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Topics *to be covered*

1. Diffraction
2.
3.
4.

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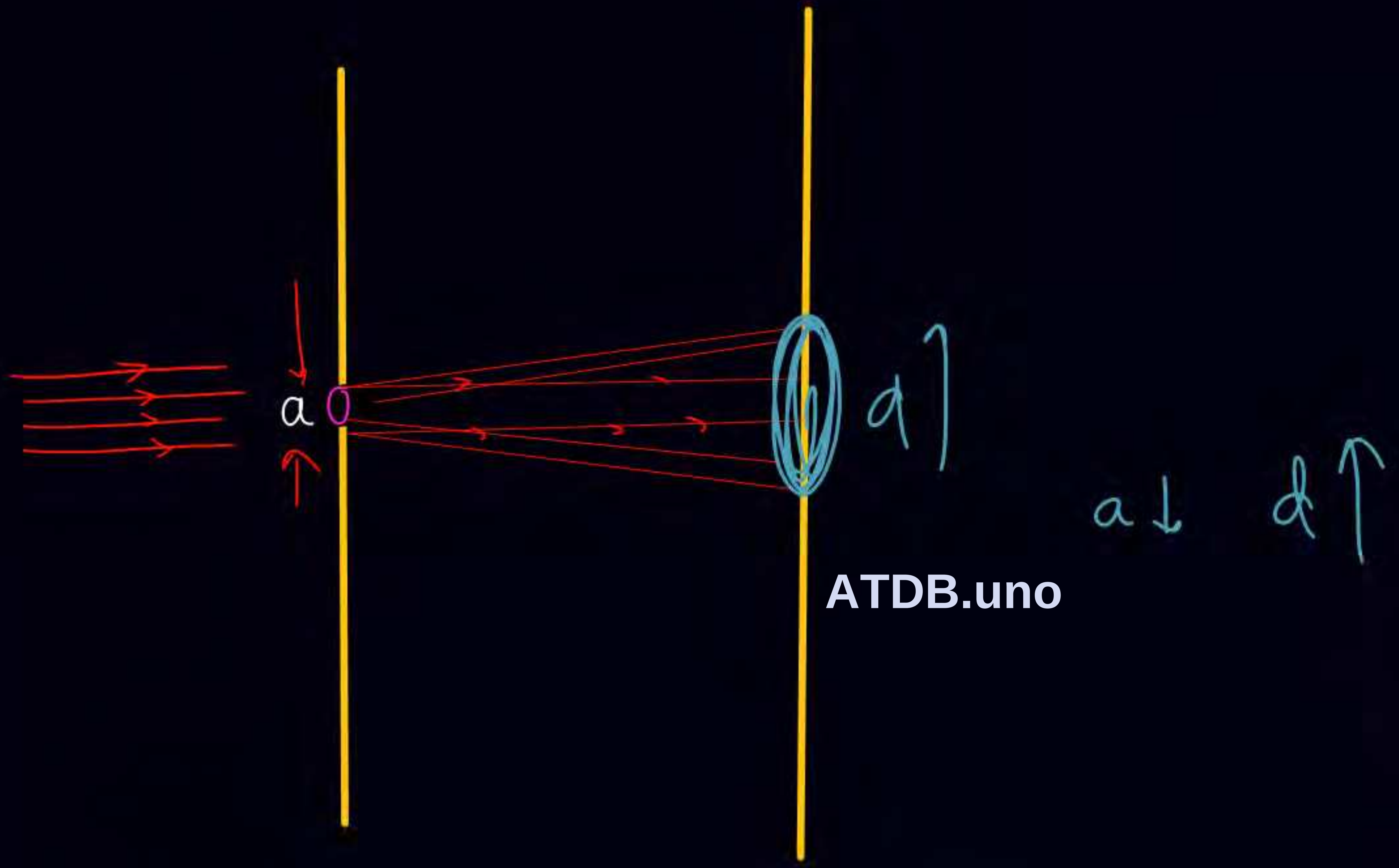

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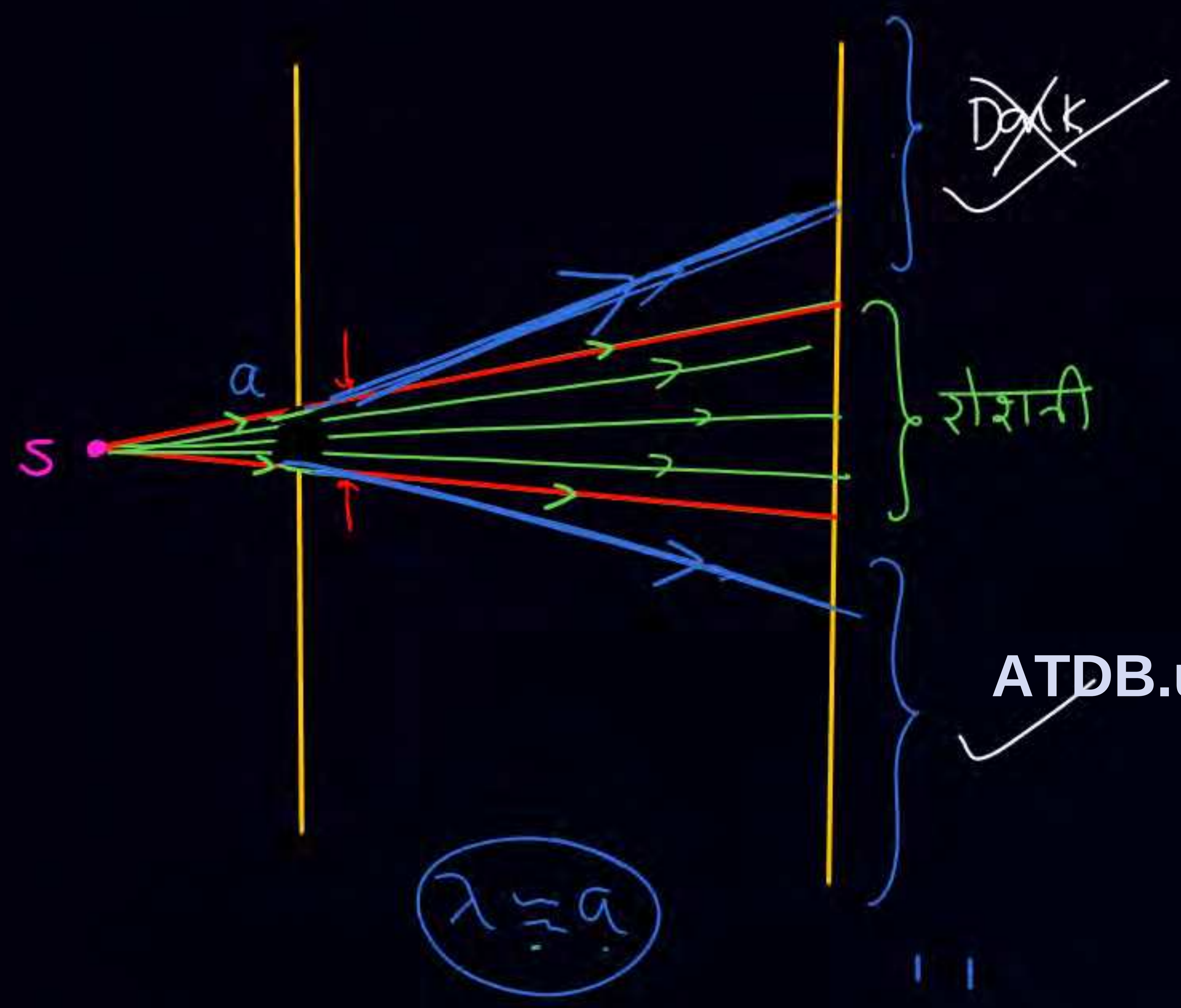

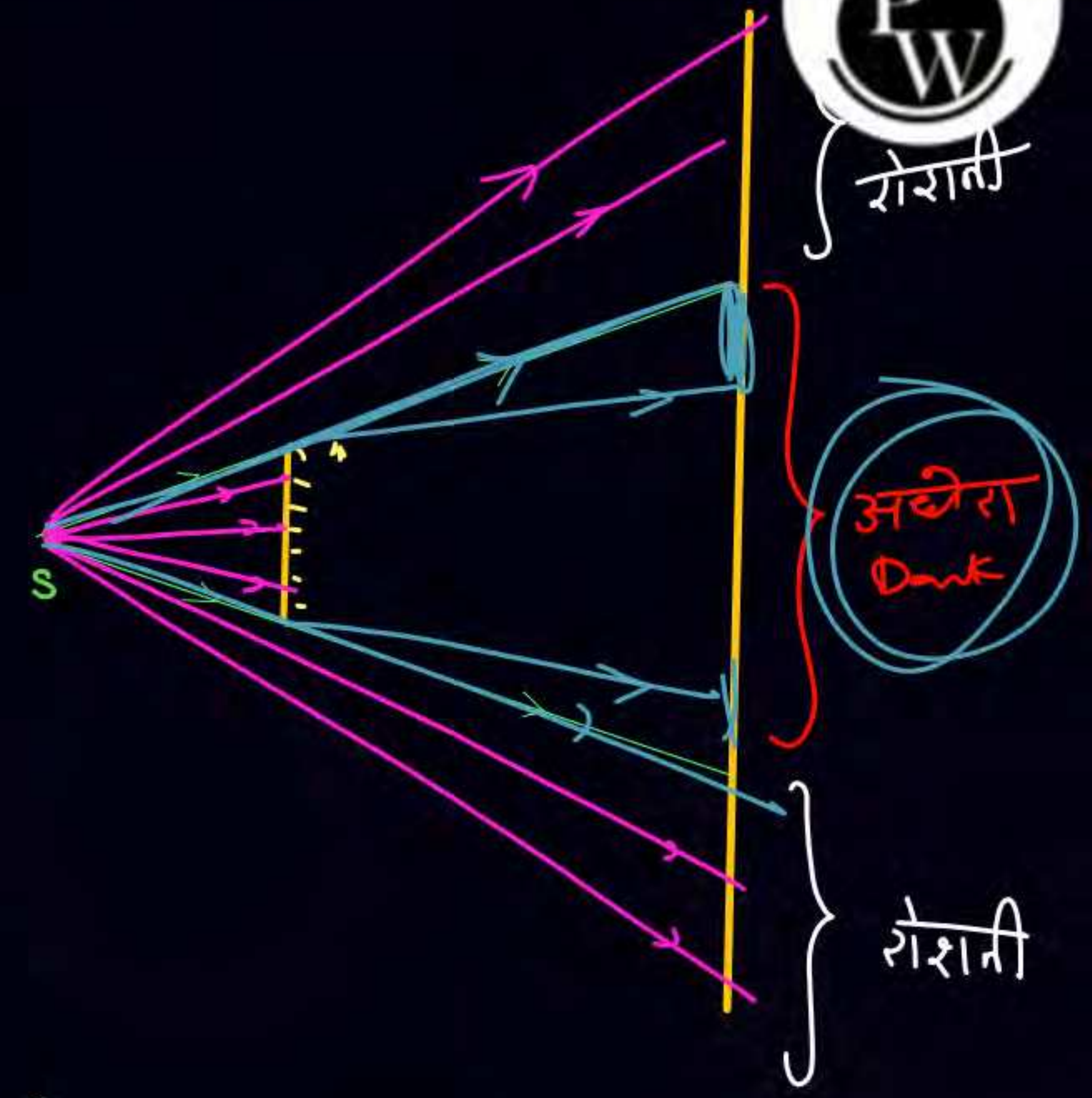

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17.10 DIFFRACTION OF LIGHT

When a wave is obstructed by an obstacle, the rays bend round the corner. This phenomenon is known as *diffraction*. We can explain the effect using Huygens' principle. When a wavefront is partially obstructed, only the wavelets from the exposed parts superpose and the resulting wavefront has a different shape. This allows for the bending round the edges. In case of light waves, beautiful fringe patterns comprising maximum and minimum intensity are formed due to diffraction.

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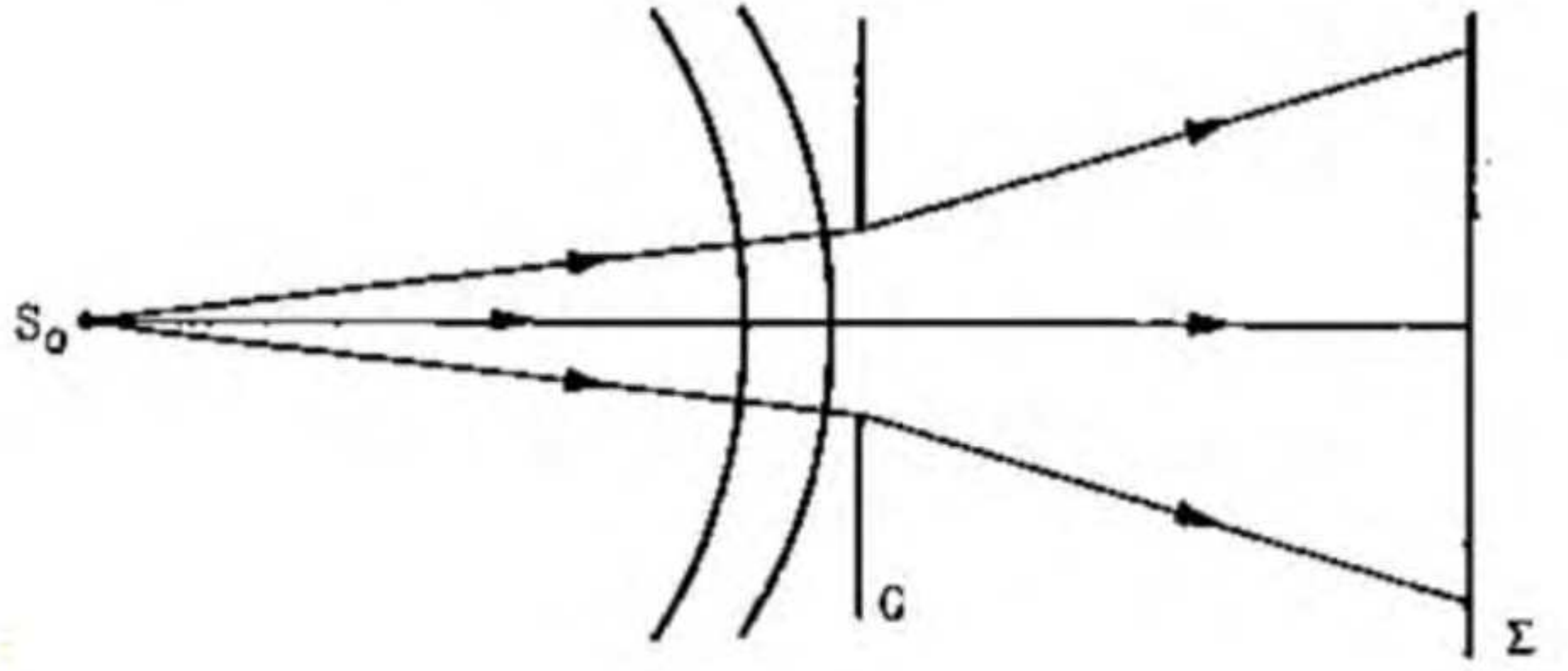

Figure 17.11

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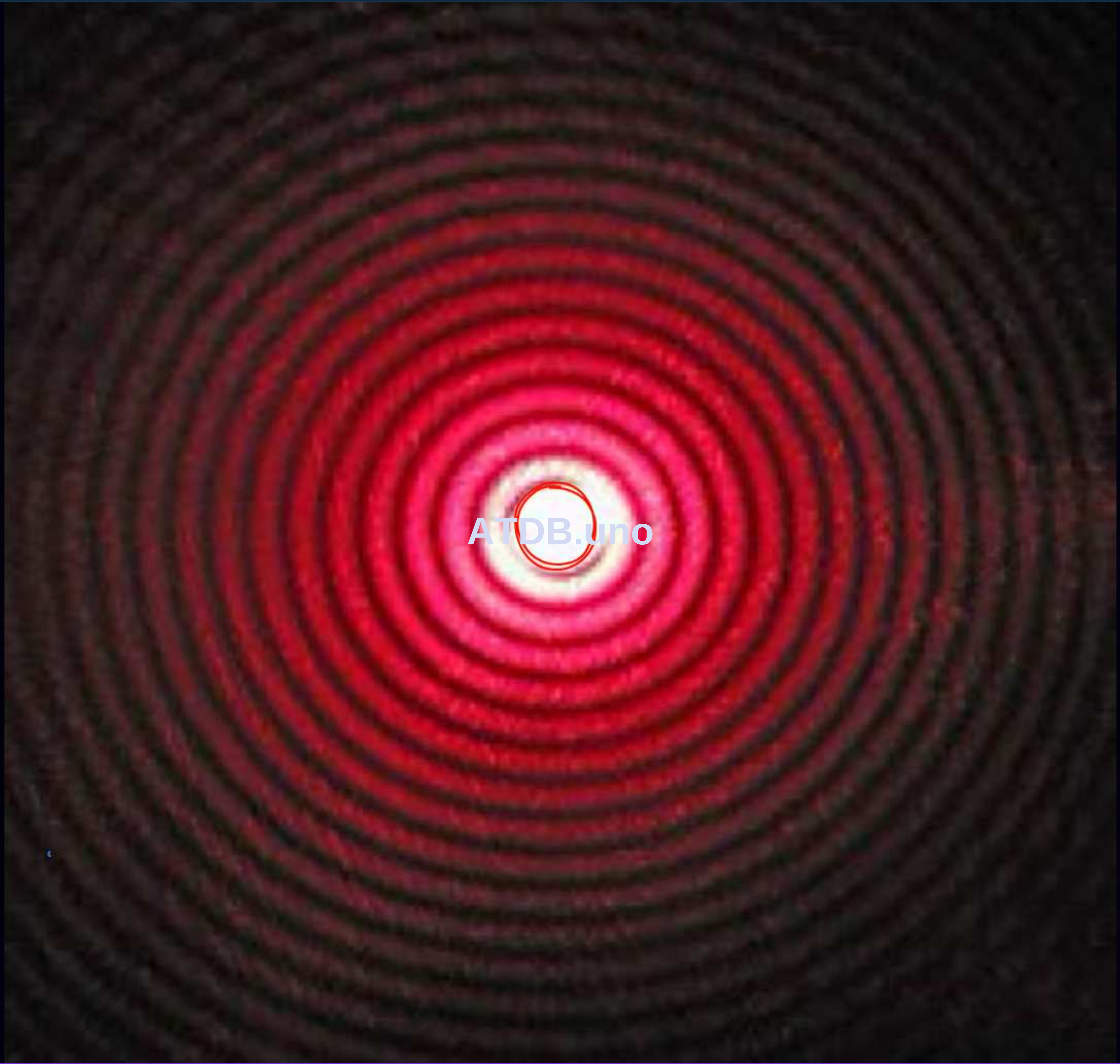

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FRAUNHOFER DIFFRACTION BY A CIRCULAR APERTURE

The mathematical analysis shows that the first dark ring is formed by the light diffracted from the hole at an angle θ with the axis $\sin\theta = \frac{1.22\lambda}{b}$.

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The radius of the diffraction disc is given by $R = \frac{1.22\lambda D}{b}$,

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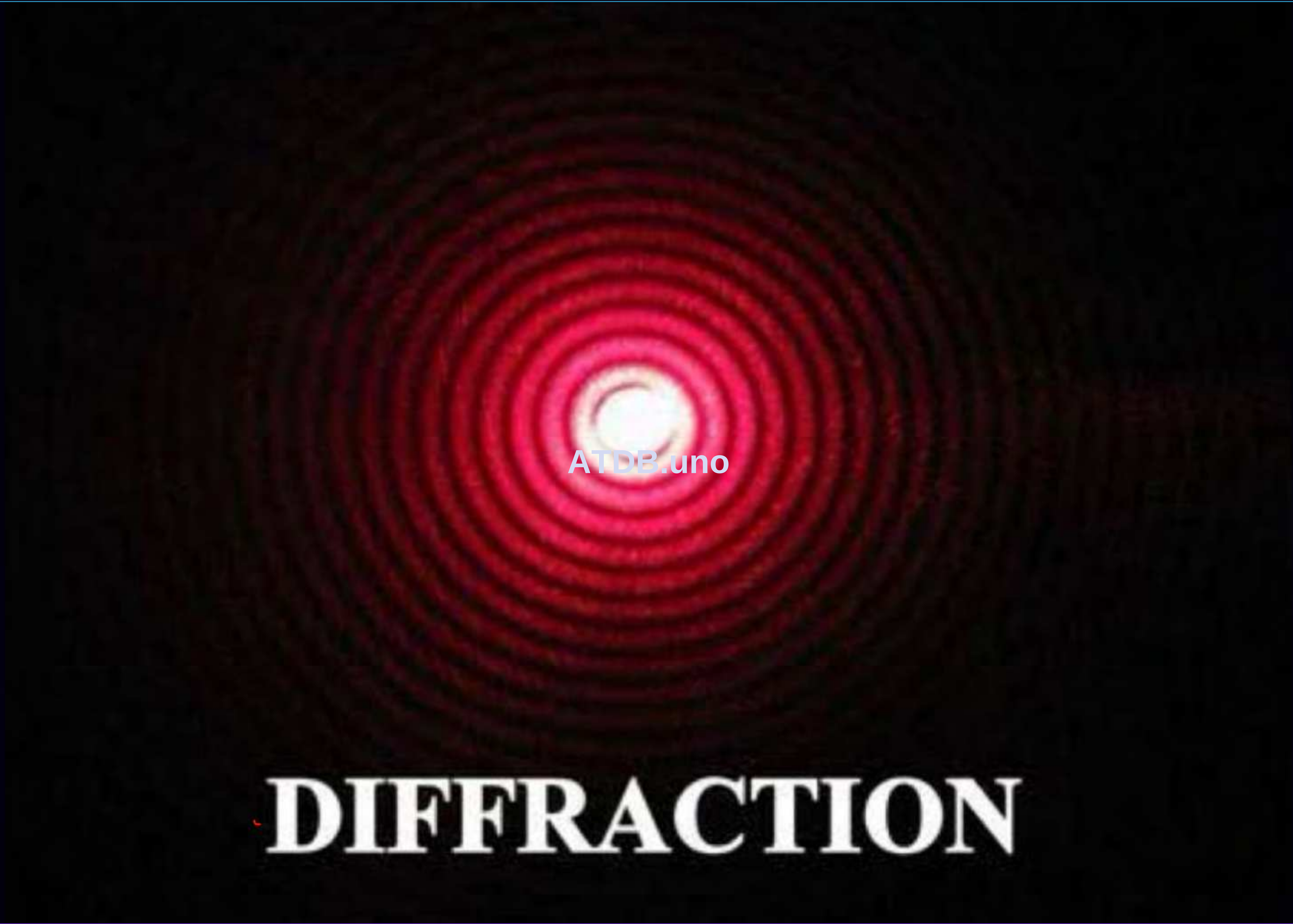

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Diffraction By Circular Aperture 'Airy Disk'

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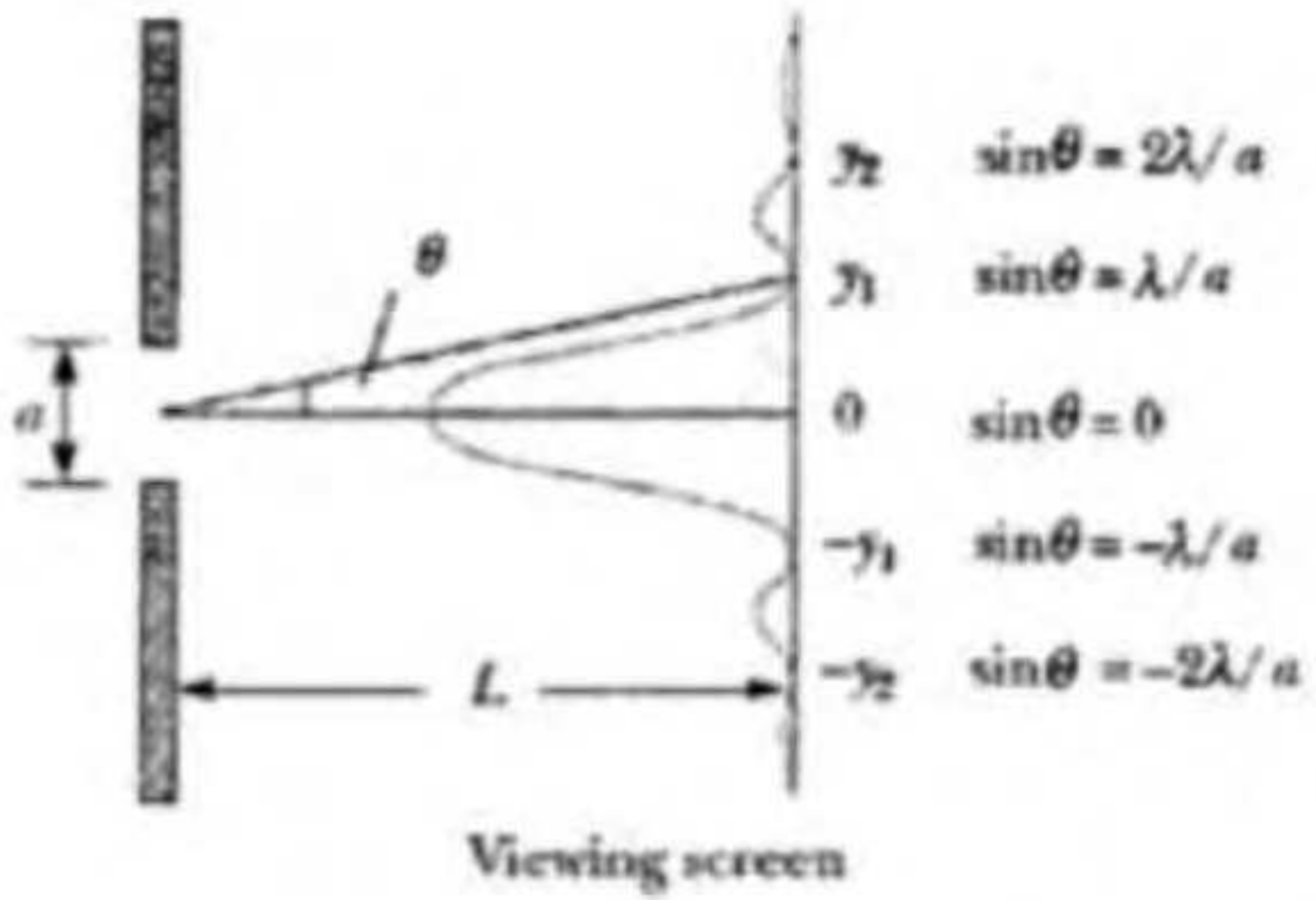
Properties of dark & bright fringes:



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(a) It results from superposition of secondary wavelets originating from various parts of single coherent source.

(b) Diffraction fringes are never of equal width.

(c) Intensity of all the bright fringes is not the same.

(d) Dark fringes are not perfectly dark.

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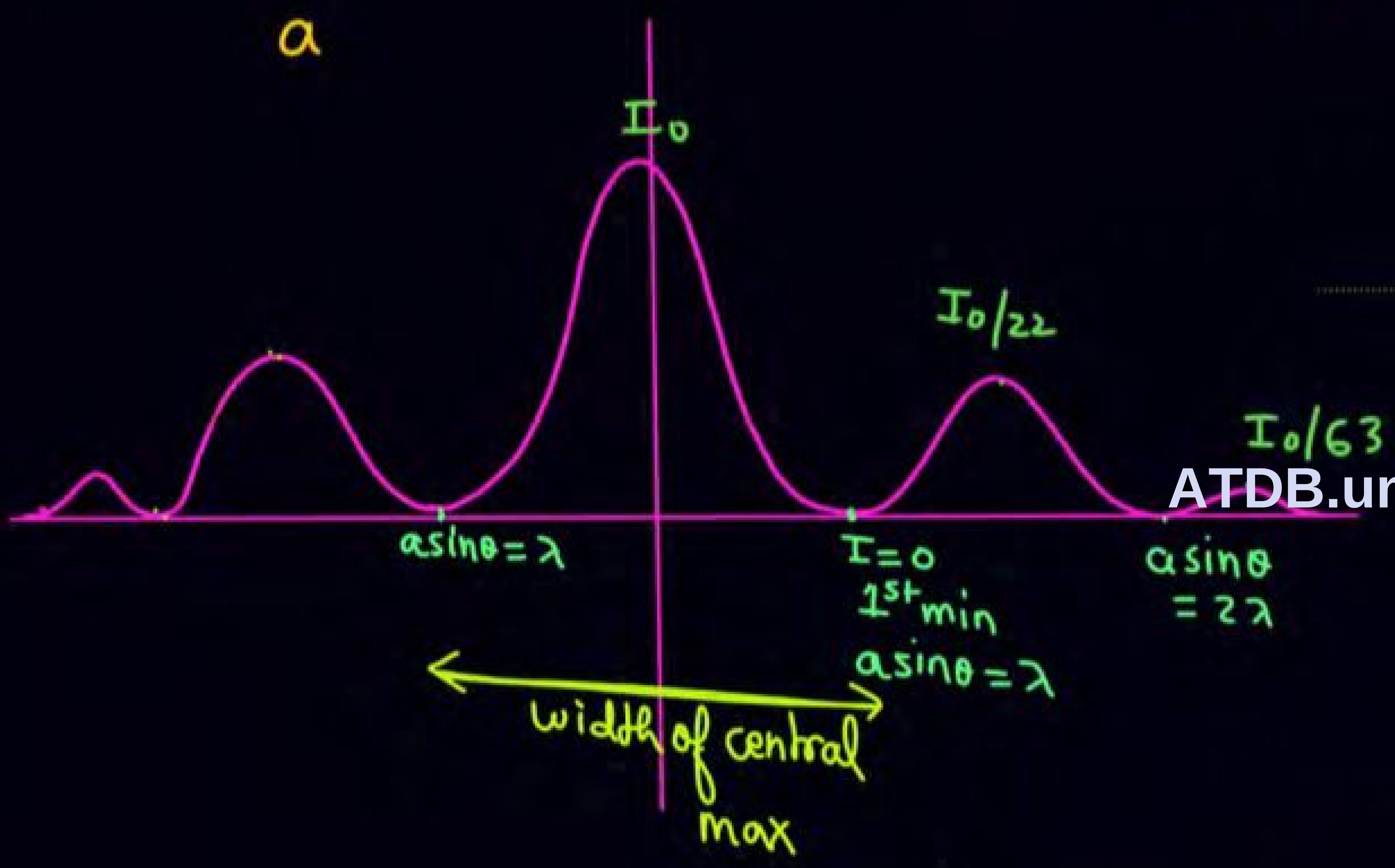
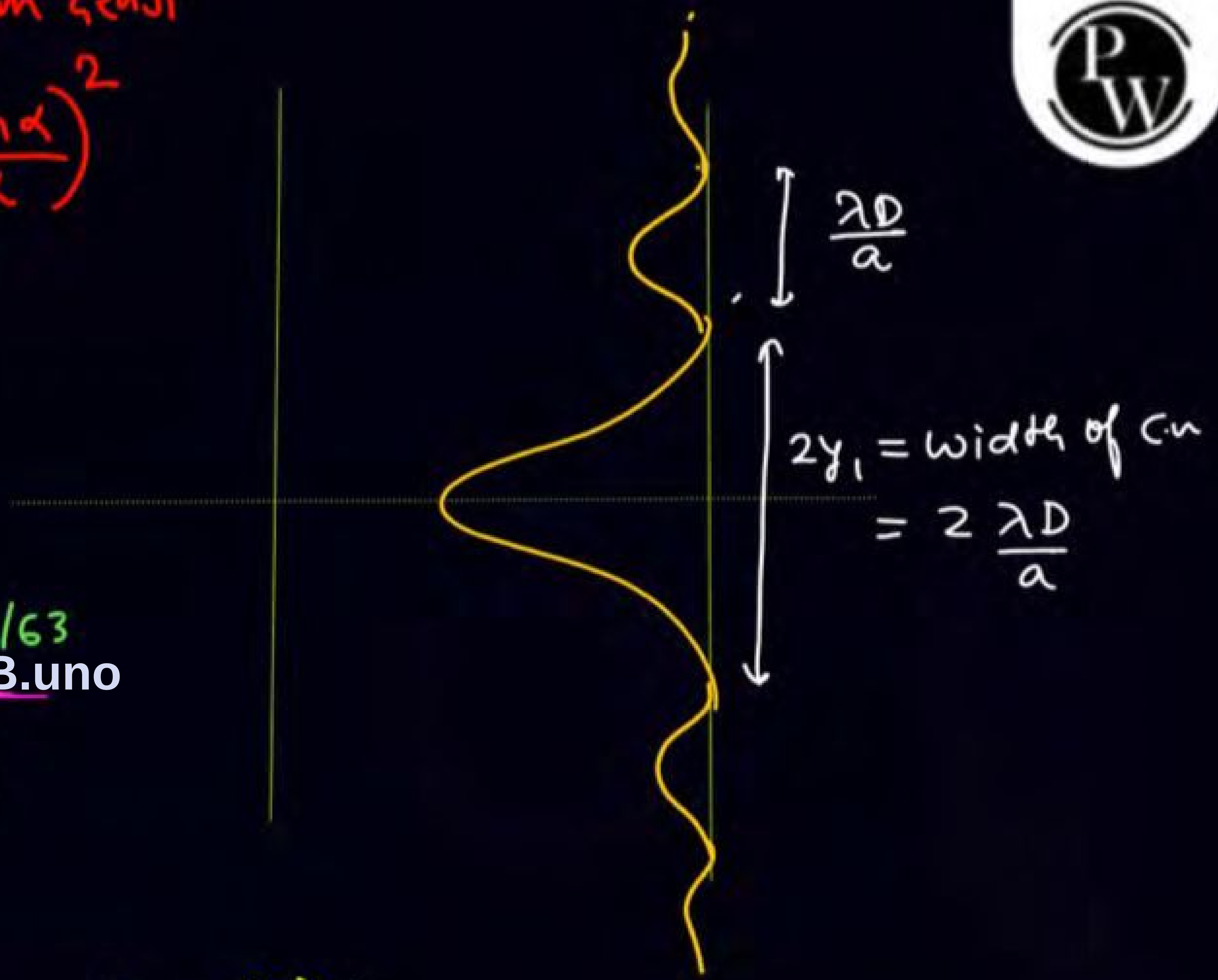
$$I = I_{max}\left(\frac{\sin\alpha}{\alpha}\right)^2$$





$$w = \frac{2\lambda D}{d}$$

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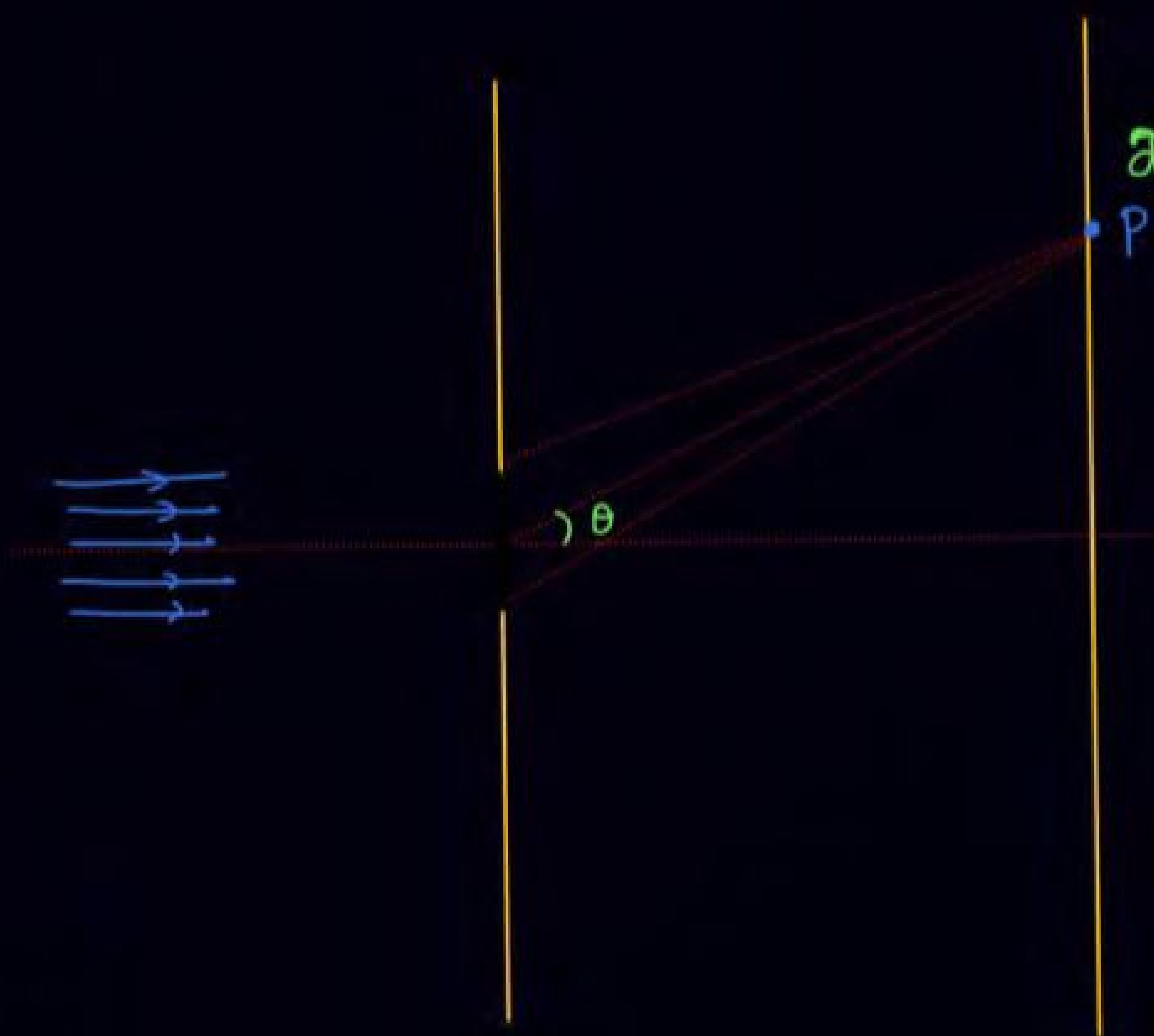
$a\sin\theta = n\lambda$, (n^{th} minima)



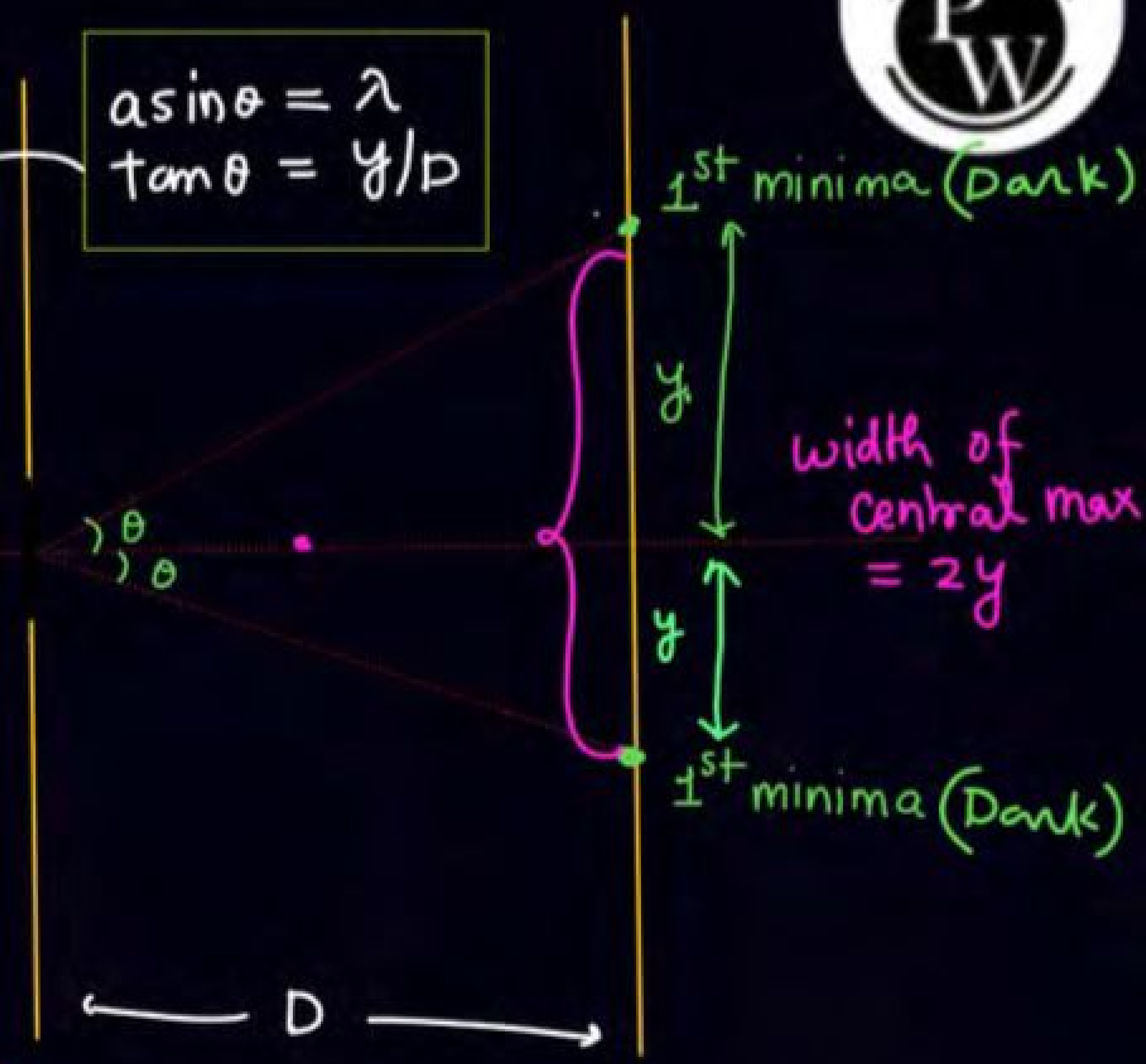
$\tan\theta = \frac{y}{D}$

$a\sin\theta = \lambda$
$\tan\theta = y/D$

If θ is very small

$a \cdot \frac{y}{D} = \lambda$

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



Width of central Max $= 2y = \frac{2\lambda D}{a}$

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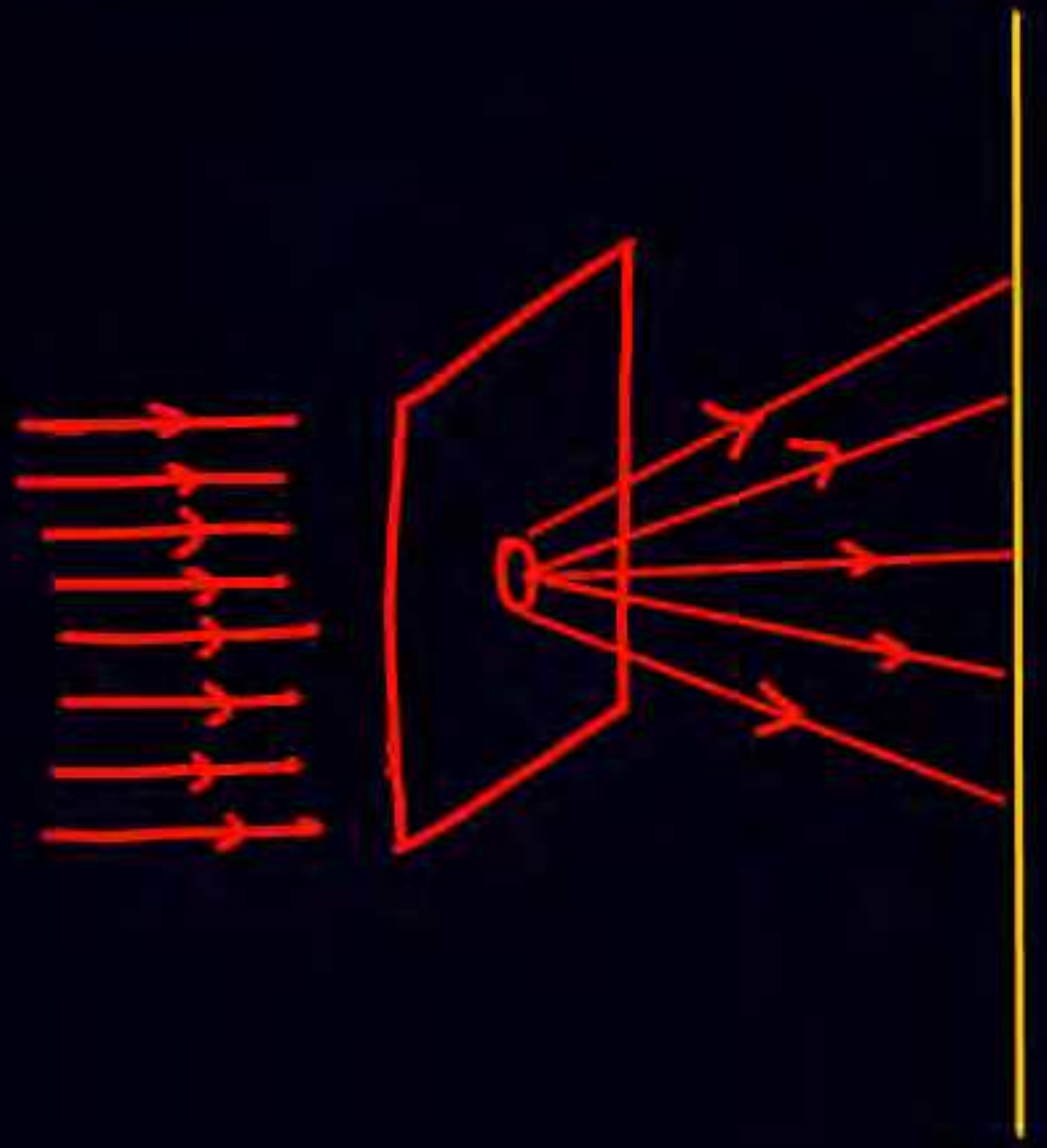
Diffraction → Bending of light rays from sharp edges of an opaque obstacle or aperture and its spreading in the shadow region is defined as differaction of light or deviation of light from its ractilinear propagation.

* Size of an obstcle or aperture should be nearly equal to the wavelength of light

$$\lambda \approx a$$

* If $\lambda <<< a \Rightarrow$ Then rectilinear motion of light is observed.



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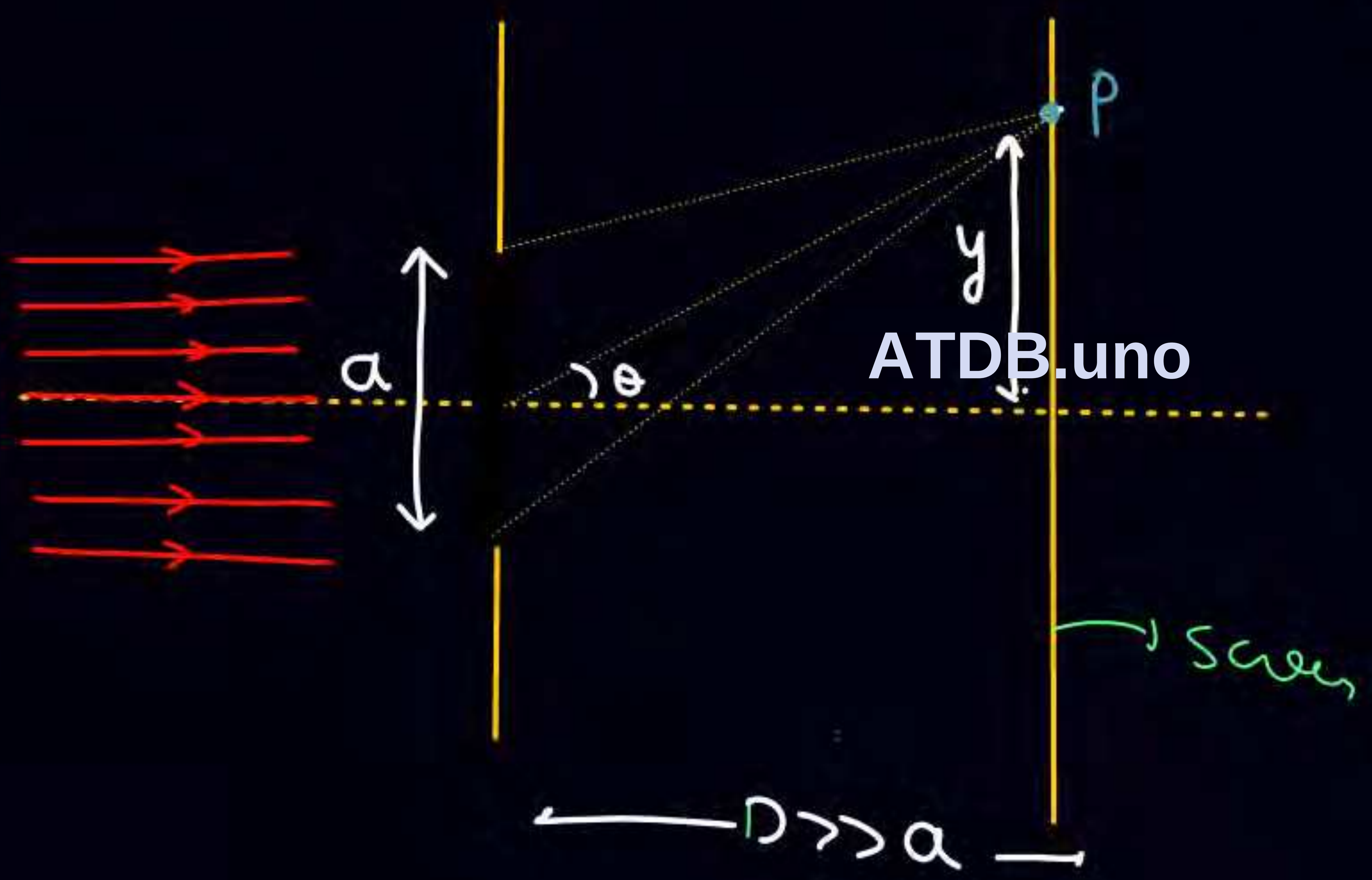
Fraunhoffer Diffraction

Diffraction through single slit



$a\sin\theta = n\lambda$ (n^{th} minima)

$\tan\theta = \frac{y}{D}$

$a\sin\theta = \lambda$ (1^{st} minima)

$a\sin\theta = 2\lambda$ (2^{nd} minima)

$a\sin\theta = \frac{3\lambda}{2}$ (1^{st} secondary max)

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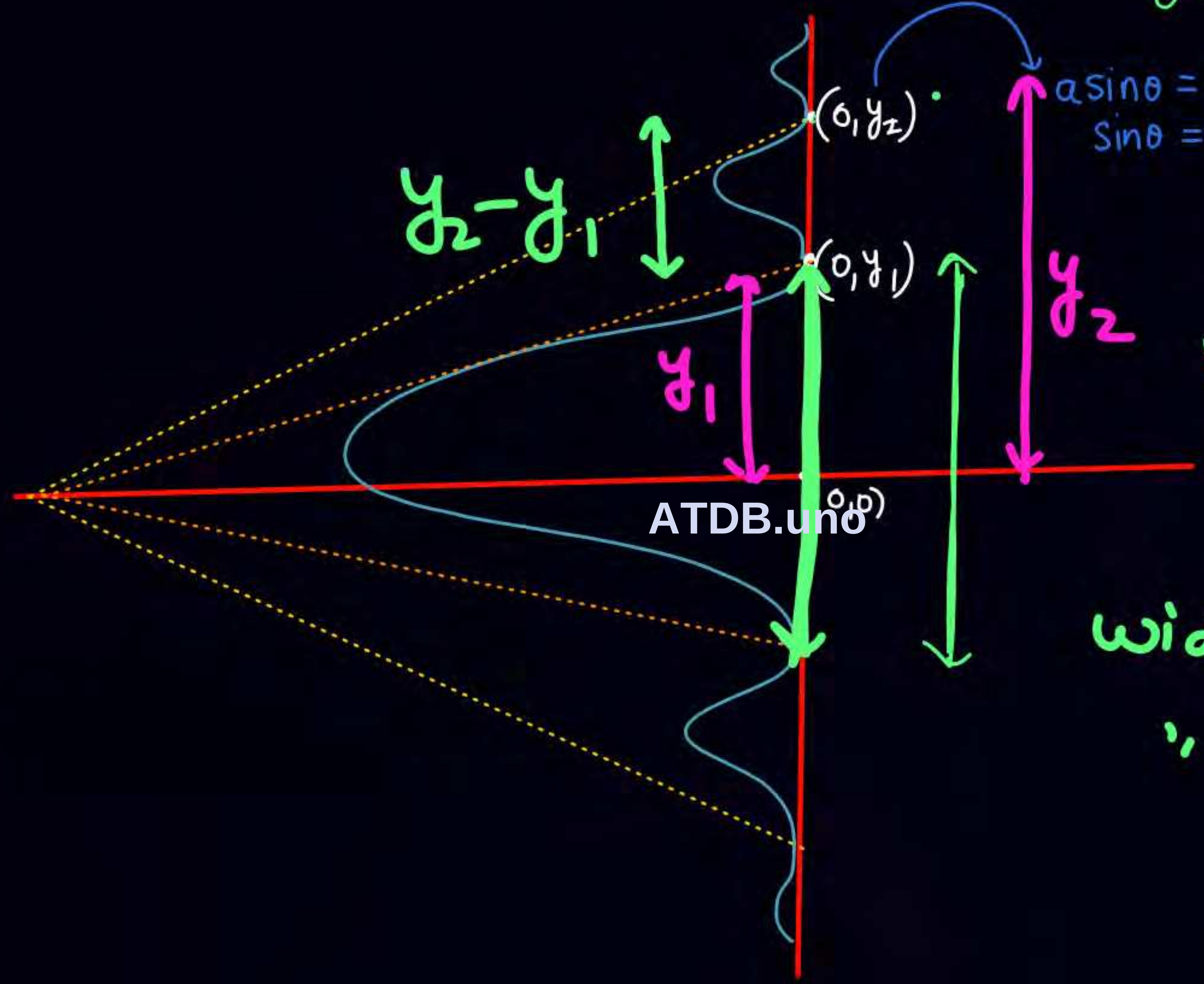

$\theta \longrightarrow$ very small

$a\sin\theta = 2\lambda$

$\sin\theta = \frac{2\lambda}{a} \approx \tan\theta \approx \frac{y_2}{D}$

$$\boxed{y_2 = \frac{2\lambda D}{a}}$$

$y_1 = \frac{\lambda D}{a}$

width of c.m $= 2y_1$

" " 1^{st} secondary max $= \frac{\lambda D}{a}$

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SKC

काम का डब्बा

$a\sin\theta = n\lambda$ (for n^{th} minima)

width of central maxima $= \dfrac{2\lambda D}{a}$

Angular spread $= 2\theta = \dfrac{2\lambda}{a}$

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For any Stylebaji Use ⇛ $\tan\theta = y/D$

$a\sin\theta = n\lambda$

↓

(n^{th} minima)

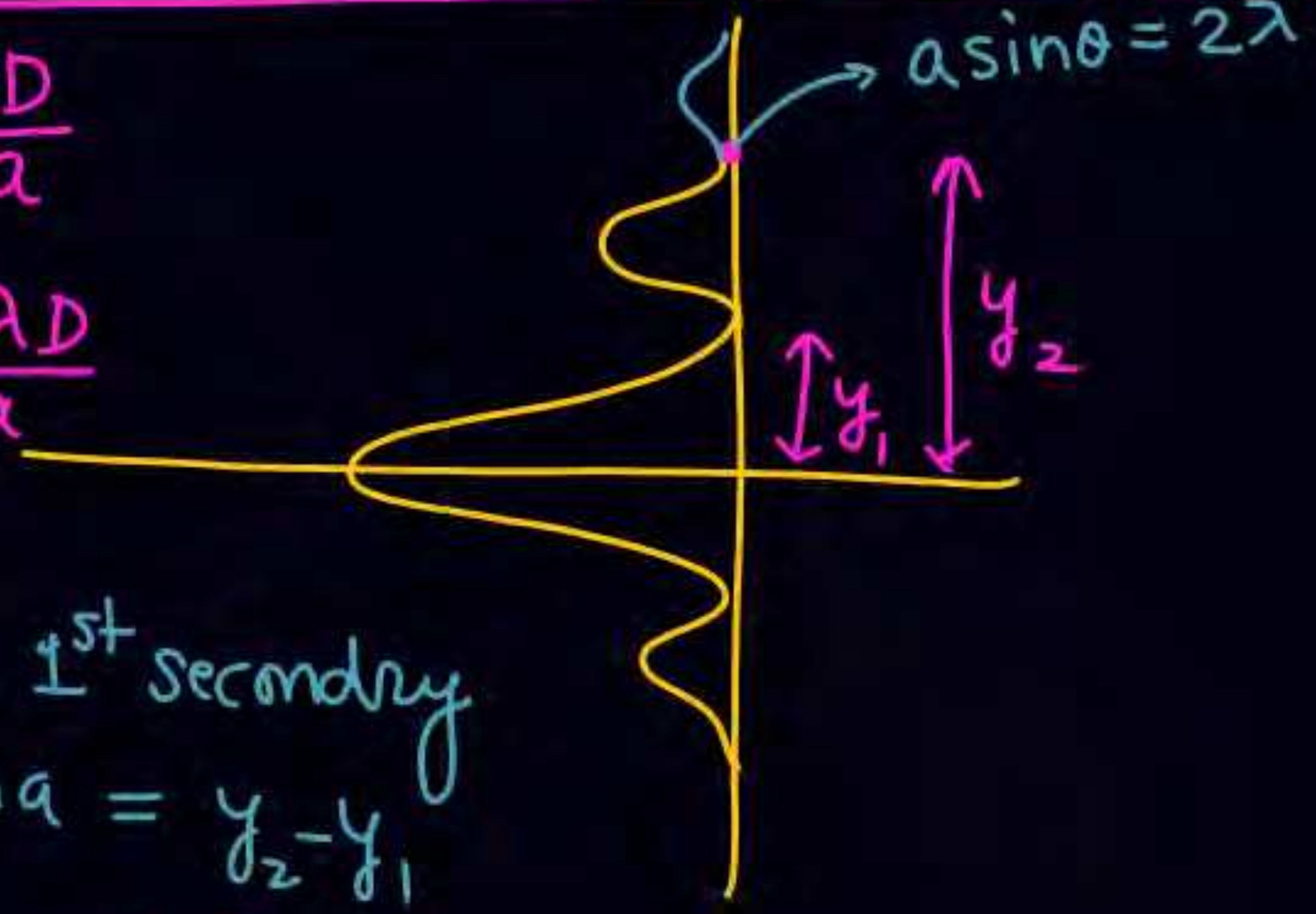
If θ is very small

width of central max $= \dfrac{2\lambda D}{a}$

width of 1^{st} secondry max $\cong \lambda D/a$

$y_1 = \dfrac{\lambda D}{a}$

$y_2 = \dfrac{2\lambda D}{a}$



width of 1^{st} secondry maxima $= y_2 - y_1$

$= \dfrac{\lambda D}{a}$

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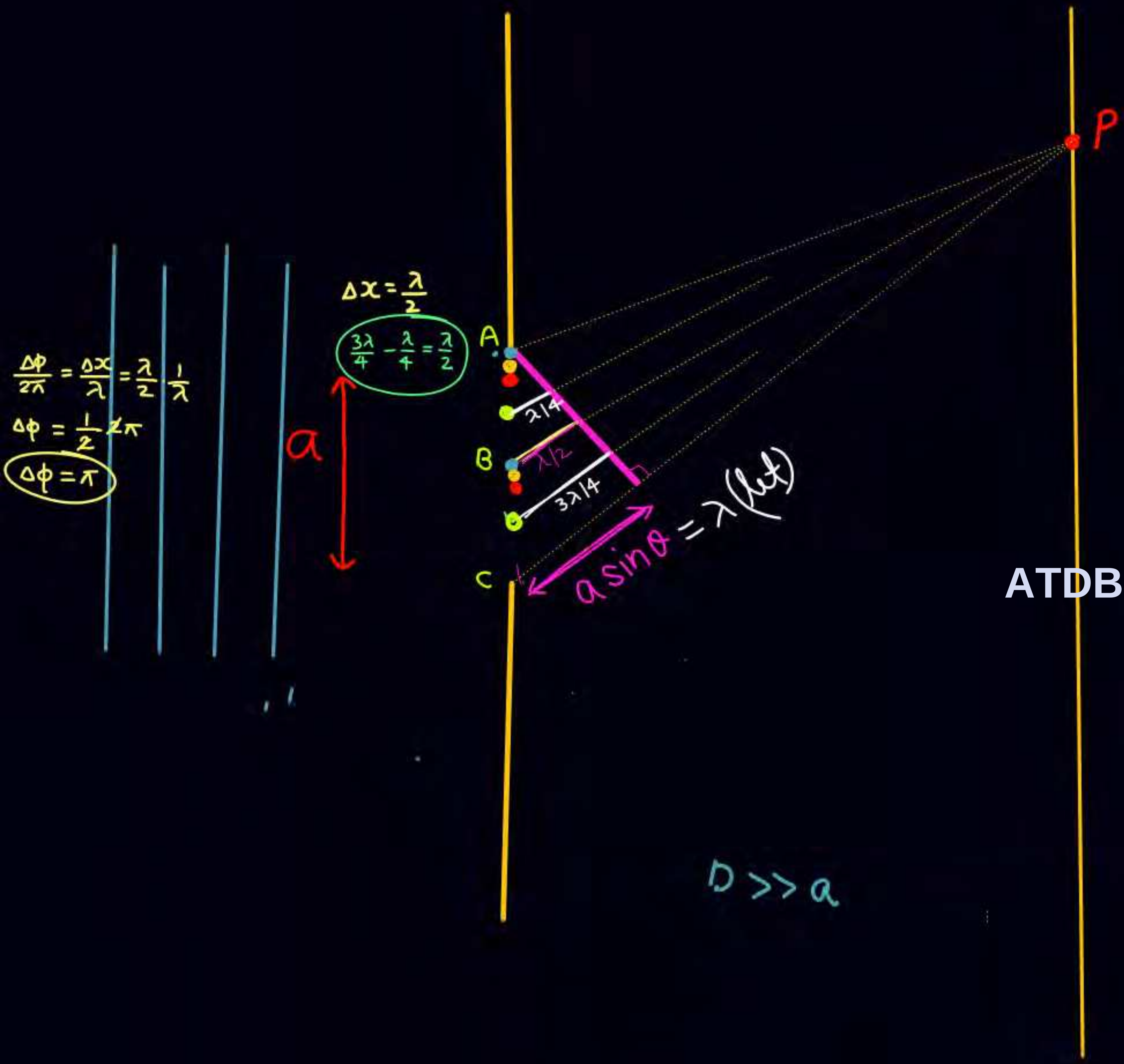

$a\sin\theta = \lambda$ (Let) (1^{st} minima)

$a\sin\theta = 2\lambda$ = (2^{nd} minima)

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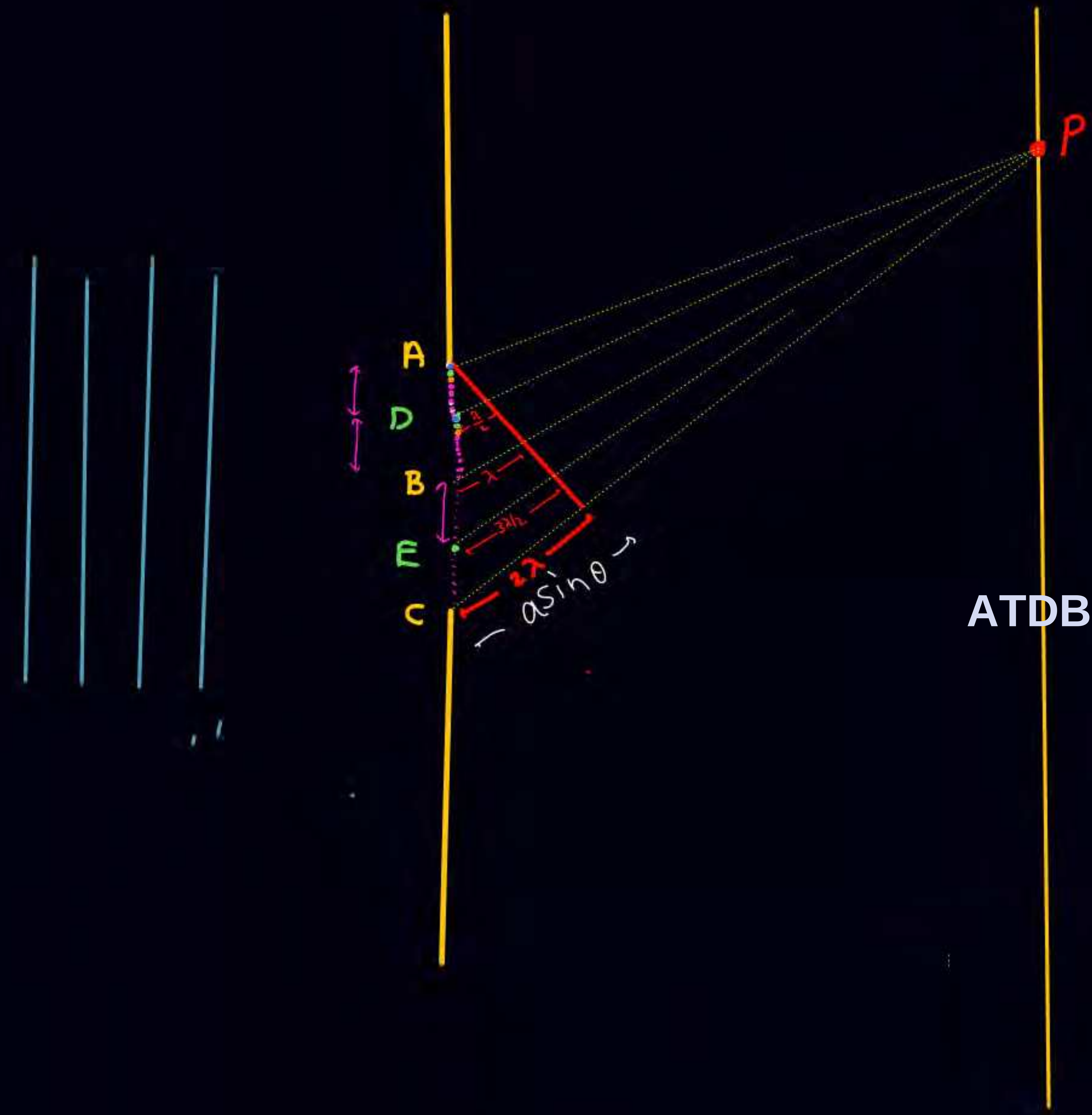

$a\sin\theta = \lambda$ (Let)

(1st minima)

$a\sin\theta = 2\lambda$ = (2nd minima)

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$a \sin\theta = \lambda$ 1st minima

$a \sin\theta = 2\lambda$ 2nd minima

$a \sin\theta = \frac{3\lambda}{2}$ (1st secondry maxima)

$a \sin\theta = \frac{5\lambda}{2}$ (2nd " maxima)

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QUESTION

A single slit of width a is illuminated by a monochromatic light of wavelength 600 nm. The value of a for which first minimum appears at $\theta = 30°$ on the screen will be: [15 April 2023 - Shift 1]

$a \sin\theta = n\lambda \quad (n=1)$

$a \sin 30 = 1 \times 600 \times 10^{-9}$

$a = 1200 \times 10^{-9}$

(1) 1.2 μm

(2) 3 μm

(3) 1.8 μm

(4) 0.6 μm

Ans : (1)

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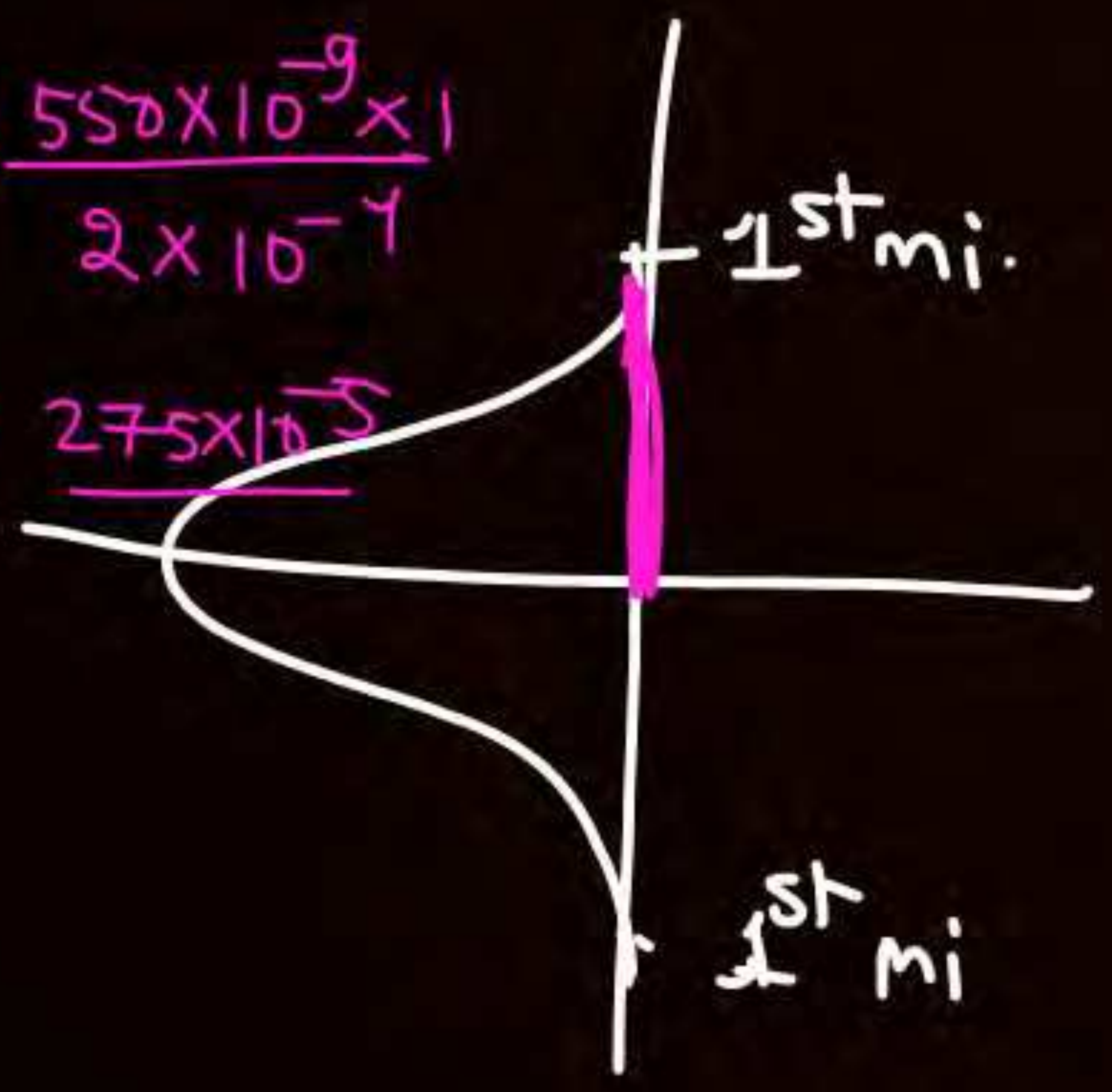
QUESTION

In a single slit experiment, a parallel beam of green light of wavelength 550 nm passes through a slit of width 0.20 mm. The transmitted light is collected on a screen 100 cm away. The distance of first order minima from the central maximum will be $x \times 10^{-5}$ m. The value of x is: **[05 Apr. 2024 - Shift 2]**

$$\frac{\lambda D}{a} = \frac{550 \times 10^{-9} \times 1}{2 \times 10^{-4}} = 275 \times 10^{-5}$$



$$a \sin\theta = 1 \times \lambda \qquad \tan\theta = \frac{y}{D}$$

$$2 \times 10^{-4} \sin\theta = 550 \times 10^{-9}$$

$$\sin\theta = \frac{550}{2} \times 10^{-5} \approx \frac{y}{D}$$

$$y = 275 \times 10^{-5}$$

Ans. (275)

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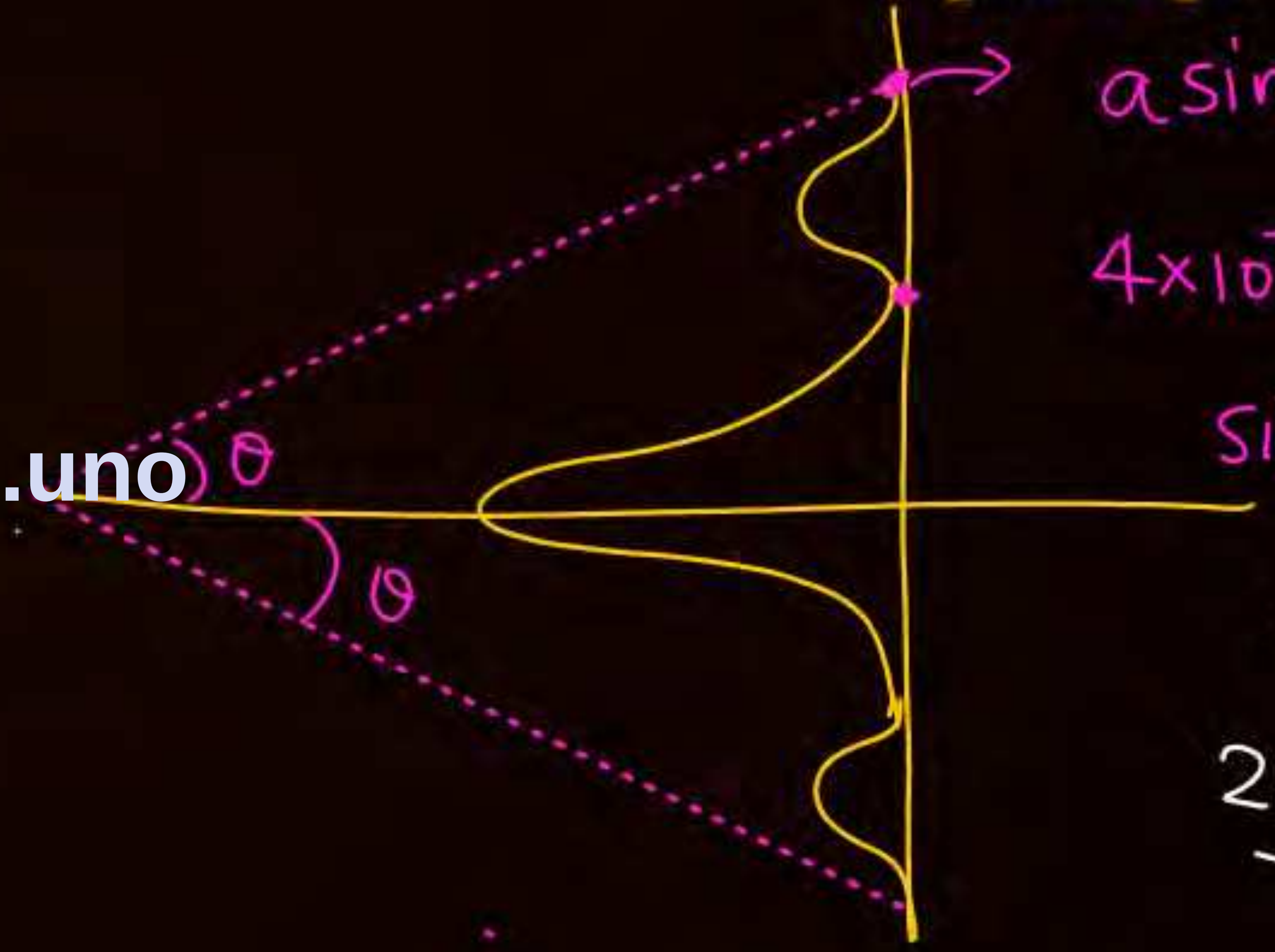
QUESTION

A parallel beam of monochromatic light of wavelength 600 nm passes through single slit of 0.4 mm width. Angular divergence corresponding to second order minima would be __6__ $\times 10^{-3}$ rad.

[08 Apr. 2024 - Shift 1]

$a = 4 \times 10^{-4}$

$\lambda = 600 \times 10^{-9}$



$a \sin\theta = 2\lambda$

$4 \times 10^{-4} \times \sin\theta = 2 \times 600 \times 10^{-9}$

$\sin\theta = 3 \times 10^{-3} = .003$

$\theta \approx 3 \times 10^{-3}$

$2\theta \approx 6 \times 10^{-3}$

Ans. (6)

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QUESTION

In a single slit diffraction pattern, a light of wavelength 6000 Å is used. The distance between the first and third minima in the diffraction pattern is found to be 3 mm when the screen in placed 50 cm away from slits. The width of the slit is __2__ $\times 10^{-4}$ m.

[29 Jan. 2024 - Shift 2]

$y_1 = \frac{\lambda D}{a}$ $\quad$ $y_3 = \frac{3\lambda D}{a}$

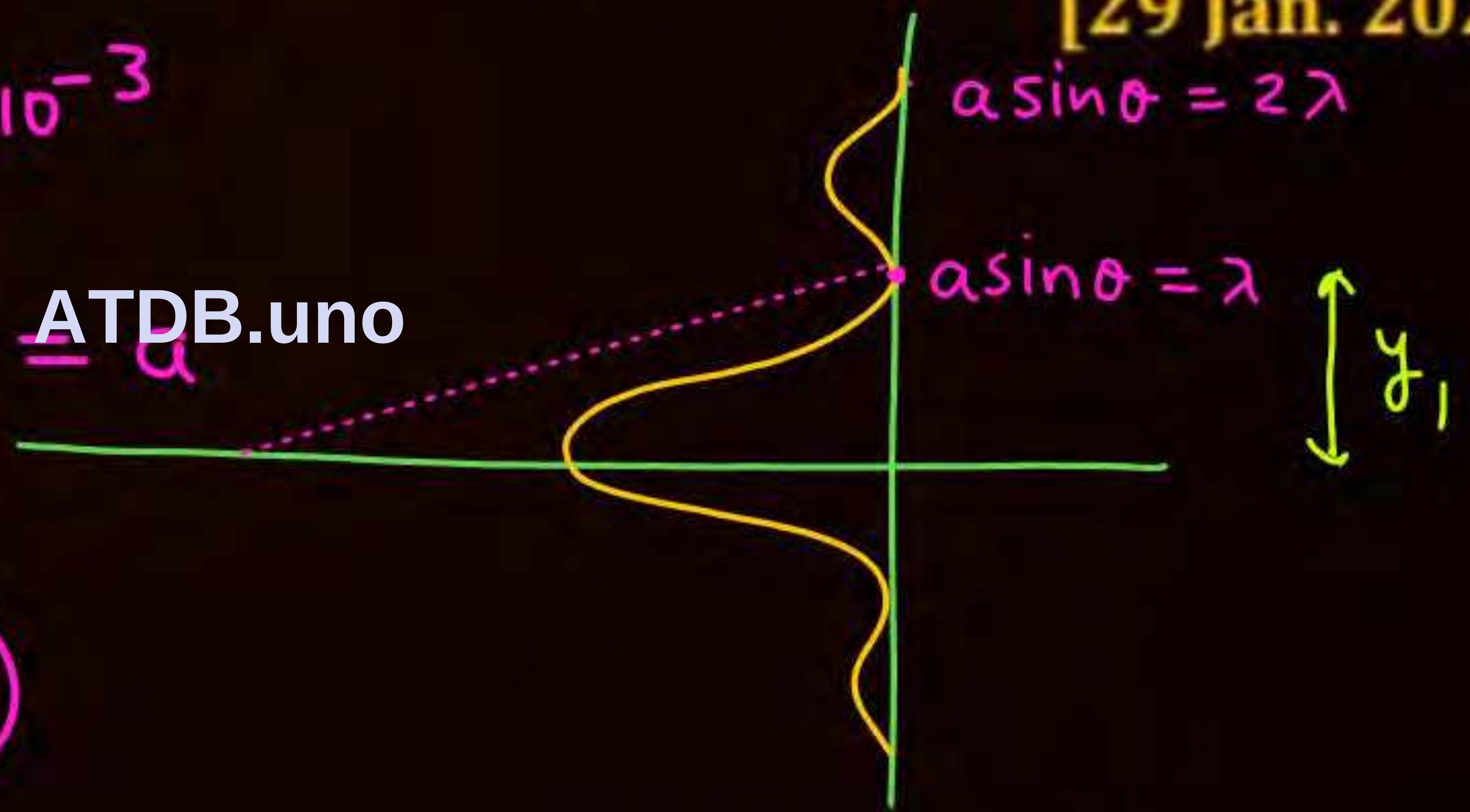
$\tan\theta = \frac{y}{D}$

$d\sin\theta =$ ✓

$\frac{2\lambda D}{a} = 3\times 10^{-3}$

$\frac{2\times 6\times 10^{-7}\times \frac{1}{2}}{3\times 10^{-3}} = a$

$2\times 10^{-4} = a$



Ans. (2)

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QUESTION

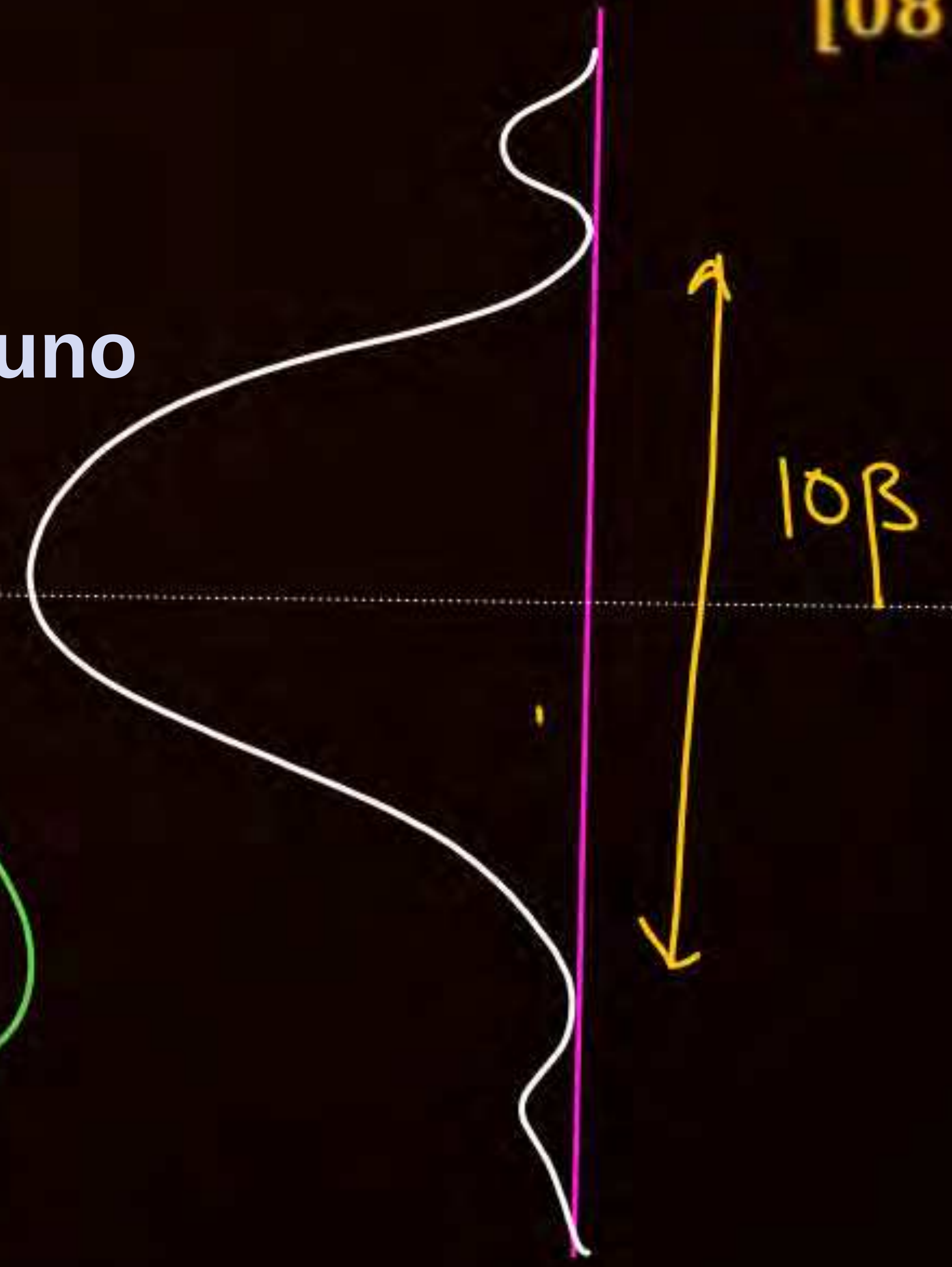
Two slits are 1 mm apart and the screen is located 1 m away from the slits. A light of wavelength 500 nm is used. The width of each slit to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern is ___2___ $\times 10^{-4}$ m

[08 Apr. 2024 - Shift 2]

$$2\frac{\lambda D}{a} = 10\,\beta_{YDSE}$$

$$\frac{2 \times \lambda \cdot D}{a} = 10\,\frac{\lambda \cdot D}{d}$$

$$\frac{2}{a} = \frac{10}{10^{-3}} \Rightarrow a = 2 \times 10^{-4}$$



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Ans. (2)

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QUESTION

$f \equiv D$

A parallel beam of monochromatic light of wavelength 5000 · Å is incident normally on a single narrow slit of width 0.001 mm. The light is focused by convex lens on screen, placed on its focal plane. The first minima will be formed for the angle of diffraction of ______ (degree). [27 Jan 2024 - Shift 2]

$a\sin\theta = \lambda$

$1\times10^{-6}\sin\theta = 5000\times10^{-10}$

$\sin\theta = 5\times10^{-1} = \frac{5}{10} = \frac{1}{2}$

$\theta = 30°$

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Ans. (30)

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QUESTION

A monochromatic light of wavelength 6000 Å is incident on the single slit of width 0.01 mm. If the diffraction pattern is formed at the focus of the convex lens of focal length 20 cm, the linear width of the central maximum is: [01 Feb. 2024 - Shift 1]

$D = 20 \times 10^{-2}$

$\frac{2\lambda D}{a} = \frac{2 \times 6000 \times 10^{-10} \times 20 \times 10^{-2}}{1 \times 10^{-5}}$

$= 240 \times 10^{-4}$

(1) 60 mm

(2) 24 mm

(3) 120 mm

(4) 12 mm

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Ans. (2)

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QUESTION

The diffraction pattern of a light of wavelength 400 nm diffracting from a slit of width 0.2 mm is focused on the focal plane of a convex lens of focal length 100 cm. = D The width of the 1st secondary maxima will be: [30 Jan. 2024 - Shift 1]

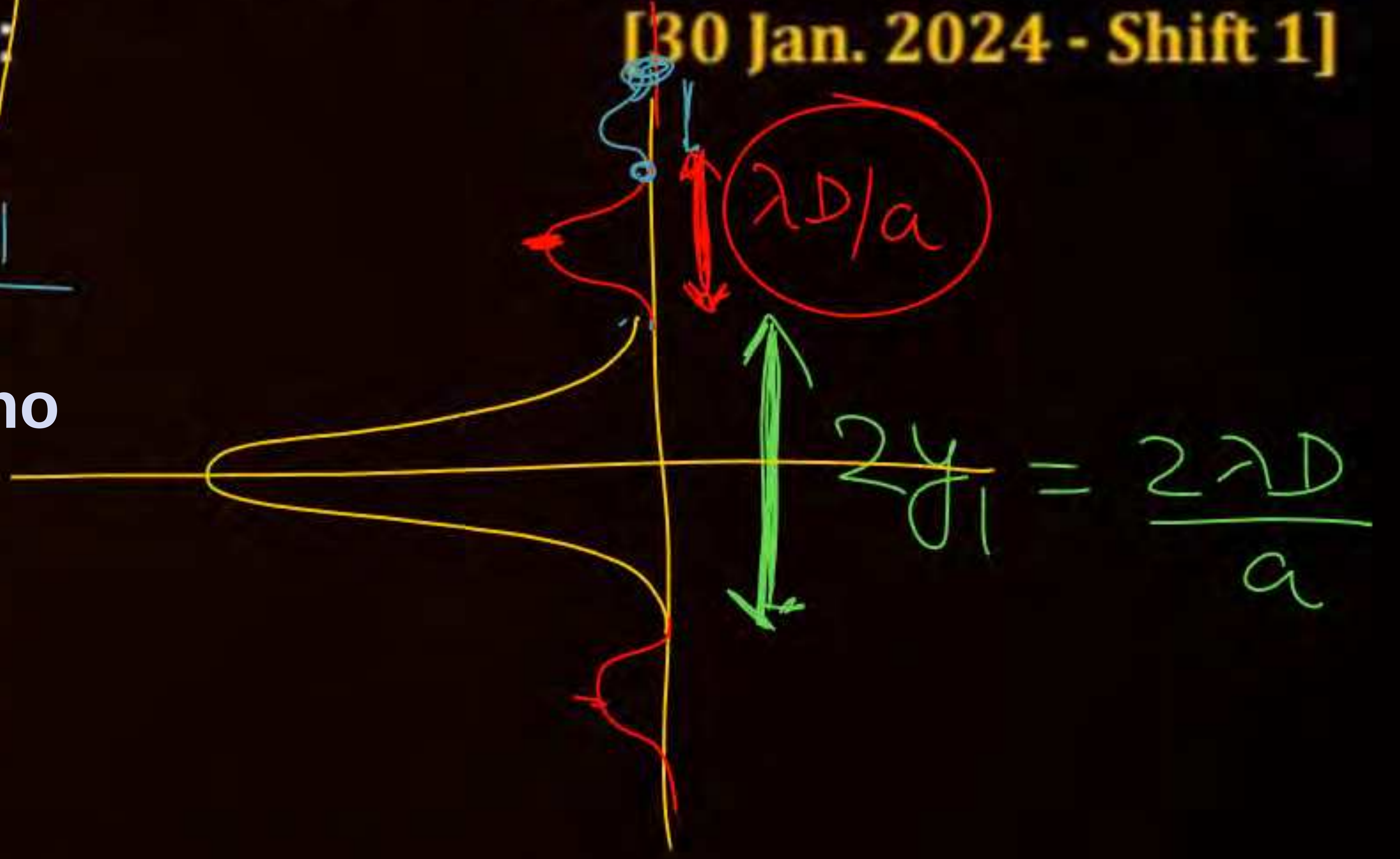
(1) 2 mm

(2) 2 cm

(3) 0.02 mm

(4) 0.2 mm

$$\frac{\lambda D}{a} = \frac{400 \times 10^{-9} \times 1}{2 \times 10^{-4}} = 2 \times 10^{-3} = 2\ \text{mm}$$



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Ans. (1)

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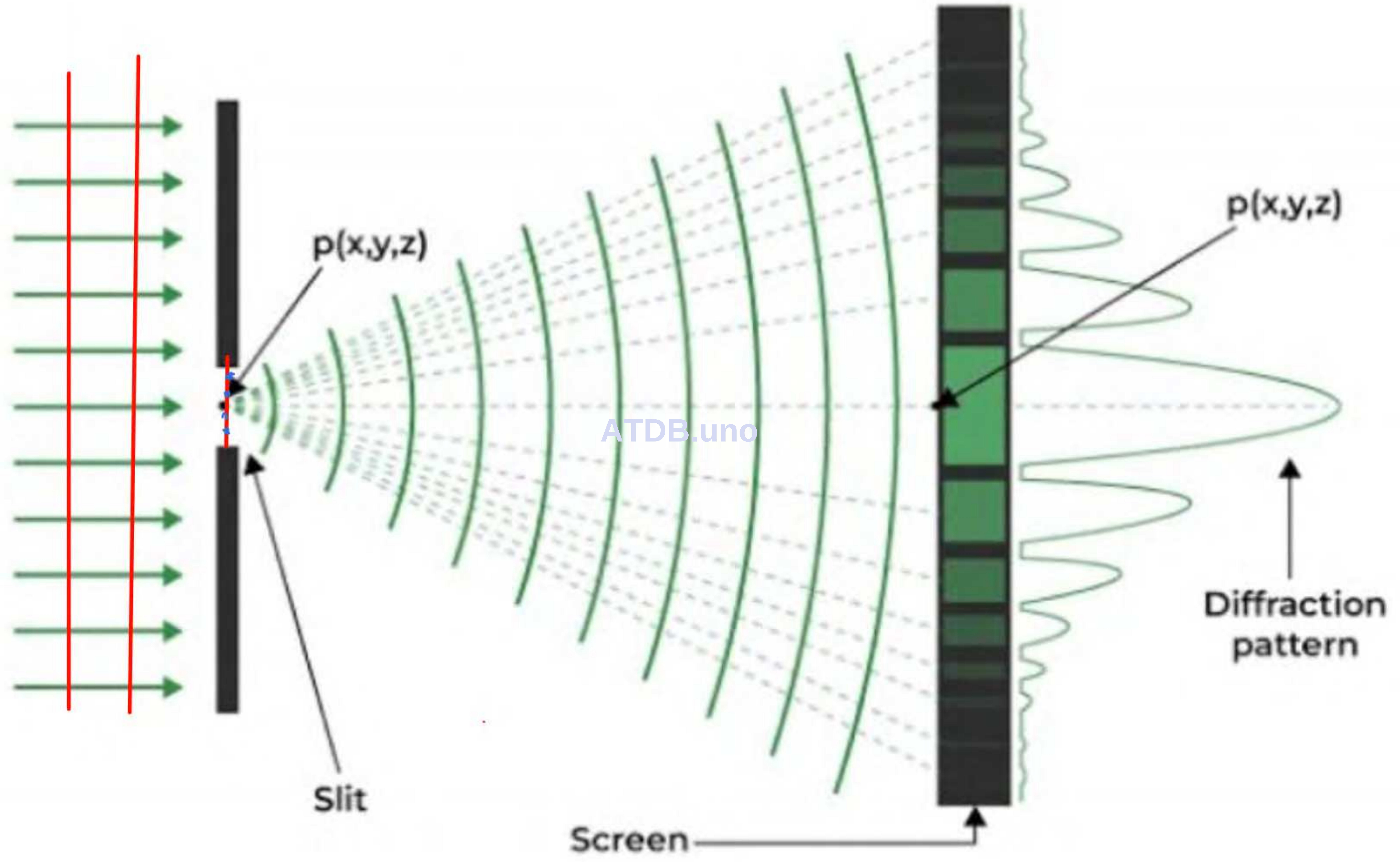

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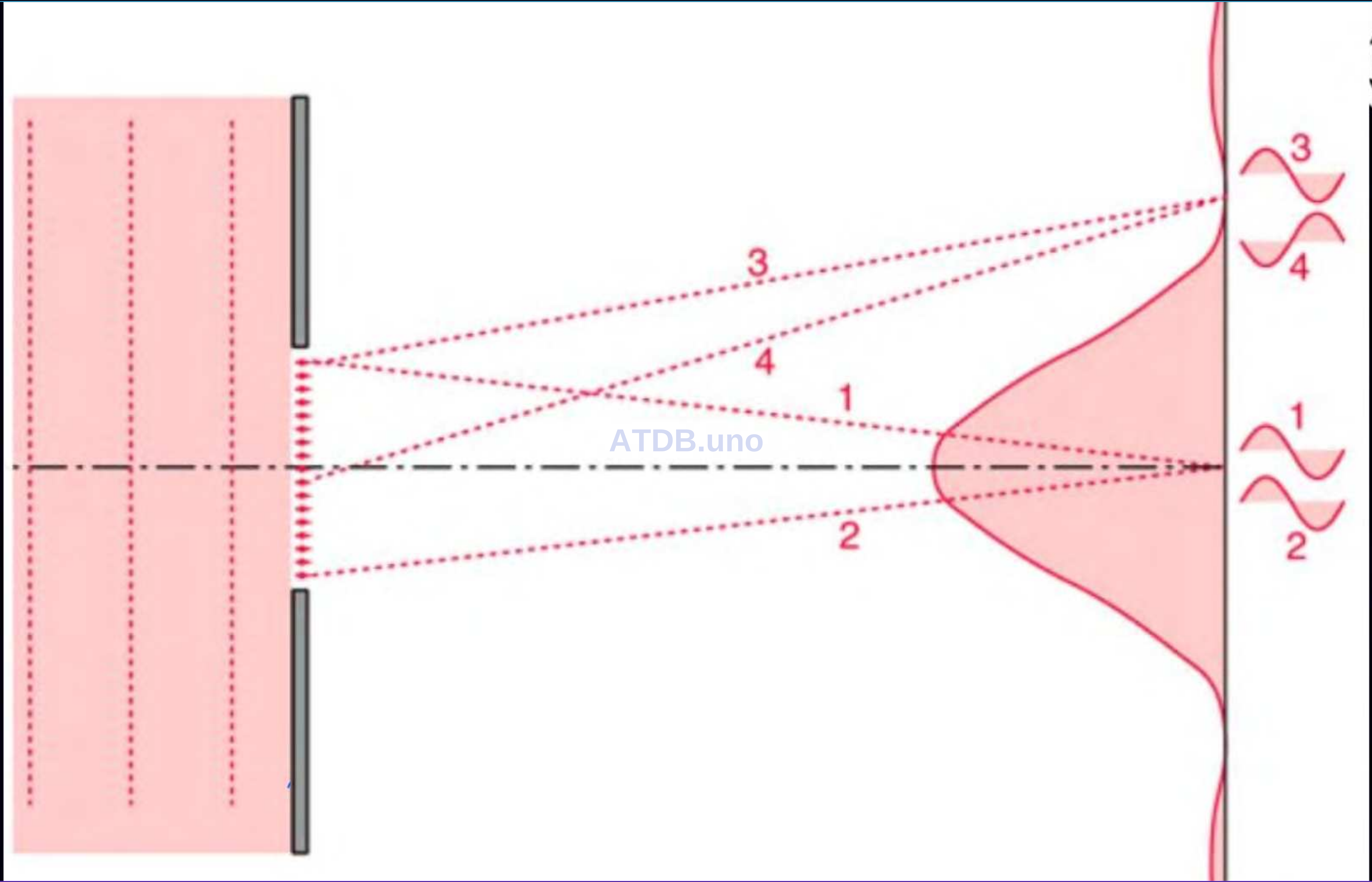

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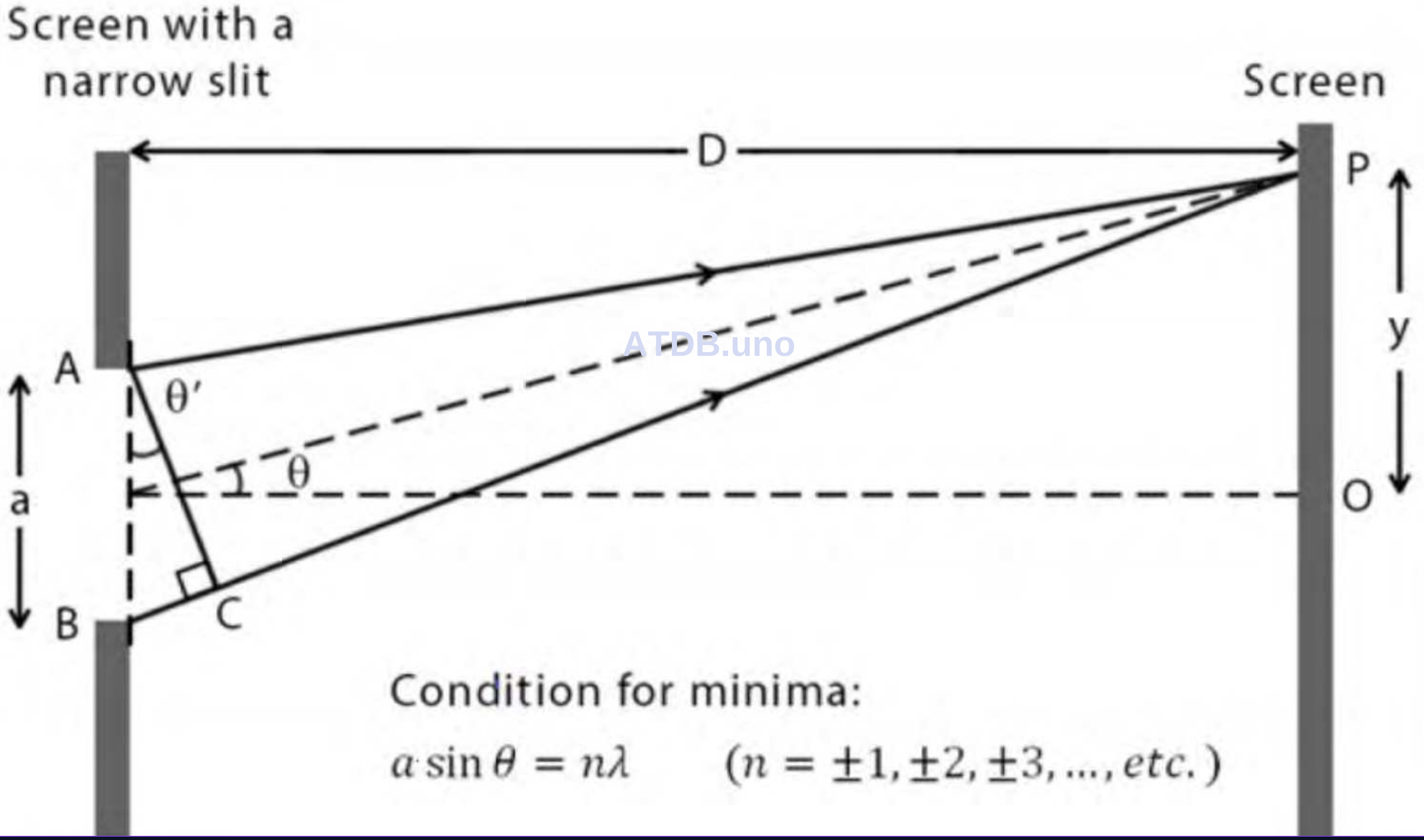
Single-Slit Diffraction Equations



Condition for minima:

$$a \sin\theta = n\lambda \qquad (n = \pm 1, \pm 2, \pm 3, \ldots, etc.)$$

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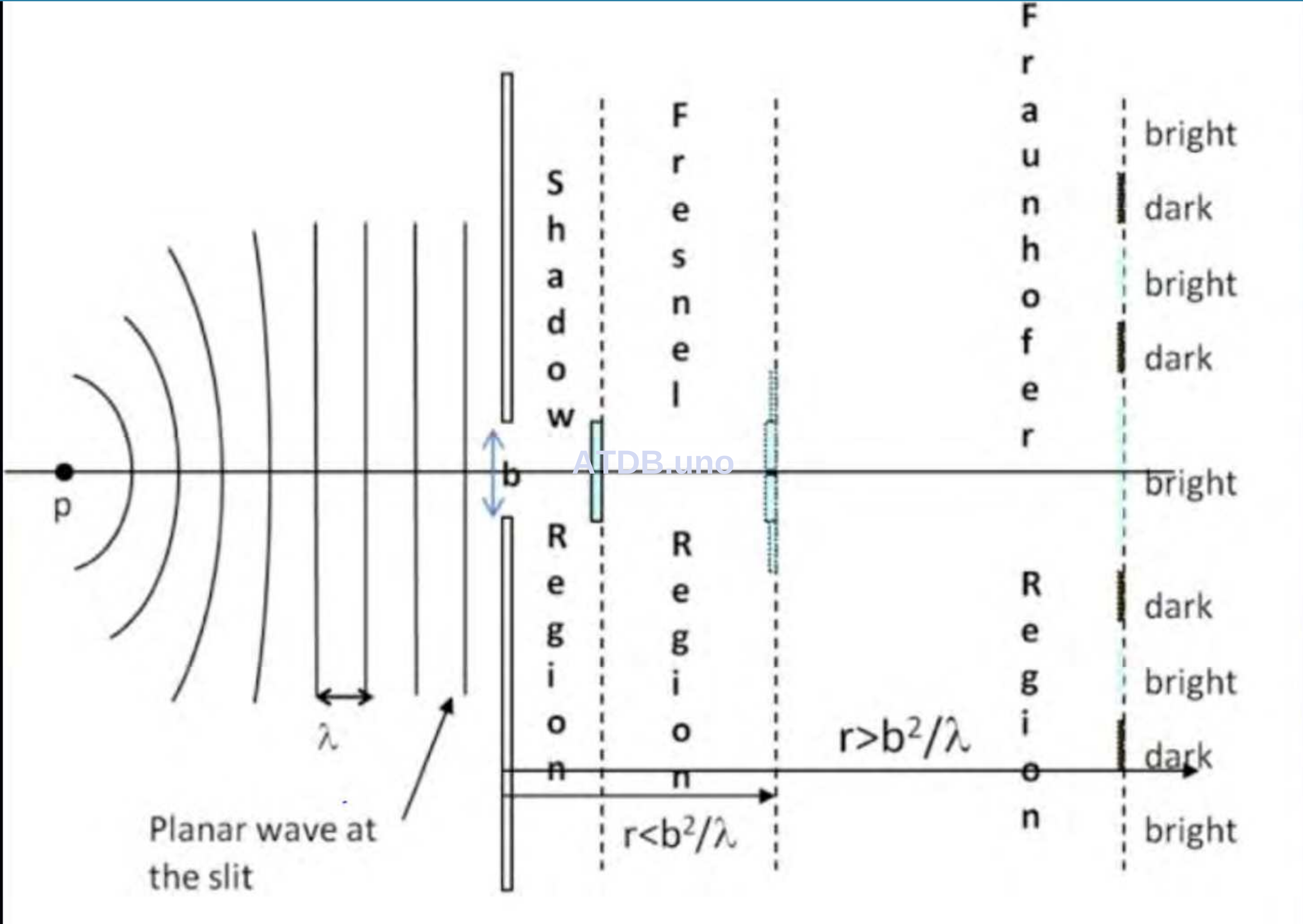

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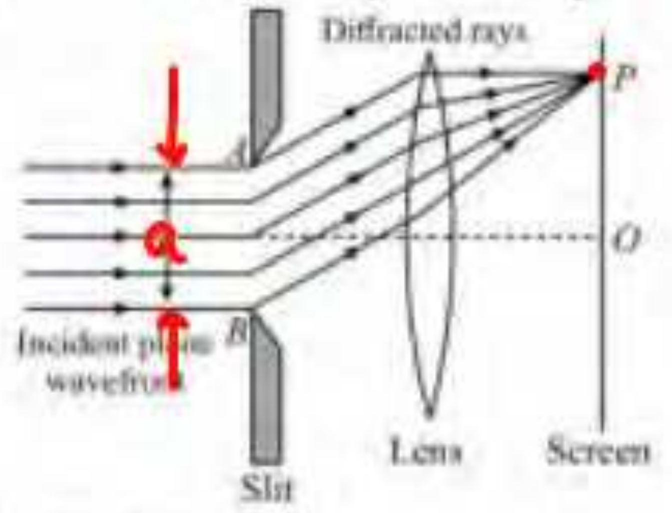
...er Diffraction: Fraunhoffer diffraction deals ...fronts that are plane on arrival and an effective viewing distance of infinity. If follows that fraunhoffer diffraction is an important special case of fresnel diffraction. In young's double slit experiment, we assume the screen to be relatively distant, that we have fraunhoffer conditions.

Difference Between Interference and Diffraction of Light

S. No.	Interference	Diffraction
1.	Two coherent sources are necessary.	Multiple coherent sources are required.
2.	All fringes have same width.	Fringes have unequal width.
3.	Width of central bright fringes is equal to other fringes.	Width of bright central fringe is just double of other fringes.
4.	All bright fringes have equal intensity.	As order of bright fringes increases, intensity goes down.
5.	**For bright fringe:** $d\sin\theta = n\lambda$	**For bright fringe:** $a\sin\theta = (2n-1)\lambda/2$
6.	**For dark fringes:** $d\sin\theta = (2n-1)\lambda/2$	**For dark fringe:** $a\sin\theta = n\lambda$

FRAUNHOFFER DIFFRACTION FOR SINGLE SLIT

In this diffraction pattern central maxima is bright on the both side of it, maxima and minima occurs symmetrically



1. **For Diffraction Maxima**
   $a\sin\theta = (2n-1)\lambda/2$
2. **For Diffraction Minima**
   $a\sin\theta = n\lambda$
3. The maxima or minima is observed due to the superposition of waves emerging from infinite secondary points sources between points A and B of slit.
4. **Fringe width of central maximum**
   The distance between two secondary minima formed on two sides of central maximum is known as the width of central maximum

$W = \frac{2...}{...}$
f = foc...
a = wi...
Angula...

DIFFER... AND FR...

1.	The ... dista... obst... finite... and ...
2.	Wav... sphe...
3.	No s... is re...
4.	No l...

COMPA... LIGHT

1. Genera... than li... of ordi... compa...
2. (a) O... (b) Vi... ob... w... ob...
3. Genera... becaus...

DIFFRA...

When a be... projected o... bright fring...

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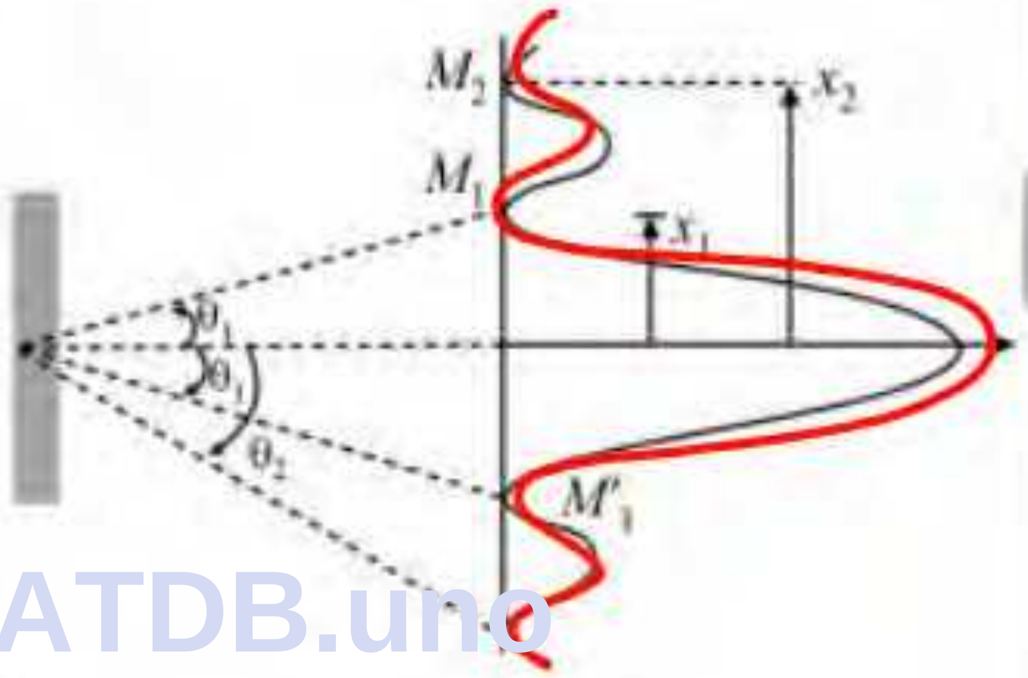
9:51 ...tance from the diffracting obstacle 92



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$$W = \frac{2\lambda f}{a}$$

f = focal distance of convex lens

a = width of slit

Angular width = $\Delta\theta = \frac{2\lambda}{a}$

DIFFERENCE BETWEEN FRESNEL AND FRAUNHOFFER DIFFRACTION

	Fresnel	Fraunhoffe
1.	The source is at finite distance on one side of obstacle and screen also at finite distance from obstacle and on the other side.	Source & screen are effectively at infinit distance from obsta
2.	Wave front is either spherical or cylindrical.	Plane wave front.

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