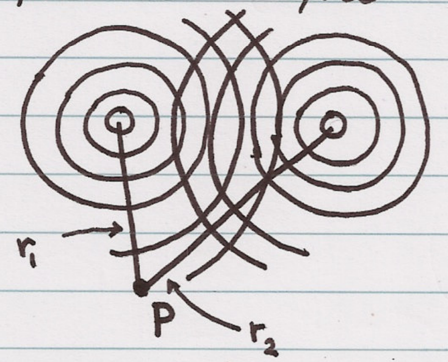
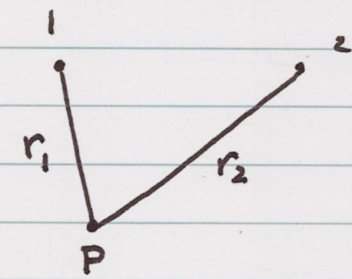
Interference of Waves

- Simultaneous drop 2 pebbles into a pond
- Ripples will interfere

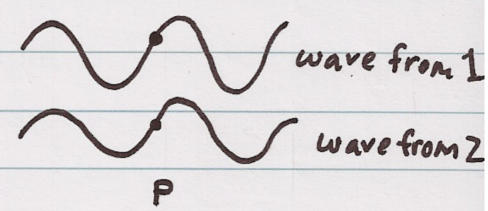




- Interested in interference at some point P
- Two extremes

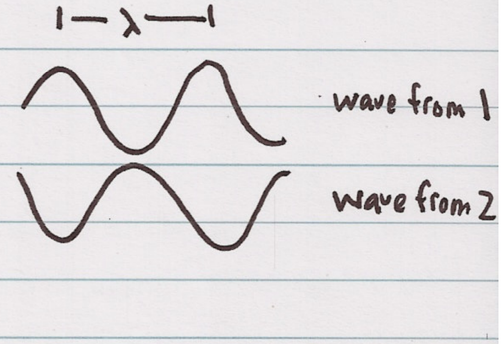
Constructive interference:

waves from sources (pebble impacts) are in the same part of their cycle at P (e.g. both at peak)



Destructive interference:

waves from sources are shifted in their cycles by $\frac{1}{2}$ wavelength at P (eg wave 1 at peak, wave 2 at trough)



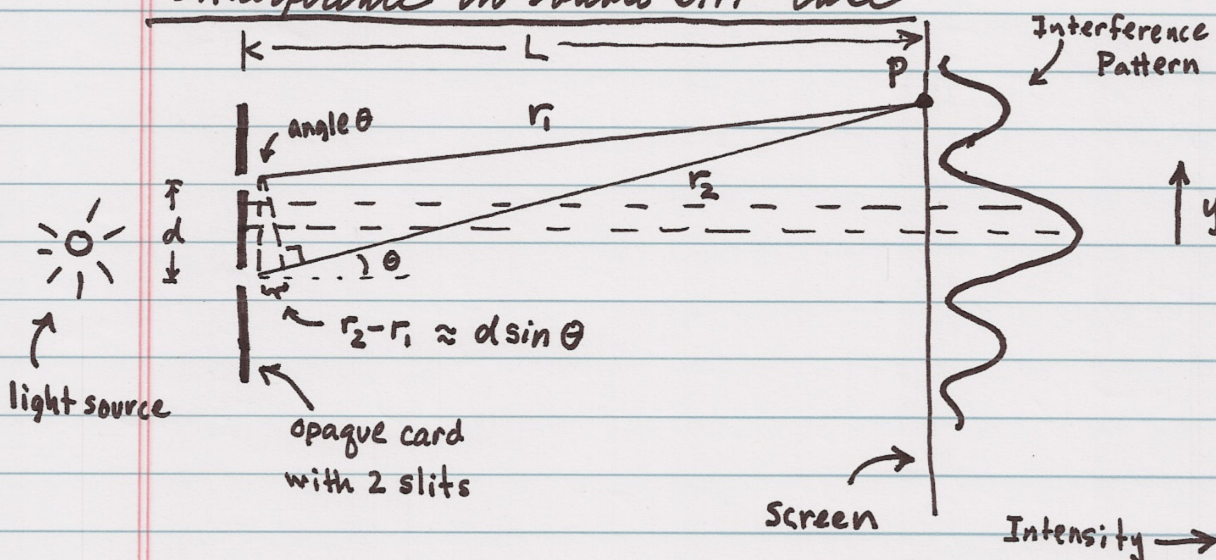
Constructive Interference occurs when

$$r_2 - r_1 = m\lambda \quad (m = 0, \pm 1, \pm 2, \ldots)$$

Destructive Interference occurs when

$$r_2 - r_1 = \left(m + \tfrac{1}{2}\right)\lambda \quad (m = 0, \pm 1, \pm 2, \ldots)$$

Interference in Double Slit Case



For $L \gg d$ $\quad r_2 - r_1 \approx d\sin\theta \quad$ (r_2, r_1 are almost parallel)

For point P

$$y_P = L\tan\theta \approx L\sin\theta = L\,\frac{r_2 - r_1}{d}$$

If P is at bright spot (constructive interference)

$$y_{Bright} = L\,\frac{m\lambda}{d}$$

If P at dark spot

$$y_{Dark} = L\,(m+\tfrac{1}{2})\frac{\lambda}{d}$$

$$y_{Bright} = m\frac{\lambda}{d}L \qquad \text{C. I.}$$

$$y_{Dark} = (m+\tfrac{1}{2})\frac{\lambda}{d}L \qquad \text{D. I.}$$

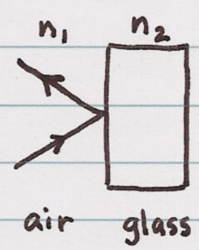
$m = 0, \pm 1, \pm 2, \ldots$

Interference in Thin Films

① Reflection & Phase Change

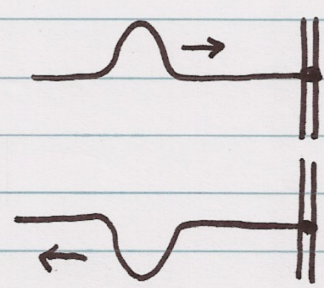
Phase of a wave can change on reflection depending on the nature of the interface:

Wave propagating in medium with index n_1 undergoes 180° phase change on reflection at interface of medium with index n_2, if $n_2 > n_1$



180° phase change because $n_{glass} > n_{air}$

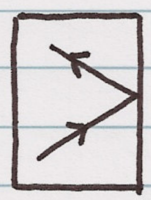
$(n_2 > n_1)$

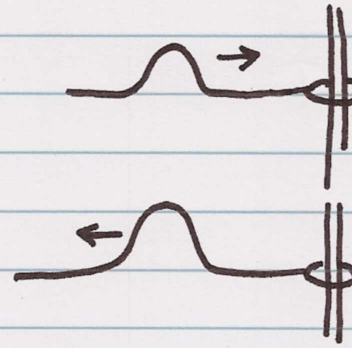


rope rigidly connected to pole

180° phase change on reflection

analog

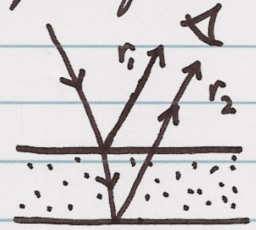




<u>NO</u> phase change
because $n_{air} < n_{glass}$
$(n_2 < n_1)$

analog

② Principle of Thin film Interference



Same as double slit:
two rays reach your eye
(one reflects from surface
other refracts then reflects
from bottom).

$\lambda = \dfrac{\lambda_{vac}}{n_{film}}$

$r_2 - r_1 \approx 2d$

If $r_2 - r_1 = m\lambda$ C.I.
If $r_2 - r_1 = (m + \frac{1}{2})\lambda$ D.I.
} Assume No phase shifts on reflection

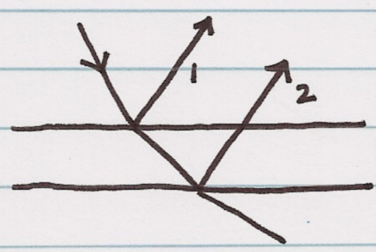
③ Case 1: No phase shift on reflection

$n_1 > n_2$, $n_2 > n_3$

(eg glass) n_1

(eg water) n_2

(eg air) n_3



$2d = m\lambda$ C.I.

$2d = (m \pm \frac{1}{2})\lambda$ D.I.

$n_{glass} = 1.5 > n_{water} = 1.3 > n_{air} = 1.0$

④ Case 2: One phase shift on reflection
(from either top surface or bottom)

$n_2 > n_1$, $n_2 > n_3$ OR $n_1 > n_2$, $n_2 < n_3$

↑ reflection ↑ reflection

$2d = (m + \frac{1}{2})\lambda$ C.I.
$2d = m\lambda$ D.I.

⑤ Case 3: Two phase shifts on reflection
(from both top and bottom surfaces)

$2d = m\lambda$ C.I.
$2d = (m + \frac{1}{2})\lambda$ D.I.
} phase shifts cancel
Same as Case 1
(no phase shifts case)