# PHYSICS 571 – Master's of Science Teaching

# "Electromagnetism and Light"
# Lecture 8 – Labs and demos that you can do with your kit – Part II

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**Outline**

**Magnetism**

Homopolar Motor

Galvanometer

**Induction**

Induction

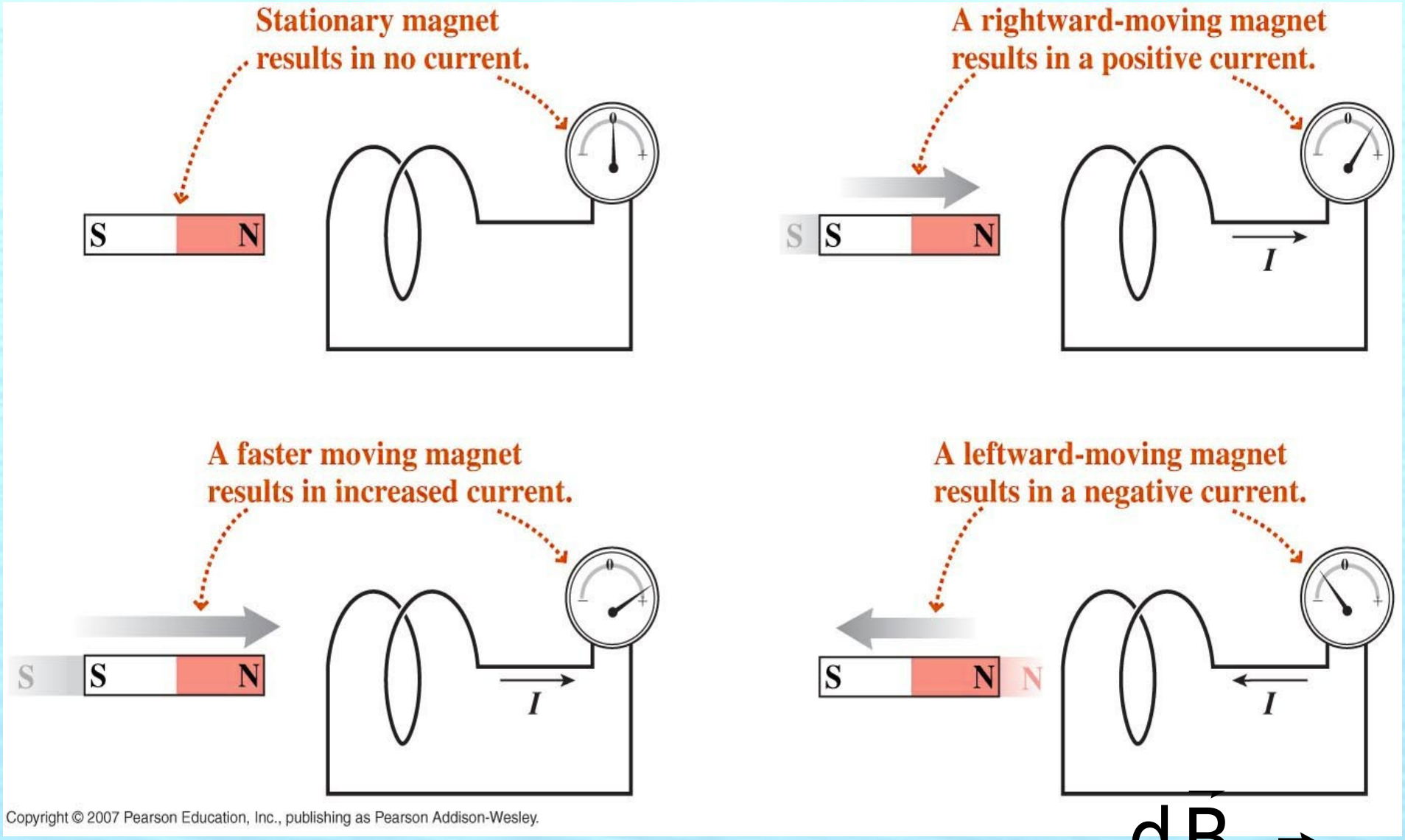
Transformer

**Light**

Lenses

Double Slit experiment

# Electromagnetic Induction






$$V_{induced} = \frac{d\vec{B}}{dt} \cdot \vec{A}$$

**Electromagnetic Induction:**

You can do it! ***(bold items are in your kit)***

Needed:

**Spool of #26 magnet wire**

**2 clip leads**

**1/2” x 1/2” N48 cylinder magnets**

**Amico Class 2.5  Amperemeter**

**Soldering iron**

Toilet paper tube

Duct Tape/Electrical tape

# Electromagnetic Induction:

You can do it!


Wrap 100 turns of wire around toilet paper tube

Tin ends with soldering iron.

Connect ends to two screws indicated by arrows.

Push magnet into tube

**Electromagnetic Induction:**

You can do it!

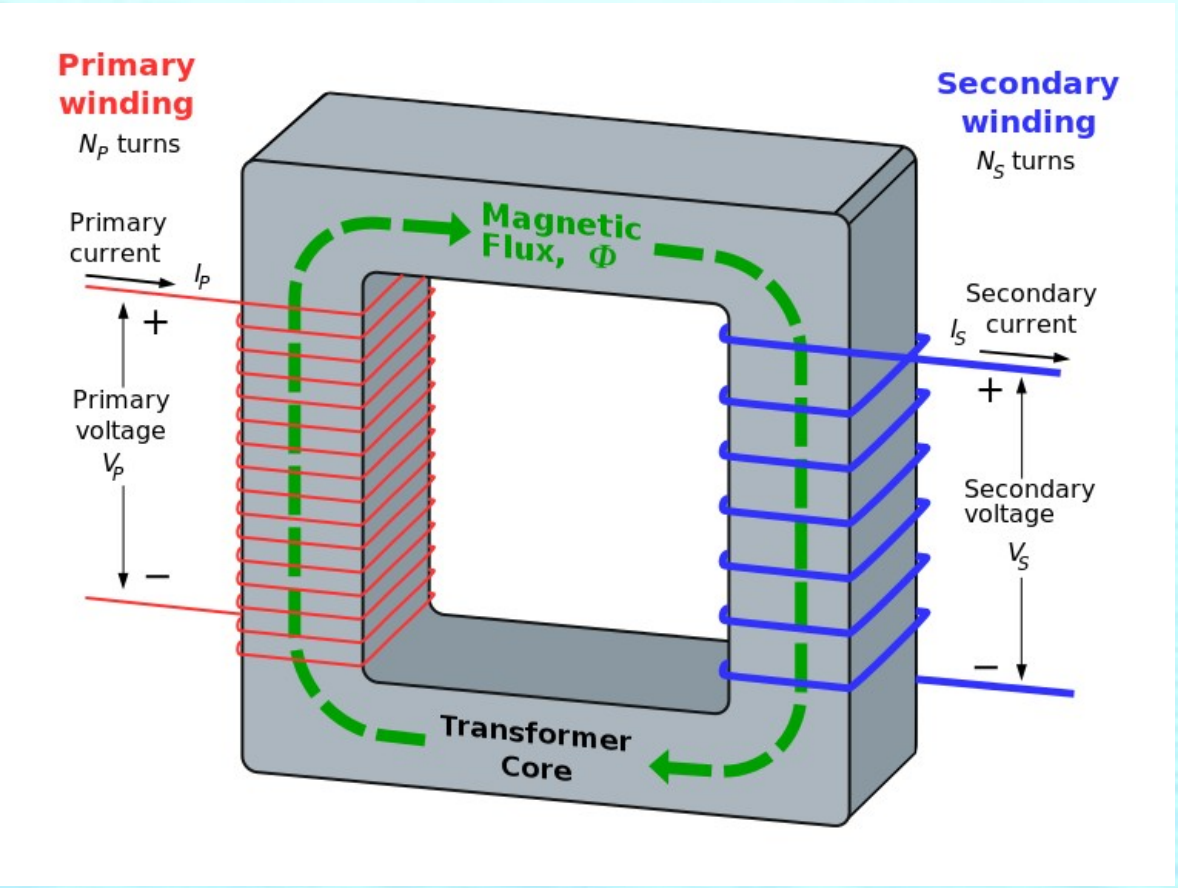
$$V_{induced} = \frac{d\vec{B}}{dt} \cdot \vec{A} = \frac{dB}{dt} A N_{windings}$$

B for rare earth magnets is about 0.1 T.

Area of TP tube $A = \pi d^2/4 = \pi\, 0.04^2/4 = 1.25 \times 10^{-3} m^2$

$$\frac{dB}{dt} = \frac{0.1\ T}{0.1}\ s = 1\ T/s$$

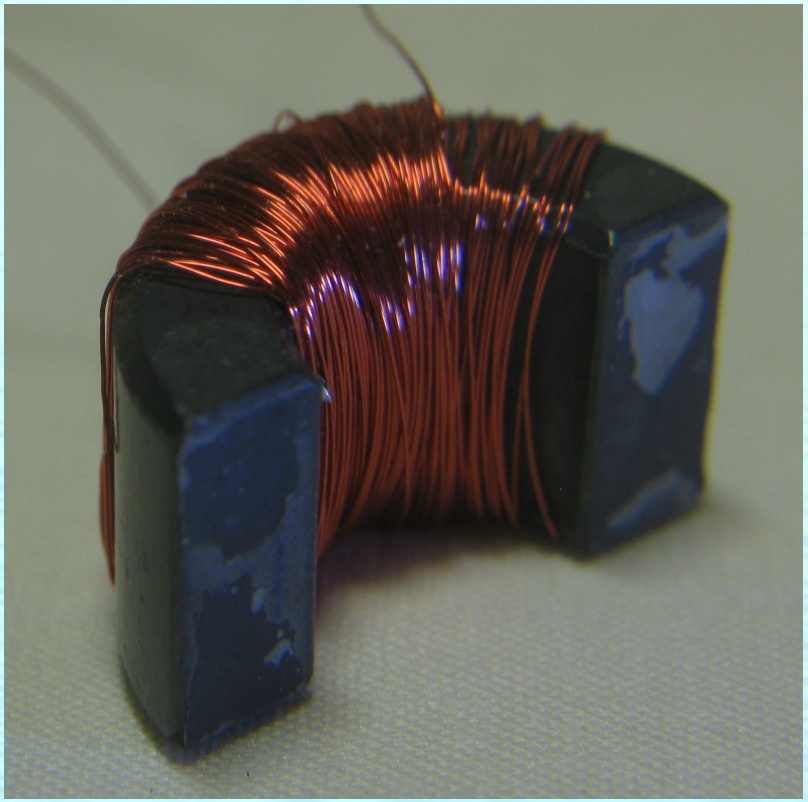
$$V_{induced} = \frac{dB}{dt} A N_{windings} = 1\ T/s \times 1.25 \times 10^{-3} \times 100 = 0.125\ Volts$$




# Transformer

Current comes in the "primary" coil and makes
A magnetic field.
Changes in that current change the field.
A "secondary" coil Sees these changes
As changing flux and Makes a new EMF.

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$



$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

# Transformer

The transformer needs a source of alternating current (The battery will not do).
The cheapest and safest source is a function generator.
To measure the Alternating current (Your multimeter Will do that).

**Transformer:**

You can do it! ***(bold items are in your kit)***

<u>Needed:</u>

**Lots of #26 magnet wire**

**Multimeter set to "AC" setting**

**Soldering iron**

Cheap function generator (e.g. Elenco) set to 100 Hz sinewave

Large iron bolt or "ferrite core"


by Elenco

# 1MHz Function Generator Kit

4.2 out of 5 stars ▾ 33 customer reviews

List Price: ~~$38.25~~

Price: $32.80 Prime

You Save: $5.45 (14%)

Only 5 left in stock.

Sold by Corydor and Fulfilled by Amazon. Gift-wrap available.

**Want it Tuesday, April 21?** Order within **16 hrs 17 mins** and choose **One-Day Shipping** at checkout. Details

8 new from $32.80

**Specifications for this item**

| | |
|---|---|
| Brand Name | Elenco |
| EAN | 0756619001623 |
| Number of Items | 1 |

# Image formation by a convex lens

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$$

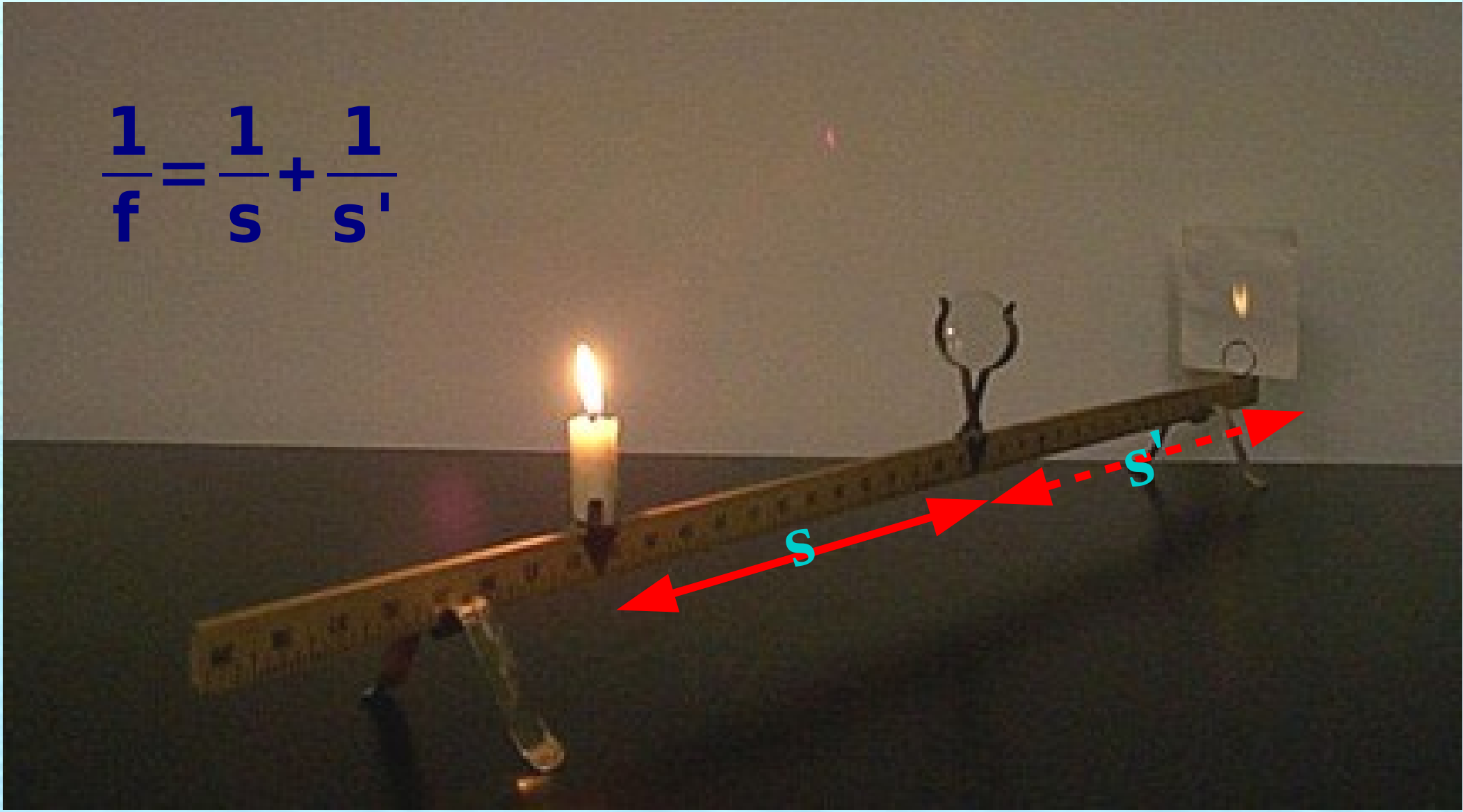


**Image formation by a convex lens:**

You can do it! ***(bold items are in your kit)***

<u>Needed:</u>

**17.5 mm focal length lens**

Meter stick

Bar of soap and saw (or lump of clay …)

Candle and matches

Darkened room

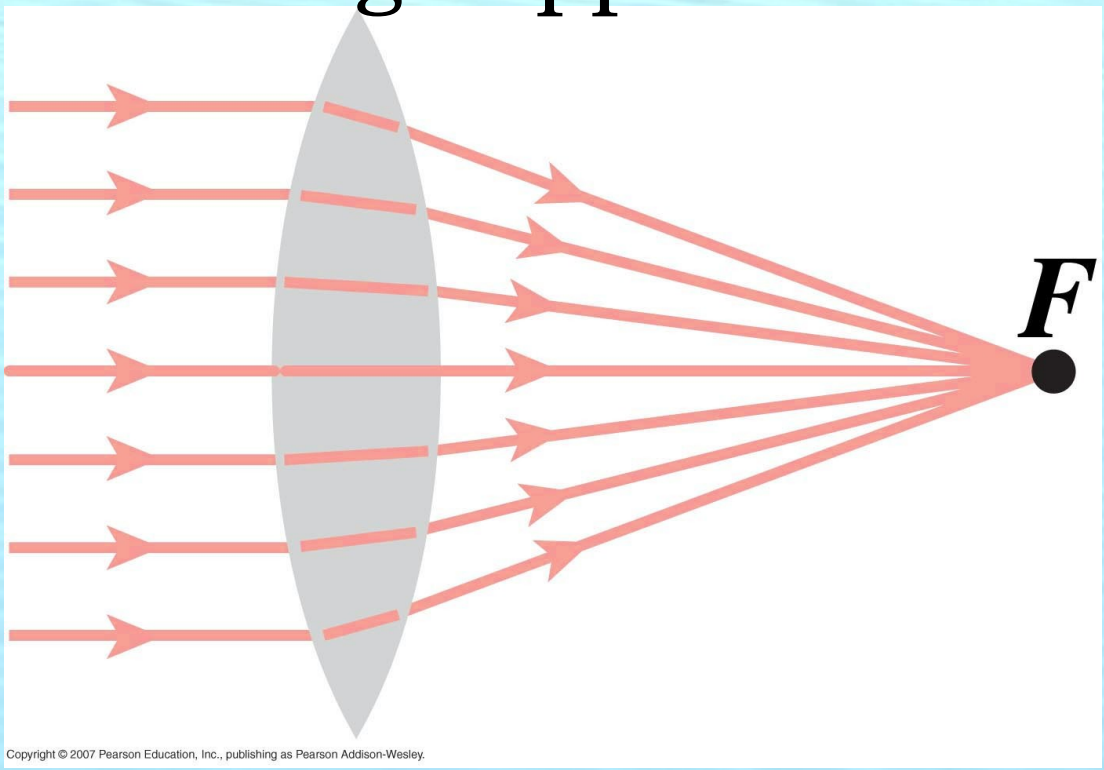
# Focal point and focal length

Focal point (F):

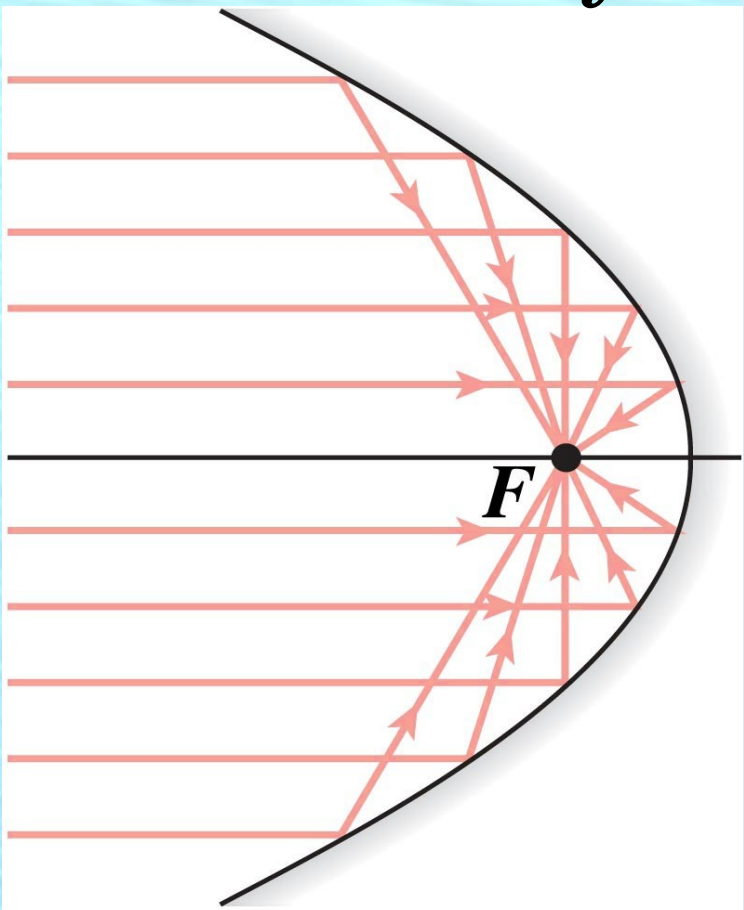
The point at which parallel rays converge.

Focal length (f): f = distance to focal point.

"f" is a property of a lens … not necessarily where image appears.







**Concave mirror can form a real image that appears out in front of the mirror.**

# Image position and magnification

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$$

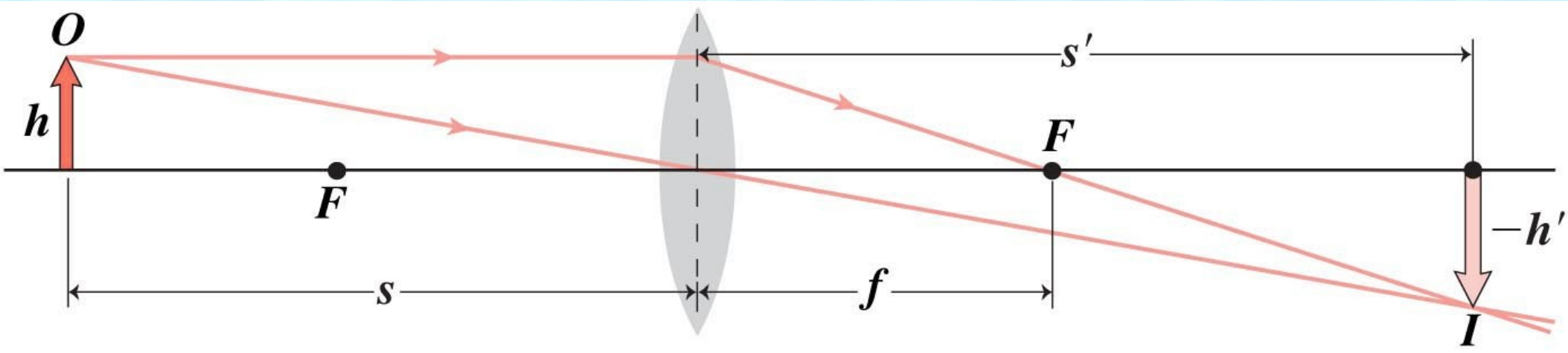
$$m = \frac{-s'}{s}$$

s = distance to object

s' = distance to image

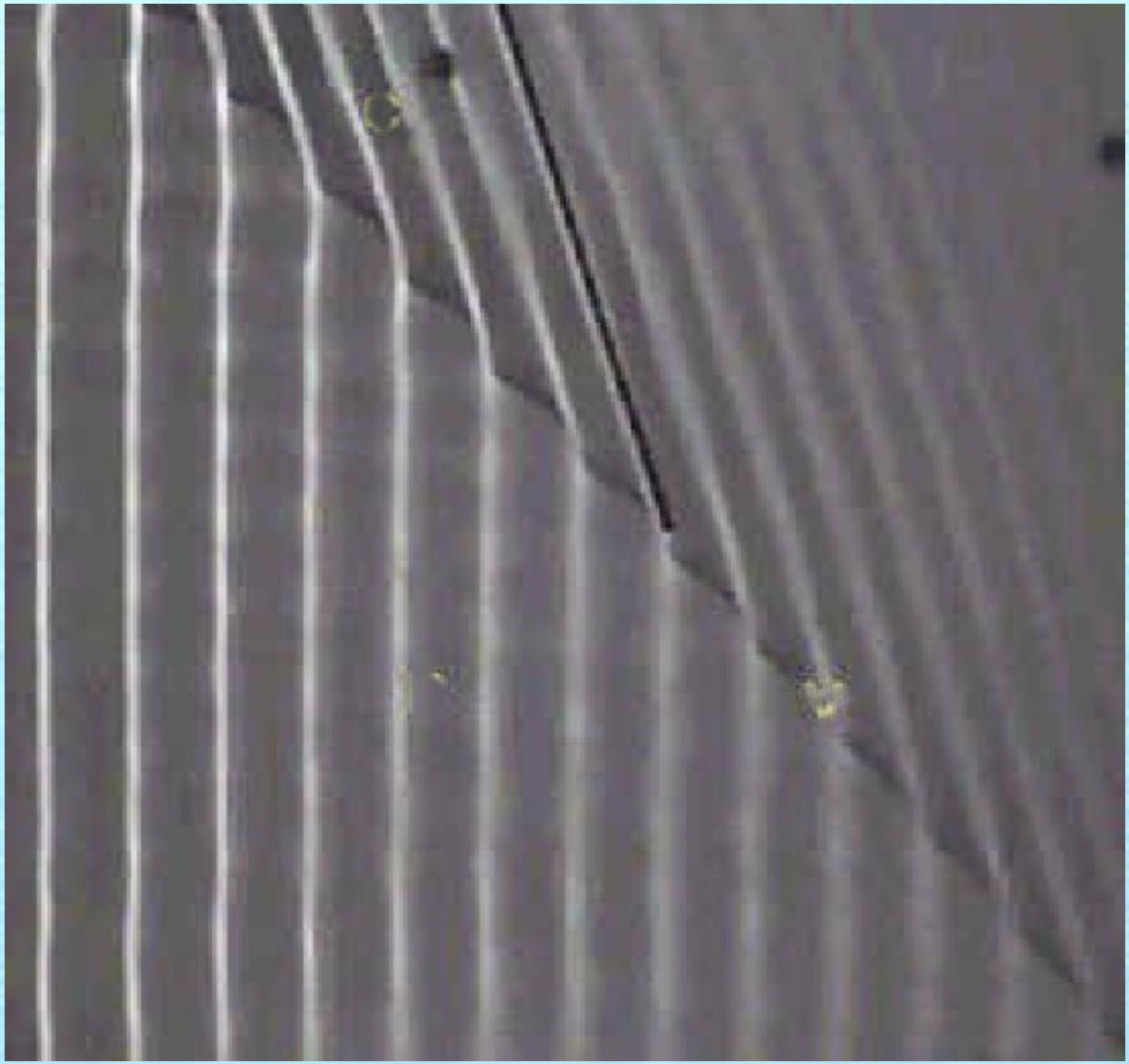
f = focal length

m = magnification



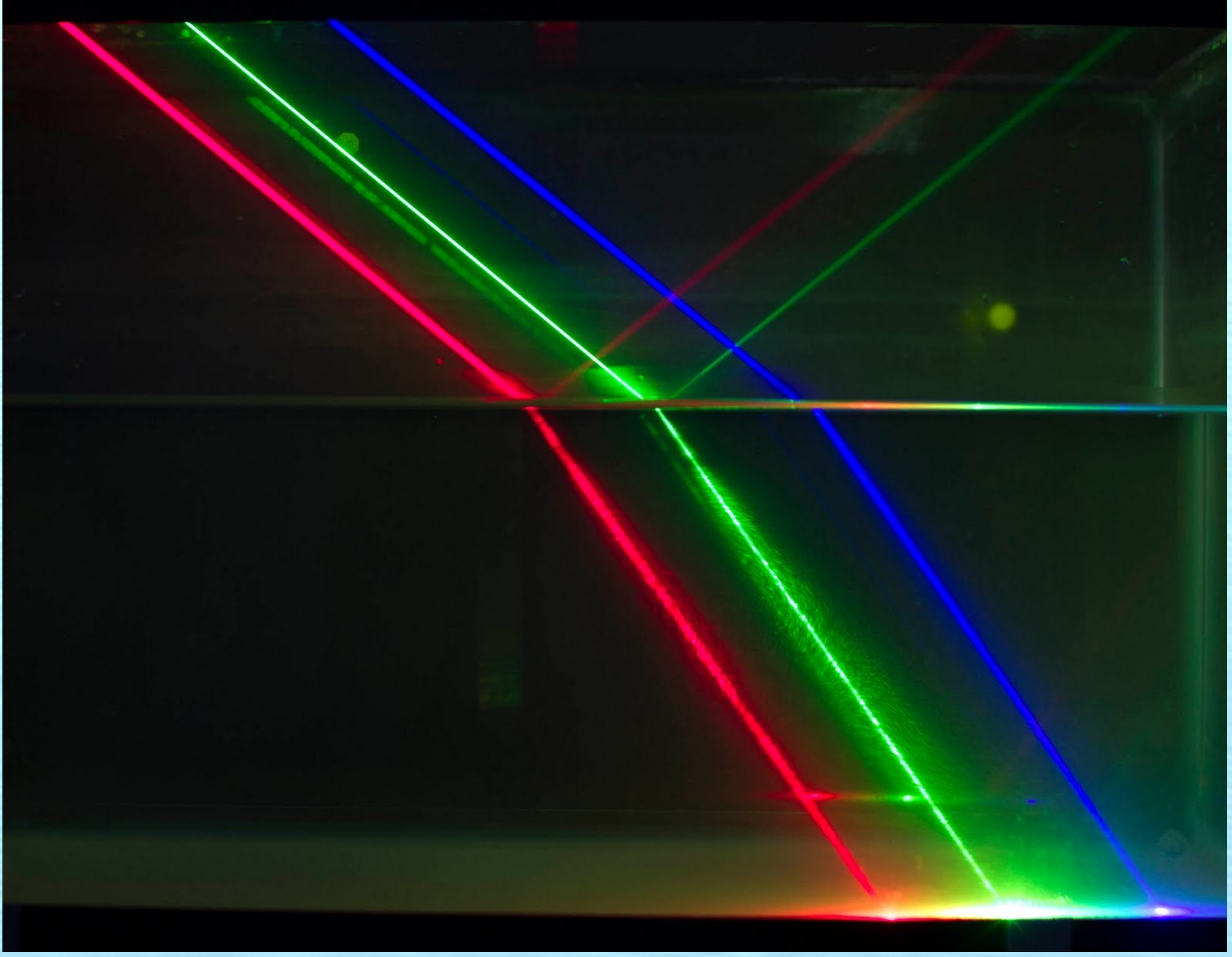
**Snell's law** $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

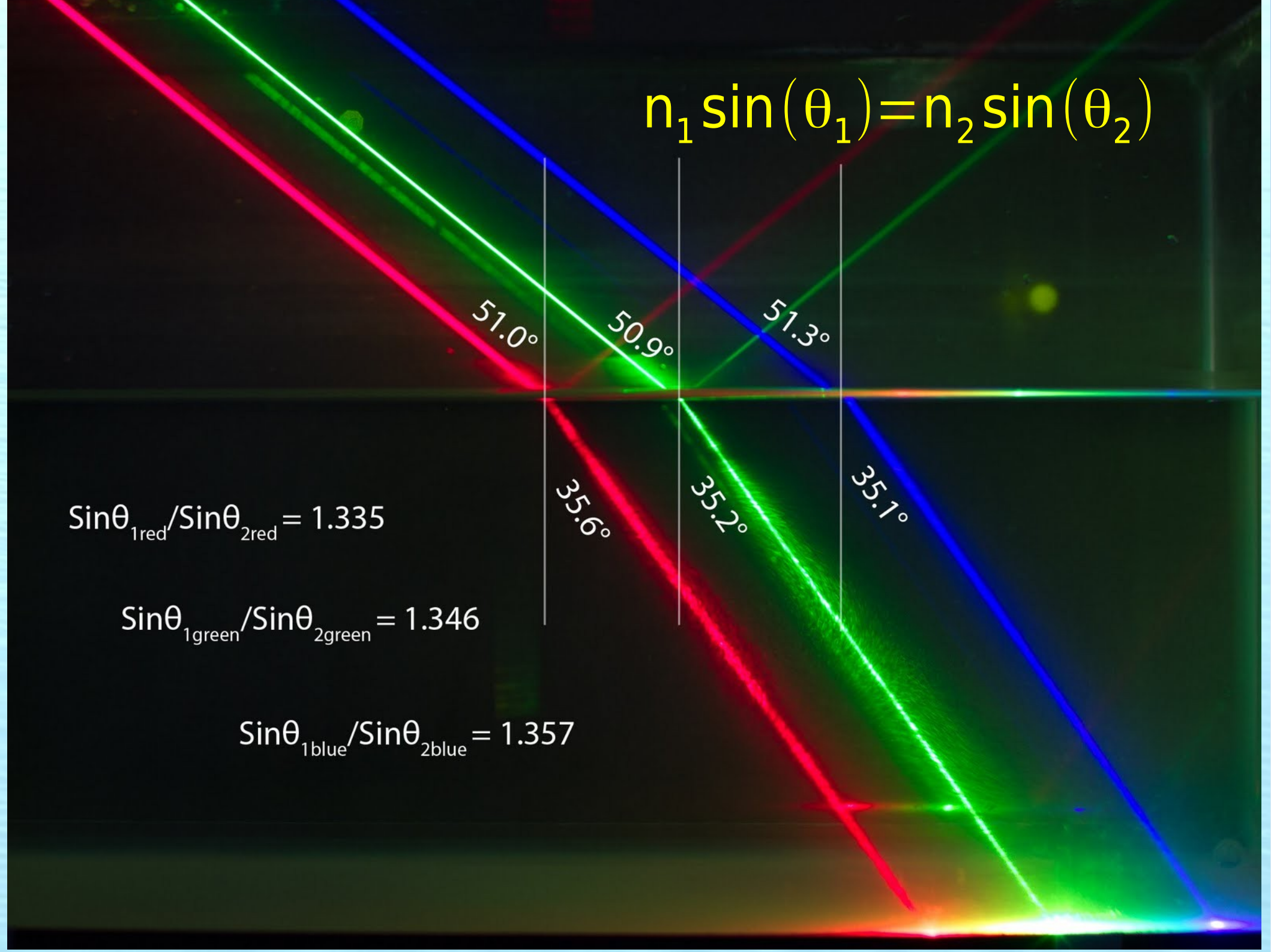
**Applies to ALL waves**



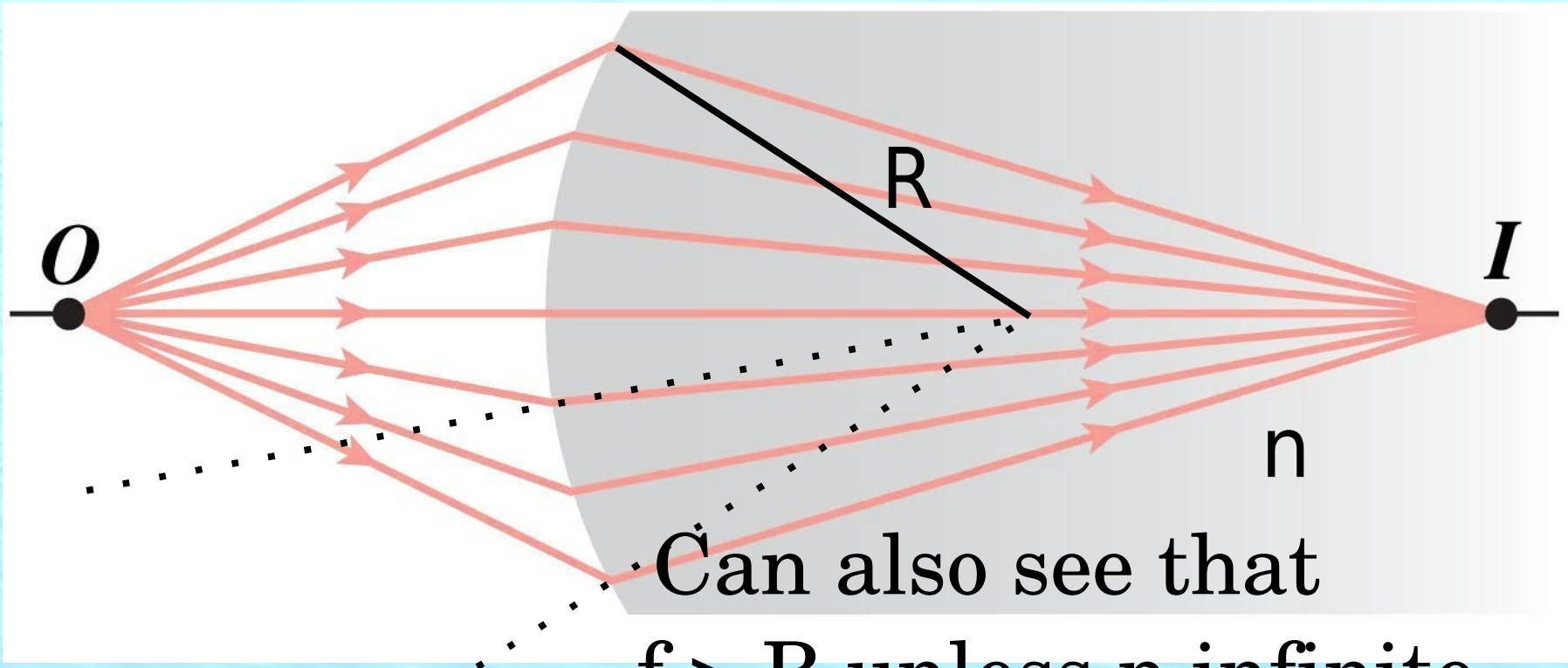
Refraction is CAUSED by the change of speed as light goes from one medium to Another.

Slowing waves bend toward normal




$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$
51.0°
50.9°
51.3°
35.6°
35.2°
35.1°
$\text{Sin}\theta_{1red}/\text{Sin}\theta_{2red} = 1.335$
$\text{Sin}\theta_{1green}/\text{Sin}\theta_{2green} = 1.346$
$\text{Sin}\theta_{1blue}/\text{Sin}\theta_{2blue} = 1.357$

Snell's law in combination with a
Curved surface makes lenses work.




Can also see that

f > R unless n infinite

$$f = \frac{R}{(n-1)}$$

**Double Slit Interference:**

You can do it! ***(bold items are in your kit)***

<u>Needed:</u>

**Microscope slide (some kits)**

**Two Razor Blades (some kits)**

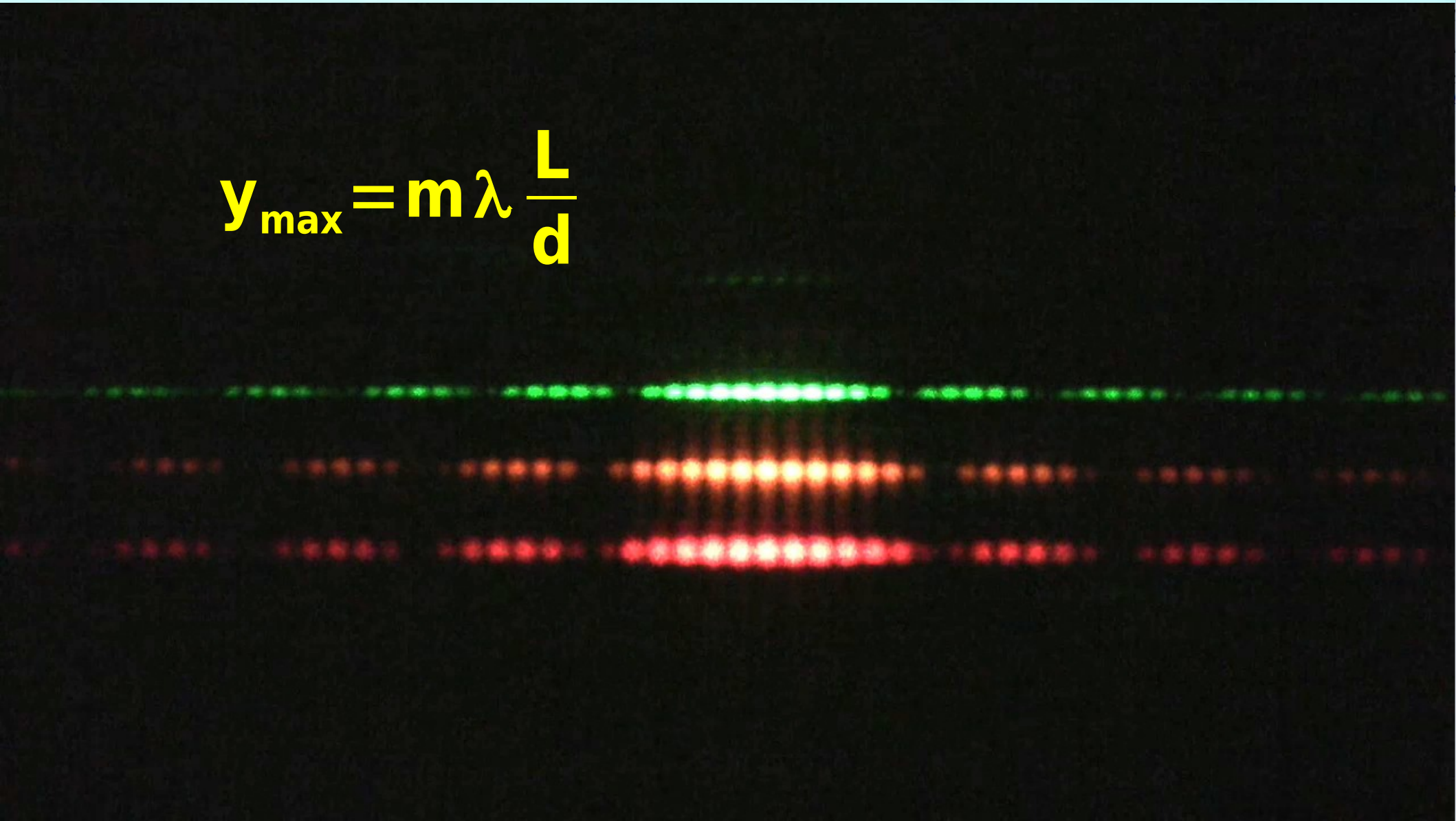
Black Sharpie

Laser Pointer

Darkened Room

**If you do a red and a green laser on same slits, you can show that red light has a longer wavelength than green.**

$$y_{max} = m\lambda \frac{L}{d}$$



# Double Slit Interference:

You can do it!

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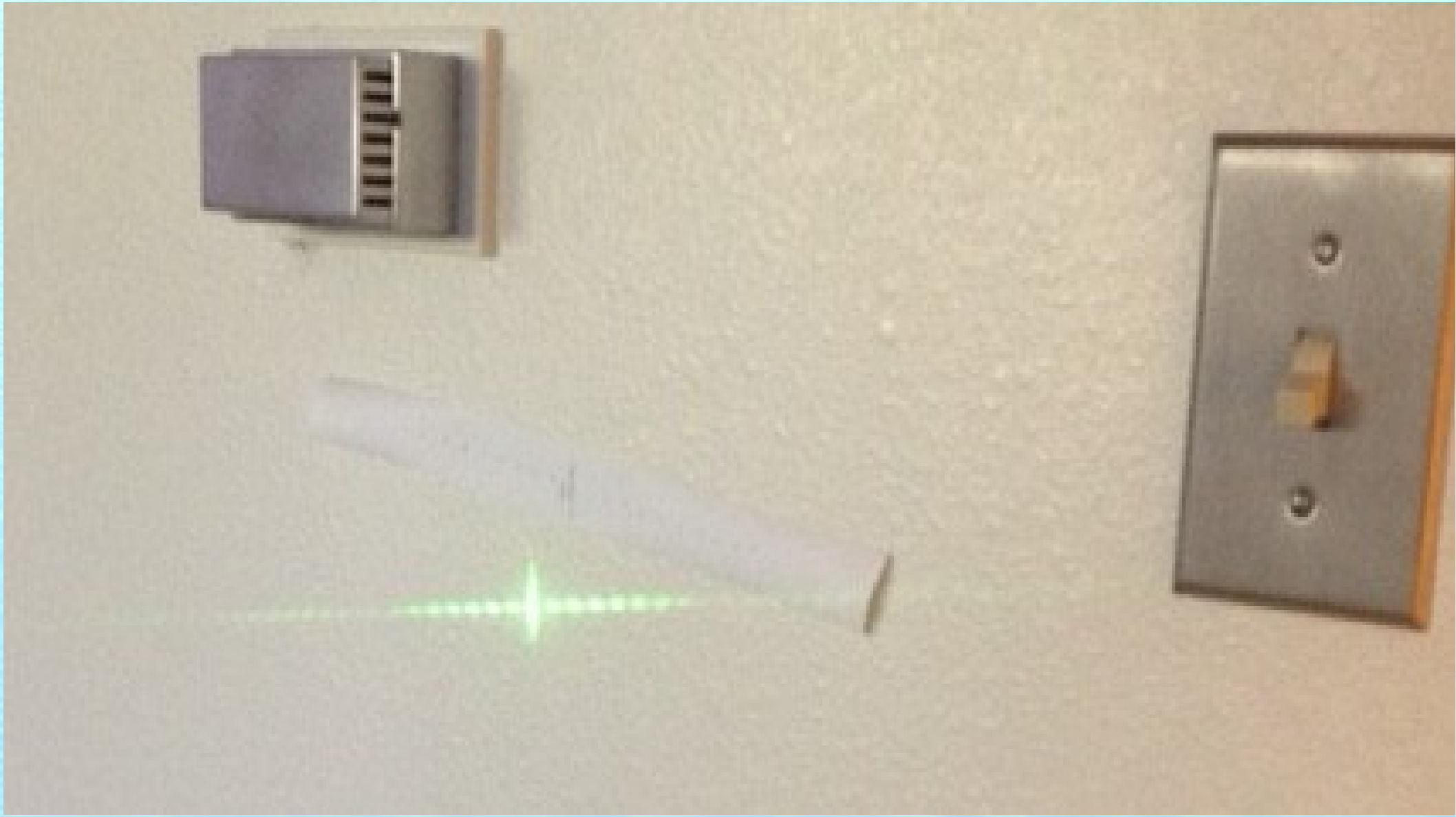
You can do it!



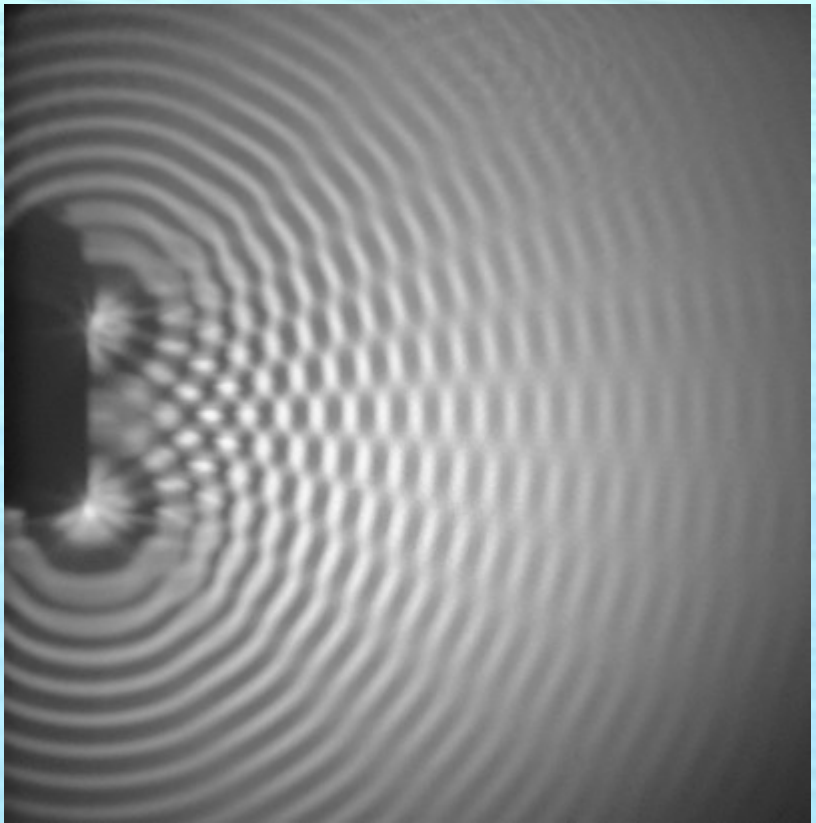
**Double Slit Interference:**

You can do it!

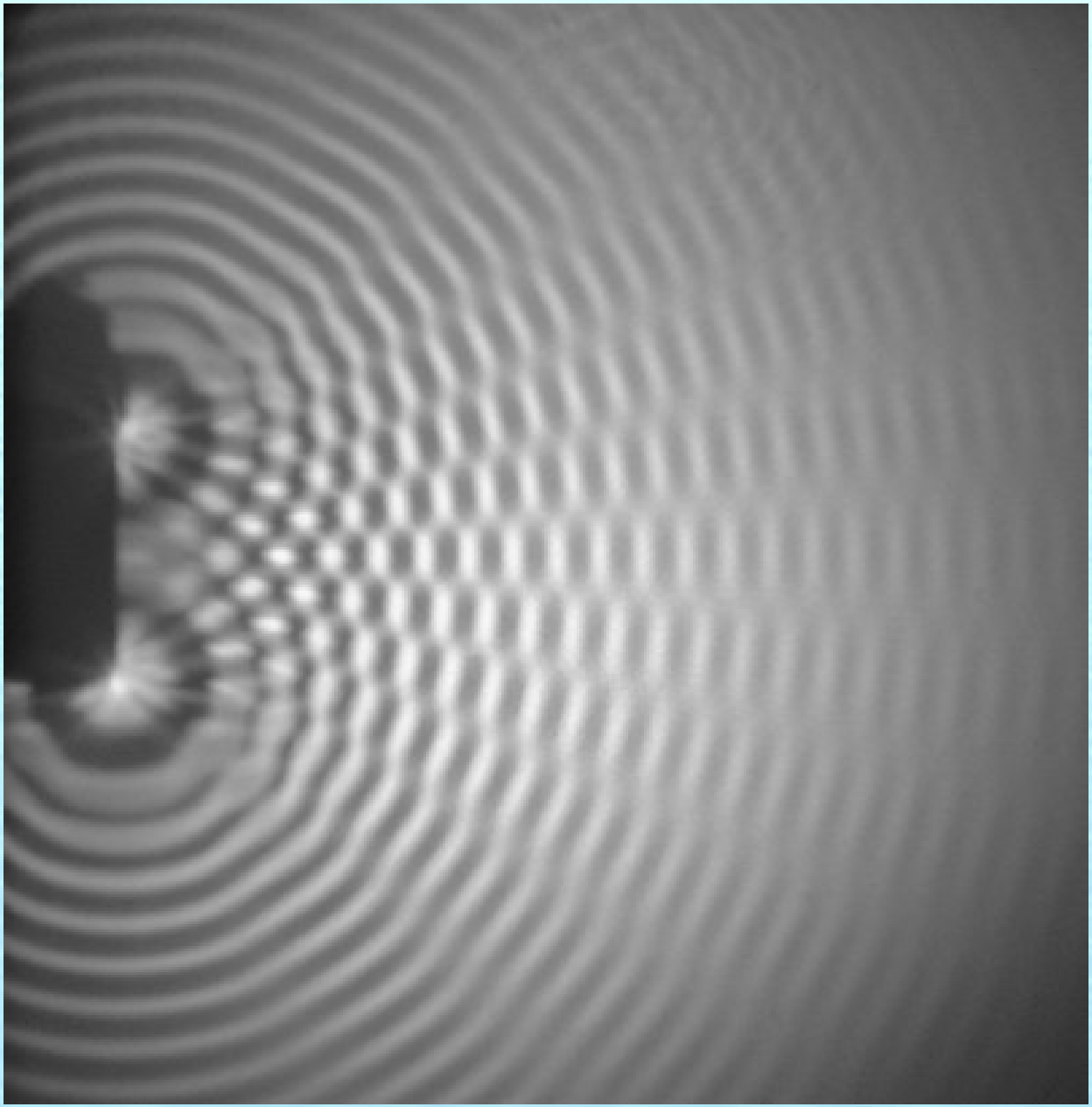
When you have two waves, they add to eachother.  Sometimes they reinforce, sometimes they cancel.
This is called “interference”

**Ripple Tank:**

A glass bottomed-pan
Of water on an overhead
Projector with motor-
driven “dippers”



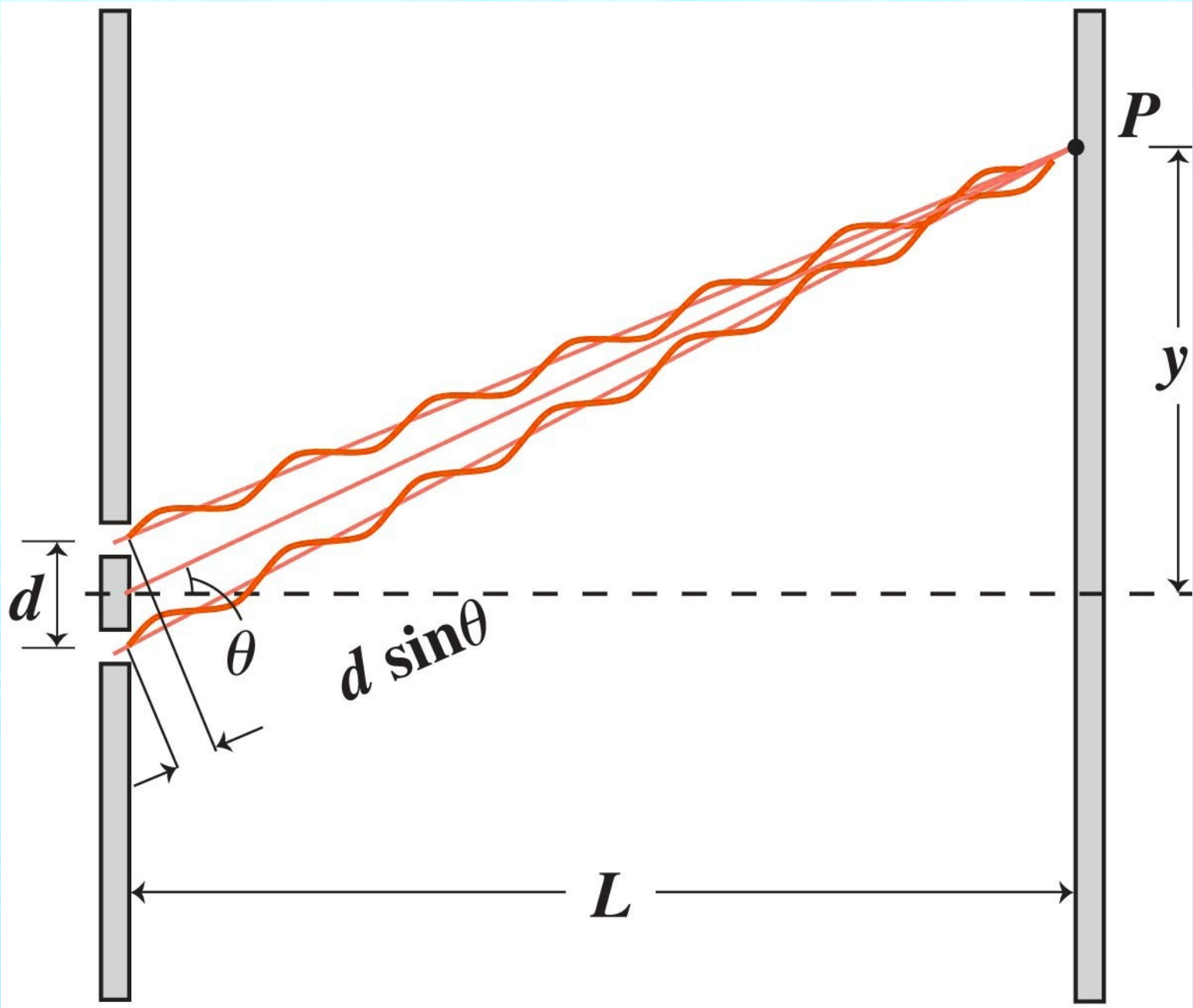
# Interference:



http://phet.colorado.edu/en/simulation/wave-interference

# Double slit Constructive interference

$$y_{max} = m\lambda\frac{L}{d}$$



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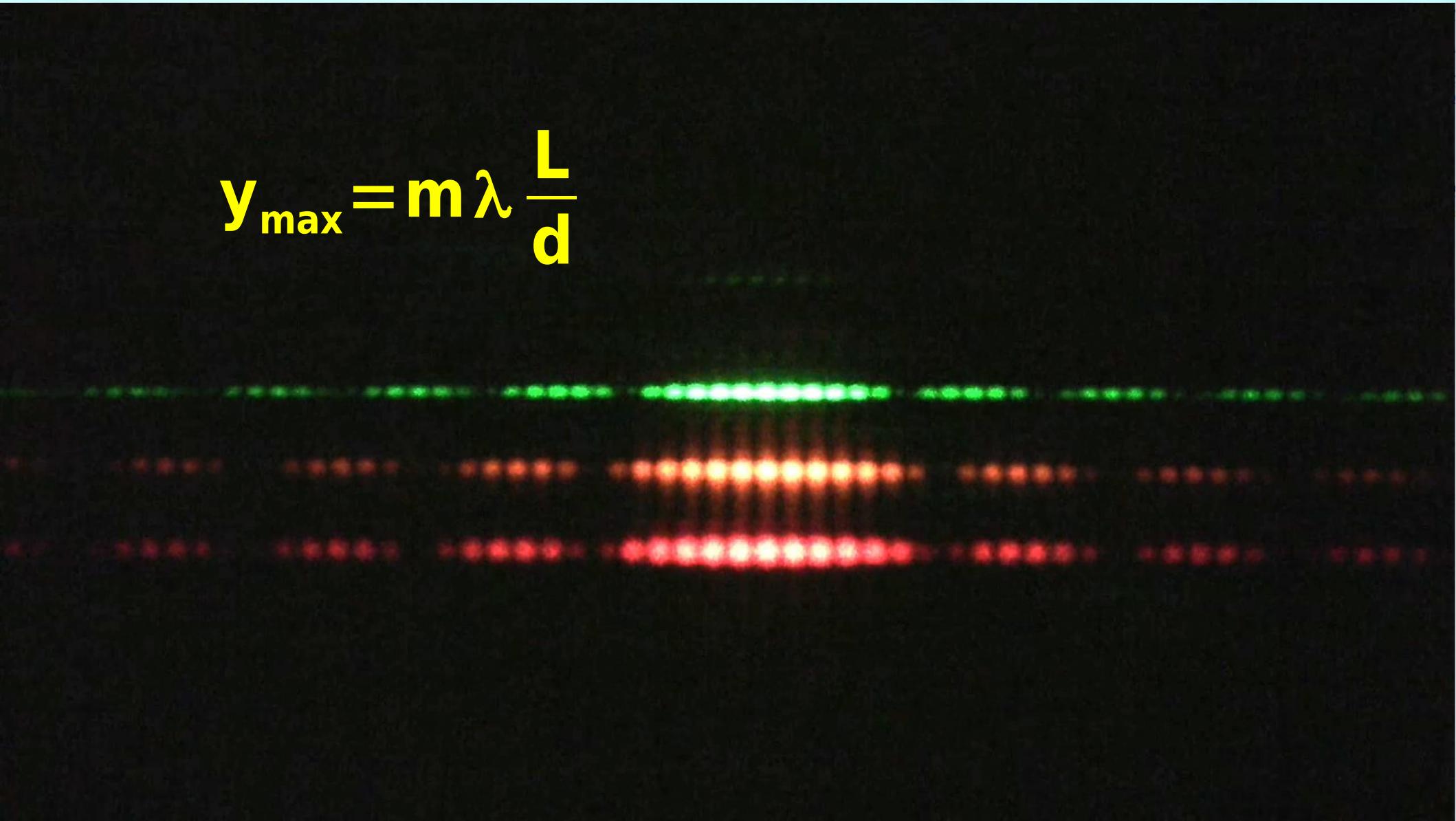
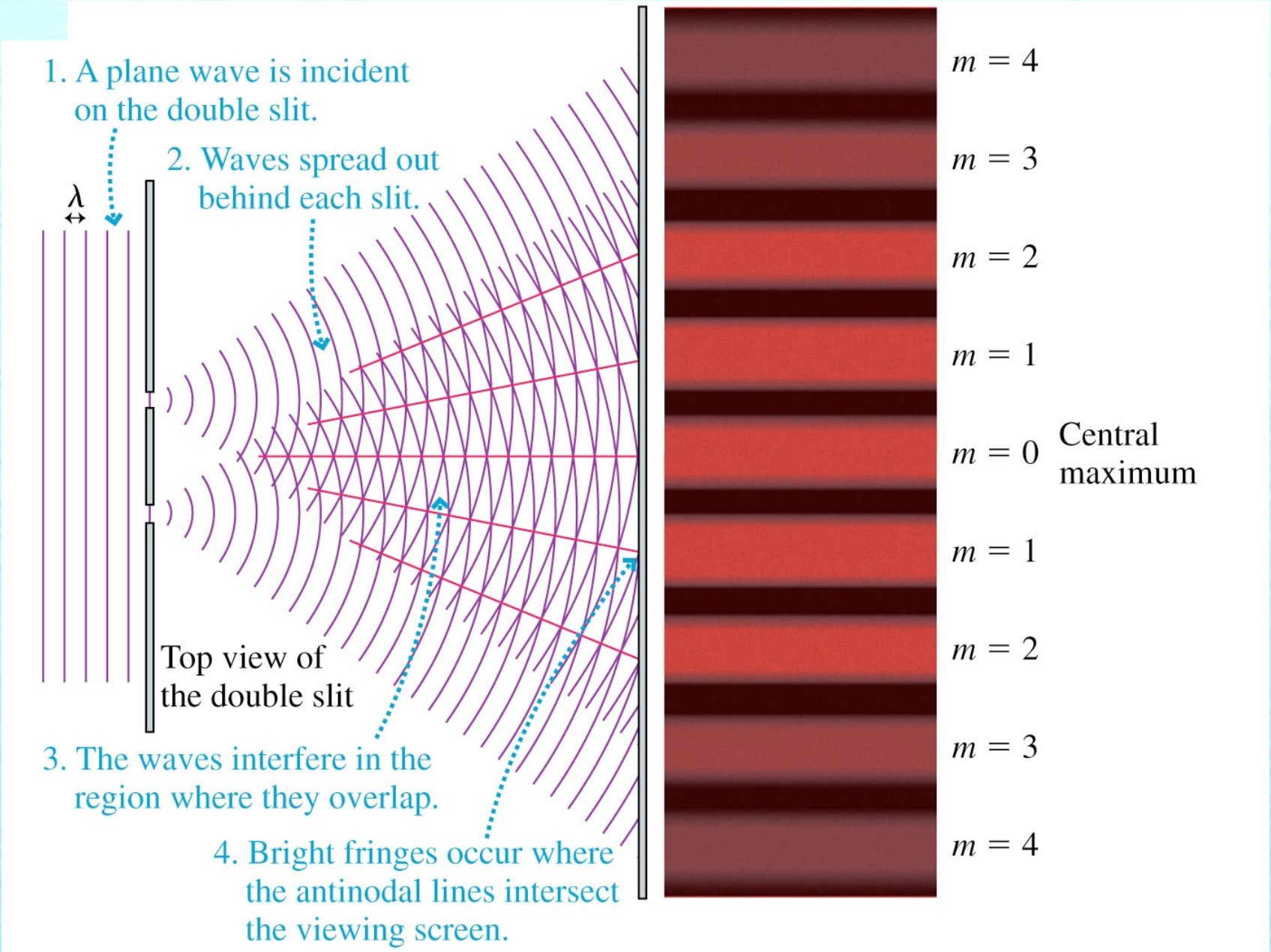


# Young's Double-Slit Experiment

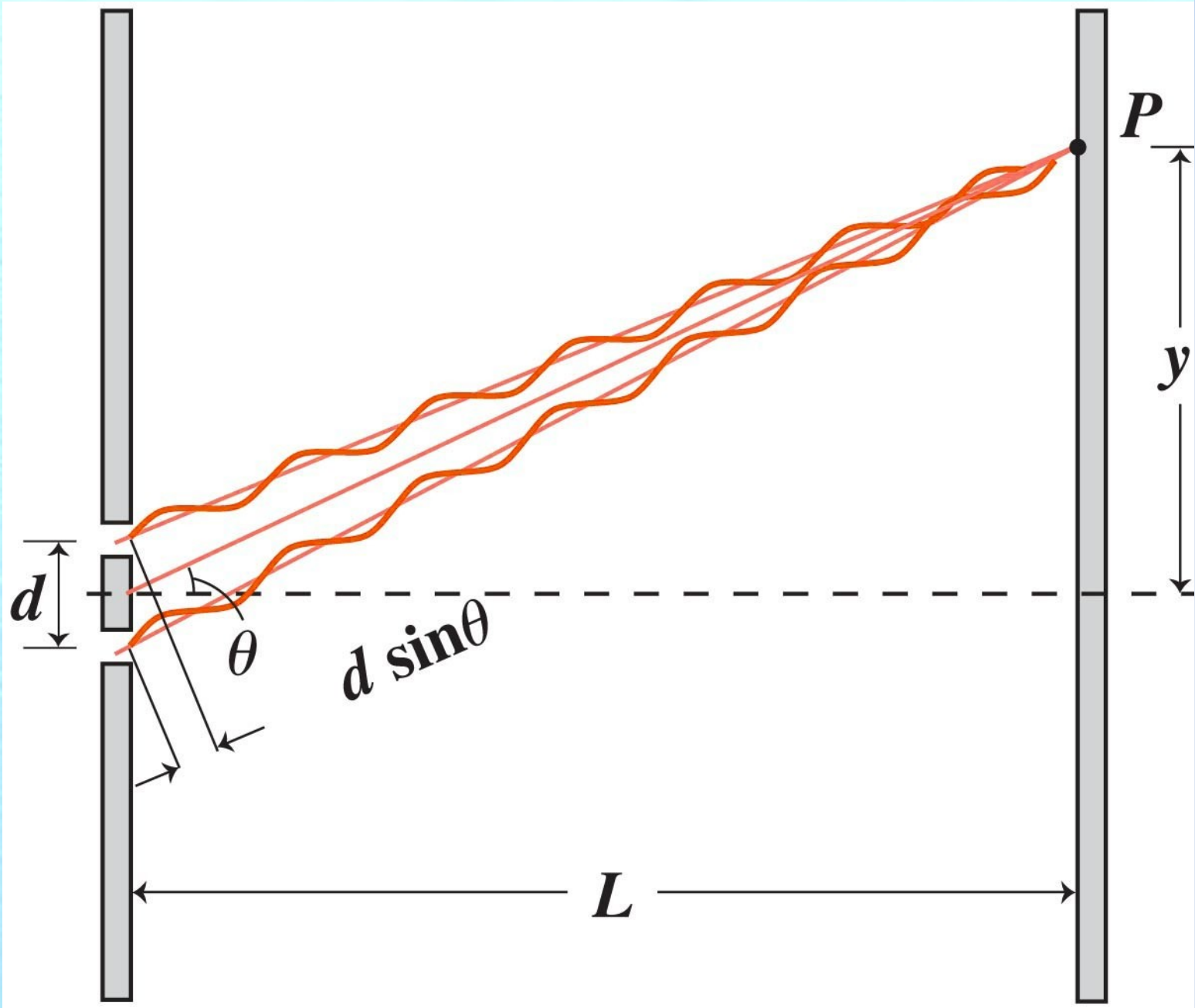


# Double slit Constructive interference

$$d \sin\theta = m\lambda$$

$$d\frac{y}{L} = m\lambda$$

$$y_{max} = m\lambda\frac{L}{d}$$



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