KEY

First Name:_____ Last Name:_____

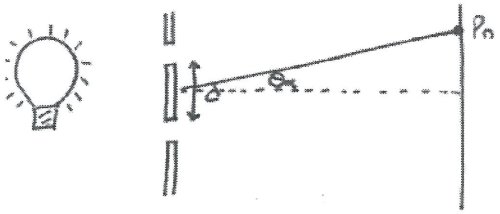
L09 – Worksheet – Diffraction, Interference, and Polarization

Textbook Questions

for constructive interference.
for $n = 1, 2, 3, 4 \ldots$

Best equation to use is

$$\lambda = \frac{d \sin\theta}{n}$$



Pg 689 #1: Light of an unknown wavelength is incident on two slits separated by 0.20 mm. The second bright fringe is located at an angle of 0.26^0 from the central antinode. What is the light's wavelength?

$\lambda = ?$
$d = 0.20 \times 10^{-3}\ m$
$n = 2$
$\theta_2 = 0.26°$

$$\sin\theta_n = \frac{n\lambda}{d}$$

$$\sin 0.26° = \frac{(2)\lambda}{0.20 \times 10^{-3}\ m}$$

$$\lambda = 4.538 \times 10^{-7}\ m$$

Pg 689 #2: Blue light of 460 cm is incident on two slits that are 0.55 mm apart. What is the angle of diffraction for the third antinodal line?

$\lambda = 460 \times 10^{-9}\ m$
$d = 0.55 \times 10^{-3}\ m$
$n = 3$
$\theta_3 = ?$

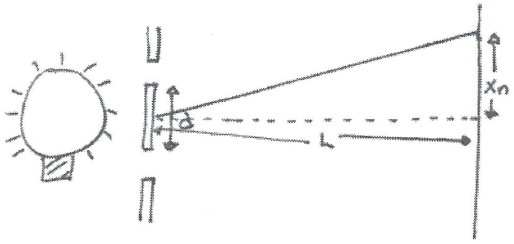
$$\sin\theta_n = \frac{n\lambda}{d}$$

$$\sin\theta_3 = \frac{(3)(460 \times 10^{-9}\ m)}{(0.55 \times 10^{-3}\ m)}$$

$$\theta_3 = 0.1438°$$

KEY

$\lambda = \frac{xd}{nL}$



only works for $\theta < 10°$

Better to use $\lambda = \frac{d \sin\theta}{n}$

unless we have a HUGE L and a tiny x.

Pg 691 #2: Monochromatic light is incident on two slits separated by 3.00×10^{-5} m. The distance between antinodes is 3.10×10^{-2} m. If the screen is 1.50 m from the slits, what is the light's color and wavelength?

$d = 3.00 \times 10^{-5}\ m$
$x_1 = 3.10 \times 10^{-2}\ m$
$n = 1$
$L = 1.50\ m$
$\lambda = ?$

$$\lambda = \frac{xd}{nL} = \frac{(3.10 \times 10^{-2}\ m)(3.00 \times 10^{-5}\ m)}{(1)(1.50\ m)}$$

$\lambda = 6.20 \times 10^{-7}\ m$ or $620 \times 10^{-9}\ m$ or $620\ nm$

(See table on pg 676, red).

Pg 697 #6: In an experiment similar to Young's, how far apart are two slits if the 3rd antinode is measured to be 20^0 from the central antinode, when light with a wavelength of 650 nm is used?

$n = 1.5$
$\lambda = 425 \times 10^{-9}\ m$
$d = 6.00 \times 10^{-6}\ m$
$\theta_{1.5} = ?$

$$\sin\theta_n = \frac{n\lambda}{d}$$

$$\sin\theta_{1.5} = \frac{(1.5)(425 \times 10^{-9}\ m)}{(6.00 \times 10^{-6}\ m)}$$

$\theta_{1.5} = 6.099°$

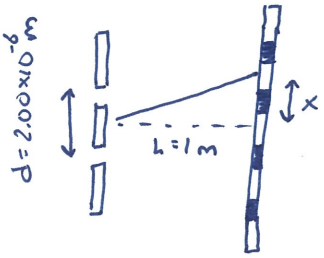
KEY

Pg 697 #8: Light with a wavelength of 700 nm is diffracted by a diffraction grating with 5.00×10^3 lines/cm. If the screen is positioned 1.00 m away from the grating, what is the distance between the 1st and central antinodes?

$\frac{5000 \text{ lines}}{\text{cm}} = \frac{500{,}000 \text{ lines}}{\text{m}} \Rightarrow d = 2.00 \times 10^{-6} \text{ m}$

OPTION #1

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



$(700 \times 10^{-9}) = \frac{x\,(2.00 \times 10^{-6})}{(1)(1)}$

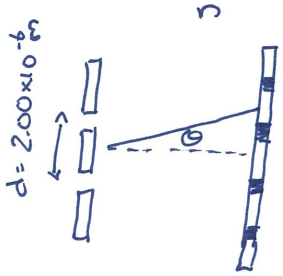
$x = 0.35 \text{ m}$

But wait...

$\theta = 19.29°$, so we can't even use this eqn.

Option #2

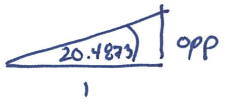
$\lambda = \frac{d \sin\theta}{n}$



$(700 \times 10^{-9}) = \frac{(2.00 \times 10^{-6}) \sin\theta}{(1)}$

$\sin\theta = 0.35$

$\theta = 20.4873°$



$\tan(20.4875) = \frac{opp}{1}$

$opp = 0.3736 \text{ m}$

$x = 0.37 \text{ m}$ Best Answer!

Pg 697 #11: Light emitted from an unknown gas sample is incident on a diffraction grating with 5.00×10^2 lines/cm. The antinodes appear on a screen 1.50 m away and are separated by 3.10×10^{-2} m. What is the wavelength and frequency of the light?

$\lambda = ?$

$f = ?$

$c = 3.0 \times 10^8 \text{ m/s}$

$d = \frac{0.01 \text{ m}}{5.00 \times 10^2 \text{ lines}} = 2.0 \times 10^{-5} \text{ m}$

$L = 1.50 \text{ m}$

$x_1 = 3.10 \times 10^{-2} \text{ m}$

$n = 1$

$\lambda = \frac{x d}{n L} = \frac{(3.10 \times 10^{-2} \text{ m})(2.0 \times 10^{-5} \text{ m})}{(1)(1.50 \text{ m})}$

$\lambda = 4.133 \times 10^{-7} \text{ m}$

$c = f\lambda$

$3.0 \times 10^8 \text{ m/s} = f\,(4.133 \times 10^{-7} \text{ m})$

$f = 7.258 \times 10^{14} \text{ Hz}$

KEY

Diploma Questions – Diffraction and Interference (Basic Concepts)

Q577: To explain both the interference and diffraction of light scientists use

a. A wave model
b. A particle model → Particle model with "photons" is the second half of this unit.
c. Dispersion phenomena
d. Polarization phenomena

Q578: The wave theory of light is REQUIRED to explain

a. The Compton effect → Particle model
b. Reflection in a mirror → Wave or Particle model
c. The photoelectric effect → Particle model
d. Interference and diffraction of light

Q586: The alternate dark and bright bands that are produced when light passes through a double slit are caused by

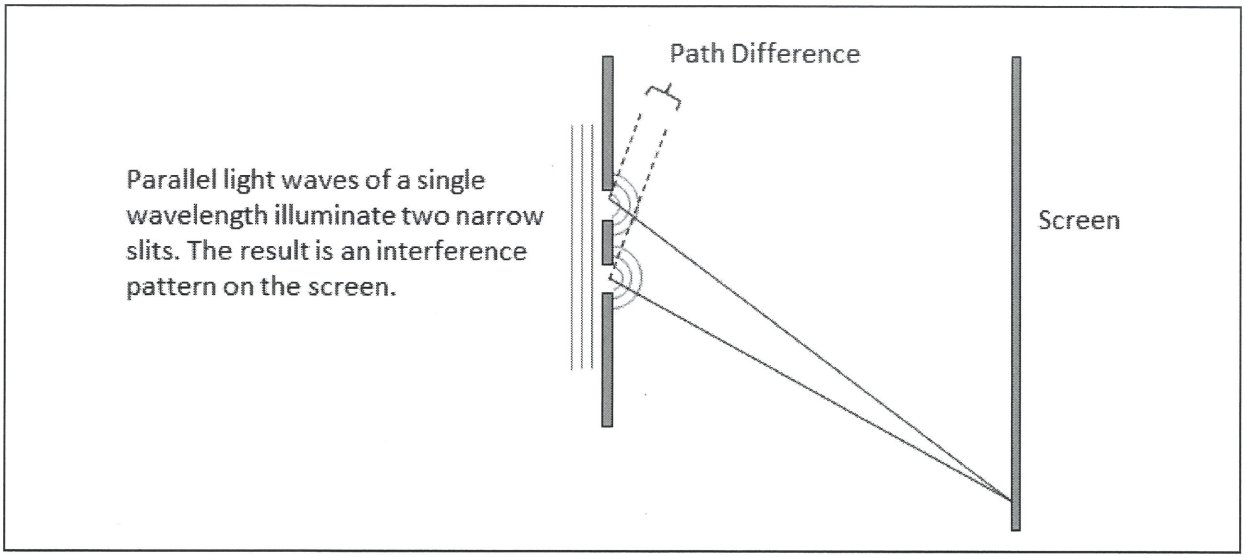
a. Polarization
b. Interference
c. Dispersion
d. Refraction

KEY

Diploma Questions – Diffraction and Interference (Constructive and Destructive Interference)

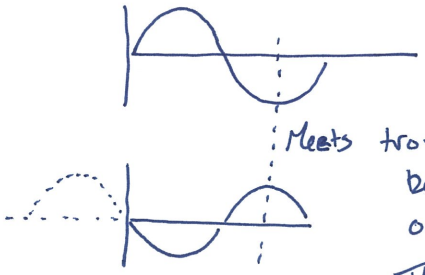
L08 - Diffraction and Interference (Constructive and Destructive Interference) #587,589

Use the following information to answer Q587:



Q587: The path difference that results in destructive interference (minima) is

a. ½ λ
b. λ
c. 2λ
d. 3λ



Meets trough to crest for "destructive" interference because waves are 180° or $\frac{1}{2}\lambda$ out of phase.

This should be familiar from Math 30-1.

Q589: The overlapping of two waves will result in constructive interference if they meet

a. Out of phase
b. Sinusoidally
c. Crest to trough
d. Trough to trough or crest to crest.

KEY

Diploma Questions – Diffraction and Interference (Algebra)

Q611: A beam of monochromatic light passes through two slits, producing an interference pattern. For the distance between adjacent fringes to be doubled, the slit separation distance must be

a. Quartered
b. Halved
c. Doubled
d. Quadrupled

$\lambda = \frac{d \sin\theta}{n}$ or $\lambda = \frac{xd}{nL}$

$\lambda = \frac{(2x)(\frac{1}{2}d)}{nL}$ gives same λ.

Q612: One of the observations of a double-slit experiment is an interference pattern in which the distance from the central maximum to the first-order image is X. If the wavelength of the light and the slit separation were both doubled, what would be the distance between the central maximum and the first-order image?

a. 4X
b. 2X
c. X
d. X/4

$\lambda = \frac{xd}{nL}$

$x = \frac{\lambda nL}{d}$

$x_{new} = \frac{(2\lambda)(n)(L)}{(2d)} = \frac{\lambda nL}{D}$: Same as before.

Diploma Questions –Polarization (Basic Concepts)

Q617: A red light beam passes through two transparent plates of glass with no apparent loss of brightness. When one of the plates is rotated 90^0, however, no light gets through. This observation can be explained by the concept of

a. Reflection
b. Refraction
c. Interference
d. Polarization

Q618: A polarizing filter is set so that the light passing through it has MAXIMUM brightness. How far must the filter be rotated so that the light passing through it will be of MINIMUM brightness?

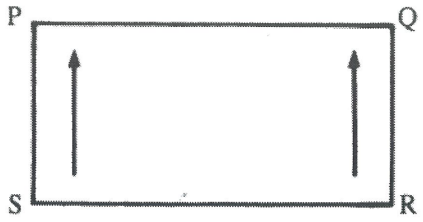
a. 360^0
b. 180^0
c. 135^0
d. 90^0

KEY

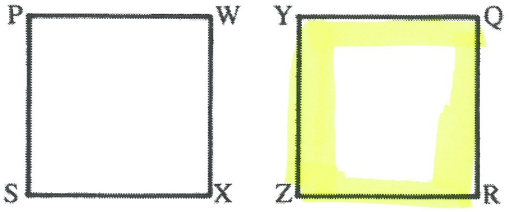
Diploma Questions –Polarization (Diagrams)

Use the following information to answer Q633:

The rectangle represents a sheet of polarizing filter.

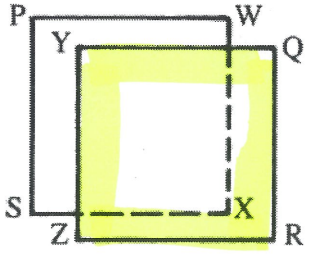


The filter is cut as shown.

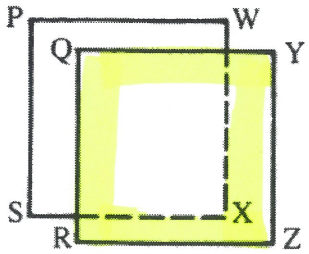


Q633: If the minimum amount of light is to pass through the overlapping area, the filters could be arranged

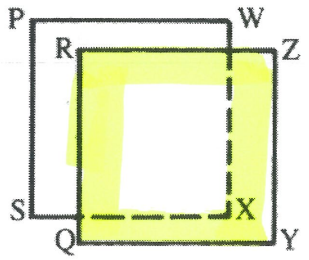
A.



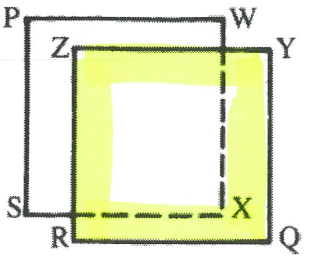
B.



C.



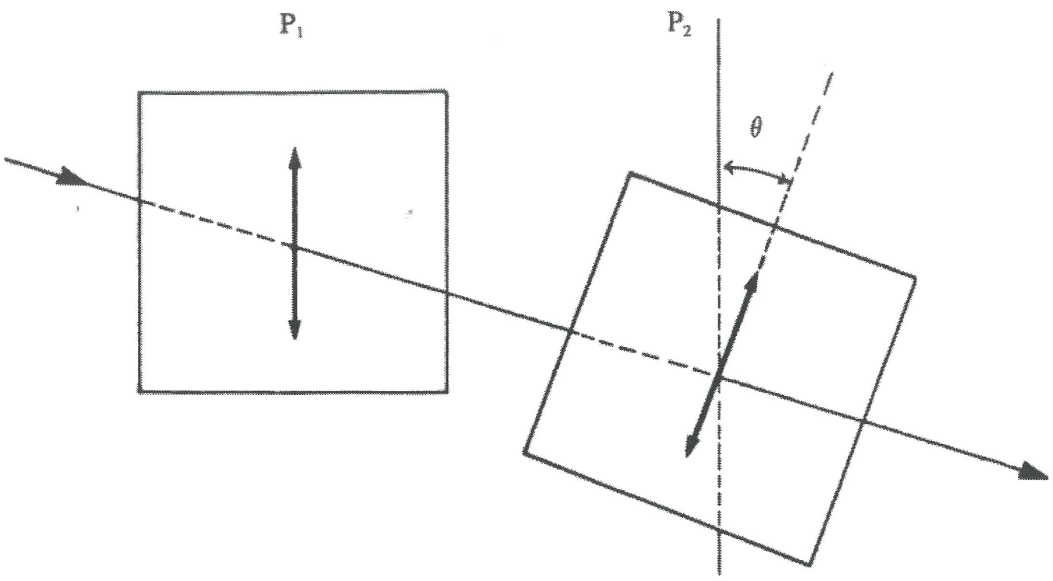
D.



KEY

Use the following information to answer Q634:

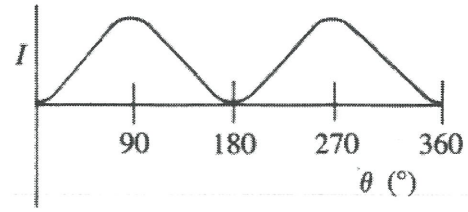
Transmission of Light through Two Polarizing Filters



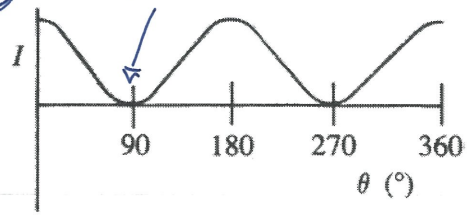
A beam of unpolarized light passes in turn through a pair of polarizing filters, P_1 and P_2. P_1 is fixed in position, while P_2 is allowed to rotate through 360^0 from the position where $\vartheta = 0^0$.

Q634: The graph which best shows how intensity (*I*) of the beam of light emerging from P_2 varies with the angle ϑ is

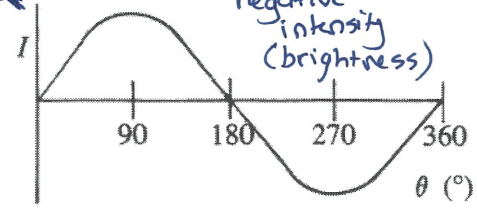
A.



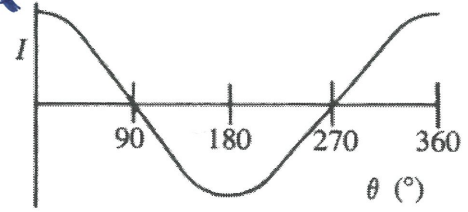
B. Minimum at 90°



~~C.~~ Can't have negative intensity (brightness)

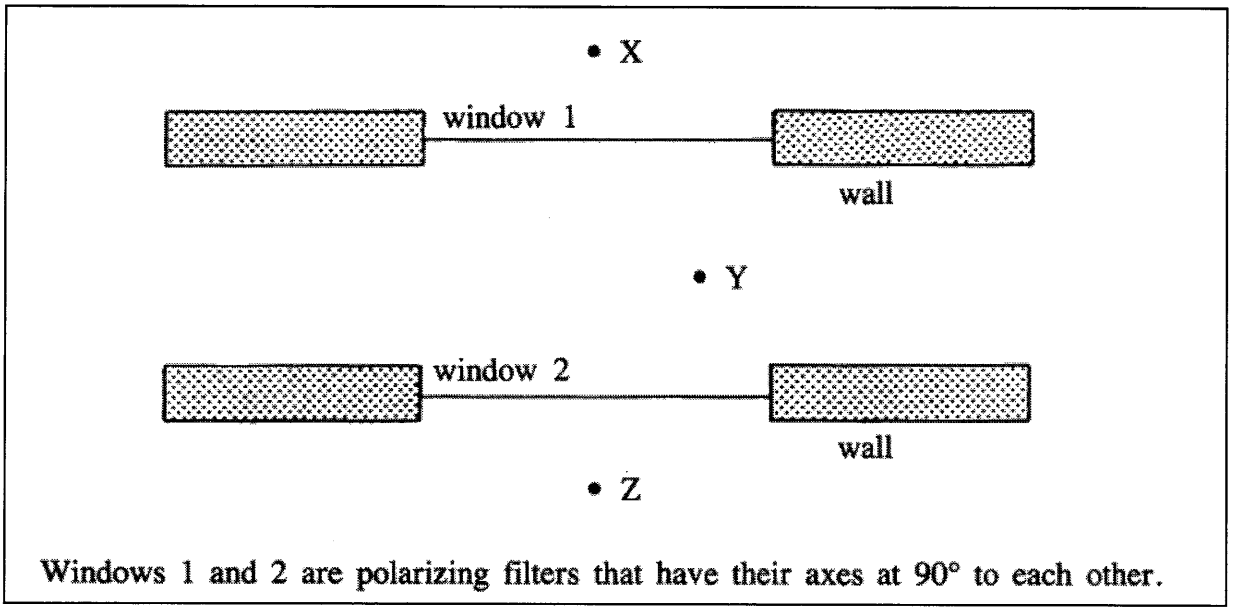


~~D.~~



KEY

Use the following information to answer Q635:



Windows 1 and 2 are polarizing filters that have their axes at 90° to each other.

Q635: If people at X and Y record what they can see, the result should be that

a. X sees only Z, and Y sees only X
(b) X sees only Y and Y sees both X and Z
c. X sees both Y and Z, and Y sees only Z
d. X sees nothing, and Y sees both X and Z

Challenge Questions

Pg 689 #3: The second nodal line of an interference pattern occurs at 0.095^0 relative to the central antinode. The two slits are separated by 0.40 mm. What is the wavelength and color of light producing this pattern?

$n = 1.5$ (Second nodal line)
$\theta_2 = 0.095°$
$d = 0.40 \times 10^{-3}\ m$
$\lambda = ?$
Color = ?

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

$$\sin(0.095) = \frac{(1.5)\lambda}{0.40 \times 10^{-3}\ m}$$

$\lambda = 4.4215 \times 10^{-7}\ m$
or $442 \times 10^{-9}\ m$ or $442\ nm$
Checking Table 13.5 (Pg 676), this is violet.

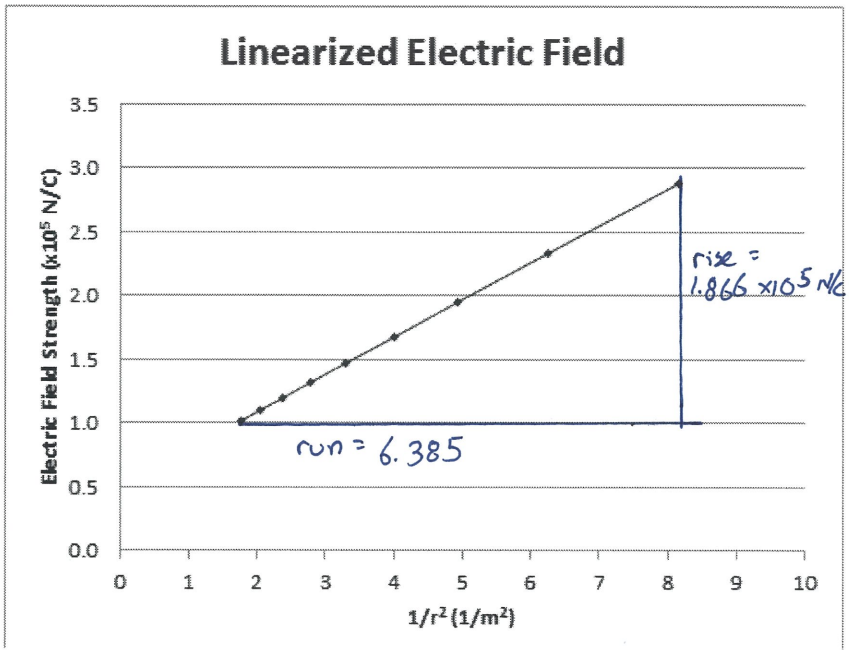
KEY

Cumulative Review from Previous Units

Use the following information to answer Q1:

The strength of an electric field is measured at various distances from a negatively charged sphere, and graphed below.

r	1/r^2	E (x10^5)
0.350	8.163	2.885
0.400	6.250	2.326
0.450	4.938	1.943
0.500	4.000	1.669
0.550	3.306	1.466
0.600	2.778	1.312
0.650	2.367	1.192
0.700	2.041	1.096
0.750	1.778	1.019



Q1: The negatively charged sphere has a charge of ***a.bc*** x 10^{-d} C, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

3	2	5	6

$|\vec{E}| = \frac{kq}{r^2}$

$|\vec{E}| = (kq)\frac{1}{r^2} + 0$

$y = (m)x + b$

$m = kq$

$\frac{1.866 \times 10^5}{6.385} = (8.99 \times 10^9)\, q$

$q = 3.25 \times 10^{-6}\ C.$