Tutorial 4

P32 $\lambda = 2 \times 0.53 Å$ $\quad (r = 0.53 Å, \ \lambda = 2r)$

$$\lambda = \frac{h}{\sqrt{2mKE}} \qquad KE = k_B T \qquad , m = 1.66 \times 10^{-27}$$

$k_B = 1.38 \times 10^{-23}$

$T \approx 852.85 K$

P33 $\vec{k_1} = (\hat{i} + \hat{j} + \hat{k}) \frac{2\pi}{\lambda}$

$\vec{k_2} = \frac{2\pi}{\lambda} \hat{k}$

$y_1 = A e^{i(\vec{k_1} \cdot \vec{r_1} - \omega t)}$, $y_2 = A e^{i(\vec{k_2} \cdot \vec{r_2} - \omega t)}$.

Assuming the disturbances are parallel

$y = y_1 + y_2$

Since interference occurs when they superpose at the same point in space

$\vec{r_1} = \vec{r_2} = x\hat{i} + y\hat{j} + z\hat{k} = \vec{r}$

$$y = A\left(e^{i(x+y+z)\frac{2\pi}{\lambda} - \omega t} + e^{\left[i(z)\frac{2\pi}{\lambda} - \omega t\right]}\right)$$

$I \propto |y|^2 = yy^*$

$$\therefore I \propto A^2 \left(1 + 1 + e^{i(\vec{k_1} - \vec{k_2}) \cdot \vec{r}} + e^{-i(\vec{k_1} - \vec{k_2}) \cdot \vec{r}}\right).$$

$$I \propto 2A^2 \left(1 + \cos\left(\frac{2\pi}{\lambda}\left[(\hat{i} + \hat{j}) \cdot (x\hat{i} + y\hat{j} + z\hat{k})\right]\right)\right)$$

$$I \propto 2A^2 \left(1 + \cos\left(\frac{2\pi}{\lambda}(x+y)\right)\right)$$

P 34 $d = 0.0005\ m$

$D = 2\ m$

$\lambda = 5.89 \times 10^{-7}\ m$

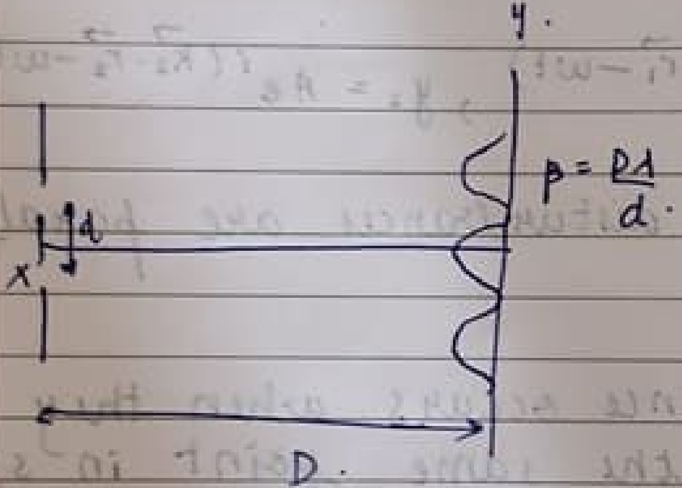
$\beta = \frac{D\lambda}{d} = 2.348 \times 10^{-3} \approx 0.00233\ m$

P 35. $d \sin\theta = n\lambda$

$\sin\theta = \frac{\lambda}{d}$ $\quad \theta = 1.262^\circ$

P 36

(a)



(b) $\beta = 5\ mm$

$d = 0.8\ mm$

$D = 1.6\ m$

$\beta = \frac{D\lambda}{d}$

$\lambda = 2.5\ \mu m$

?

(c) $\mu t - t = d \sin\theta$

$t = \frac{11 \times 10^{-6}}{0.8}$

$t = 13.75\ \mu m$

(d) $n\lambda_1 = \left(\frac{2m-1}{2}\right)\lambda_2$ $\quad \left(\begin{array}{l}\lambda_1 = 450 \\ \lambda_2 = 600\end{array}\right)$

$m = 2, n = 2$ $\therefore$ 2^{nd} max & 2^{nd} min

Generated by CamScanner

P37 a) $\lambda = \frac{h}{\sqrt{2mKE}}$ — (1)

$d \sin\theta = n\lambda$ — (2)

$n = 1 \qquad m = 9.1 \times 10^{-31}$

$E = 54\,eV \qquad \theta = 50°$

On solving, $d = 2.18\,Å$.

(b) $\sin\theta \propto \lambda \propto \frac{1}{\sqrt{E}}$

$\therefore \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sqrt{E_2}}{\sqrt{E_1}}$

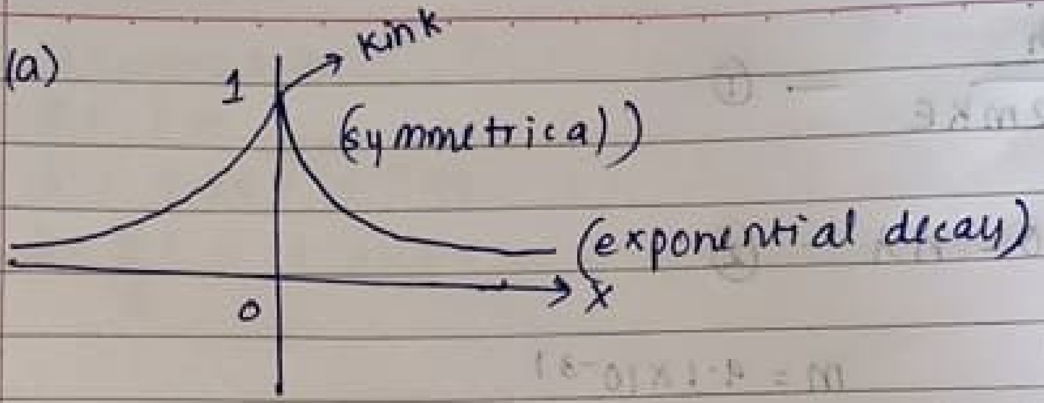
$\therefore \frac{\sin 50° \times \sqrt{54}}{\sqrt{100}} = \sin\theta_2$

(c) $\frac{\sqrt{E_2}}{\sqrt{E_1}} \propto \frac{\lambda_1}{\lambda_2} \propto \frac{\sqrt{m_2}}{\sqrt{m_1}}$

$\therefore \frac{E_2}{E_1} = \frac{m_2}{m_1}$

$\frac{E_2}{54} = \frac{m_{He}}{m_e}$

P38. (a)



(b) $f(x)|_{max} = 1$

$$\frac{1}{2} = e^{-\alpha|x|}$$

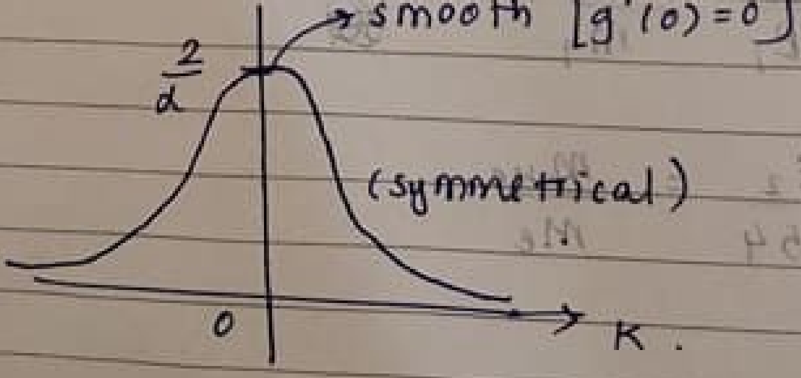
$$\Rightarrow |x| = \frac{\ln 2}{\alpha}$$

(c) $$g(k) = \int_{-\infty}^{\infty} f(x)\, e^{ikx}\, dx$$

$$= \int_{-\infty}^{0} e^{(\alpha+ik)x}\, dx + \int_{0}^{\infty} e^{-(\alpha+ik)x}\, dx$$

$$g(k) = \frac{1}{\alpha+ik} + \frac{1}{\alpha-ik} = \frac{2\alpha}{\alpha^2+k^2}.$$

(d)



Camlin Page
Date / /

(e) $g(k)\Big|_{max} = \frac{2}{\alpha}.$ $\qquad \frac{1}{2} g(k)\Big|_{max} = \frac{1}{\alpha}$

$\frac{1}{\alpha} = \frac{2\alpha}{\alpha^2 + k^2} \qquad k^2 = \alpha^2 , \qquad k = \pm \alpha$

(f) $\Delta x = \frac{2 \ln 2}{\alpha} \qquad \Delta k = 2\alpha$

$\Delta x \cdot \Delta k = 4 \ln 2 = 2.77$