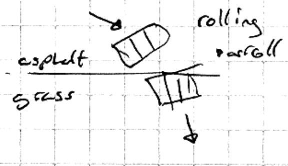
# Waves PHYS 2020

Is light a wave or a particle?

Particles reflect and refract (in a sense)


particles have a distinct and precise location and are like "packages" of mass

So do waves....

waves are spread continuously through a region of the "medium" (water, air etc...

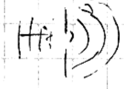
↳ thing that is waving

Things waves do that particles dont!

- they can interfere with each other - consider water, accoustics examples.

Show pictures of water wave interference to explain how.

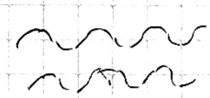
- they bend around obstacles (to a degree) → diffraction



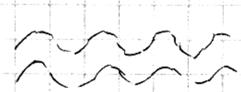
↳ this is why people thought light would be made of particles, it was not observed to bend around corners (like sound waves) - in reality it does, but not much due to its short wavelength.

to get sustained predictable interference - we need
1. coherence - all in phase
2. the same wavelength

Not in phase (incoherent)

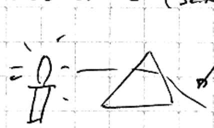


in phase (coherent)



↓ how do you do this with light?

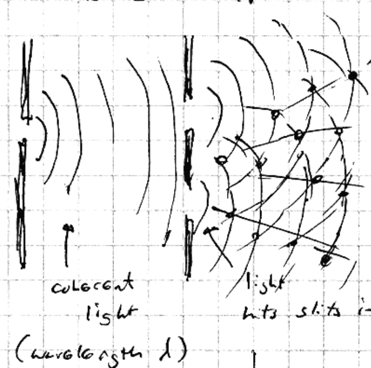
Monochromatic (same wavelength



use a prism to select a specific wavelength

then use a pinhole to get a coherent wave front

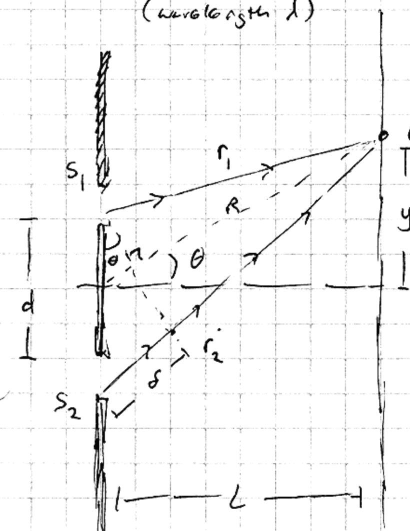
# Young's Double Slit Experiment




constructive interference along specific lines

leads to light dark pattern

( fringes




constructive interference if

$$\delta = r_2 - r_1 = m\lambda$$

($\delta$: path difference; $\lambda$: wavelength; $m$: integer (called order number))

destructive interference if

$$r_2 - r_1 = \left(m + \tfrac{1}{2}\right)\lambda$$

$$\sin\theta = \frac{\delta}{d} \qquad \delta = d\sin\theta$$

for small $\theta$ → $R \approx L$

$$\sin\theta = \frac{y}{R} \approx \frac{y}{L}$$

$$\delta = d\sin\theta = \frac{dy}{L}$$

constructive interference (small angle)

$$\delta = m\lambda$$

$$m\lambda = \frac{dy}{L} \qquad y = \frac{Lm\lambda}{d}$$

$$y_{bright} = \frac{Lm\lambda}{d}$$

destructive interference

$$y_{dark} = \frac{\lambda L}{d}\left(m + \frac{1}{2}\right)$$

Examples ( Green? light )

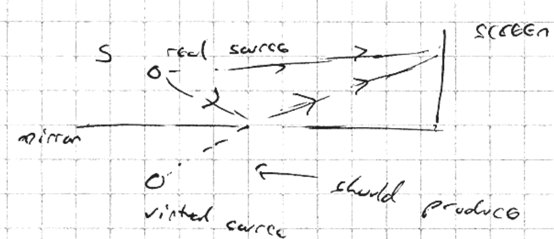
$\lambda = 500$ nm     Let $d = 0.5$ mm

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

$$= \frac{(1\,m)(500 \times 10^{-9})}{(0.5 \times 10^{-3})}(1) = 0.001\ m$$

1 mm!

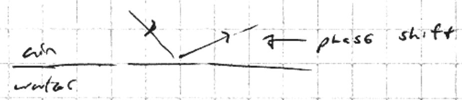
## Lloyd's mirror

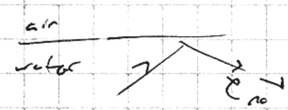



should produce results just like the double slit, however, the light and dark fringes are switched!

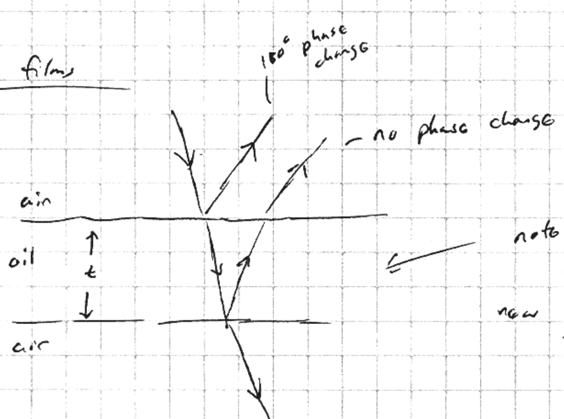
why? Apparently, the reflection shifts light by a 180° phase change!

↳ this only happens with reflection off a surface with a higher index of refraction.




## Thin films




note wavelength of light changes in the medium

new wavelength is $\lambda_n = \frac{\lambda}{n}$

so $\lambda = n\lambda_n$

the reflected wave has a path distance of

$\frac{\lambda}{2}$ (from phase shift)

the refracted has a path distance of

$2t$ ~~$\lambda_n$~~ = ~~$2t\lambda$~~ ~~$n$~~

↳ adjust to $2tn$ for shorter wavelength

Constructive interference if

$2tn$ ~~$\frac{2t\lambda}{\lambda n}$~~ $= (m + \frac{1}{2})\lambda$

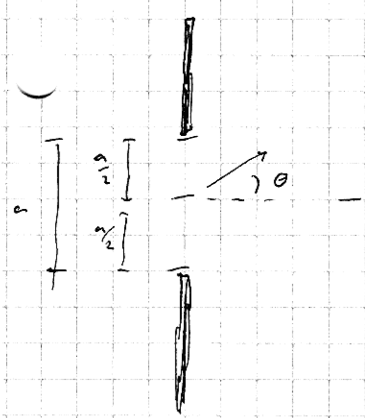
$t = \frac{\lambda}{2n}(m + \frac{1}{2})$

destructive interference if

$t = \frac{\lambda}{2n}(m)$

## Single - slit - Diffraction

consider a wider slit!




Destructive interference

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

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

then divide into more parts

$$\sin\theta_{dark} = m\frac{\lambda}{a} \qquad m = \pm 1, 2, 3, \ldots$$

intensity graph