UG TRB PHYSICS

UNIT 8 - OPTICS AND SPECTROSCOPY

PRACTICE PROBLEMS WITH SOLUTIONS

QUESTION 1

1. A plano-convex lens is made of glass with the paraxial focal length of 20 cm and marginal focal length of 19.4 cm. Find its longitudinal spherical aberration.

Given:

$f_p = 20$ cm

$f_m = 19.4$ cm

Formula:

$LSA = f_p - f_m$

Substitute:

$LSA = 20 - 19.4 = 0.6$ cm

Answer: LSA = 0.6 cm

PRACTICE PROBLEM

Problem 1

A plano-convex lens is made of glass with the paraxial focal length of 25 cm and marginal focal length of 24.5 cm. Find its longitudinal spherical aberration.

Given:

$f_p = 25$ cm

$f_m = 24.5$ cm

Formula:

$LSA = f_p - f_m$

Substitute:

LSA = 25 - 24.5

LSA = 0.5 cm

Answer: LSA = 0.5 cm

Problem 2

A plano-convex lens is made of glass with the paraxial focal length of 15 cm and marginal focal length of 14.7 cm. Find its longitudinal spherical aberration.

Given:

f_p = 15 cm

f_m = 14.7 cm

Formula:

LSA = f_p - f_m

Substitute:

LSA = 15 - 14.7

LSA = 0.3 cm

Answer: LSA = 0.3 cm

Problem 3

A plano-convex lens is made of glass with the paraxial focal length of 30 cm and marginal focal length of 29.2 cm. Find its longitudinal spherical aberration.

Given:

f_p = 30 cm

f_m = 29.2 cm

Formula:

LSA = f_p - f_m

Substitute:

LSA = 30 - 29.2

LSA = 0.8 cm

Answer: LSA = 0.8 cm

Problem 4

A plano-convex lens is made of glass with the paraxial focal length of 18 cm and marginal focal length of 17.5 cm. Find its longitudinal spherical aberration.

Given:

f_p = 18 cm

f_m = 17.5 cm

Formula:

LSA = f_p - f_m

Substitute:

LSA = 18 - 17.5

LSA = 0.5 cm

Answer: LSA = 0.5 cm

Problem 5

A plano-convex lens is made of glass with the paraxial focal length of 22 cm and marginal focal length of 21.6 cm. Find its longitudinal spherical aberration.

Given:

f_p = 22 cm

f_m = 21.6 cm

Formula:

LSA = f_p - f_m

Substitute:

LSA = 22 - 21.6

LSA = 0.4 cm

Answer: LSA = 0.4 cm

QUESTION 2

2. Two plano-convex lenses have focal lengths of 10 cm and 4 cm. At what distance should they be placed to minimize spherical aberration?

Given:

$f_1 = 10$ cm

$f_2 = 4$ cm

Formula:

$D = f_1 - f_2$

Substitute:

$D = 10 - 4 = 6$ cm

Answer: D = 6 cm

PRACTICE PROBLEM

Problem 1

Two plano-convex lenses have focal lengths of 12 cm and 5 cm. At what distance should they be placed to minimize spherical aberration?

Given:

$f_1 = 12$ cm

$f_2 = 5$ cm

Formula:

$D = f_1 - f_2$

Substitute:

D = 12 - 5

D = 7 cm

Answer: D = 7 cm

Problem 2

Two plano-convex lenses have focal lengths of 8 cm and 3 cm. At what distance should they be placed to minimize spherical aberration?

Given:

$f_1 = 8$ cm

$f_2 = 3$ cm

Formula:

$D = f_1 - f_2$

Substitute:

D = 8 - 3

D = 5 cm

Answer: D = 5 cm

Problem 3

Two plano-convex lenses have focal lengths of 15 cm and 7 cm. At what distance should they be placed to minimize spherical aberration?

Given:

$f_1 = 15$ cm

$f_2 = 7$ cm

Formula:

$D = f_1 - f_2$

Substitute:

D = 15 - 7

D = 8 cm

Answer: D = 8 cm

Problem 4

Two plano-convex lenses have focal lengths of 20 cm and 9 cm. At what distance should they be placed to minimize spherical aberration?

Given:

$f_1 = 20$ cm

$f_2 = 9$ cm

Formula:

$D = f_1 - f_2$

Substitute:

D = 20 - 9

D = 11 cm

Answer: D = 11 cm

Problem 5

Two plano-convex lenses have focal lengths of 6 cm and 2 cm. At what distance should they be placed to minimize spherical aberration?

Given:

$f_1 = 6$ cm

$f_2 = 2$ cm

Formula:

$D = f_1 - f_2$

Substitute:

D = 6 - 2

D = 4 cm

Answer: D = 4 cm

QUESTION 3

3. A convex lens has a mean focal length of 20 cm. The refractive indices for red and violet light are 1.51 and 1.53, respectively. Find the dispersive power of the prism.

Given:

f = 20 cm

$n_v = 1.53$

$n_r = 1.51$

Formula:

$n_\gamma = (n_v + n_r)/2$

$\omega = (n_v - n_r)/(n_\gamma - 1)$

Substitute:

$n_\gamma = (1.53 + 1.51)/2 = 1.52$

$\omega = 0.02/0.52 \approx 0.0385$

Answer: $\omega \approx 0.0385$

PRACTICE PROBLEM

Problem 1

A convex lens has a mean focal length of 25 cm. The refractive indices for red and violet light are 1.50 and 1.52, respectively. Find the dispersive power of the prism.

Given:

f = 25 cm

$n_v = 1.52$

$n_r = 1.50$

Formula:

$n_\gamma = (n_v + n_r)/2$

$\omega = (n_v - n_r)/(n_\gamma - 1)$

Substitute:

$n_\gamma = (1.52 + 1.50)/2 = 1.51$

$\omega = (1.52 - 1.50)/(1.51 - 1)$

$\omega \approx 0.0392$

Answer: $\omega \approx 0.0392$

Problem 2

A convex lens has a mean focal length of 18 cm. The refractive indices for red and violet light are 1.49 and 1.51, respectively. Find the dispersive power of the prism.

Given:

$f = 18$ cm

$n_v = 1.51$

$n_r = 1.49$

Formula:

$n_\gamma = (n_v + n_r)/2$

$\omega = (n_v - n_r)/(n_\gamma - 1)$

Substitute:

$n_\gamma = (1.51 + 1.49)/2 = 1.5$

$\omega = (1.51 - 1.49)/(1.5 - 1)$

$\omega \approx 0.0400$

Answer: $\omega \approx 0.0400$

Problem 3

A convex lens has a mean focal length of 22 cm. The refractive indices for red and violet light are 1.52 and 1.54, respectively. Find the dispersive power of the prism.

Given:

f = 22 cm

$n_v = 1.54$

$n_r = 1.52$

Formula:

$n_\gamma = (n_v + n_r)/2$

$\omega = (n_v - n_r)/(n_\gamma - 1)$

Substitute:

$n_\gamma = (1.54 + 1.52)/2 = 1.53$

$\omega = (1.54 - 1.52)/(1.53 - 1)$

$\omega \approx 0.0377$

Answer: $\omega \approx 0.0377$

Problem 4

A convex lens has a mean focal length of 30 cm. The refractive indices for red and violet light are 1.48 and 1.50, respectively. Find the dispersive power of the prism.

Given:

f = 30 cm

$n_v = 1.50$

$n_r = 1.48$

Formula:

$n_\gamma = (n_v + n_r)/2$

$\omega = (n_v - n_r)/(n_\gamma - 1)$

Substitute:

$n_\gamma = (1.50 + 1.48)/2 = 1.49$

$\omega = (1.50 - 1.48)/(1.49 - 1)$

$\omega \approx 0.0408$

Answer: $\omega \approx 0.0408$

Problem 5

A convex lens has a mean focal length of 15 cm. The refractive indices for red and violet light are 1.51 and 1.55, respectively. Find the dispersive power of the prism.

Given:

$f = 15$ cm

$n_v = 1.55$

$n_r = 1.51$

Formula:

$n_\gamma = (n_v + n_r)/2$

$\omega = (n_v - n_r)/(n_\gamma - 1)$

Substitute:

$n_\gamma = (1.55 + 1.51)/2 = 1.53$

$\omega = (1.55 - 1.51)/(1.53 - 1)$

$\omega \approx 0.0755$

Answer: $\omega \approx 0.0755$

QUESTION 4

4. Two convex lenses of focal lengths 10 cm and 6 cm are used in an eyepiece. At what distance should they be placed to be achromatic?

Given:

$f_1 = 10$ cm

$f_2 = 6$ cm

Formula:

$d = (f_1 + f_2)/2$

Substitute:

$d = (10 + 6)/2 = 8$ cm

Answer: d = 8 cm

PRACTICE PROBLEM

Problem 1

Two convex lenses of focal lengths 12 cm and 8 cm are used in an eyepiece. At what distance should they be placed to be achromatic?

Given:

$f_1 = 12$ cm

$f_2 = 8$ cm

Formula:

$d = (f_1 + f_2)/2$

Substitute:

$d = (12 + 8)/2$

$d = 10$ cm

Answer: d = 10 cm

Problem 2

Two convex lenses of focal lengths 15 cm and 5 cm are used in an eyepiece. At what distance should they be placed to be achromatic?

Given:

$f_1 = 15$ cm

$f_2 = 5$ cm

Formula:

$d = (f_1 + f_2)/2$

Substitute:

$d = (15 + 5)/2$

$d = 10$ cm

Answer: d = 10 cm

Problem 3

Two convex lenses of focal lengths 20 cm and 10 cm are used in an eyepiece. At what distance should they be placed to be achromatic?

Given:

$f_1 = 20$ cm

$f_2 = 10$ cm

Formula:

$d = (f_1 + f_2)/2$

Substitute:

$d = (20 + 10)/2$

$d = 15$ cm

Answer: d = 15 cm

Problem 4

Two convex lenses of focal lengths 18 cm and 6 cm are used in an eyepiece. At what distance should they be placed to be achromatic?

Given:

$f_1 = 18$ cm

$f_2 = 6$ cm

Formula:

$d = (f_1 + f_2)/2$

Substitute:

$d = (18 + 6)/2$

$d = 12$ cm

Answer: d = 12 cm

Problem 5

Two convex lenses of focal lengths 25 cm and 15 cm are used in an eyepiece. At what distance should they be placed to be achromatic?

Given:

$f_1 = 25$ cm

$f_2 = 15$ cm

Formula:

$d = (f_1 + f_2)/2$

Substitute:

$d = (25 + 15)/2$

$d = 20$ cm

Answer: d = 20 cm

QUESTION 5

5. A crown glass prism of refractive index 1.518 is combined with a flint glass prism of refractive index 1.655 to produce dispersion without deviation at an angle of 6°. Find the angle of the flint glass prism A′.

Given:

$n_1 = 1.518$

$n_2 = 1.655$

$A = 6°$

Formula:

$A' = -[(n_1 - 1)/(n_2 - 1)]A$

Substitute:

$A' = -[(1.518 - 1)/(1.655 - 1)] \times 6$

$A' \approx -4.75°$

Answer: $A' \approx -4.75°$

PRACTICE PROBLEM

Problem 1

A crown glass prism of refractive index 1.520 is combined with a flint glass prism of refractive index 1.660 to produce dispersion without deviation at an angle of 5°. Find the angle of the flint glass prism A′.

Given:

$n_1 = 1.520$

$n_2 = 1.660$

$A = 5°$

Formula:

$A' = -[(n_1 - 1)/(n_2 - 1)]A$

Substitute:

$A' = -[(1.520 - 1)/(1.660 - 1)] \times 5$

$A' \approx -3.94°$

Answer: $A' \approx -3.94°$

Problem 2

A crown glass prism of refractive index 1.515 is combined with a flint glass prism of refractive index 1.650 to produce dispersion without deviation at an angle of 7°. Find the angle of the flint glass prism A'.

Given:

$n_1 = 1.515$

$n_2 = 1.650$

$A = 7°$

Formula:

$A' = -[(n_1 - 1)/(n_2 - 1)]A$

Substitute:

$A' = -[(1.515 - 1)/(1.650 - 1)] \times 7$

$A' \approx -5.55°$

Answer: $A' \approx -5.55°$

Problem 3

A crown glass prism of refractive index 1.518 is combined with a flint glass prism of refractive index 1.670 to produce dispersion without deviation at an angle of 8°. Find the angle of the flint glass prism A'.

Given:

$n_1 = 1.518$

$n_2 = 1.670$

$A = 8°$

Formula:

$A' = -[(n_1 - 1)/(n_2 - 1)]A$

Substitute:

$A' = -[(1.518 - 1)/(1.670 - 1)] \times 8$

$A' \approx -6.19°$

Answer: $A' \approx -6.19°$

Problem 4

A crown glass prism of refractive index 1.512 is combined with a flint glass prism of refractive index 1.655 to produce dispersion without deviation at an angle of 6°. Find the angle of the flint glass prism A'.

Given:

$n_1 = 1.512$

$n_2 = 1.655$

$A = 6°$

Formula:

$A' = -[(n_1 - 1)/(n_2 - 1)]A$

Substitute:

$A' = -[(1.512 - 1)/(1.655 - 1)] \times 6$

$A' \approx -4.69°$

Answer: $A' \approx -4.69°$

Problem 5

A crown glass prism of refractive index 1.519 is combined with a flint glass prism of refractive index 1.660 to produce dispersion without deviation at an angle of 10°. Find the angle of the flint glass prism A′.

Given:

$n_1 = 1.519$

$n_2 = 1.660$

$A = 10°$

Formula:

$A' = -[(n_1 - 1)/(n_2 - 1)]A$

Substitute:

$A' = -[(1.519 - 1)/(1.660 - 1)] \times 10$

$A' \approx -7.86°$

Answer: $A' \approx -7.86°$

QUESTION 6

6. A Ramsden eyepiece consists of two plano-convex lenses, each of focal length f = 3 cm. Calculate the distance between the two lenses and the equivalent focal length of the eyepiece.

Given:

$f_1 = f_2 = 3$ cm

Formula:

$d = (2/3)f$

$f_eq = (f_1 f_2)/(f_1 + f_2 - d)$

Substitute:

$d = (2/3) \times 3 = 2$ cm

$f_eq = 9/(6 - 2) = 2.25$ cm

Answer: d = 2 cm; f_eq = 2.25 cm

PRACTICE PROBLEM

Problem 1

A Ramsden eyepiece consists of two plano-convex lenses, each of focal length f = 4 cm. Calculate the distance between the two lenses and the equivalent focal length of the eyepiece.

Given:

$f_1 = f_2 = 4$ cm

Formula:

$d = (2/3)f$

$f_eq = (f_1f_2)/(f_1 + f_2 - d)$

Substitute:

$d = (2/3) \times 4 = 2.667$ cm

$f_eq = (4 \times 4)/(4 + 4 - 2.667) = 3$ cm

Answer: d = 2.667 cm; f_eq = 3 cm

Problem 2

A Ramsden eyepiece consists of two plano-convex lenses, each of focal length f = 5 cm. Calculate the distance between the two lenses and the equivalent focal length of the eyepiece.

Given:

$f_1 = f_2 = 5$ cm

Formula:

$d = (2/3)f$

$f_eq = (f_1f_2)/(f_1 + f_2 - d)$

Substitute:

$d = (2/3) \times 5 = 3.333$ cm

$f_eq = (5 \times 5)/(5 + 5 - 3.333) = 3.75$ cm

Answer: d = 3.333 cm; f_eq = 3.75 cm

Problem 3

A Ramsden eyepiece consists of two plano-convex lenses, each of focal length f = 6 cm. Calculate the distance between the two lenses and the equivalent focal length of the eyepiece.

Given:

$f_1 = f_2 = 6$ cm

Formula:

$d = (2/3)f$

$f_eq = (f_1f_2)/(f_1 + f_2 - d)$

Substitute:

$d = (2/3) \times 6 = 4$ cm

$f_eq = (6 \times 6)/(6 + 6 - 4) = 4.5$ cm

Answer: d = 4 cm; f_eq = 4.5 cm

Problem 4

A Ramsden eyepiece consists of two plano-convex lenses, each of focal length f = 2.5 cm. Calculate the distance between the two lenses and the equivalent focal length of the eyepiece.

Given:

$f_1 = f_2 = 2.5$ cm

Formula:

$d = (2/3)f$

$f_eq = (f_1f_2)/(f_1 + f_2 - d)$

Substitute:

$d = (2/3) \times 2.5 = 1.667$ cm

$f_eq = (2.5 \times 2.5)/(2.5 + 2.5 - 1.667) = 1.875$ cm

Answer: $d = 1.667$ cm; $f_eq = 1.875$ cm

Problem 5

A Ramsden eyepiece consists of two plano-convex lenses, each of focal length f = 3.5 cm. Calculate the distance between the two lenses and the equivalent focal length of the eyepiece.

Given:

$f_1 = f_2 = 3.5$ cm

Formula:

$d = (2/3)f$

$f_eq = (f_1f_2)/(f_1 + f_2 - d)$

Substitute:

$d = (2/3) \times 3.5 = 2.333$ cm

$f_eq = (3.5 \times 3.5)/(3.5 + 3.5 - 2.333) = 2.625$ cm

Answer: $d = 2.333$ cm; $f_eq = 2.625$ cm

QUESTION 7

7. Two coherent sources have an intensity ratio of 100:1. Find the ratio of the maximum intensity (I_{max}) to the minimum intensity (I_{min}) in the interference pattern.

Given:

$I_1 = 100$

$I_2 = 1$

Formula:

$r = \sqrt{(I_1/I_2)}$

$I_{max}/I_{min} = [(r + 1)/(r - 1)]^2$

Substitute:

$r = \sqrt{100} = 10$

$I_{max}/I_{min} = (11/9)^2 = 121/81 \approx 1.49$

Answer: $I_{max}/I_{min} \approx 1.49$

PRACTICE PROBLEM

Problem 1

Two coherent sources have an intensity ratio of 64:1. Find the ratio of I_{max} to I_{min} in the interference pattern.

Given:

$I_1 = 64$

$I_2 = 1$

Formula:

$r = \sqrt{(I_1/I_2)}$

$I_{max}/I_{min} = [(r + 1)/(r - 1)]^2$

Substitute:

$r = \sqrt{(64/1)} = 8$

$I_{max}/I_{min} = [(8 + 1)/(8 - 1)]^2 \approx 1.6531$

Answer: $I_{max}/I_{min} \approx 1.6531$

Problem 2

Two coherent sources have an intensity ratio of 49:4. Find the ratio of I_{max} to I_{min} in the interference pattern.

Given:

$I_1 = 49$

$I_2 = 4$

Formula:

$r = \sqrt{(I_1/I_2)}$

$I_{max}/I_{min} = [(r + 1)/(r - 1)]^2$

Substitute:

$r = \sqrt{(49/4)} = 3.5$

$I_{max}/I_{min} = [(3.5 + 1)/(3.5 - 1)]^2 \approx 3.24$

Answer: $I_{max}/I_{min} \approx 3.24$

Problem 3

Two coherent sources have an intensity ratio of 121:1. Find the ratio of I_{max} to I_{min} in the interference pattern.

Given:

$I_1 = 121$

$I_2 = 1$

Formula:

$r = \sqrt{(I_1/I_2)}$

$I_{max}/I_{min} = [(r + 1)/(r - 1)]^2$

Substitute:

$r = \sqrt{(121/1)} = 11$

$I_{max}/I_{min} = [(11 + 1)/(11 - 1)]^2 \approx 1.44$

Answer: $I_{max}/I_{min} \approx 1.44$

Problem 4

Two coherent sources have an intensity ratio of 81:16. Find the ratio of I_{max} to I_{min} in the interference pattern.

Given:

$I_1 = 81$

$I_2 = 16$

Formula:

$r = \sqrt{(I_1/I_2)}$

$I_{max}/I_{min} = [(r + 1)/(r - 1)]^2$

Substitute:

$r = \sqrt{(81/16)} = 2.25$

$I_{max}/I_{min} = [(2.25 + 1)/(2.25 - 1)]^2 \approx 6.76$

Answer: $I_{max}/I_{min} \approx 6.76$

Problem 5

Two coherent sources have an intensity ratio of 36:1. Find the ratio of I_{max} to I_{min} in the interference pattern.

Given:

$I_1 = 36$

$I_2 = 1$

Formula:

$r = \sqrt{(I_1/I_2)}$

$I_{max}/I_{min} = [(r + 1)/(r - 1)]^2$

Substitute:

$r = \sqrt{(36/1)} = 6$

$I_{max}/I_{min} = [(6 + 1)/(6 - 1)]^2 \approx 1.96$

Answer: $I_{max}/I_{min} \approx 1.96$

QUESTION 8

8. In a Young's Double Slit Experiment (YDSE), the slits are separated by 0.18 mm, and the screen is 80 cm away. If the fourth bright fringe is at a distance of 10.8 mm from the central fringe, find the wavelength of the light used.

Given:

$d = 0.18\ mm = 1.8 \times 10^{-4}\ m$

$D = 80\ cm = 0.80\ m$

$n = 4$

$x = 10.8\ mm = 1.08 \times 10^{-2}\ m$

Formula:

$\lambda = xd/(nD)$

Substitute:

$\lambda = (0.0108 \times 0.00018)/(4 \times 0.80)$

$\lambda = 6.075 \times 10^{-7}\ m = 6075\ Å$

Answer: $\lambda = 6.075 \times 10^{-7}\ m \approx 6075\ Å$

PRACTICE PROBLEM

Problem 1

In a YDSE, the slits are separated by 0.20 mm, and the screen is 90 cm away. If the 3th bright fringe is at a distance of 12 mm from the central fringe, find the wavelength of the light used.

Given:

$d = 0.20\ mm = 0.000200\ m$

$D = 90\ cm = 0.90\ m$

$n = 3$

$x = 12\ mm = 0.012\ m$

Formula:

$\lambda = xd/(nD)$

Substitute:

$\lambda = (0.012 \times 0.000200)/(3 \times 0.90)$

$\lambda = 8.8889e\text{-}07$ m = 8889 Å

Answer: $\lambda = 8.8889e\text{-}07$ m ≈ 8889 Å

Problem 2

In a YDSE, the slits are separated by 0.15 mm, and the screen is 70 cm away. If the 5th bright fringe is at a distance of 9 mm from the central fringe, find the wavelength of the light used.

Given:

d = 0.15 mm = 0.000150 m

D = 70 cm = 0.70 m

n = 5

x = 9 mm = 0.009 m

Formula:

$\lambda = xd/(nD)$

Substitute:

$\lambda = (0.009 \times 0.000150)/(5 \times 0.70)$

$\lambda = 3.8571e\text{-}07$ m = 3857 Å

Answer: $\lambda = 3.8571e\text{-}07$ m ≈ 3857 Å

Problem 3

In a YDSE, the slits are separated by 0.25 mm, and the screen is 100 cm away. If the 2th bright fringe is at a distance of 15 mm from the central fringe, find the wavelength of the light used.

Given:

d = 0.25 mm = 0.000250 m

D = 100 cm = 1.00 m

n = 2

x = 15 mm = 0.015 m

Formula:

$\lambda = xd/(nD)$

Substitute:

$\lambda = (0.015 \times 0.000250)/(2 \times 1.00)$

$\lambda = 1.8750e\text{-}06$ m = 18750 Å

Answer: $\lambda = 1.8750e\text{-}06$ m ≈ 18750 Å

Problem 4

In a YDSE, the slits are separated by 0.18 mm, and the screen is 60 cm away. If the 6th bright fringe is at a distance of 12 mm from the central fringe, find the wavelength of the light used.

Given:

d = 0.18 mm = 0.000180 m

D = 60 cm = 0.60 m

n = 6

x = 12 mm = 0.012 m

Formula:

$\lambda = xd/(nD)$

Substitute:

$\lambda = (0.012 \times 0.000180)/(6 \times 0.60)$

$\lambda = 6.0000e\text{-}07$ m = 6000 Å

Answer: $\lambda = 6.0000e\text{-}07$ m ≈ 6000 Å

Problem 5

In a YDSE, the slits are separated by 0.22 mm, and the screen is 85 cm away. If the 4th bright fringe is at a distance of 14 mm from the central fringe, find the wavelength of the light used.

Given:

d = 0.22 mm = 0.000220 m

D = 85 cm = 0.85 m

n = 4

x = 14 mm = 0.014 m

Formula:

$\lambda = xd/(nD)$

Substitute:

$\lambda = (0.014 \times 0.000220)/(4 \times 0.85)$

λ = 9.0588e-07 m = 9059 Å

Answer: λ = 9.0588e-07 m ≈ 9059 Å

QUESTION 9

9. A green light of wavelength 5100 Å from a narrow slit is incident on a double slit. If the overall separation of 10 fringes on a screen 200 cm away is 2 cm, find the slit separation.

Given:

$\lambda = 5100$ Å $= 5.10 \times 10^{-5}$ cm

D = 200 cm

N = 10

Overall separation = 2 cm

Formula:

β = total separation/N

$d = \lambda D/\beta$

Substitute:

$\beta = 2/10 = 0.2$ cm

$d = (5.10 \times 10^{-5} \times 200)/0.2 = 0.051$ cm

$d = 0.51$ mm

Answer: d = 0.51 mm

PRACTICE PROBLEM

Problem 1

A red light of wavelength 6500 Å from a narrow slit is incident on a double slit. If the overall separation of 12 fringes on a screen 150 cm away is 3 cm, find the slit separation.

Given:

$\lambda = 6500$ Å $= 6.5e\text{-}05$ cm

$D = 150$ cm

$N = 12$

Overall separation = 3 cm

Formula:

β = total separation/N

$d = \lambda D/\beta$

Substitute:

$\beta = 3/12 = 0.25$ cm

$d = (6.5e\text{-}05 \times 150)/0.25 = 0.039$ cm

$d = 0.39$ mm

Answer: d = 0.39 mm

Problem 2

A blue light of wavelength 4800 Å from a narrow slit is incident on a double slit. If the overall separation of 8 fringes on a screen 100 cm away is 1.6 cm, find the slit separation.

Given:

$\lambda = 4800$ Å $= 4.8e\text{-}05$ cm

$D = 100$ cm

$N = 8$

Overall separation = 1.6 cm

Formula:

β = total separation/N

$d = \lambda D/\beta$

Substitute:

$\beta = 1.6/8 = 0.2$ cm

$d = (4.8e\text{-}05 \times 100)/0.2 = 0.024$ cm

$d = 0.24$ mm

Answer: d = 0.24 mm

Problem 3

A yellow light of wavelength 5900 Å from a narrow slit is incident on a double slit. If the overall separation of 15 fringes on a screen 250 cm away is 3.75 cm, find the slit separation.

Given:

$\lambda = 5900$ Å $= 5.9e\text{-}05$ cm

$D = 250$ cm

$N = 15$

Overall separation = 3.75 cm

Formula:

β = total separation/N

$d = \lambda D/\beta$

Substitute:

$\beta = 3.75/15 = 0.25$ cm

$d = (5.9e\text{-}05 \times 250)/0.25 = 0.059$ cm

d = 0.59 mm

Answer: d = 0.59 mm

Problem 4

A green light of wavelength 5200 Å from a narrow slit is incident on a double slit. If the overall separation of 20 fringes on a screen 300 cm away is 4 cm, find the slit separation.

Given:

$\lambda = 5200$ Å $= 5.2e\text{-}05$ cm

D = 300 cm

N = 20

Overall separation = 4 cm

Formula:

β = total separation/N

$d = \lambda D/\beta$

Substitute:

$\beta = 4/20 = 0.2$ cm

$d = (5.2e\text{-}05 \times 300)/0.2 = 0.078$ cm

d = 0.78 mm

Answer: d = 0.78 mm

Problem 5

A violet light of wavelength 4300 Å from a narrow slit is incident on a double slit. If the overall separation of 10 fringes on a screen 180 cm away is 1.8 cm, find the slit separation.

Given:

$\lambda = 4300$ Å $= 4.3e\text{-}05$ cm

$D = 180$ cm

$N = 10$

Overall separation = 1.8 cm

Formula:

β = total separation/N

$d = \lambda D/\beta$

Substitute:

$\beta = 1.8/10 = 0.18$ cm

$d = (4.3e\text{-}05 \times 180)/0.18 = 0.043$ cm

$d = 0.43$ mm

Answer: d = 0.43 mm

QUESTION 10

10. A parallel beam of sodium light of wavelength 589×10^{-9} m is incident on a thin glass plate of refractive index 1.5, such that the angle of refraction into the plate is 60°. Calculate the smallest thickness of the plate that will make it appear dark by reflection.

Given:

$\lambda = 589 \times 10^{-9}$ m

$n = 1.5$

$r = 60°$

Formula:

$2nt \cos r = \lambda$

$t = \lambda/(2n \cos r)$

Substitute:

$t = (589 \times 10^{-9})/(2 \times 1.5 \times \cos 60°)$

$t \approx 3.927 \times 10^{-7}$ m = 393 nm

Answer: $t \approx 3.93 \times 10^{-7}$ m = 393 nm

PRACTICE PROBLEM

Problem 1

A parallel beam of light of wavelength 600×10^{-9} m is incident on a thin glass plate of refractive index 1.6, such that the angle of refraction is 45°. Calculate the smallest thickness of the plate that will make it appear dark by reflection.

Given:

$\lambda = 600 \times 10^{-9}$ m

$n = 1.6$

$r = 45°$

Formula:

$2nt \cos r = \lambda$

$t = \lambda/(2n \cos r)$

Substitute:

$t = (600 \times 10^{-9})/(2 \times 1.6 \times \cos 45°)$

$t \approx 2.6517e\text{-}07$ m = 265.17 nm

Answer: t ≈ 2.6517e-07 m = 265.17 nm

Problem 2

A parallel beam of light of wavelength 550×10^{-9} m is incident on a thin glass plate of refractive index 1.5, such that the angle of refraction is 30°. Calculate the smallest thickness of the plate that will make it appear dark by reflection.

Given:

$\lambda = 550 \times 10^{-9}$ m

$n = 1.5$

$r = 30°$

Formula:

$2nt \cos r = \lambda$

$t = \lambda/(2n \cos r)$

Substitute:

$t = (550 \times 10^{-9})/(2 \times 1.5 \times \cos 30°)$

$t \approx 2.1170e\text{-}07$ m = 211.70 nm

Answer: t ≈ 2.1170e-07 m = 211.70 nm

Problem 3

A parallel beam of light of wavelength 620×10^{-9} m is incident on a thin glass plate of refractive index 1.4, such that the angle of refraction is 60°. Calculate the smallest thickness of the plate that will make it appear dark by reflection.

Given:

$\lambda = 620 \times 10^{-9}$ m

$n = 1.4$

$r = 60°$

Formula:

$2nt \cos r = \lambda$

$t = \lambda/(2n \cos r)$

Substitute:

$t = (620 \times 10^{-9})/(2 \times 1.4 \times \cos 60°)$

$t \approx 4.4286e\text{-}07$ m = 442.86 nm

Answer: $t \approx 4.4286e\text{-}07$ m = 442.86 nm

Problem 4

A parallel beam of light of wavelength 500×10^{-9} m is incident on a thin glass plate of refractive index 1.5, such that the angle of refraction is 50°. Calculate the smallest thickness of the plate that will make it appear dark by reflection.

Given:

$\lambda = 500 \times 10^{-9}$ m

$n = 1.5$

$r = 50°$

Formula:

$2nt \cos r = \lambda$

$t = \lambda/(2n \cos r)$

Substitute:

$t = (500 \times 10^{-9})/(2 \times 1.5 \times \cos 50°)$

$t \approx 2.5929e\text{-}07$ m = 259.29 nm

Answer: $t \approx 2.5929e\text{-}07$ m = 259.29 nm

Problem 5

A parallel beam of light of wavelength 570×10^{-9} m is incident on a thin glass plate of refractive index

1.6, such that the angle of refraction is 60°. Calculate the smallest thickness of the plate that will make it appear dark by reflection.

Given:

$\lambda = 570 \times 10^{-9}$ m

n = 1.6

r = 60°

Formula:

$2nt \cos r = \lambda$

$t = \lambda/(2n \cos r)$

Substitute:

$t = (570 \times 10^{-9})/(2 \times 1.6 \times \cos 60°)$

$t \approx 3.5625e\text{-}07$ m = 356.25 nm

Answer: $t \approx 3.5625e\text{-}07$ m = 356.25 nm

QUESTION 11

11. A glass wedge of angle 0.01 radian is illuminated by monochromatic light of wavelength 6000 Å falling normally on it. At what distance from the edge of the wedge will the 10th fringe be observed by reflected light?

Given:

$\theta = 0.01$ rad

m = 10

$\lambda = 6000$ Å $= 6 \times 10^{-7}$ m

Formula:

$2\theta x = m\lambda$

$x = m\lambda/(2\theta)$

Substitute:

$x = (10 \times 6 \times 10^{-7})/(2 \times 0.01)$

$x = 3 \times 10^{-4}$ m = 0.3 mm

Answer: x = 0.3 mm

PRACTICE PROBLEM

Problem 1

A glass wedge of angle 0.02 radian is illuminated by light of wavelength 5000 Å. Find the distance from the edge where the 8th fringe will appear by reflected light.

Given:

$\theta = 0.02$ rad

$m = 8$

$\lambda = 5000$ Å = 5.000e-07 m

Formula:

$2\theta x = m\lambda$

$x = m\lambda/(2\theta)$

Substitute:

$x = (8 \times 5.000e\text{-}07)/(2 \times 0.02)$

x = 1.0000e-04 m = 0.1000 mm

Answer: x = 0.1000 mm

Problem 2

A glass wedge of angle 0.015 radian is illuminated by light of wavelength 5500 Å. Find the distance from the edge where the 12th fringe will appear by reflected light.

Given:

$\theta = 0.015$ rad

m = 12

λ = 5500 Å = 5.500e-07 m

Formula:

2θx = mλ

x = mλ/(2θ)

Substitute:

x = (12 × 5.500e-07)/(2 × 0.015)

x = 2.2000e-04 m = 0.2200 mm

Answer: x = 0.2200 mm

Problem 3

A glass wedge of angle 0.01 radian is illuminated by light of wavelength 6200 Å. Find the distance from the edge where the 15th fringe will appear by reflected light.

Given:

θ = 0.01 rad

m = 15

λ = 6200 Å = 6.200e-07 m

Formula:

2θx = mλ

x = mλ/(2θ)

Substitute:

x = (15 × 6.200e-07)/(2 × 0.01)

x = 4.6500e-04 m = 0.4650 mm

Answer: x = 0.4650 mm

Problem 4

A glass wedge of angle 0.025 radian is illuminated by light of wavelength 6000 Å. Find the distance from the edge where the 5th fringe will appear by reflected light.

Given:

$\theta = 0.025$ rad

$m = 5$

$\lambda = 6000$ Å $= 6.000e\text{-}07$ m

Formula:

$2\theta x = m\lambda$

$x = m\lambda/(2\theta)$

Substitute:

$x = (5 \times 6.000e\text{-}07)/(2 \times 0.025)$

$x = 6.0000e\text{-}05$ m $= 0.0600$ mm

Answer: x = 0.0600 mm

Problem 5

A glass wedge of angle 0.012 radian is illuminated by light of wavelength 5800 Å. Find the distance from the edge where the 10th fringe will appear by reflected light.

Given:

$\theta = 0.012$ rad

$m = 10$

$\lambda = 5800$ Å $= 5.800e\text{-}07$ m

Formula:

$2\theta x = m\lambda$

$x = m\lambda/(2\theta)$

Substitute:

$x = (10 \times 5.800e\text{-}07)/(2 \times 0.012)$

$x = 2.4167e\text{-}04$ m = 0.2417 mm

Answer: x = 0.2417 mm

QUESTION 12

12. In the Fraunhofer diffraction pattern due to a narrow slit, a screen is placed 2 m away from the lens to obtain the pattern. If the slit width is 0.2 mm, and the first minima lie 5 mm on either side of the central maximum, find the wavelength of light used.

Given:

$a = 0.2$ mm $= 2 \times 10^{-4}$ m

$x = 5$ mm $= 5 \times 10^{-3}$ m

$D = 2$ m

$n = 1$

Formula:

$a \sin\theta = n\lambda$

For small θ, $\sin\theta \approx x/D$

$\lambda = ax/(nD)$

Substitute:

$\lambda = (2 \times 10^{-4} \times 5 \times 10^{-3})/(1 \times 2)$

$\lambda = 5 \times 10^{-7}$ m = 5000 Å

Answer: $\lambda = 5 \times 10^{-7}$ m = 5000 Å

PRACTICE PROBLEM

Problem 1

In the Fraunhofer diffraction pattern due to a narrow slit, a screen is placed 1.5 m away. The slit width is 0.25 mm, and the first minima lie 4 mm on either side of the central maximum. Find the wavelength.

Given:

a = 0.25 mm = 2.500e-04 m

x = 4 mm = 4.000e-03 m

D = 1.5 m

n = 1

Formula:

$a \sin\theta = n\lambda$

$\lambda = ax/(nD)$

Substitute:

$\lambda = (2.500e\text{-}04 \times 4.000e\text{-}03)/1.5$

$\lambda = 6.6667e\text{-}07$ m = 6667 Å

Answer: $\lambda = 6.6667e\text{-}07$ m ≈ 6667 Å

Problem 2

In the Fraunhofer diffraction pattern due to a narrow slit, a screen is placed 2.5 m away. The slit width is 0.3 mm, and the first minima lie 6 mm on either side of the central maximum. Find the wavelength.

Given:

a = 0.3 mm = 3.000e-04 m

x = 6 mm = 6.000e-03 m

D = 2.5 m

n = 1

Formula:

$a \sin\theta = n\lambda$

$\lambda = ax/(nD)$

Substitute:

$\lambda = (3.000e\text{-}04 \times 6.000e\text{-}03)/2.5$

$\lambda = 7.2000e\text{-}07$ m = 7200 Å

Answer: $\lambda = 7.2000e\text{-}07$ m ≈ 7200 Å

Problem 3

In the Fraunhofer diffraction pattern due to a narrow slit, a screen is placed 3 m away. The slit width is 0.15 mm, and the first minima lie 3 mm on either side of the central maximum. Find the wavelength.

Given:

a = 0.15 mm = 1.500e-04 m

x = 3 mm = 3.000e-03 m

D = 3 m

n = 1

Formula:

$a \sin\theta = n\lambda$

$\lambda = ax/(nD)$

Substitute:

$\lambda = (1.500e\text{-}04 \times 3.000e\text{-}03)/3$

$\lambda = 1.5000e\text{-}07$ m = 1500 Å

Answer: $\lambda = 1.5000e\text{-}07$ m ≈ 1500 Å

Problem 4

In the Fraunhofer diffraction pattern due to a narrow slit, a screen is placed 2 m away. The slit width is 0.2 mm, and the first minima lie 6 mm on either side of the central maximum. Find the wavelength.

Given:

a = 0.2 mm = 2.000e-04 m

x = 6 mm = 6.000e-03 m

D = 2 m

n = 1

Formula:

$a \sin\theta = n\lambda$

$\lambda = ax/(nD)$

Substitute:

$\lambda = (2.000e\text{-}04 \times 6.000e\text{-}03)/2$

$\lambda = 6.0000e\text{-}07$ m = 6000 Å

Answer: $\lambda = 6.0000e\text{-}07$ m ≈ 6000 Å

Problem 5

In the Fraunhofer diffraction pattern due to a narrow slit, a screen is placed 1.8 m away. The slit width is 0.18 mm, and the first minima lie 5 mm on either side of the central maximum. Find the wavelength.

Given:

a = 0.18 mm = 1.800e-04 m

x = 5 mm = 5.000e-03 m

D = 1.8 m

n = 1

Formula:

$a \sin\theta = n\lambda$

$\lambda = ax/(nD)$

Substitute:

$\lambda = (1.800e\text{-}04 \times 5.000e\text{-}03)/1.8$

$\lambda = 5.0000e\text{-}07$ m = 5000 Å

Answer: $\lambda = 5.0000e\text{-}07$ m ≈ 5000 Å

QUESTION 13

13. What is the radius of the first half-period zone in a zone plate behaving like a convex lens of focal length 60 cm for light of wavelength 6000 Å?

Given:

f = 60 cm = 0.6 m

n = 1

$\lambda = 6000$ Å $= 6 \times 10^{-7}$ m

Formula:

$r_n = \sqrt{(n\lambda f)}$

Substitute:

$r_1 = \sqrt{(1 \times 6 \times 10^{-7} \times 0.6)}$

$r_1 = 6 \times 10^{-4}$ m = 0.6 mm

Answer: r_1 = 0.6 mm

PRACTICE PROBLEM

Problem 1

Find the radius of the first half-period zone in a zone plate of focal length 50 cm for light of wavelength 5000 Å.

Given:

f = 50 cm = 0.50 m

n = 1

$\lambda = 5000$ Å $= 5.000e\text{-}07$ m

Formula:

$r_n = \sqrt{(n\lambda f)}$

Substitute:

$r_1 = \sqrt{(1 \times 5.000e\text{-}07 \times 0.50)}$

$r_1 = 5.0000e\text{-}04$ m = 0.5000 mm

Answer: $r_1 \approx$ 0.5000 mm

Problem 2

Find the radius of the first half-period zone in a zone plate of focal length 70 cm for light of wavelength 6000 Å.

Given:

f = 70 cm = 0.70 m

n = 1

λ = 6000 Å = 6.000e-07 m

Formula:

$r_n = \sqrt{(n\lambda f)}$

Substitute:

$r_1 = \sqrt{(1 \times 6.000e\text{-}07 \times 0.70)}$

$r_1 = 6.4807e\text{-}04$ m = 0.6481 mm

Answer: $r_1 \approx$ 0.6481 mm

Problem 3

Find the radius of the first half-period zone in a zone plate of focal length 80 cm for light of wavelength 5500 Å.

Given:

f = 80 cm = 0.80 m

$n = 1$

$\lambda = 5500$ Å $= 5.500\text{e-}07$ m

Formula:

$r_n = \sqrt{(n\lambda f)}$

Substitute:

$r_1 = \sqrt{(1 \times 5.500\text{e-}07 \times 0.80)}$

$r_1 = 6.6332\text{e-}04$ m $= 0.6633$ mm

Answer: $r_1 \approx 0.6633$ mm

Problem 4

Find the radius of the first half-period zone in a zone plate of focal length 40 cm for light of wavelength 6500 Å.

Given:

$f = 40$ cm $= 0.40$ m

$n = 1$

$\lambda = 6500$ Å $= 6.500\text{e-}07$ m

Formula:

$r_n = \sqrt{(n\lambda f)}$

Substitute:

$r_1 = \sqrt{(1 \times 6.500\text{e-}07 \times 0.40)}$

$r_1 = 5.0990\text{e-}04$ m $= 0.5099$ mm

Answer: $r_1 \approx 0.5099$ mm

Problem 5

Find the radius of the first half-period zone in a zone plate of focal length 60 cm for light of wavelength 5200 Å.

Given:

f = 60 cm = 0.60 m

n = 1

λ = 5200 Å = 5.200e-07 m

Formula:

$r_n = \sqrt{(n\lambda f)}$

Substitute:

$r_1 = \sqrt{(1 \times 5.200e\text{-}07 \times 0.60)}$

r_1 = 5.5857e-04 m = 0.5586 mm

Answer: $r_1 \approx 0.5586$ mm

QUESTION 14

14. A diffraction grating has a grating element of 2×10^{-6} m. If light of wavelength 600 nm is incident on it, calculate the angle of the first-order (n = 1) maximum.

Given:

n = 1

λ = 600 nm = 6×10^{-7} m

d = 2×10^{-6} m

Formula:

$d \sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Substitute:

$\sin\theta = (6 \times 10^{-7})/(2 \times 10^{-6}) = 0.3$

$\theta = \sin^{-1}(0.3) \approx 17.46°$

Answer: θ ≈ 17.46°

PRACTICE PROBLEM

Problem 1

A diffraction grating has a grating element of 1.5e-06 m. If light of wavelength 500 nm is incident on it, calculate the angle of the first-order maximum.

Given:

$n = 1$

$\lambda = 500 \text{ nm} = 5.000\text{e-}07 \text{ m}$

$d = 1.500\text{e-}06 \text{ m}$

Formula:

$d \sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Substitute:

$\sin\theta = (5.000\text{e-}07)/(1.500\text{e-}06) = 0.3333$

$\theta = \sin^{-1}(0.3333) \approx 19.47°$

Answer: $\theta \approx 19.47°$

Problem 2

A diffraction grating has a grating element of 2e-06 m. If light of wavelength 550 nm is incident on it, calculate the angle of the first-order maximum.

Given:

$n = 1$

$\lambda = 550 \text{ nm} = 5.500\text{e-}07 \text{ m}$

$d = 2.000\text{e-}06 \text{ m}$

Formula:

$d \sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Substitute:

$\sin\theta = (5.500e\text{-}07)/(2.000e\text{-}06) = 0.2750$

$\theta = \sin^{-1}(0.2750) \approx 15.96°$

Answer: $\theta \approx 15.96°$

Problem 3

A diffraction grating has a grating element of 1e-06 m. If light of wavelength 600 nm is incident on it, calculate the angle of the first-order maximum.

Given:

$n = 1$

$\lambda = 600$ nm $= 6.000e\text{-}07$ m

$d = 1.000e\text{-}06$ m

Formula:

$d \sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Substitute:

$\sin\theta = (6.000e\text{-}07)/(1.000e\text{-}06) = 0.6000$

$\theta = \sin^{-1}(0.6000) \approx 36.87°$

Answer: $\theta \approx 36.87°$

Problem 4

A diffraction grating has a grating element of 2.5e-06 m. If light of wavelength 700 nm is incident on it, calculate the angle of the first-order maximum.

Given:

$n = 1$

$\lambda = 700$ nm = 7.000e-07 m

d = 2.500e-06 m

Formula:

$d \sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Substitute:

$\sin\theta = (7.000e\text{-}07)/(2.500e\text{-}06) = 0.2800$

$\theta = \sin^{-1}(0.2800) \approx 16.26°$

Answer: $\theta \approx 16.26°$

Problem 5

A diffraction grating has a grating element of 3e-06 m. If light of wavelength 650 nm is incident on it, calculate the angle of the first-order maximum.

Given:

n = 1

$\lambda = 650$ nm = 6.500e-07 m

d = 3.000e-06 m

Formula:

$d \sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Substitute:

$\sin\theta = (6.500e\text{-}07)/(3.000e\text{-}06) = 0.2167$

$\theta = \sin^{-1}(0.2167) \approx 12.51°$

Answer: $\theta \approx 12.51°$

QUESTION 15

15. For the refractive index of glass of 1.5, what is the polarizing angle?

Given:

n = 1.5

Formula:

$\theta_p = \tan^{-1}(n)$

Substitute:

$\theta_p = \tan^{-1}(1.5) = 56.31°$

Answer: $\theta_p = 56.31°$

PRACTICE PROBLEM

Problem 1

For a refractive index of 1.33, find the polarizing angle.

Given:

n = 1.33

Formula:

$\theta_p = \tan^{-1}(n)$

Substitute:

$\theta_p = \tan^{-1}(1.33)$

$\theta_p \approx 53.06°$

Answer: $\theta_p \approx 53.06°$

Problem 2

For a refractive index of 1.7, find the polarizing angle.

Given:

n = 1.7

Formula:

$\theta_p = \tan^{-1}(n)$

Substitute:

$\theta_p = \tan^{-1}(1.7)$

$\theta_p \approx 59.53°$

Answer: $\theta_p \approx 59.53°$

Problem 3

For a refractive index of 1.45, find the polarizing angle.

Given:

$n = 1.45$

Formula:

$\theta_p = \tan^{-1}(n)$

Substitute:

$\theta_p = \tan^{-1}(1.45)$

$\theta_p \approx 55.41°$

Answer: $\theta_p \approx 55.41°$

Problem 4

For a refractive index of 1.6, find the polarizing angle.

Given:

$n = 1.6$

Formula:

$\theta_p = \tan^{-1}(n)$

Substitute:

$\theta_p = \tan^{-1}(1.6)$

$\theta_p \approx 57.99°$

Answer: $\theta_p \approx 57.99°$

Problem 5

For a refractive index of 1.8, find the polarizing angle.

Given:

$n = 1.8$

Formula:

$\theta_p = \tan^{-1}(n)$

Substitute:

$\theta_p = \tan^{-1}(1.8)$

$\theta_p \approx 60.95°$

Answer: $\theta_p \approx 60.95°$

QUESTION 16

16. The angle between the polarizer and analyser is 60°. What percentage of the incident light intensity is transmitted?

Given:

$\theta = 60°$

Incident intensity = I_0

Formula:

$I = I_0 \cos^2\theta$

Substitute:

$I/I_0 = \cos^2 60° = 0.25$

Percentage transmitted = 25%

Answer: 25% of the incident intensity

PRACTICE PROBLEM

Problem 1

The angle between the polarizer and analyser is 30°. What percentage of the incident light intensity is transmitted?

Given:

$\theta = 30°$

Incident intensity = I_0

Formula:

$I = I_0 \cos^2\theta$

Substitute:

$I/I_0 = \cos^2 30° = 0.7500$

Percentage transmitted = 75.00%

Answer: 75.00%

Problem 2

The angle between the polarizer and analyser is 45°. What percentage of the incident light intensity is transmitted?

Given:

$\theta = 45°$

Incident intensity = I_0

Formula:

$I = I_0 \cos^2\theta$

Substitute:

$I/I_0 = \cos^2 45° = 0.5000$

Percentage transmitted = 50.00%

Answer: 50.00%

Problem 3

The angle between the polarizer and analyser is 75°. What percentage of the incident light intensity is transmitted?

Given:

$\theta = 75°$

Incident intensity = I_0

Formula:

$I = I_0 \cos^2\theta$

Substitute:

$I/I_0 = \cos^2 75° = 0.0670$

Percentage transmitted = 6.70%

Answer: 6.70%

Problem 4

The angle between the polarizer and analyser is 15°. What percentage of the incident light intensity is transmitted?

Given:

$\theta = 15°$

Incident intensity = I_0

Formula:

$I = I_0 \cos^2\theta$

Substitute:

$I/I_0 = \cos^2 15° = 0.9330$

Percentage transmitted = 93.30%

Answer: 93.30%

Problem 5

The angle between the polarizer and analyser is 90°. What percentage of the incident light intensity is transmitted?

Given:

$\theta = 90°$

Incident intensity = I_0

Formula:

$I = I_0 \cos^2\theta$

Substitute:

$I/I_0 = \cos^2 90° = 0.0000$

Percentage transmitted = 0.00%

Answer: 0.00%

QUESTION 17

17. A Nicol prism is made of a calcite crystal ($\mu_o = 1.658$ and $\mu_e = 1.486$ for sodium light) joined by a layer of Canada balsam with refractive index $\mu_\beta = 1.55$. Find its critical angle.

Given:

$\mu_o = 1.658$

$\mu_\beta = 1.55$

Formula:

$\sin C = \mu_\beta/\mu_o$

Substitute:

$\sin C = 1.55/1.658 = 0.9349$

$C = \sin^{-1}(0.9349) \approx 69.21°$

Answer: C ≈ 69.21°

PRACTICE PROBLEM

Problem 1

A Nicol prism is made of a crystal with $\mu_o = 1.600$ and $\mu_\beta = 1.50$. Find its critical angle.

Given:

$\mu_o = 1.600$

$\mu_\beta = 1.50$

Formula:

$\sin C = \mu_\beta/\mu_o$

Substitute:

$\sin C = 1.50/1.600 = 0.9375$

$C = \sin^{-1}(0.9375) \approx 69.64°$

Answer: C ≈ 69.64°

Problem 2

A Nicol prism is made of a crystal with $\mu_o = 1.700$ and $\mu_\beta = 1.55$. Find its critical angle.

Given:

$\mu_o = 1.700$

$\mu_\beta = 1.55$

Formula:

$\sin C = \mu_\beta/\mu_o$

Substitute:

$\sin C = 1.55/1.700 = 0.9118$

$C = \sin^{-1}(0.9118) \approx 65.75°$

Answer: C ≈ 65.75°

Problem 3

A Nicol prism is made of a crystal with $\mu_o = 1.620$ and $\mu_\beta = 1.52$. Find its critical angle.

Given:

$\mu_o = 1.620$

$\mu_\beta = 1.52$

Formula:

$\sin C = \mu_\beta/\mu_o$

Substitute:

$\sin C = 1.52/1.620 = 0.9383$

$C = \sin^{-1}(0.9383) \approx 69.76°$

Answer: C ≈ 69.76°

Problem 4

A Nicol prism is made of a crystal with $\mu_o = 1.658$ and $\mu_\beta = 1.60$. Find its critical angle.

Given:

$\mu_o = 1.658$

$\mu_\beta = 1.60$

Formula:

$\sin C = \mu_\beta/\mu_o$

Substitute:

$\sin C = 1.60/1.658 = 0.9650$

$C = \sin^{-1}(0.9650) \approx 74.80°$

Answer: C ≈ 74.80°

Problem 5

A Nicol prism is made of a crystal with $\mu_o = 1.640$ and $\mu_\beta = 1.50$. Find its critical angle.

Given:

$\mu_o = 1.640$

$\mu_\beta = 1.50$

Formula:

$\sin C = \mu_\beta/\mu_o$

Substitute:

$\sin C = 1.50/1.640 = 0.9146$

$C = \sin^{-1}(0.9146) \approx 66.15°$

Answer: $C \approx 66.15°$

QUESTION 18

18. Calculate the plate thickness of a half-wave plate for light of wavelength 580 nm. Principal refractive indices are $n_o = 1.544$ and $n_e = 1.553$.

Given:

$\lambda = 580 \text{ nm} = 580 \times 10^{-9} \text{ m}$

$n_o = 1.544$

$n_e = 1.553$

Formula:

$t = \lambda/[2(n_e - n_o)]$

Substitute:

$t = 580 \times 10^{-9}/[2(1.553 - 1.544)]$

$t \approx 3.22 \times 10^{-5} \text{ m}$

Answer: $t \approx 3.22 \times 10^{-5}$ m

PRACTICE PROBLEM

Problem 1

Calculate the plate thickness of a half-wave plate for light of wavelength 600 nm. ($n_o = 1.540$, $n_e = 1.550$).

Given:

$\lambda = 600 \text{ nm} = 600 \times 10^{-9} \text{ m}$

$n_o = 1.540$

$n_e = 1.550$

Formula:

$t = \lambda/[2(n_e - n_o)]$

Substitute:

$t = 600 \times 10^{-9}/[2(1.550 - 1.540)]$

$t = 3.0000e\text{-}05 \text{ m}$

Answer: $t \approx 3.0000e\text{-}05$ m

Problem 2

Calculate the plate thickness of a half-wave plate for light of wavelength 500 nm. ($n_o = 1.538$, $n_e = 1.548$).

Given:

$\lambda = 500 \text{ nm} = 500 \times 10^{-9} \text{ m}$

$n_o = 1.538$

$n_e = 1.548$

Formula:

$t = \lambda/[2(n_e - n_o)]$

Substitute:

$t = 500 \times 10^{-9}/[2(1.548 - 1.538)]$

t = 2.5000e-05 m

Answer: t ≈ 2.5000e-05 m

Problem 3

Calculate the plate thickness of a half-wave plate for light of wavelength 650 nm. (n_o = 1.542, n_e = 1.552).

Given:

$\lambda = 650 \text{ nm} = 650 \times 10^{-9} \text{ m}$

$n_o = 1.542$

$n_e = 1.552$

Formula:

$t = \lambda/[2(n_e - n_o)]$

Substitute:

$t = 650 \times 10^{-9}/[2(1.552 - 1.542)]$

t = 3.2500e-05 m

Answer: t ≈ 3.2500e-05 m

Problem 4

Calculate the plate thickness of a half-wave plate for light of wavelength 520 nm. (n_o = 1.546, n_e = 1.555).

Given:

$\lambda = 520 \text{ nm} = 520 \times 10^{-9} \text{ m}$

$n_o = 1.546$

$n_e = 1.555$

Formula:

$t = \lambda/[2(n_e - n_o)]$

Substitute:

$t = 520 \times 10^{-9}/[2(1.555 - 1.546)]$

t = 2.8889e-05 m

Answer: t ≈ 2.8889e-05 m

Problem 5

Calculate the plate thickness of a half-wave plate for light of wavelength 580 nm. ($n_o = 1.541$, $n_e = 1.551$).

Given:

$\lambda = 580 \text{ nm} = 580 \times 10^{-9} \text{ m}$

$n_o = 1.541$

$n_e = 1.551$

Formula:

$t = \lambda/[2(n_e - n_o)]$

Substitute:

$t = 580 \times 10^{-9}/[2(1.551 - 1.541)]$

t = 2.9000e-05 m

Answer: t ≈ 2.9000e-05 m

QUESTION 19

19. Calculate the plate thickness of a quarter-wave plate for light of wavelength 5.9×10^{-7} m.

Principal refractive indices are $n_o = 1.544$ and $n_e = 1.553$.

Given:

$\lambda = 5.9 \times 10^{-7} \text{ m}$

$n_o = 1.544$

$n_e = 1.553$

Formula:

$t = \lambda/[4(n_e - n_o)]$

Substitute:

$t = 5.9 \times 10^{-7}/[4(1.553 - 1.544)]$

$t \approx 1.64 \times 10^{-5}$ m

Answer: $t \approx 1.64 \times 10^{-5}$ m

PRACTICE PROBLEM

Problem 1

Calculate the plate thickness of a quarter-wave plate for light of wavelength 6.0e-07 m. Principal refractive indices are $n_o = 1.540$ and $n_e = 1.550$.

Given:

$\lambda = 6.0e\text{-}07$ m

$n_o = 1.540$

$n_e = 1.550$

Formula:

$t = \lambda/[4(n_e - n_o)]$

Substitute:

$t = 6.0e\text{-}07/[4(1.550 - 1.540)]$

$t = 1.5000e\text{-}05$ m

Answer: $t \approx 1.5000e\text{-}05$ m

Problem 2

Calculate the plate thickness of a quarter-wave plate for light of wavelength 5.5e-07 m. Principal refractive indices are $n_o = 1.538$ and $n_e = 1.548$.

Given:

$\lambda = 5.5e\text{-}07$ m

$n_o = 1.538$

$n_e = 1.548$

Formula:

$t = \lambda/[4(n_e - n_o)]$

Substitute:

$t = 5.5e\text{-}07/[4(1.548 - 1.538)]$

$t = 1.3750e\text{-}05$ m

Answer: $t \approx 1.3750e\text{-}05$ m

Problem 3

Calculate the plate thickness of a quarter-wave plate for light of wavelength 6.5e-07 m. Principal refractive indices are $n_o = 1.542$ and $n_e = 1.552$.

Given:

$\lambda = 6.5e\text{-}07$ m

$n_o = 1.542$

$n_e = 1.552$

Formula:

$t = \lambda/[4(n_e - n_o)]$

Substitute:

$t = 6.5e\text{-}07/[4(1.552 - 1.542)]$

$t = 1.6250e\text{-}05$ m

Answer: $t \approx 1.6250e\text{-}05$ m

Problem 4

Calculate the plate thickness of a quarter-wave plate for light of wavelength 5.2e-07 m. Principal refractive indices are $n_o = 1.546$ and $n_e = 1.555$.

Given:

$\lambda = 5.2e\text{-}07$ m

$n_o = 1.546$

$n_e = 1.555$

Formula:

$t = \lambda/[4(n_e - n_o)]$

Substitute:

$t = 5.2e\text{-}07/[4(1.555 - 1.546)]$

$t = 1.4444e\text{-}05$ m

Answer: $t \approx 1.4444e\text{-}05$ m

Problem 5

Calculate the plate thickness of a quarter-wave plate for light of wavelength 5.8e-07 m. Principal refractive indices are $n_o = 1.541$ and $n_e = 1.551$.

Given:

$\lambda = 5.8e\text{-}07$ m

$n_o = 1.541$

$n_e = 1.551$

Formula:

$t = \lambda/[4(n_e - n_o)]$

Substitute:

$t = 5.8e\text{-}07/[4(1.551 - 1.541)]$

t = 1.4500e-05 m

Answer: t ≈ 1.4500e-05 m

QUESTION 20

20. A 30 cm long tube containing sugar solution rotates the plane of polarization by 12°. If the specific rotation of sugar is 68°, calculate the strength of the solution.

Given:

θ = 12°

L = 30 cm = 3 dm

S = 68°

Formula:

c = θ/(LS)

Substitute:

c = 12/(3 × 68)

c = 0.0588 g/cm³

Answer: c ≈ 0.0588 g/cm³

PRACTICE PROBLEM

Problem 1

A 40 cm long tube containing sugar solution rotates the plane of polarization by 15°. If the specific rotation of sugar is 75°, calculate the strength of the solution.

Given:

θ = 15°

L = 40 cm = 4 dm

S = 75°

Formula:

$c = \theta/(LS)$

Substitute:

$c = 15/(4 \times 75)$

$c = 0.0500\ g/cm^3$

Answer: $c \approx 0.0500\ g/cm^3$

Problem 2

A 25 cm long tube containing sugar solution rotates the plane of polarization by 10°. If the specific rotation of sugar is 60°, calculate the strength of the solution.

Given:

$\theta = 10°$

$L = 25\ cm = 2.5\ dm$

$S = 60°$

Formula:

$c = \theta/(LS)$

Substitute:

$c = 10/(2.5 \times 60)$

$c = 0.0667\ g/cm^3$

Answer: $c \approx 0.0667\ g/cm^3$

Problem 3

A 50 cm long tube containing sugar solution rotates the plane of polarization by 18°. If the specific rotation of sugar is 72°, calculate the strength of the solution.

Given:

$\theta = 18°$

$L = 50\ cm = 5\ dm$

S = 72°

Formula:

$c = \theta/(LS)$

Substitute:

$c = 18/(5 \times 72)$

$c = 0.0500\ g/cm^3$

Answer: $c \approx 0.0500\ g/cm^3$

Problem 4

A 35 cm long tube containing sugar solution rotates the plane of polarization by 14°. If the specific rotation of sugar is 70°, calculate the strength of the solution.

Given:

θ = 14°

L = 35 cm = 3.5 dm

S = 70°

Formula:

$c = \theta/(LS)$

Substitute:

$c = 14/(3.5 \times 70)$

$c = 0.0571\ g/cm^3$

Answer: $c \approx 0.0571\ g/cm^3$

Problem 5

A 20 cm long tube containing sugar solution rotates the plane of polarization by 8°. If the specific rotation of sugar is 64°, calculate the strength of the solution.

Given:

$\theta = 8°$

L = 20 cm = 2 dm

S = 64°

Formula:

$c = \theta/(LS)$

Substitute:

$c = 8/(2 \times 64)$

$c = 0.0625\ g/cm^3$

Answer: $c \approx 0.0625\ g/cm^3$

QUESTION 21

21. A step-index fiber has a core refractive index $n_1 = 1.50$ and cladding index $n_2 = 1.45$. If the fiber is kept in air, calculate its Numerical Aperture (NA).

Given:

$n_1 = 1.50$

$n_2 = 1.45$

Formula:

$NA = \sqrt{(n_1^2 - n_2^2)}$

Substitute:

$NA = \sqrt{(1.50^2 - 1.45^2)}$

$NA = \sqrt{0.1475} \approx 0.384$

Answer: NA ≈ 0.384

PRACTICE PROBLEM

Problem 1

A step-index fiber has a core refractive index $n_1 = 1.48$ and cladding index $n_2 = 1.44$. Calculate its NA.

Given:

$n_1 = 1.48$

$n_2 = 1.44$

Formula:

$NA = \sqrt{(n_1^2 - n_2^2)}$

Substitute:

$NA = \sqrt{(1.48^2 - 1.44^2)}$

$NA = 0.3418$

Answer: NA ≈ 0.3418

Problem 2

A step-index fiber has a core refractive index $n_1 = 1.52$ and cladding index $n_2 = 1.46$. Calculate its NA.

Given:

$n_1 = 1.52$

$n_2 = 1.46$

Formula:

$NA = \sqrt{(n_1^2 - n_2^2)}$

Substitute:

$NA = \sqrt{(1.52^2 - 1.46^2)}$

$NA = 0.4228$

Answer: NA ≈ 0.4228

Problem 3

A step-index fiber has a core refractive index $n_1 = 1.50$ and cladding index $n_2 = 1.40$. Calculate its NA.

Given:

$n_1 = 1.50$

$n_2 = 1.40$

Formula:

$NA = \sqrt{(n_1^2 - n_2^2)}$

Substitute:

$NA = \sqrt{(1.50^2 - 1.40^2)}$

$NA = 0.5385$

Answer: NA ≈ 0.5385

Problem 4

A step-index fiber has a core refractive index $n_1 = 1.49$ and cladding index $n_2 = 1.45$. Calculate its NA.

Given:

$n_1 = 1.49$

$n_2 = 1.45$

Formula:

$NA = \sqrt{(n_1^2 - n_2^2)}$

Substitute:

$NA = \sqrt{(1.49^2 - 1.45^2)}$

$NA = 0.3429$

Answer: NA ≈ 0.3429

Problem 5

A step-index fiber has a core refractive index $n_1 = 1.51$ and cladding index $n_2 = 1.47$. Calculate its NA.

Given:

$n_1 = 1.51$

$n_2 = 1.47$

Formula:

$NA = \sqrt{(n_1^2 - n_2^2)}$

Substitute:

$NA = \sqrt{(1.51^2 - 1.47^2)}$

$NA = 0.3453$

Answer: NA ≈ 0.3453

QUESTION 22

22. Compute the acceptance angle for a fiber with NA = 0.384.

Given:

$NA = 0.384$

Formula:

$\theta = \sin^{-1}(NA)$

Substitute:

$\theta = \sin^{-1}(0.384) \approx 22.58°$

Answer: θ ≈ 22.58°

PRACTICE PROBLEM

Problem 1

Compute the acceptance angle for a fiber with NA = 0.342.

Given:

$NA = 0.342$

Formula:

$\theta = \sin^{-1}(NA)$

Substitute:

$\theta = \sin^{-1}(0.342)$

$\theta \approx 20.00°$

Answer: θ ≈ 20.00°

Problem 2

Compute the acceptance angle for a fiber with NA = 0.423.

Given:

NA = 0.423

Formula:

$\theta = \sin^{-1}(NA)$

Substitute:

$\theta = \sin^{-1}(0.423)$

$\theta \approx 25.02°$

Answer: θ ≈ 25.02°

Problem 3

Compute the acceptance angle for a fiber with NA = 0.539.

Given:

NA = 0.539

Formula:

$\theta = \sin^{-1}(NA)$

Substitute:

$\theta = \sin^{-1}(0.539)$

$\theta \approx 32.62°$

Answer: θ ≈ 32.62°

Problem 4

Compute the acceptance angle for a fiber with NA = 0.343.

Given:

NA = 0.343

Formula:

$\theta = \sin^{-1}(NA)$

Substitute:

$\theta = \sin^{-1}(0.343)$

$\theta \approx 20.06°$

Answer: $\theta \approx 20.06°$

Problem 5

Compute the acceptance angle for a fiber with NA = 0.345.

Given:

NA = 0.345

Formula:

$\theta = \sin^{-1}(NA)$

Substitute:

$\theta = \sin^{-1}(0.345)$

$\theta \approx 20.18°$

Answer: $\theta \approx 20.18°$

QUESTION 23

23. A He-Ne laser has a spectral bandwidth of $\Delta\nu = 10^6$ Hz. Calculate its coherence time and coherence length.

Given:

$\Delta\nu = 10^6$ Hz

$c = 3 \times 10^8$ m/s

Formula:

$\tau c = 1/\Delta\nu$

$Lc = c\tau c$

Substitute:

$\tau c = 1/10^6 = 10^{-6}$ s

$Lc = 3 \times 10^8 \times 10^{-6} = 300$ m

Answer: $\tau c = 10^{-6}$ s; Lc = 300 m

PRACTICE PROBLEM

Problem 1

A He-Ne laser has a spectral bandwidth of 5e+05 Hz. Calculate its coherence time and coherence length.

Given:

$\Delta\nu = 5e+05$ Hz

$c = 3 \times 10^8$ m/s

Formula:

$\tau c = 1/\Delta\nu$

$Lc = c\tau c$

Substitute:

$\tau c = 1/(5e+05) = 2.000e-06$ s

$Lc = 3 \times 10^8 \times 2.000e-06 = 600$ m

Answer: τc = 2.000e-06 s; Lc = 600 m

Problem 2

A He-Ne laser has a spectral bandwidth of 2e+06 Hz. Calculate its coherence time and coherence length.

Given:

$\Delta\nu = 2e+06$ Hz

$c = 3 \times 10^8$ m/s

Formula:

$\tau c = 1/\Delta\nu$

$Lc = c\tau c$

Substitute:

$\tau c = 1/(2e+06) = 5.000e-07$ s

$Lc = 3 \times 10^8 \times 5.000e-07 = 150$ m

Answer: $\tau c = 5.000e-07$ s; Lc = 150 m

Problem 3

A He-Ne laser has a spectral bandwidth of 1e+05 Hz. Calculate its coherence time and coherence length.

Given:

$\Delta\nu = 1e+05$ Hz

$c = 3 \times 10^8$ m/s

Formula:

$\tau c = 1/\Delta\nu$

$Lc = c\tau c$

Substitute:

$\tau c = 1/(1e+05) = 1.000e-05$ s

$Lc = 3 \times 10^8 \times 1.000e-05 = 3e+03$ m

Answer: $\tau c = 1.000e-05$ s; Lc = 3e+03 m

Problem 4

A He-Ne laser has a spectral bandwidth of 8e+05 Hz. Calculate its coherence time and coherence length.

Given:

$\Delta\nu = 8e+05$ Hz

$c = 3 \times 10^8$ m/s

Formula:

$\tau c = 1/\Delta\nu$

$Lc = c\tau c$

Substitute:

$\tau c = 1/(8e+05) = 1.250e-06$ s

$Lc = 3 \times 10^8 \times 1.250e-06 = 375$ m

Answer: τc = 1.250e-06 s; Lc = 375 m

Problem 5

A He-Ne laser has a spectral bandwidth of 1.5e+06 Hz. Calculate its coherence time and coherence length.

Given:

$\Delta\nu = 1.5e+06$ Hz

$c = 3 \times 10^8$ m/s

Formula:

$\tau c = 1/\Delta\nu$

$Lc = c\tau c$

Substitute:

$\tau c = 1/(1.5e+06) = 6.667e-07$ s

$Lc = 3 \times 10^8 \times 6.667e\text{-}07 = 200$ m

Answer: τc = 6.667e-07 s; Lc = 200 m

QUESTION 24

24. A He-Ne laser emits light of wavelength 6328 Å. Calculate the energy of a single photon in Joules.

Given:

$\lambda = 6328$ Å $= 6.328 \times 10^{-7}$ m

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ J s

Formula:

$E = hc/\lambda$

Substitute:

$E = (6.63 \times 10^{-34} \times 3 \times 10^8)/(6.328 \times 10^{-7})$

$E \approx 3.14 \times 10^{-19}$ J

Answer: $E \approx 3.14 \times 10^{-19}$ J

PRACTICE PROBLEM

Problem 1

A He-Ne laser emits light of wavelength 5800 Å. Calculate the energy of a single photon.

Given:

$\lambda = 5800$ Å $= 5.8000e\text{-}07$ m

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ J s

Formula:

$E = hc/\lambda$

Substitute:

$E = (6.63 \times 10^{-34} \times 3 \times 10^{8})/(5.8000e\text{-}07)$

$E = 3.429e\text{-}19$ J

Answer: E ≈ 3.429e-19 J

Problem 2

A He-Ne laser emits light of wavelength 5000 Å. Calculate the energy of a single photon.

Given:

$\lambda = 5000$ Å $= 5.0000e\text{-}07$ m

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ J s

Formula:

$E = hc/\lambda$

Substitute:

$E = (6.63 \times 10^{-34} \times 3 \times 10^{8})/(5.0000e\text{-}07)$

$E = 3.978e\text{-}19$ J

Answer: E ≈ 3.978e-19 J

Problem 3

A He-Ne laser emits light of wavelength 6320 Å. Calculate the energy of a single photon.

Given:

$\lambda = 6320$ Å $= 6.3200e\text{-}07$ m

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ J s

Formula:

$E = hc/\lambda$

Substitute:

$E = (6.63 \times 10^{-34} \times 3 \times 10^{8})/(6.3200e\text{-}07)$

$E = 3.147e\text{-}19$ J

Answer: E ≈ 3.147e-19 J

Problem 4

A He-Ne laser emits light of wavelength 5500 Å. Calculate the energy of a single photon.

Given:

$\lambda = 5500$ Å $= 5.5000e\text{-}07$ m

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ J s

Formula:

$E = hc/\lambda$

Substitute:

$E = (6.63 \times 10^{-34} \times 3 \times 10^{8})/(5.5000e\text{-}07)$

$E = 3.616e\text{-}19$ J

Answer: E ≈ 3.616e-19 J

Problem 5

A He-Ne laser emits light of wavelength 6000 Å. Calculate the energy of a single photon.

Given:

$\lambda = 6000$ Å $= 6.0000e\text{-}07$ m

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ J s

Formula:

$E = hc/\lambda$

Substitute:

$E = (6.63 \times 10^{-34} \times 3 \times 10^{8})/(6.0000e\text{-}07)$

$E = 3.315e\text{-}19$ J

Answer: E ≈ 3.315e-19 J

QUESTION 25

25. A solution of a compound has a concentration of 0.1 M. When placed in a cell of thickness 1 cm, it absorbs 50% of the incident light with an absorbance of 0.301. Calculate its Molar Extinction Coefficient.

Given:

A = 0.301

c = 0.1 M

l = 1 cm

Formula:

$A = \varepsilon cl \Rightarrow \varepsilon = A/(cl)$

Substitute:

$\varepsilon = 0.301/(0.1 \times 1)$

$\varepsilon = 3.01$ L mol^{-1} cm^{-1}

Answer: ε = 3.01 L mol^{-1} cm^{-1}

PRACTICE PROBLEM

Problem 1

A solution of a compound has a concentration of 0.2 M. When placed in a 1 cm cell, it has an absorbance of 0.450. Calculate its Molar Extinction Coefficient.

Given:

A = 0.450

c = 0.2 M

l = 1 cm

Formula:

$A = \varepsilon cl \Rightarrow \varepsilon = A/(cl)$

Substitute:

$\varepsilon = 0.450/(0.2 \times 1)$

$\varepsilon = 2.25\ L\ mol^{-1}\ cm^{-1}$

Answer: $\varepsilon = 2.25\ L\ mol^{-1}\ cm^{-1}$

Problem 2

A solution of a compound has a concentration of 0.05 M. When placed in a 1 cm cell, it has an absorbance of 0.150. Calculate its Molar Extinction Coefficient.

Given:

A = 0.150

c = 0.05 M

l = 1 cm

Formula:

$A = \varepsilon cl \Rightarrow \varepsilon = A/(cl)$

Substitute:

$\varepsilon = 0.150/(0.05 \times 1)$

$\varepsilon = 3\ L\ mol^{-1}\ cm^{-1}$

Answer: $\varepsilon = 3\ L\ mol^{-1}\ cm^{-1}$

Problem 3

A solution of a compound has a concentration of 0.15 M. When placed in a 1 cm cell, it has an absorbance of 0.600. Calculate its Molar Extinction Coefficient.

Given:

A = 0.600

c = 0.15 M

l = 1 cm

Formula:

$A = \varepsilon cl \Rightarrow \varepsilon = A/(cl)$

Substitute:

$\varepsilon = 0.600/(0.15 \times 1)$

$\varepsilon = 4\ L\ mol^{-1}\ cm^{-1}$

Answer: $\varepsilon = 4\ L\ mol^{-1}\ cm^{-1}$

Problem 4

A solution of a compound has a concentration of 0.08 M. When placed in a 1 cm cell, it has an absorbance of 0.240. Calculate its Molar Extinction Coefficient.

Given:

A = 0.240

c = 0.08 M

l = 1 cm

Formula:

$A = \varepsilon cl \Rightarrow \varepsilon = A/(cl)$

Substitute:

$\varepsilon = 0.240/(0.08 \times 1)$

$\varepsilon = 3\ L\ mol^{-1}\ cm^{-1}$

Answer: $\varepsilon = 3\ L\ mol^{-1}\ cm^{-1}$

Problem 5

A solution of a compound has a concentration of 0.12 M. When placed in a 1 cm cell, it has an absorbance of 0.360. Calculate its Molar Extinction Coefficient.

Given:

A = 0.360

c = 0.12 M

l = 1 cm

Formula:

$A = \varepsilon cl \Rightarrow \varepsilon = A/(cl)$

Substitute:

$\varepsilon = 0.360/(0.12 \times 1)$

$\varepsilon = 3\ L\ mol^{-1}\ cm^{-1}$

Answer: $\varepsilon = 3\ L\ mol^{-1}\ cm^{-1}$

QUESTION 26

26. The incident laser has a wavenumber of 20,000 cm^{-1}. The molecule has a Raman shift of 500 cm^{-1}. Find the wavenumbers of the Stokes and Anti-Stokes lines.

Given:

$\tilde{\nu}_i = 20{,}000\ cm^{-1}$

$\Delta\tilde{\nu} = 500\ cm^{-1}$

Formula:

$\tilde{\nu}Stokes = \tilde{\nu}_i - \Delta\tilde{\nu}$

$\tilde{\nu}Anti\text{-}Stokes = \tilde{\nu}_i + \Delta\tilde{\nu}$

Substitute:

$\tilde{\nu}Stokes = 20{,}000 - 500 = 19{,}500\ cm^{-1}$

$\tilde{\nu}$Anti-Stokes = 20,000 + 500 = 20,500 cm^{-1}

Answer: Stokes = 19,500 cm^{-1}; Anti-Stokes = 20,500 cm^{-1}

PRACTICE PROBLEM

Problem 1

The incident laser has a wavenumber of 18,000 cm^{-1}. The molecule has a Raman shift of 400 cm^{-1}.

Find the wavenumbers of the Stokes and Anti-Stokes lines.

Given:

$\tilde{\nu}_i$ = 18,000 cm^{-1}

$\Delta\tilde{\nu}$ = 400 cm^{-1}

Formula:

$\tilde{\nu}$Stokes = $\tilde{\nu}_i$ - $\Delta\tilde{\nu}$

$\tilde{\nu}$Anti-Stokes = $\tilde{\nu}_i$ + $\Delta\tilde{\nu}$

Substitute:

$\tilde{\nu}$Stokes = 18,000 - 400 = 17,600 cm^{-1}

$\tilde{\nu}$Anti-Stokes = 18,000 + 400 = 18,400 cm^{-1}

Answer: Stokes = 17,600 cm^{-1}; Anti-Stokes = 18,400 cm^{-1}

Problem 2

The incident laser has a wavenumber of 25,000 cm^{-1}. The molecule has a Raman shift of 600 cm^{-1}.

Find the wavenumbers of the Stokes and Anti-Stokes lines.

Given:

$\tilde{\nu}_i$ = 25,000 cm^{-1}

$\Delta\tilde{\nu}$ = 600 cm^{-1}

Formula:

$\tilde{\nu}$Stokes = $\tilde{\nu}_i$ - $\Delta\tilde{\nu}$

$\tilde{\nu}$Anti-Stokes = $\tilde{\nu}_i + \Delta\tilde{\nu}$

Substitute:

$\tilde{\nu}$Stokes = 25,000 - 600 = 24,400 cm^{-1}

$\tilde{\nu}$Anti-Stokes = 25,000 + 600 = 25,600 cm^{-1}

Answer: Stokes = 24,400 cm^{-1}; Anti-Stokes = 25,600 cm^{-1}

Problem 3

The incident laser has a wavenumber of 22,000 cm^{-1}. The molecule has a Raman shift of 450 cm^{-1}.

Find the wavenumbers of the Stokes and Anti-Stokes lines.

Given:

$\tilde{\nu}_i$ = 22,000 cm^{-1}

$\Delta\tilde{\nu}$ = 450 cm^{-1}

Formula:

$\tilde{\nu}$Stokes = $\tilde{\nu}_i - \Delta\tilde{\nu}$

$\tilde{\nu}$Anti-Stokes = $\tilde{\nu}_i + \Delta\tilde{\nu}$

Substitute:

$\tilde{\nu}$Stokes = 22,000 - 450 = 21,550 cm^{-1}

$\tilde{\nu}$Anti-Stokes = 22,000 + 450 = 22,450 cm^{-1}

Answer: Stokes = 21,550 cm^{-1}; Anti-Stokes = 22,450 cm^{-1}

Problem 4

The incident laser has a wavenumber of 19,500 cm^{-1}. The molecule has a Raman shift of 550 cm^{-1}.

Find the wavenumbers of the Stokes and Anti-Stokes lines.

Given:

$\tilde{\nu}_i$ = 19,500 cm^{-1}

$\Delta\tilde{\nu}$ = 550 cm^{-1}

Formula:

$\tilde{\nu}_{Stokes} = \tilde{\nu}_i - \Delta\tilde{\nu}$

$\tilde{\nu}_{Anti\text{-}Stokes} = \tilde{\nu}_i + \Delta\tilde{\nu}$

Substitute:

$\tilde{\nu}_{Stokes} = 19{,}500 - 550 = 18{,}950\ cm^{-1}$

$\tilde{\nu}_{Anti\text{-}Stokes} = 19{,}500 + 550 = 20{,}050\ cm^{-1}$

Answer: Stokes = 18,950 cm^{-1}; Anti-Stokes = 20,050 cm^{-1}

Problem 5

The incident laser has a wavenumber of 21,000 cm^{-1}. The molecule has a Raman shift of 500 cm^{-1}.

Find the wavenumbers of the Stokes and Anti-Stokes lines.

Given:

$\tilde{\nu}_i = 21{,}000\ cm^{-1}$

$\Delta\tilde{\nu} = 500\ cm^{-1}$

Formula:

$\tilde{\nu}_{Stokes} = \tilde{\nu}_i - \Delta\tilde{\nu}$

$\tilde{\nu}_{Anti\text{-}Stokes} = \tilde{\nu}_i + \Delta\tilde{\nu}$

Substitute:

$\tilde{\nu}_{Stokes} = 21{,}000 - 500 = 20{,}500\ cm^{-1}$

$\tilde{\nu}_{Anti\text{-}Stokes} = 21{,}000 + 500 = 21{,}500\ cm^{-1}$

Answer: Stokes = 20,500 cm^{-1}; Anti-Stokes = 21,500 cm^{-1}

QUESTION 27

27. If we shine a laser of 22,000 cm^{-1} on a sample, a new light comes out at 21,200 cm^{-1}. What is the Raman shift?

Given:

$\tilde{\nu}_i = 22{,}000\ cm^{-1}$

$\tilde{\nu}_s = 21{,}200\ cm^{-1}$

Formula:

$\Delta\tilde{\nu} = |\tilde{\nu}_i - \tilde{\nu}_s|$

Substitute:

$\Delta\tilde{\nu} = |22{,}000 - 21{,}200| = 800\ cm^{-1}$

Answer: $\Delta\tilde{\nu} = 800\ cm^{-1}$

PRACTICE PROBLEM

Problem 1

Incident laser wavenumber = 20,500 cm^{-1}; scattered light wavenumber = 19,900 cm^{-1}. Find the Raman shift.

Given:

$\tilde{\nu}_i = 20{,}500\ cm^{-1}$

$\tilde{\nu}_s = 19{,}900\ cm^{-1}$

Formula:

$\Delta\tilde{\nu} = |\tilde{\nu}_i - \tilde{\nu}_s|$

Substitute:

$\Delta\tilde{\nu} = |20{,}500 - 19{,}900|$

$\Delta\tilde{\nu} = 600\ cm^{-1}$

Answer: $\Delta\tilde{\nu} = 600\ cm^{-1}$

Problem 2

Incident laser wavenumber = 23,000 cm^{-1}; scattered light wavenumber = 22,300 cm^{-1}. Find the Raman shift.

Given:

$\tilde{\nu}_i = 23{,}000\ cm^{-1}$

$\tilde{\nu}_s = 22{,}300\ cm^{-1}$

Formula:

$\Delta\tilde{\nu} = |\tilde{\nu}_i - \tilde{\nu}_s|$

Substitute:

$\Delta\tilde{\nu} = |23{,}000 - 22{,}300|$

$\Delta\tilde{\nu} = 700\ cm^{-1}$

Answer: $\Delta\tilde{\nu} = 700\ cm^{-1}$

Problem 3

Incident laser wavenumber = 21,500 cm^{-1}; scattered light wavenumber = 20,900 cm^{-1}. Find the Raman shift.

Given:

$\tilde{\nu}_i = 21{,}500\ cm^{-1}$

$\tilde{\nu}_s = 20{,}900\ cm^{-1}$

Formula:

$\Delta\tilde{\nu} = |\tilde{\nu}_i - \tilde{\nu}_s|$

Substitute:

$\Delta\tilde{\nu} = |21{,}500 - 20{,}900|$

$\Delta\tilde{\nu} = 600\ cm^{-1}$

Answer: $\Delta\tilde{\nu} = 600\ cm^{-1}$

Problem 4

Incident laser wavenumber = 19,800 cm^{-1}; scattered light wavenumber = 19,200 cm^{-1}. Find the Raman shift.

Given:

$\tilde{\nu}_i = 19{,}800\ cm^{-1}$

$\tilde{\nu}_s = 19{,}200\ cm^{-1}$

Formula:

$\Delta\tilde{\nu} = |\tilde{\nu}_i - \tilde{\nu}_s|$

Substitute:

$\Delta\tilde{\nu} = |19{,}800 - 19{,}200|$

$\Delta\tilde{\nu} = 600\ cm^{-1}$

Answer: $\Delta\tilde{\nu} = 600\ cm^{-1}$

Problem 5

Incident laser wavenumber = 22,500 cm^{-1}; scattered light wavenumber = 21,900 cm^{-1}. Find the Raman shift.

Given:

$\tilde{\nu}_i = 22{,}500\ cm^{-1}$

$\tilde{\nu}_s = 21{,}900\ cm^{-1}$

Formula:

$\Delta\tilde{\nu} = |\tilde{\nu}_i - \tilde{\nu}_s|$

Substitute:

$\Delta\tilde{\nu} = |22{,}500 - 21{,}900|$

$\Delta\tilde{\nu} = 600\ cm^{-1}$

Answer: $\Delta\tilde{\nu} = 600\ cm^{-1}$