

Physics 30 – Lesson 12 Diffraction Gratings

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Practice problems

1) $\lambda = 700 \times 10^{-9} \text{ m}$
 $n = 3$

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

/4 $\theta = ?$

$$d = \frac{1}{200000} \text{ m}$$

$$\theta = \sin^{-1} \frac{3(700 \times 10^{-9} \text{ m})}{\left(\frac{1}{200000}\right)}$$

$$\boxed{\theta = 24.8^\circ}$$

2) $\lambda = 6.00 \times 10^{-7} \text{ m}$
 $l = 1.50 \text{ m}$

$$\lambda = \frac{dx}{nl}$$

/4 $n = 2$

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

$x_2 = 0.463 \text{ m}$

$$d = \frac{2(6.00 \times 10^{-7} \text{ m})(1.50 \text{ m})}{0.463 \text{ m}}$$

$d = ?$

$$d = 3.89 \times 10^{-6} \text{ m}$$

$$\frac{1}{3.89 \times 10^{-6} \text{ m}} = 2.57 \times 10^5 \frac{\text{lines}}{\text{m}} = \boxed{2.57 \times 10^3 \frac{\text{lines}}{\text{cm}}}$$

Assignment

1) $\lambda = 5000 \text{ \AA} = 5.0 \times 10^{-7} \text{ m}$
 $n = 2$

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

/5 $\theta = 32^\circ$

$$d = \frac{2(5.0 \times 10^{-7} \text{ m})}{\sin 32^\circ}$$

$d = ?$

$$d = 1.89 \times 10^{-6} \text{ m}$$

$$\frac{1}{1.89 \times 10^{-6} \text{ m}} = 530000 \frac{\text{lines}}{\text{m}}$$

$$= \boxed{5300 \frac{\text{lines}}{\text{cm}}}$$

2) $\lambda = 5.30 \times 10^{-7} \text{ m}$
 $n = 2 \rightarrow \text{minimum}$

$$d = \frac{(n - \frac{1}{2})\lambda}{\sin \theta}$$

/4 $\theta = 16.0^\circ$

$$d = \frac{(2 - \frac{1}{2})(5.30 \times 10^{-7} \text{ m})}{\sin(16^\circ)}$$

$d = ?$

$$d = 2.88 \times 10^{-6} \text{ m}$$

$$\frac{1}{2.88 \times 10^{-6} \text{ m}} = \boxed{3.47 \times 10^5 \frac{\text{lines}}{\text{m}}}$$

3) $\lambda = 6.50 \times 10^{-7} \text{ m}$
 $d = \frac{1}{15000}$
 /4 $d = 6.67 \times 10^{-5} \text{ m}$
 $L = 4.9 \text{ m}$
 $\Delta x = ? \quad (n=1)$

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

$$\Delta x = \frac{(6.50 \times 10^{-7} \text{ m})(4.9 \text{ m})}{(6.67 \times 10^{-5} \text{ m})}$$

$$\boxed{\Delta x = 4.8 \text{ cm}}$$

4) $f = 5.0 \times 10^{14} \text{ Hz}$
 /4 $\lambda = \frac{c}{f} = \frac{3.00 \times 10^8 \text{ m/s}}{5.0 \times 10^{14} \text{ Hz}}$
 $\lambda = 6.0 \times 10^{-7} \text{ m}$
 $n = 3$
 $\theta = ?$

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

$$\theta = \sin^{-1} \frac{3(6.0 \times 10^{-7} \text{ m})}{\left(\frac{1}{420000}\right)}$$

$$\boxed{\theta = 49^\circ}$$

$$d = \frac{1}{420000} \text{ m}$$

5) $d = \frac{1}{10^5} \text{ m}$
 /3 $\lambda = 7.0 \times 10^{-7} \text{ m}$
 $\theta = 90^\circ$
 $n = ?$

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

$$n = \frac{\left(\frac{1}{10^5} \text{ m}\right) (\sin 90^\circ)}{7.0 \times 10^{-7} \text{ m}}$$

$$\boxed{n = 14}$$

6) $L = 4.0 \text{ m}$
 $\Delta x = ?$
 /6 $d = \frac{1}{18000} \text{ m}$

$$v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m/s}}{1.33}$$

$$v = 2.26 \times 10^8 \text{ m/s}$$

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

$$\Delta x = \frac{4.51 \times 10^{-7} \text{ m}(4.0 \text{ m})}{\left(\frac{1}{18000} \text{ m}\right)}$$

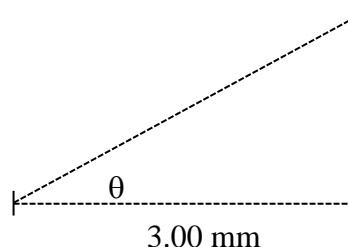
$$\boxed{\Delta x = 3.2 \text{ cm}}$$

$$\lambda = \frac{v}{f} = \frac{2.26 \times 10^8 \text{ m/s}}{5.0 \times 10^{14} \text{ Hz}}$$

$$\lambda = 4.51 \times 10^{-7} \text{ m}$$

7) $\lambda = 7.90 \times 10^{-7} \text{ m}$
 $n = 1$
 /5 $x = 1.20 \text{ mm} = 0.00120 \text{ m}$
 $L = 0.00300 \text{ m}$

Note that x is quite large compared to L.
 From the geometry we can calculate θ .



$$\theta = \tan^{-1} \left(\frac{1.20}{3.00} \right)$$

$$\theta = 21.8^\circ$$

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

$$d = \frac{(1)7.90 \times 10^{-7} \text{ m}}{\sin 21.8}$$

$$\boxed{d = 2.13 \times 10^{-6} \text{ m}}$$

8)	$f = 5.50 \times 10^{14} \text{ Hz}$	3rd bright band	5th dark band
	$\lambda = 5.45 \times 10^{-7} \text{ m}$	$x = \frac{n\lambda L}{d}$	$x = \frac{(n - \frac{1}{2})\lambda L}{d}$
	$d = \frac{1}{6000} \text{ m}$	$x_3 = \frac{3(5.45 \times 10^{-7} \text{ m})(2.50 \text{ m})}{(\frac{1}{6000} \text{ m})}$	$x = \frac{(5 - \frac{1}{2})(5.45 \times 10^{-7} \text{ m})(2.50 \text{ m})}{(\frac{1}{6000} \text{ m})}$
/5	$L = 2.50 \text{ m}$	$x_3 = 0.0245 \text{ m}$	$x_{5-\frac{1}{2}} = 0.0368 \text{ m}$

$$\Delta x = x_{5-\frac{1}{2}} - x_3 = 0.0368 \text{ m} - 0.0245 \text{ m}$$

$$\boxed{\Delta x = 1.23 \text{ cm}}$$

9)	$d = \frac{1}{62000} \text{ m}$	$\lambda = \frac{d\Delta x}{L}$	$f = \frac{c}{\lambda}$
	$\Delta x = 0.0522 \text{ m}$	$\lambda = \frac{(\frac{1}{62000} \text{ m})(0.0522 \text{ m})}{1.50 \text{ m}}$	$f = \frac{3.0 \times 10^8 \text{ m/s}}{5.61 \times 10^{-7} \text{ m}}$
/4	$L = 1.50 \text{ m}$	$\lambda = 5.61 \times 10^{-7} \text{ m}$	$f = 5.3 \times 10^{14} \text{ Hz}$
	$\lambda = ?$		

10)	$\Delta x = ?$	$\Delta x = \frac{\lambda L}{d}$
	$d = \frac{1}{93000} \text{ m}$	$\Delta x = \frac{5.61 \times 10^{-7} \text{ m}(1.50 \text{ m})}{(\frac{1}{93000} \text{ m})}$
/3		$\Delta x = 0.0783 \text{ m}$

11)	$L = 3.00 \text{ m}$	$\Delta x = \frac{\lambda L}{d}$
/3		$\Delta x = \frac{5.61 \times 10^{-7} \text{ m}(3.0 \text{ m})}{(\frac{1}{62000} \text{ m})}$
		$\Delta x = 0.104 \text{ m}$

12)	$\lambda = 7.02 \times 10^{-7} \text{ m}$	$\Delta x = \frac{\lambda L}{d}$
/3		$\Delta x = \frac{7.02 \times 10^{-7} \text{ m}(1.50 \text{ m})}{(\frac{1}{62000} \text{ m})}$
		$\Delta x = 0.065 \text{ m}$