D}{a}\right]$$

$$MN = \frac{3\lambda_1 D}{a} + \frac{3\lambda_1 D}{a} \Rightarrow MN = \frac{6\lambda_1 D}{a}$$

$$MN = \frac{3 \times 2\lambda_1 D}{a} \Rightarrow MN = 3L$$

3.2) Calculate the value of the wavelength.

Using the expression $L = \frac{2\lambda_1 D}{a}$

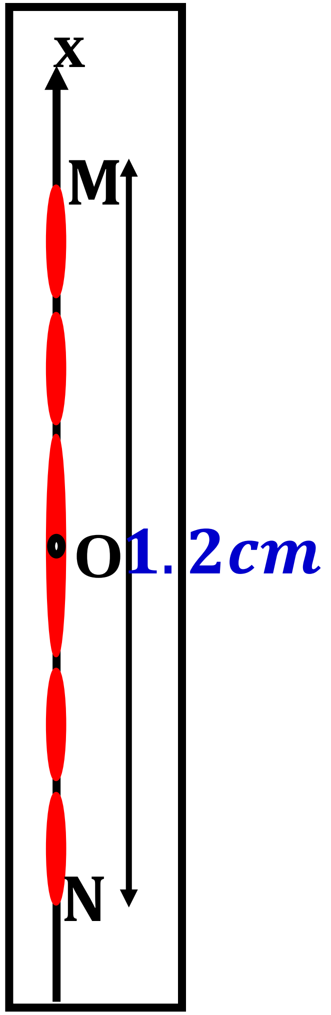
$$L = \frac{2\lambda_1 D}{a} \Rightarrow \frac{L}{1} = \frac{2\lambda_1 D}{a} \Rightarrow \lambda_1 = \frac{L \times a}{2D}$$

$$MN = 3L \Rightarrow L = \frac{MN}{3} = \frac{1.2}{3} = 0.4cm$$

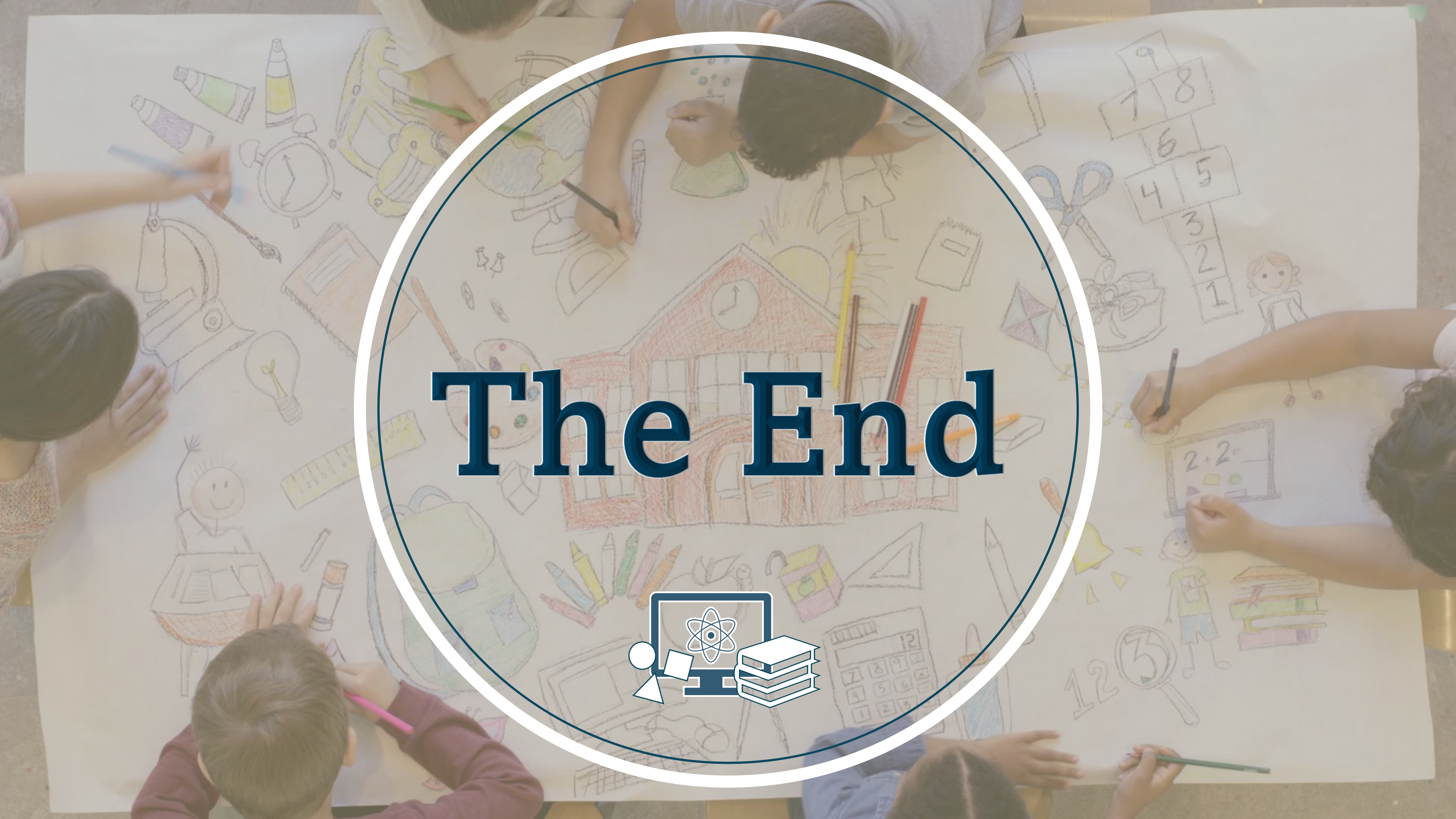
$$\lambda_1 = \frac{L \times a}{2D} = \frac{0.4 \times 10^{-2} \times 0.45 \times 10^{-3}}{2 \times 2}$$

$$\lambda_1 = 0.045 \times 10^{-5} m = 450nm$$

Document 2



Screen (E)



The End


?
Quiz
Time

The purpose of this exercise is to specify the width of square particles that can enter the mesh of a powder sieve.

A sieve is a tool for separating wanted elements from unwanted material or for controlling the particle size distribution of a sample (Doc. 1).

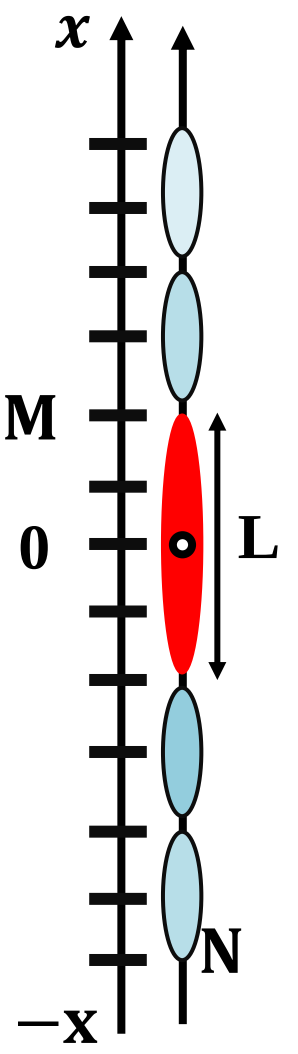
Document 1

For this purpose, we perform the following diffraction experiments.

1) Single rectangular slit Diffraction:

A laser source of monochromatic light of wavelength in air is $\lambda = 600nm$ is used to illuminate a vertical slit having the same width «a» of a square particle from the powder we want to place into the sieve.
Diffraction pattern is observed on a screen placed at a distance $D = 3m$ from the axis of this slit (Doc. 2).

Document 2

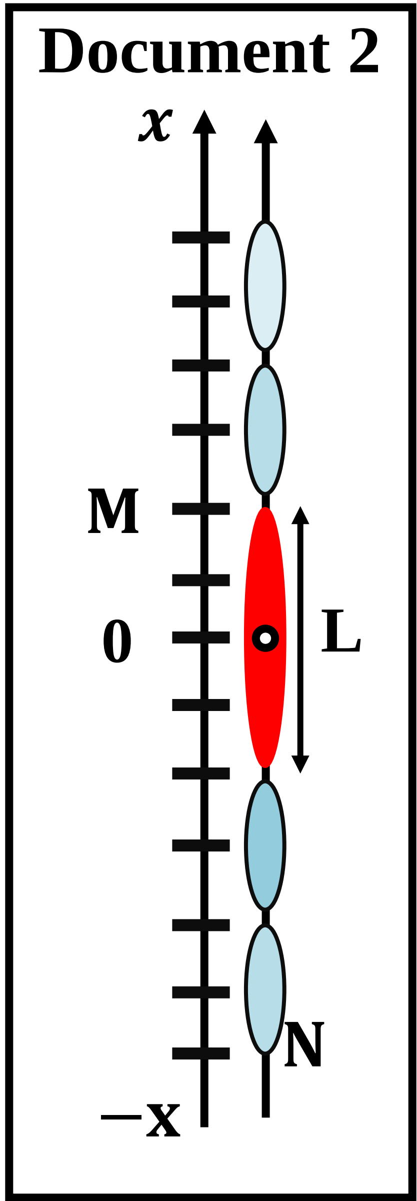


1.1) For what values of "a" diffraction occurs?

The diffraction takes place if the width a is very small ($a \leq 1m$)

1.2) Describe the observed diffraction pattern.

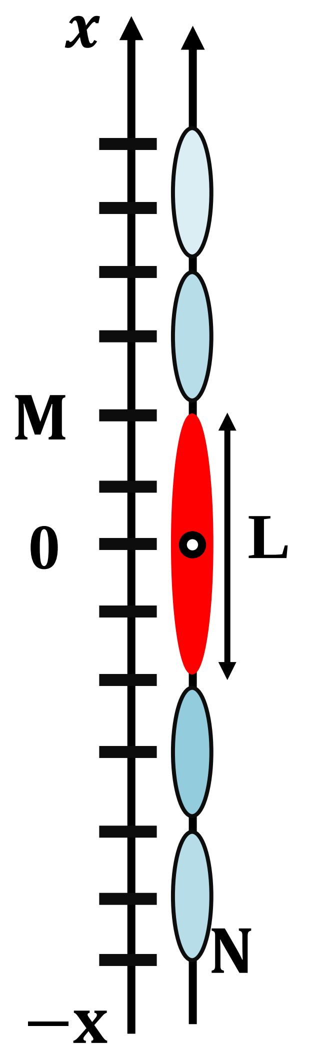
- **Alternative bright and dark fringes.**
- **The size of the central bright fringe is double the width of any other bright fringe.**
- **The direction of the pattern of fringes is perpendicular to that of the slit.**
- **Central bright fringe of maximum intensity.**



1.3) What aspect of light is confirmed by this experiment?

This experiment shows that the light apply the wave aspect of light

Document 2



2) Width of the slit:

Let M be the center of the first dark fringe in the positive side and O be the center of the central bright fringe whose linear width is L.

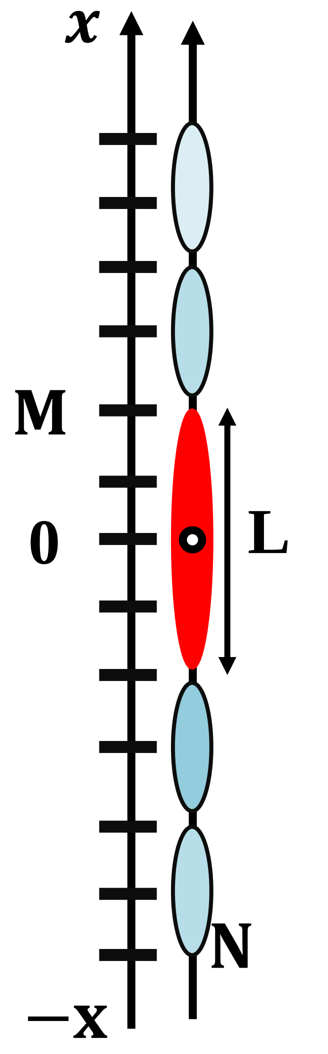
For small values of the angle θ take $\tan\theta = \sin\theta = \theta$ in radian.

The scale of x-axis in (Doc. 2) is: $1div \to 1.2mm$.

2.1) Determine the expression of $\overline{OM} = x$ in terms of, D and a.

2.2) Deduce the expression of L in terms of λ, D and a.

Document 2



2.3) Show that $L = 4.8\ mm$.

2.4) Deduce the width a of the square particle.

2.5) Choose the correct statement(s):

Statement 1: **If we increase the intensity of the laser light, the linear width L of central fringe increases.**

Statement 2: **If we decrease the intensity of the laser light, the linear width of the central fringe remains the same.**

Statement 3: **If we increase the distance between the source of light and the axis of the slit, the number of fringes on the screen decreases.**

2.1) Determine the expression of $\overline{OM} = x$ in terms of λ, D and a.

$$\tan\theta_1 = \frac{opp}{adj} = \frac{OM}{D}$$

θ_1 is very small: $tan\theta_1 = \theta_1$

$$\theta_1 = \frac{x}{D}$$

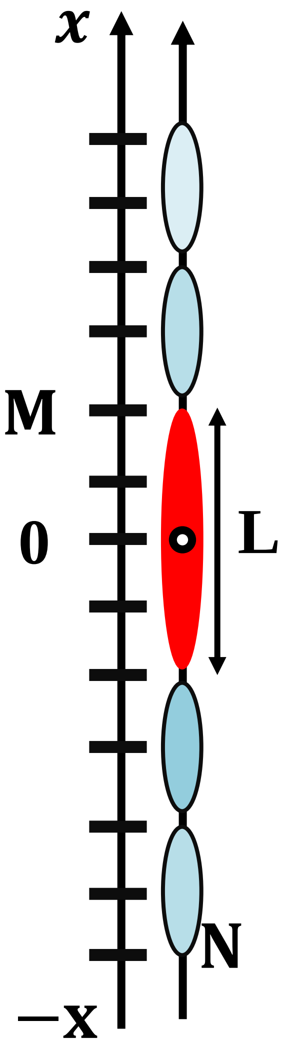
And

$$\theta_1 = \frac{n\lambda}{a} = \frac{\lambda}{a}$$

$$\frac{x}{D} = \frac{\lambda}{a}$$

$$x = \frac{\lambda D}{a}$$

Document 2



2.2) Deduce the expression of L in terms of λ, D and a.

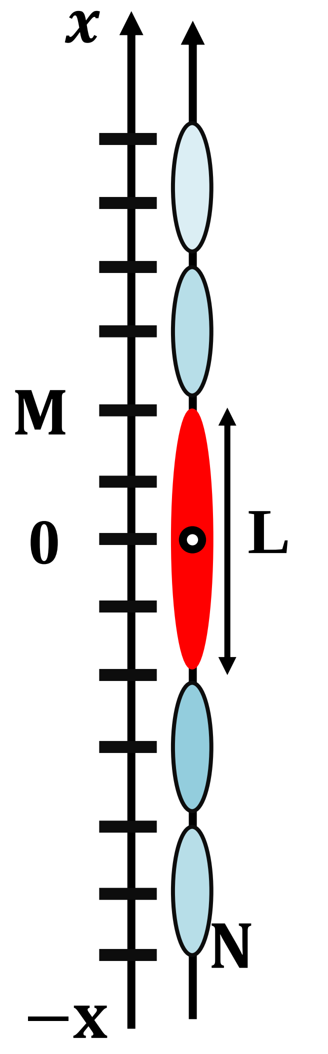
X is the distance between the center of C.B.F O and the first D.F:

$$x = \frac{L}{2} \Rightarrow L = 2x$$

$$x = \frac{\lambda D}{a}$$

$$L = \frac{2\lambda D}{a}$$

Document 2



Diffraction of light — Quiz 2 — Duration 25min

2.3) Show that $L = 4.8\ mm$.

From the figure L stands for 4 divisions, where each division is $1.2mm$

$$L = 4 divisions \Rightarrow L = 4 \times 1.2 = 4.8mm$$

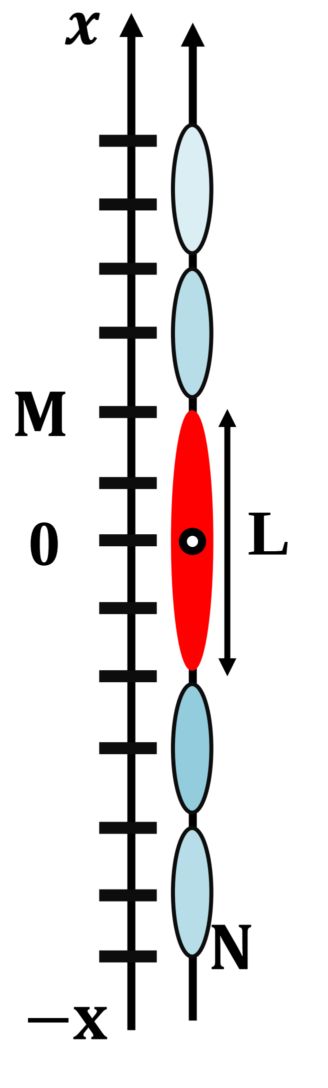
2.4) Deduce the width a of the square particle.

$$L = \frac{2\lambda D}{a} \Rightarrow a = \frac{2\lambda D}{L}$$

$$a = \frac{2 \times 600 \times 10^{-6} \times 3}{4.8 \times 10^{-3}} \Rightarrow a = 0.75 \times 10^{-3}$$

$$a = 75mm$$

Document 2



2.5) Choose the correct statement(s):

Statement 1: **If we increase the intensity of the laser light, the linear width L of central fringe increases.**

Statement 2: **If we decrease the intensity of the laser light, the linear width of the central fringe remains the same.**

Statement 3: **If we increase the distance between the source of light and the axis of the slit, the number of fringes on the screen decreases.**

Statement 1: **If we increase the intensity of the laser light, the linear width L of central fringe increases.**

False:

If we increase the intensity of the laser light, the linear width L of central fringe remains the same.

Statement 2: **If we decrease the intensity of the laser light, the linear width of the central fringe remains the same.**

True:

The leaner width of CBF is independent of the intensity of light

Statement 3: **If we increase the distance between the source of light and the axis of the slit, the number of fringes on the screen decreases.**

False:

If we increase the distance between the source of light and the axis of the slit, the number of fringes on the screen remains the same (independent)

3) Powder Square Mesh Sieve

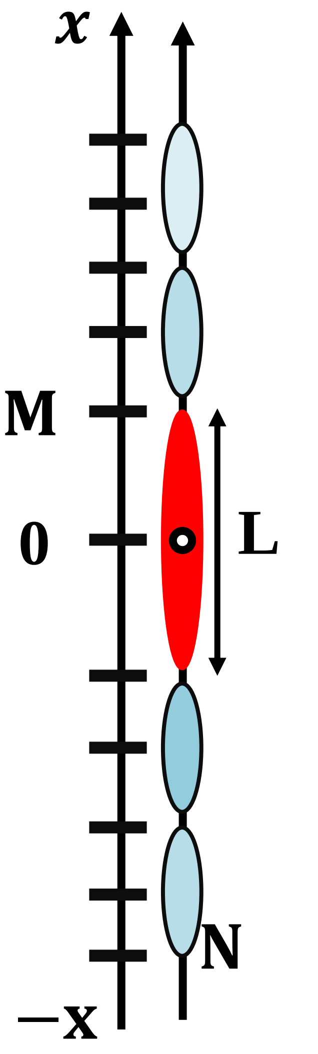
We perform diffraction phenomenon under the same previous conditions ($\lambda = 600\,nm$, $D = 3m$) on the square mesh sieve having a width a_1.

The linear width of the central bright fringe observed is $L_1 = 7.2mm$. (Doc. 2).

3.1) Calculate a_1.

3.2) What condition should the width of a square particle have to pass through the mesh of this sieve?

Document 2



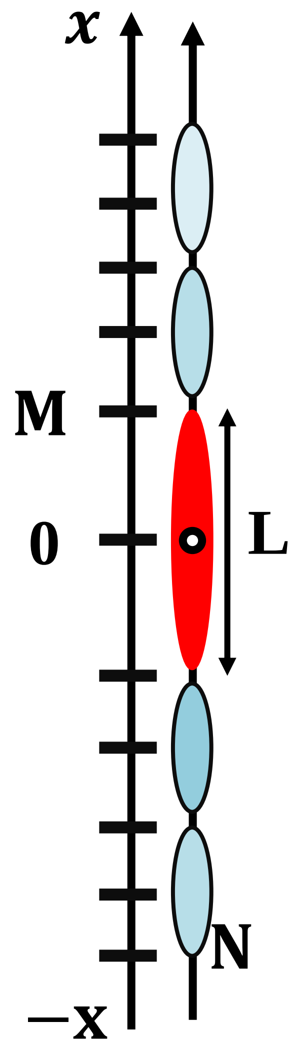
3.1) Calculate a_1.

$$L_1 = \frac{2\lambda D}{a_1} \Rightarrow a_1 = \frac{2\lambda D}{L_1}$$

$$a_1 = \frac{2 \times 600 \times 10^{-6} \times 3}{7.2 \times 10^{-3}}$$

$$a_1 = 0.5 \times 10^{-3} = 0.5mm$$

Document 2



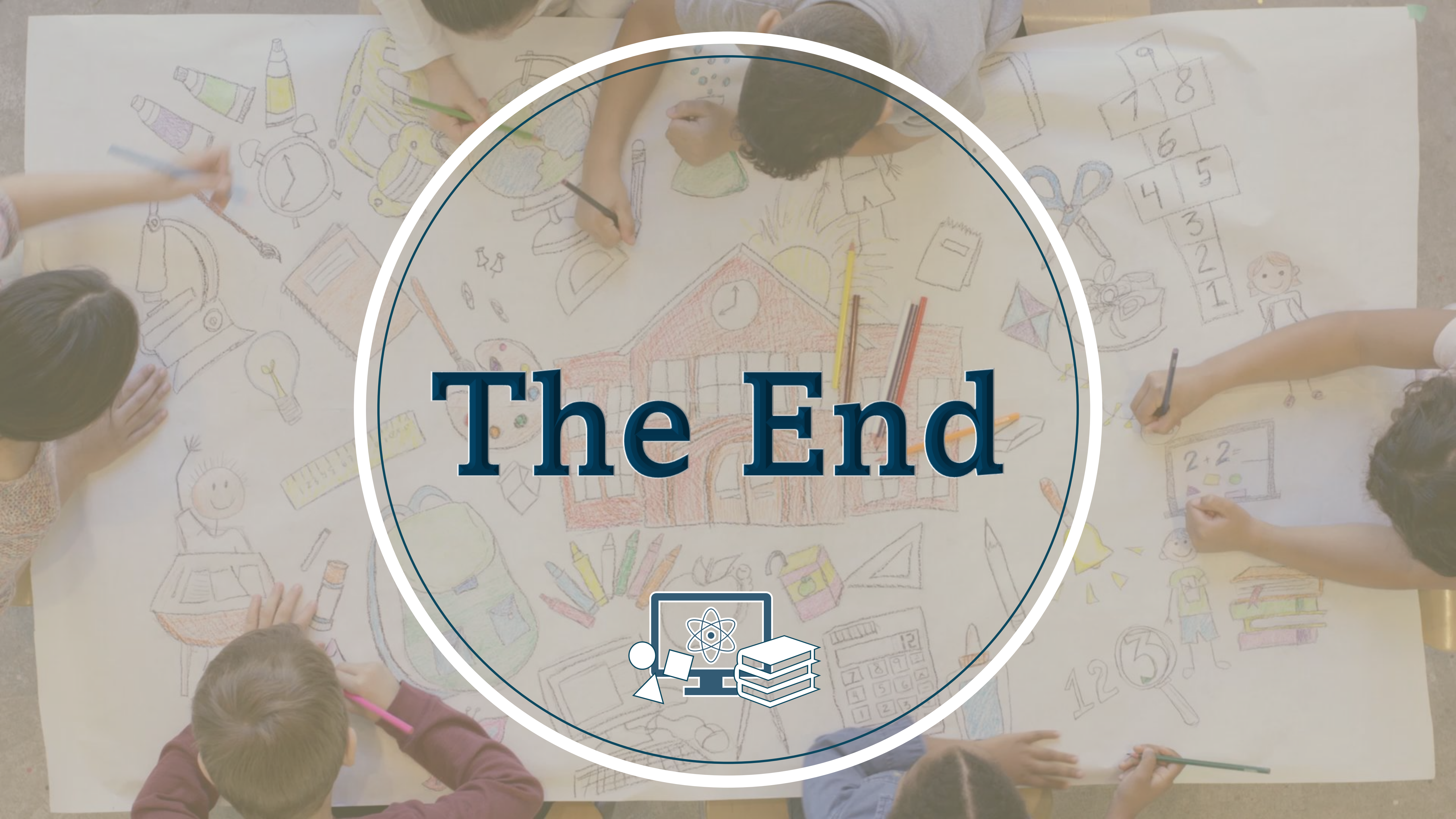
3.2) What condition should the width of a square particle have to pass through the mesh of this sieve?

The width (a) of the square particles be less than $0.5mm$

3.3) Can we use this sieve, to justify. separate the square particles having width "a"?

No, we can't use its, because the sieve have a width $a = 0.75mm$

$$a = 0.75mm > 0.5mm$$


The End