

5-14. $\lambda = \frac{D \sin \phi}{n}$ (Equation 5-6)

For 54 eV electrons $\lambda = 0.165 \text{ nm}$ and $\sin \phi = (0.165 \text{ nm})n/0.215 \text{ nm} = 0.767n$

For $n = 2$ and larger $\sin \phi > 1$, so no values of n larger than one are possible.

5-17. (a) $y = y_1 + y_2$

$$= 0.002m \cos(8.0x/m - 400t/s) + 0.002m \cos(7.6x/m - 380t/s)$$

$$= 2(0.002m) \cos\left[\frac{1}{2}(8.0x/m - 7.6x/m) - \frac{1}{2}(400t/s - 380t/s)\right] \\ \times \cos\left[\frac{1}{2}(8.0x/m + 7.6x/m) - \frac{1}{2}(400t/s + 380t/s)\right]$$

$$= 0.004m \cos(0.2x/m - 10t/s) \times \cos(7.8x/m - 390t/s)$$

(b) $v = \frac{\bar{\omega}}{\bar{k}} = \frac{390/s}{7.8/m} = 50 \text{ m/s}$

(c) $v_g = \frac{\Delta\omega}{\Delta k} = \frac{20/s}{0.4/m} = 50 \text{ m/s}$

(d) Successive zeros of the envelope requires that $0.2 \Delta x/m = \pi$, thus $\Delta x = \frac{\pi}{0.2} = 5\pi \text{ m}$ with

5-18. (a) $v = f\lambda$ Thus, $\frac{dv}{d\lambda} = f + \lambda \frac{df}{d\lambda}$, multiplying by λ , $\lambda \frac{dv}{d\lambda} = \lambda f + \lambda^2 \frac{df}{d\lambda} = v + \frac{\lambda^2}{2\pi} \frac{d\omega}{d\lambda}$

$$- \frac{\lambda^2}{2\pi} \frac{d\omega}{d\lambda} = v - \lambda \frac{dv}{d\lambda} \text{ Because } k = 2\pi/\lambda, dk = -(2\pi/\lambda^2)d\lambda \text{ and}$$

$$\frac{d\omega}{dk} = v_g = v - \lambda \frac{dv}{d\lambda}$$

(b) v decreases as λ decreases. $dv/d\lambda$ is positive.

5-19. (a) $c = f\lambda = \lambda/T \rightarrow T = \lambda/c = 2 \times 10^{-2} m / 3 \times 10^8 m/s = 6.7 \times 10^{-11} s/wave$

The number of waves $= 0.25 \mu s / (6.7 \times 10^{-11} s/wave) = 3.73 \times 10^3$

Length of the packet $= (\# \text{ waves})(\lambda) = 2 \times 10^{-2} m (3.73 \times 10^3) = 74.6 m$

(b) $f = c/\lambda = (3 \times 10^8 m/s) / 2 \times 10^{-2} m = 1.50 \times 10^{10} Hz$

(c) $\Delta\omega\Delta t \approx 1 \rightarrow \Delta\omega \approx 1/\Delta t = 1/0.25 \times 10^{-6} s = 4.0 \times 10^6 rad/s = 637 kHz$