SPH4U1 Task – 2D Waves Name: Sol'n

A light wave traveling in air strikes a piece of glass as shown. The frequency of the incident wave is 4.75×10^{14} Hz. The angle of incidence is 25° and the angle of refraction is 15°.

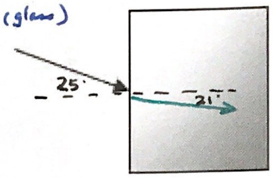
1- air 2- glass

1. Find the speed of light in the glass.

$\frac{v_2}{v_1} = \frac{\sin\theta_2}{\sin\theta_1}$ $v_2 = \frac{(3\times10^8)(\sin 15)}{(\sin 25°)}$

$\therefore v = 1.83\times10^8$ (glass)

$v_2 = 1.83 \times 10^8$ m/s (glass)



2. Find the index of refraction of the glass.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1 \frac{\sin(25)}{\sin(15)} = n_2$ $n_2 = 1.63$ (glass)

$\therefore n_2 = 1.63$ (glass)

3. Find the wavelength of the incident light wave.

$c = f\cdot\lambda$ $3\times10^8 = 4.75\times10^{14}\lambda$

$632\times10^{-9} = \lambda$

$632\text{ nm} = \lambda$

$\therefore \lambda = 632\text{nm}$

4. Find the frequency and wavelength of the refracted light wave.

$v = f\cdot\lambda$ $1.83\times10^8 = 4.75\times10^{14}\cdot\lambda$

$385\times10^{-9}\text{m} = \lambda$

$385\text{ nm} = \lambda$

$\therefore \lambda = 385\text{ nm}$

5. What is the critical angle of the light once it is <u>inside</u> the glass?

$\sin\theta_c = \frac{n_{air}}{n_{glass}}$ n = 1.63 | n = 1

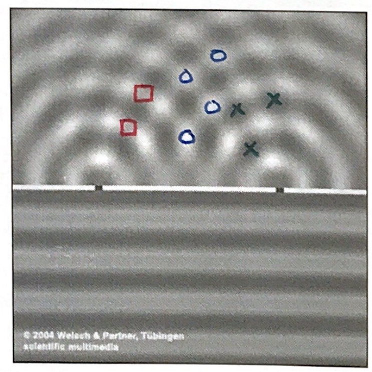
$\sin\theta_c = \frac{1}{1.63}$ $\theta_c = 38°$

$\therefore \theta_c = 38°$ (glass-air interface)

6. What is the critical angle of the light once it is inside the glass if the glass is <u>submerged in water</u>? Ln = 1.33

$\sin\theta_c = \frac{n_{water}}{n_{glass}}$

$\sin\theta_c = \frac{1.33}{1.63}$ $\theta_c = 54.7°$ critical angle is 54.7°



The incident wave train pictured in the lower half of the photograph has an amplitude of 3.7 cm. Assume the wave energy is not lost in passing through the two gaps in the barrier wall. The lightest-colored portions in the upper half of the photograph are the highest regions of water (positive maxima). The darkest-colored portions are the lowest regions of water (negative maxima). For the following questions, ***heights are to be referenced to equilibrium, which is 0*** *cm.*

light – crest dark – trough Amp = 3.7cm

7. State Huygens' principle.

"Every point on a wave front emits a spherical wavelet of the same velocity and wavelength as the original wave"

8. What will be the height of the lightest-colored portions of the waves in the upper half of the photograph?

Constructive interference (crests) positive = 3.7 + 3.7 = 7.4 cm (above eq'lm)

9. What will be the height of the darkest-colored portions of the waves in the upper half of the photograph?

constructive interference (troughs) Negative = −3.7 − 3.7 = −7.4 cm (below eq'lm)

10. What is the height of the highest crest in the bottom portion (wave train) of the photograph?

height = 3.7 cm

11. Place a small circle at a single point of your choosing that shows positive constructive interference, place an "x" at any location that shows negative constructive interference, and place a small square at any location where there is destructive interference resulting in a minima.

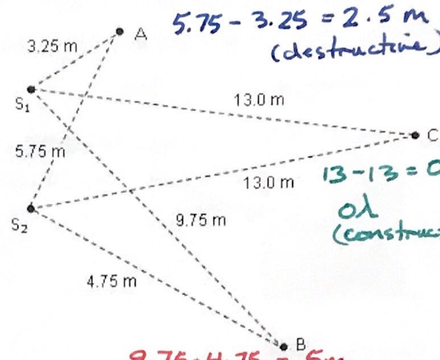
o positive constructive interference (light + light)

x Negative constructive interference (dark + dark)

□ destructive interference (minima) (dark + light)

The following questions concern path difference and waves.

12. Two sources S_1 and S_2 each produce coherent vibrations in water having a wavelength of 5 m and an amplitude of 5 cm. Three surrounding points are shown. The lines connecting the sources to the points show the distance the points are from the sources.



$\frac{\lambda}{2}$ → $5.75 - 3.25 = 2.5$ m (destructive)

$13 - 13 = 0$, 0λ (constructive)

$9.75 - 4.75 = 5$m, 1λ (constructive)

Complete the table:

$\lambda = 5$m Amp = 5cm

Point	Amplitude/cm
A	0 cm
B	10 cm
C	10 cm

13. What does the term coherent mean in the context of these waves?

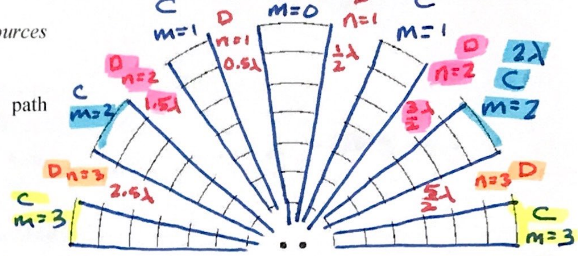
Coherent → same frequency, in phase, same amplitude

The interference patterns caused by two coherent wave sources are shown to the right.

C - constructive
D - destructive

14. Label the regions in the medium representing path differences of:

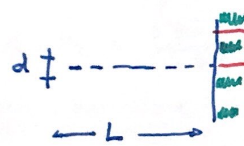
PD = 3.0λ,
PD = 2.5λ,
PD = 2.0λ, and
PD = 1.5λ from the two sources.



The following questions are about ***Young's double-slit diffraction.***

15. Coherent light having a wavelength of 675 nm is incident on an opaque card having two vertical slits separated by 0.275 mm. A screen is located 3.25 m away from the card. What is the distance between the central maximum and the first maximum?

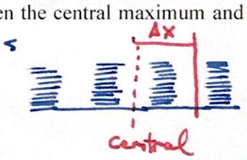
$S = \frac{\lambda D}{d}$ or $\Delta x = \frac{\lambda L}{d}$



$S = \frac{(675\times10^{-9})(3.25)}{(0.275\times10^{-3})}$

$S = 7.977\times10^{-3}$m

$S \doteq 8$mm



16. Coherent light of an unknown frequency is projected onto a double-slit with slit separation 0.350 mm onto a screen that is 10.5 meters away. The separation between the central maximum and the nearest maximum is 1.50 cm. What is the wavelength of the incident light?

$d = 0.350$ mm
$L = 10.5$m
$\Delta x = 1.50$cm
$\lambda = ?$

$\Delta x = \frac{\lambda L}{d}$

$\frac{d\,\Delta x}{L} = \lambda$

$\frac{(0.350\times10^{-3})(1.5\times10^{-2})}{10.5} = \lambda$

5×10^{-7}m $= \lambda$

500 nm $= \lambda$

The following questions are about wave behavior.

17. What behavior of waves causes the straight waves to become curved waves when they pass through the gaps in the barrier?

Diffraction - follows Hyguens wavelet principle

18. What behavior of waves causes the curved waves to produce the highs and lows previously calculated?

- interference and superposition lead to highs and lows