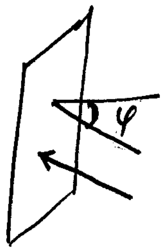
1.1 Дано: $\sigma = 1\,см^2$; $R = 0{,}5$; $\varphi = 45^\circ$, $\omega = 10^2$ Дж/см^3

Найти: F_τ

Решение:



$$P_n = \frac{F_n}{S} = \omega \cdot \cos^2\varphi(1+r)$$

$$P_\tau = \frac{F_\tau}{S} = \omega\cos\varphi(\sin\varphi + r\sin\varphi) =$$

$$= \omega\frac{\sin 2\varphi}{2}(1+r)$$

$$F_\tau = S\omega\,\frac{\sin 2\varphi}{2}(1-r) =$$

$$= 10^{-4}\cdot 10^2\cdot 10^6\cdot \frac{1}{2}\cdot\frac{1}{2} = 2500\ Н$$

1.2 Дано: $E_y(x,t) = E_0\sin(kx)\cos(\omega t)$

Найти: $B_z(x,t)$

Решение: $E_y = cB_z$; $\frac{\partial H_z}{\partial x} = -\varepsilon_0\frac{\partial E_y}{\partial t}$

$$= \varepsilon_0\omega E_0\sin(kx)\sin(\omega t)$$

$$H_z = -\varepsilon_0 E_0\frac{\omega}{k}\sin(\omega t)\cos(kx)$$

$$\frac{\omega}{k} = v = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = c$$

$$B_z = \mu_0 H_z = -\mu_0 c\,\varepsilon_0 E_0\sin(\omega t)\cos(kx)$$

1.3 Дано: $E_y(x,t) = E_0\sin(kx)\cos(\omega t)$

Найти: S_x

Решение: $\frac{\partial H}{\partial x} = -\varepsilon_0\frac{\partial E}{\partial t} \Rightarrow$

$$H = \sqrt{\frac{\varepsilon_0}{\mu_0}}E_0\sin(\omega t)\cos(kx)$$

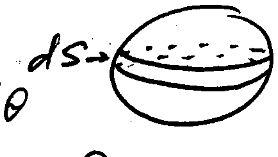
$$\bar{S} = [\bar{E}\times\bar{H}]$$

$$S = \frac{1}{4}\sqrt{\frac{\varepsilon_0}{\mu_0}}E_0^2\sin(2\omega t)\sin(2kx)$$

1.4 Дано: $E = 200$ В/м, $R = 50$ см, $t = 1$ мин

Найти: W

Решение:



$$ds = r^2\sin\theta\,d\varphi\,d\theta$$

$$dW = \langle k\rangle ds\cdot\tau\cos\theta \Rightarrow$$

$$W = \int_0^{2\pi}d\varphi\int_0^{\pi/2}d\theta\langle k\rangle\tau R^2\sin\theta\cos\theta$$

$$= \frac{1}{2}\pi R^2\langle k\rangle\tau$$

$$\langle k\rangle = c\cdot\frac{1}{2}\cdot\varepsilon_0 E_0^2$$

$$W = \frac{1}{2}\pi R^2 c\frac{1}{2}\varepsilon_0 E^2\cdot\tau =$$

$$= \frac{1}{4}\pi R^2E^2c\,\varepsilon_0\tau =$$

$$= \frac{1}{4}\cdot 3{,}14\cdot\frac{1}{4}\cdot 4\cdot 10^4\cdot 3\cdot 10^8\cdot 8{,}85\cdot 10^{-12}\cdot 60$$

1.5 Дано: ω, $R = 1$

Найти: P

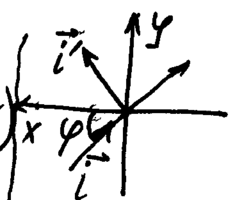
Решение: $P = (1+R)\omega\cos^2\varphi$

$\varphi = 0^\circ \Rightarrow P = 2\omega$

1.6 Дано: ω, $\varphi = 60^\circ$, a, ρ, τ

Найти: $\vec{F}$

Решение:



$$N_{пад} = N\rho + N\tau + N(1-\rho-\tau)$$

$$P_1 = \frac{h\nu}{c}\cdot N\cdot S\cdot c\cdot\Delta t\cos\varphi$$

$$P_2 = \frac{h\nu}{c}\cdot NSc\Delta t\rho\cos\varphi\cdot\vec{i}' +$$

$$+ \frac{h\nu}{c}N\tau c\Delta t\cos\varphi\cdot\vec{i};\quad h\nu N = \omega$$

$$F = \omega S\Delta t\cos\varphi(\tau\vec{i} + \rho\vec{i}' - \vec{i}) =$$

$$= \omega S\cos\varphi\,\vec{i}(\tau-1)(\vec{i}'\rho+1)$$

$$F_x = \Delta t\omega S\cos\varphi(-\cos\varphi(\tau-1) + \rho\cos\varphi)$$

$$F_y = \Delta t\omega S\cos\varphi(\cos\varphi(\tau-1) + \rho\cos\varphi)$$

$$|F| = \sqrt{F_x^2 + F_y^2};\quad tg(\hat{n,F}) = F_y/F_x$$

(1.7) Дано: $t = 0{,}5$ мс, $W = 1$ Дж, $S = 1\,см^2$, $r = 0{,}1$

Найти: F

Решение: $\omega = \dfrac{W}{cS\Delta t}$.

$p = \omega(1+r)\cos^2\varphi, \quad \varphi = 0^\circ$

$F = (W/sc\Delta t)(1+r)\cdot S =$

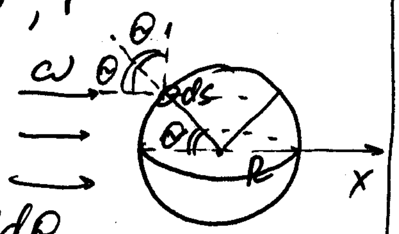
$= \dfrac{W}{c\Delta t}(1+r) = \dfrac{1}{3\cdot 10^8\cdot 0{,}5\cdot 10^{-3}}\cdot 1{,}1 =$

$= 0{,}73\cdot 10^{-5}$ Н

(1.8) Дано: R, ω, r

Найти: F

Решение:



$dS = R^2 \sin\theta\, d\varphi\, d\theta$

$p = (1+r)\omega\cos^2\theta$

$dF' = p\,dS = (1+r)\omega\cos^2\theta R^2\sin\theta\, d\varphi\, d\theta$

$dF = \cos\theta\cdot dF'$

$F = -\int_0^{\pi/2} 2\pi R^2\omega(1+r)\cos^3\theta \underbrace{\sin\theta\, d\theta}_{d\cos\theta} =$

$= -\dfrac{2(1+r)R^2\omega\cos^4\theta}{4}\Big|_0^{\pi/2} =$

$= \dfrac{(1+r)}{2}\cdot\pi R^2\omega$

(1.9) Дано: $H, 2\alpha, \omega$

Найти: F

Решение: $p_{пад} = \dfrac{\hbar\omega}{c} N S c\Delta t \cos\alpha$

$dS_{бок} = \pi(R+r)l$

$r = x\,tg\alpha, \quad R = (x+\Delta x)\,tg\alpha$

$l = \Delta x\cos\alpha$

$dS = \pi((x+\Delta x)tg\alpha + x\,tg\alpha)\dfrac{\Delta x}{\cos\alpha} =$

$= \pi\,tg\alpha\cos\alpha\cdot 2x\,dx$

$S = \int_0^h dS = \dfrac{\pi H\,tg\alpha}{\cos\alpha}$

$P_{отраж} = P_{пад}\cdot\cos 2\alpha \Rightarrow \Delta P = P_{пад}(1-\cos 2\alpha)$

$= F = N\pi\hbar\omega H\,tg\alpha(1-\cos 2\alpha) =$

$= \omega\pi H\,tg\alpha(1-\cos 2\alpha)$

(1.10) Дано: $\tau = 0{,}16$ мкс, $W = 10$ Дж, $D = 1$ мм, $\alpha = 30^\circ$, $R = 0{,}87$

Найти: P

$\omega = \dfrac{W}{cS\Delta t} = \dfrac{W}{c\Delta t\cdot\frac{\pi D^2}{4}}$

$P = \omega(1+R)\cos^2\varphi, \quad \varphi = 30^\circ$

$P = \dfrac{W4(1+R)}{c\Delta t\,\pi D^2}\cdot\dfrac{3}{4} = \dfrac{10\cdot 1{,}87\cdot 3}{3\cdot 10^8\cdot 0{,}16\cdot 10^{-6}\times 3{,}14\cdot 10^{-6}}$

$=$

(1.11) Дано: $\tau = 0{,}16$ мкс, $W = 10$ Дж

$D = 1$ мм

Найти: E_{max}, B_{max}

Решение: $I = \frac{W}{\Delta t \cdot S}$, $I = \langle k \rangle \cdot t$

$\langle k \rangle = C\varepsilon_0 E^2/2$; $\frac{W}{\Delta t \cdot S} = \frac{C\varepsilon_0 E^2 t}{2}$

$\Rightarrow E = \frac{1}{t}\sqrt{\frac{2W}{SC\varepsilon_0}}$

$E = CB$

(1.12) Дано: $\vec{E} = \vec{E}_0 \cos(\omega t - \vec{k}\vec{r})$, $\vec{k}$

Найти: $\vec{H}(t)$, $\vec{r} = 0$ $\vec{E}$

Решение: $\vec{B} = B_0 \frac{[\vec{k}\,\vec{E}]}{|\vec{k}|\cdot|\vec{E}|}$;

$|\vec{E}_0| = c|\vec{B}_0|$

$\vec{B} = \frac{E_0}{c} \cdot \frac{[\vec{k}\,\vec{E}]}{|\vec{k}||\vec{E}|}\cos(\omega t - \vec{k}\vec{r})$

$\vec{H} = \frac{\vec{B}}{\mu_0}$

(1.13) Дано: a, R, $\varphi = 45°$, I

Найти: F_n, F_τ

Решение: $\omega = \frac{W}{Sct}$

$I = \frac{W}{St} \Rightarrow I = \omega C$

$\Rightarrow \omega = \frac{I}{C}$, $S = a^2$

$F_n = \omega S \cos^2\varphi\,(1+R)$

$F_\tau = \omega S(1-R)\frac{\sin 2\varphi}{2}$

(1.14) Дано: ω, φ, R, $S = 1$

Найти: F_τ

Решение:

$F_\tau = \frac{\omega S(1-R)\sin 2\varphi}{2}$

(1.15) Дано: $\tau = 0{,}5$ мс,

$W = 1$ Дж, $S = 1$ см^2

Найти: E_0, B_0

Решение: $I = \frac{W}{tS}$,

$I = \langle k \rangle \cdot t$, $\langle k \rangle = \frac{C\varepsilon_0 E_0^2}{2}$

$\frac{W}{tS} = \frac{C\varepsilon_0 E_0^2 t}{2} \Rightarrow$

$E_0 = \frac{1}{t}\sqrt{\frac{2W}{SC\varepsilon_0}}$

$= \frac{1}{0{,}5\cdot 10^{-3}}\sqrt{\frac{2\cdot 1}{10^{-4}\cdot 3\cdot 10^{8}\cdot 8{,}85\cdot 10^{-12}}}$

$=$

2.1

λ, α, τ, L

$x_7 - ?$

Полосы одинаковой толщины $\Rightarrow$

$x = 6x_{свет} + 6x_{темн}$

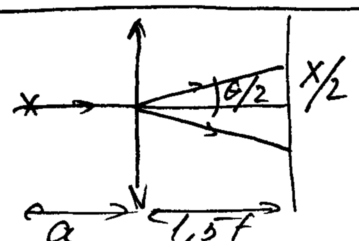
$x_{свет} = x_{темн}$ $\quad x = 6 \cdot \Delta x$

$$\Delta x = \frac{\lambda(L+\tau)}{2\tau\alpha} \qquad x = \frac{3\lambda(L+\tau)}{\tau\alpha}$$

2.2.

$f = 10$ см
$d = 0{,}5$ см
$\lambda = 500$ нм
$a = 5$ см
$1{,}5f$

$N - ?$



$$\frac{\Theta}{2} = \frac{d}{2 \cdot a} \qquad \Theta = \frac{d}{a}$$

$$x_{m+1} - x_m = \frac{\lambda}{\Theta} = \frac{\lambda a}{d}$$

$$x = \Theta \cdot 1{,}5f = \frac{1{,}5fd}{a}$$

$$N = \frac{x}{x_{m+1} - x_m} = \frac{1{,}5f d \cdot d}{a \cdot \lambda a} =$$

$$= \frac{1{,}5 \cdot 0{,}1 \cdot 0{,}5^2}{5^2 \cdot 500 \cdot 10^{-9}} = 3000$$

2.3

$\lambda = 600$ нм
$f = 60$ мм
$R_6 = 6$ мм

$m - ?$

$$2h\cos\varphi = m\lambda$$

$$\varphi = \frac{R_6}{f}$$

В центре: $(m+6)\lambda = 2h.$

$$(m+6) = \frac{m}{\cos\varphi}$$

$$m = \frac{6\cos\varphi}{1 - \cos\varphi} = \frac{6 \cdot \cos\frac{R_6}{f}}{1 - \cos\frac{R_6}{f}} = 3{,}9 \cdot 10^6$$

2.4

$\lambda = 5000$ Å
$f = 10$ см
$d = 0{,}5$ мм
$N = 5$

$a - ?$

$$\Theta = \frac{d}{F} \qquad x = \Theta \cdot a$$

$$\Delta x = \frac{\lambda}{\Theta} = \frac{\lambda F}{d}$$

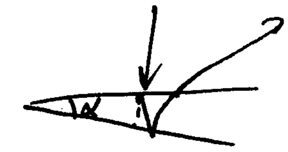
$$N = \left(\frac{\Delta x}{x}\right)^{-1} = \left(\frac{\lambda F \cdot F}{d \cdot d \cdot a}\right)^{-1}$$

$$a = \frac{\lambda F^2}{d^2} N = \frac{500 \cdot 10^{-9} \cdot 0{,}1^2 \cdot 5}{0{,}5^2 \cdot 10^{-6}} = 10 \text{ см}$$

2.5

$\alpha = 10^{-3}$ рад
$\lambda = 500$ нм
$x = 10$ см
$V = \frac{2}{\pi} = 0{,}637$

$\Delta\lambda - ?$



$$\Delta = 2x\sin\alpha$$

$$\nu = \frac{c}{\lambda}$$

$$\delta\nu = \frac{c\,\delta\lambda}{\lambda^2}$$

$$V = \left|\operatorname{sinc}\frac{\delta\omega}{2}\tau\right| = \left|\operatorname{sinc}\frac{2\pi}{c}\frac{\delta\nu}{2}\Delta\right|$$

$$\frac{2}{\pi} = \operatorname{sinc}\frac{\pi\,\delta\lambda}{\lambda^2}\Delta$$

$$\frac{2\pi\,\delta\lambda}{\lambda^2}x\sin\alpha = \frac{\pi}{2}$$

$$\delta\lambda = \frac{\lambda^2}{4x\sin\alpha} = \frac{(5 \cdot 10^{-7})^2}{4 \cdot 0{,}1 \cdot 10^{-3}} = 6{,}2 \text{ Å}$$

2.6

$\lambda = 5000$ Å
$n = 1{,}5$
$\alpha = 1'$
$\frac{\lambda}{\Delta\lambda} = 100$

$x - ?$

$$\Delta = 2xn\sin\alpha = m\lambda$$

$$\frac{\lambda}{\Delta\lambda} = m_{max}$$

$$2xn\sin\alpha = \frac{\lambda}{\Delta\lambda}\lambda$$

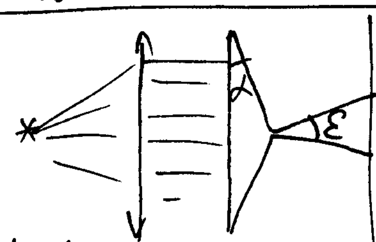
$$x = \frac{\lambda^2}{2\Delta\lambda \cdot n\sin\alpha} =$$

$$= \frac{5000 \cdot 10^{-10} \cdot 100}{2 \cdot 1{,}5 \sin 1/60} = 0{,}057 = 6 \text{ см}.$$

2.7

λ, α, n, L

$\frac{\lambda}{\Delta\lambda}$



$$\varepsilon = (n-1)\alpha$$

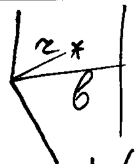
$$\Delta x = \frac{\lambda}{\varepsilon} = \frac{\lambda}{(n-1)\alpha}$$

$$\frac{L}{2} = m\Delta x \qquad \Delta\lambda = \frac{\lambda}{m}$$

$$\frac{\lambda}{\Delta\lambda} = m = \frac{L}{2\Delta x} = \frac{L(n-1)\alpha}{2\lambda}$$

2.8

$r = 10$ см
$b = 120$ см
$\lambda = 5500$ Å
$D_{max} = 0{,}5$ мм
$\varphi - ?$



$$\Delta x = \frac{\lambda(r+b)}{2r\varphi}$$

$$D \le \frac{\Delta x}{2}$$

$$\frac{\lambda(r+b)}{2r\varphi} = 2D$$

$$\varphi = \frac{\lambda(r+b)}{4Dr} = \frac{5500\cdot10^{-10}(10+120)\cdot10^{-2}}{4\cdot0{,}5\cdot10^{-3}\cdot10\cdot10^{-2}} =$$

$$= 36\cdot10^{-4} = 0{,}0036$$

2.9

$\lambda_1 = 589{,}0$ нм
$\lambda_2 = 589{,}6$ нм
Δh.

$$\begin{cases} 2h_1 = m\lambda_1 \\ 2h_1 = (m+\frac{1}{2})\lambda_2 \\ 2h_2 = m_2\lambda_1 \\ 2h_2 = (m_2+\frac{3}{2})\lambda_2 \end{cases}$$

$$m = \frac{\lambda_2}{2(\lambda_1-\lambda_2)} \quad m_2 = \frac{3\lambda_2}{2(\lambda_1-\lambda_2)}$$

$$\frac{h_1}{h_2} = \frac{m}{m_2} = \frac{1}{3}.$$

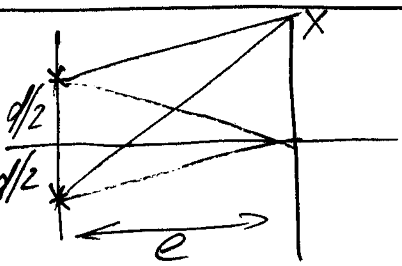
$$h_2 = 3h_1$$

$$\Delta h = h_2 - h_1 = 2h_1 = m\lambda_1$$

$$\Delta h = \frac{\lambda_2\lambda_1}{2(\lambda_1-\lambda_2)} = 0{,}6 \text{ мм}$$

2.10

$d = 2{,}5$ мм
$l = 100$ см
$x = 5$ мм
$h - ?$



$$\Delta_1 = \frac{xd}{l}$$

$$\Delta_2 = \frac{xd}{l} + (n-1)h$$

$$m\lambda = \Delta$$

$$x_{m_1} = \frac{m\lambda l}{d}$$

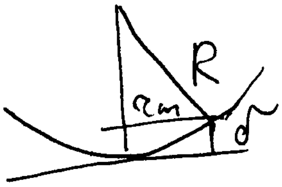
$$x_{m_2} = \frac{(m\lambda-(n-1)h)\,l}{d}$$

$$x = x_{m_2} - x_{m_1} = \frac{(n-1)hl}{d}$$

$$h = \frac{xd}{(n-1)l} = \frac{5\cdot10^{-3}\cdot2{,}5\cdot10^{-3}}{0{,}5} = 2{,}5 \text{ мкм.}$$

2.11.

R, d_1, d_2
$m - ?$



$$2\delta = m\lambda$$

$$\delta = R - \sqrt{R^2 - r_m^2} = \frac{1}{2}\frac{r_m^2}{R}$$

$$\frac{d_1^2}{4R} = m\lambda$$

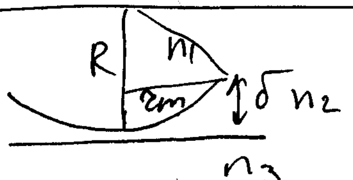
$$\frac{d_2^2}{4R} = (m+5)\lambda$$

$$\frac{d_1^2}{d_2^2} = \frac{m}{m+5} \quad m(d_2^2 - d_1^2) = 5d_1^2$$

$$m = \frac{5d_1^2}{d_2^2 - d_1^2}$$

2.12

$n_1 < n_2 < n_3$
R, R_N
$\lambda - ?$



$$l_1 = n_1 l_0 + \frac{\lambda}{2}$$

$$l_2 = n_1 l_0 + n_2\delta + \frac{\lambda}{2}$$

$$\Delta = 2n_2\delta \quad \delta = \frac{R_N^2}{2R}$$

$$n_2\cdot\frac{R_N^2}{R} = (2N+1)\lambda$$

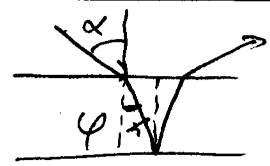
$$\lambda = \frac{n_2 R_N^2}{R(2N+1)}$$

2.13 не решено

2.15.

$n=1,33$
$\lambda_1=0,64$ мкм
$\lambda_2=0,4$ мкм
$\alpha=30^\circ$

h_{min} — ?



$$m\lambda_1=2hn\cos\varphi$$

$$\cos\varphi=\sqrt{1-\left(\frac{\sin\alpha}{n}\right)^2}$$

$$m\lambda_1=\left(m+\frac{1}{2}\right)\lambda_2$$

$$m_{max}=\frac{\lambda_2}{\lambda_1-\lambda_2}.$$

$$h=\frac{\lambda_1\lambda_2}{\lambda_1-\lambda_2}\frac{1}{2n}\frac{1}{\sqrt{1-\left(\frac{\sin\alpha}{n}\right)^2}}=$$

$$=\frac{0,64\cdot0,4\cdot10^{-6}}{0,24\cdot2\cdot1,33}\frac{1}{\sqrt{1-\left(\frac{1}{2\cdot1,33}\right)^2}}=0,43\text{ мкм}$$

2.16

$\Delta\lambda=21$ Å
$\lambda=5780$ Å

d — ?

Смазывание первый раз:

$$m\lambda_1=\left(m+\frac{1}{2}\right)\lambda_2$$

$$m=\frac{\lambda_2}{2(\lambda_1-\lambda_2)}$$

$$2d=\frac{\lambda_2\lambda_1}{2(\lambda_1-\lambda_2)}\Rightarrow d=\frac{\lambda_1\lambda_2}{4(\lambda_1-\lambda_2)}=$$

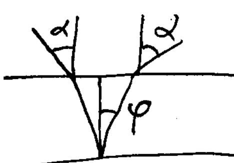
$$=\frac{\lambda_1\lambda_2}{4\Delta\lambda}=\frac{\lambda_{ср}^2-\Delta\lambda^2}{4\Delta\lambda}=$$

$$=\frac{5780^2-21^2}{4\cdot21}=4\cdot10^{-5}\text{ м}=40\text{ мкм}.$$

2.17

$d=0,15$ мкм
$\lambda_{зел}=500$ нм
$n=1,33$

α — ?



$$\Delta=2dn\cos\varphi=2d\sqrt{n^2-\sin^2\alpha}$$

$$\Delta=m\lambda.$$

$$\left(\frac{m\lambda}{2d}\right)^2=n^2-\sin^2\alpha$$

$$\alpha=\arcsin\sqrt{n^2-\left(\frac{m\lambda}{2d}\right)^2}=$$

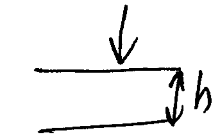
$$=\arcsin\sqrt{1,33^2-\left(\frac{500\cdot10^{-9}}{2\cdot0,15\cdot10^{-6}}\right)^2}$$

2.13
2.18 } — нерешено.

2.19.

$\lambda_{ср}, n$
h

$\Delta\lambda$ — ?



$$m_{max}=\frac{\lambda}{\Delta\lambda}.$$

$$m\lambda=2hn$$

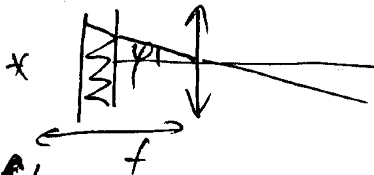
$$2hn=\frac{\lambda^2}{\Delta\lambda}$$

$$\Delta\lambda=\frac{\lambda^2}{2hn}$$

2.20

$f=10$ см
$d=26\,1/4\,\lambda$

r_5 — ?



$$f\,\mathrm{tg}\,\varphi=r_m$$

$$2d\cos\varphi=5\lambda.$$

$$\cos\varphi=\frac{5\lambda}{2d}\qquad \mathrm{tg}\,\varphi=\sqrt{-1+\frac{1}{\cos^2\varphi}}$$

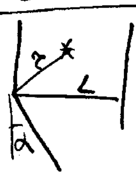
$$f\cdot\sqrt{-1+\frac{4d^2}{5\lambda^2}}=r_5$$

$$r_5=0,1\sqrt{\frac{4\cdot26^2}{16\cdot5}-1}=0,57$$

2.21

$L=1$ м
$r=10$ см
$\alpha=10'$
$\lambda=4861$ Å

Δx — ?



$$\Delta x=\frac{\lambda(l+R)}{2R\varphi}$$

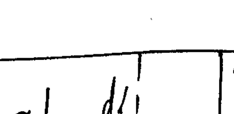
$$\Delta x=\frac{4861\cdot10^{-10}\cdot1,1\cdot6}{2\cdot0,1}=1,6\cdot10^{-5}=$$

$$=15\text{ мкм}.$$

2.22

λ, d, L, V

D — ?



$$\Delta=\Delta_1+\Delta_2=\frac{d\xi}{L}+\frac{xd}{L_1}$$

$$\int dI=\int_{-D/2}^{D/2}\frac{I_0}{D}\,d\xi\,(1+\cos k\Delta)=$$

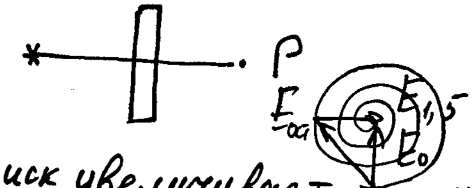
$$I=I_0\cdot2\left(1+\mathrm{sinc}\frac{kDd}{2L}\cos\frac{kxd}{L_1}\right)$$

$$V=\mathrm{sinc}\left(\frac{kdD}{2L}\right)\qquad A=\mathrm{arcsinc}\,0,66$$

$$D=\frac{AL\cdot\lambda}{\pi d}$$

3.1.

$n, \lambda, 1{,}5$ з. | $h - ?$



Диск увеличивает фазу.

Условие max: $E_{ост} \to E_{1,5}$.

$\Delta\varphi = \frac{\pi}{4} + \pi + 2\pi m$

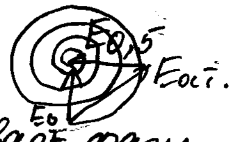
$k\Delta = \frac{5\pi}{4} + 2\pi m \quad \Delta = (n-1)h.$

$\frac{2\pi}{\lambda}(n-1)h = \frac{5\pi}{4} + 2\pi m \quad m \in \mathbb{Z}$

$$h = \frac{\left(\frac{5}{8}\pi + \pi m\right)\lambda}{\pi(n-1)} = \frac{\left(\frac{5}{8} + m\right)\lambda}{n-1}$$

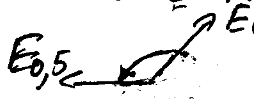
3.2.

$n, 0{,}5$ з. | $h - ?$



Диск увеличивает фазу.

Условие min: $E_{0,5} \leftarrow \bullet \rightarrow E_{ост}$



$\Delta\varphi = \frac{\pi}{4} + \frac{\pi}{2} + 2\pi m$

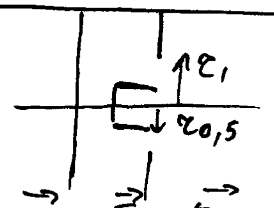
$k\Delta = \frac{3\pi}{4} + 2\pi m \quad \Delta = (n-1)h.$

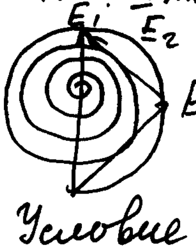
$\frac{2\pi}{\lambda}(n-1)h = \frac{3\pi}{4} + 2\pi m, \quad m \in \mathbb{Z}$

$$h = \frac{\left(\frac{3}{8} + m\right)\lambda}{n-1}$$

3.3

$I_0, \lambda, 1{,}0$ з$, 0{,}5$ з. | $h - ?$ $I_{max} - ?$

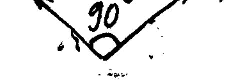




$\vec{E_1} = \vec{E_2} + \vec{E}_{0,5}$

Выемка уменьшает фазу.

Условие max: $\bullet\!\!\to E_2,\ E_{0,5}$



$\Delta\varphi = \frac{\pi}{2} + 2\pi m$

$k\Delta = \Delta\varphi \quad \Delta = (n-1)h.$

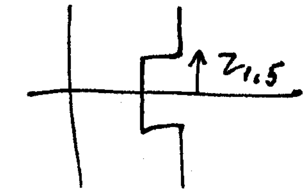
$\frac{2\pi}{\lambda}(n-1)h = \frac{\pi}{2} + 2\pi m \quad m \in \mathbb{Z}$

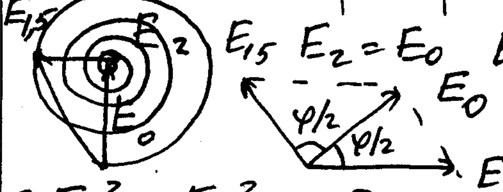
$$\boxed{h = \frac{\left(\frac{1}{4} + m\right)\lambda}{n-1}}$$

I_{max}, при $E_{max} = E_{0,5} + E_2 =$
$= 2\sqrt{2}E_0 \Rightarrow \boxed{I_{max} = E_{max}^2 = 8I_0.}$

3.4.

$\lambda, 1{,}5$ з. $I = I_0$ | $h - ?$





$E_{1,5}$ $E_2 = E_0$ $\quad E_{1,5} = \sqrt{2}E_0.$

$2E_0^2 = E_0^2 + E_0^2 - 2E_0^2\cos\varphi/2.$

$\cos\varphi/2 = 0$

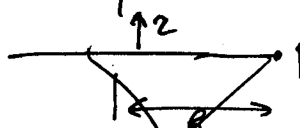
$\frac{\varphi}{2} = \frac{\pi}{2} + \pi m \quad \varphi = \pi + 2\pi m.$

$\frac{2\pi}{\lambda}(n-1)h = \pi + 2\pi m.$

$$h = \frac{\left(\frac{1}{2} + m\right)\lambda}{n-1}$$

3.5

r, λ, b, min | $\Delta b_{min} - ?$



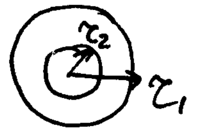
$r_m = \sqrt{\lambda m b}$

$b = \frac{r_m^2}{\lambda m} \qquad b + \Delta b = \frac{r_m^2}{\lambda(m-2)}$

$|\Delta b| = \frac{r_m^2}{\lambda}\left(\frac{1}{m-2} - \frac{1}{m}\right) =$
$= \frac{2r^2}{\lambda m(m-2)}$ $\quad m = \frac{r^2}{\lambda b}$ — подставить в последнее ур-ие

3.6

I_0, 1з, $S_k = \frac{1}{2}S_1$ | $I - ?$



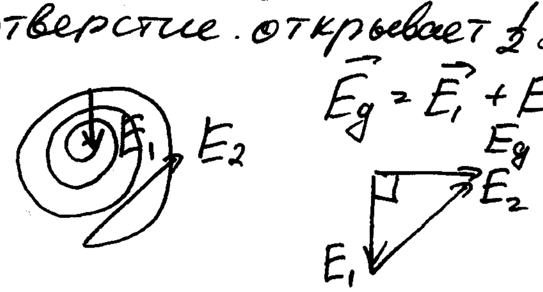
$\pi r_1^2 - \pi r_2^2 = \frac{1}{2}\pi r_1^2.$

$r_2^2 = \frac{r_1^2}{2}. \quad r_1^2 = L\lambda \quad r_2^2 = mL\lambda$

$mL\lambda = \frac{L\lambda}{2} \Rightarrow m = \frac{1}{2}$, т.е.

отверстие открывает $\frac{1}{2}$ зоны Ф.

$\vec{E_g} = \vec{E_1} + \vec{E_2}$



$E_g = E_0 \Rightarrow I = E_g^2 = E_0^2 = I_0$

Ответ: $I = I_0$.

3.7

3 зоны Френеля без линзы, с линзой

$I_c / I_{без}$ – ?

Без линзы:

$I_{без} = 4 I_0 = (2E_0)^2$

С линзой: т.к. линза не вносит разности фаз, то вместо спирали получим прямую

$E = 2\pi E_0 \cdot \frac{3}{2} = 3\pi E_0$

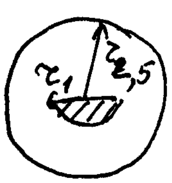
$\Rightarrow I_c = (3\pi E_0)^2 = 9\pi^2 E_0^2$

$$\frac{I_c}{I_{без}} = \frac{9\pi^2 E_0^2}{4E_0^2} = \frac{9\pi^2}{4}$$

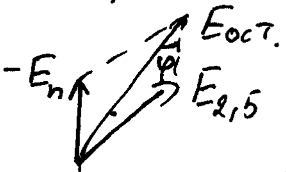
3.8

2,5 з., n, λ, $\frac{1}{2}$ ·1 з.

d – ?



$\vec{E}_{2,5} = \vec{E}_n + \vec{E}_{ост}$

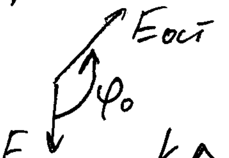


$E_{2,5} = \sqrt{2} E_0$

$E_n = E_0.$

$\varphi = arctg \frac{1}{2}$

~~П~~ластинка увеличивает фазу.



Усл. max: $\rightarrow E_{ост} \rightarrow E_n$.

$\varphi_0 = \pi - \varphi + 2\pi m.$

$k\Delta = \varphi_0 \quad \Delta = (n-1)d$

$$\frac{2\pi}{\lambda}(n-1)d = \pi - arctg\frac{1}{2} + 2\pi m.$$

$$d = \frac{\left(\frac{1}{2} + m - \frac{1}{2\pi} arctg \frac{1}{2}\right)\lambda}{n-1}.$$

3.10

I_0, φ, 1 з.

I – ?

Если без отверстия:

Пропорция:

$E_0 - 2\pi$

$E - 2\pi - \varphi$

$\Rightarrow E = \frac{E_0(2\pi - \varphi)}{2\pi}$ – для диска с отверстием.

Тогда для отверстия:

$2E_0 - E = E_0\left(1 + \frac{\varphi}{2\pi}\right)$

$I = I_0\left(1 + \frac{\varphi}{2\pi}\right)^2$

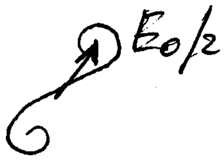
3.9

$\lambda = 0{,}5$ мкм

$r = 1$ мм

$L = 4$ м

$\frac{I_1}{I_2}$ – ?



Без отверстия:

$r^2 = m\lambda L$

$$m = \frac{10^{-6} \cdot 4}{0{,}5 \cdot 10^{-6} \cdot 4} = \frac{1}{2}$$

Для отверстия:

Отверстия + экран: $I_2 = \frac{E_0^2}{4} + 2E_0^2 = \frac{9}{4}E_0^2$

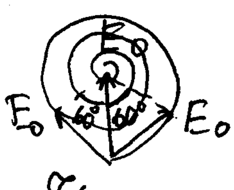
Экран: $I_1 = \frac{E_0^2}{4} = \frac{I_0}{4}.$

$\frac{I_1}{I_2} = \frac{4 I_0}{9 \cdot 4 I_0} = \frac{1}{9}$, т.е. $I \uparrow$ в 9 раз.

3.11

$I = I_0$

$\frac{R_1}{R_2}$ – ?



$90° - \frac{r_1}{2}$

$60° - R_1$

$R_1 = \frac{r_1}{3}.$

$90° - \frac{r_1}{2}$

$120° - R_2$

$\Rightarrow R_2 = \frac{2}{3} r_1$

$\frac{R_1}{R_2} = \frac{1}{2}$ Ответ: увел. в 2 раз

3.12

$a = 100$ см

$b = 150$ см

$r_1 = 1{,}00$ мм

$r_2 = 1{,}29$ мм

λ – ?

$$r_1 = \sqrt{\frac{\lambda m a b}{a+b}}$$

$$r_2 = \sqrt{\frac{\lambda(m+2)ab}{a+b}}$$

$$r_2^2 - r_1^2 = \frac{2\lambda a b}{a+b}.$$

$$\lambda = \frac{(r_2^2 - r_1^2)(a+b)}{2ab} = 0{,}6 \text{ мкм.}$$

3.13

$r = 1$ мм

$m = 5$

$\lambda = 0{,}5$ мкм

Δl – ?

$$\begin{cases} r = \sqrt{\lambda m l} \\ r = \sqrt{\lambda(m-1)(l + \Delta l)} \end{cases}$$

$$\frac{ml}{(m-1)(l+\Delta l)} = 1$$

$$\Delta l = \frac{ml}{m-1} - l = \left(\frac{5}{4} - 1\right)l = \frac{1}{4}l$$

$$l = \frac{r^2}{\lambda m}$$

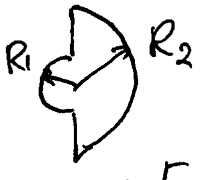
$$\Delta l = \frac{1}{m-1} \cdot \frac{r^2}{\lambda m} = \frac{10^{-6}}{20 \cdot 0{,}5 \cdot 10^{-6}} = \frac{1}{10} =$$

$= 10$ см.

3.14

$I_0,\ R_2 = 2\text{з.},\ R_1 = \frac{R_2}{2}$

$I - ?$



Для правой пластинки: $E_2 = 0$

Для левой половины: $E_1 = \frac{2E_0}{2} = E_0$

$E = E_1 + E_2 = E_0 \Rightarrow I = I_0$.

3.15

$\lambda = 535\text{нм}$

$m_{max} = 5$

$\vartheta = 35^\circ$

$d - ?$

$d\sin\varphi = m\lambda$

$d = m_{max}\lambda =$

$= 5 \cdot 535 = 2675\text{ нм}.$

3.16

$d = 2{,}2\text{мкм}$

$\Delta\vartheta = 13^\circ$

$\lambda.$

$\begin{cases} d\sin\varphi_1 = m_1\lambda \\ d\sin\varphi_2 = m_2\lambda \end{cases}$

$\vartheta = \arcsin\frac{m_1\lambda}{d} - \arcsin\frac{m_2\lambda}{d}$

$\frac{m_2\lambda}{d} = \sin\vartheta\sqrt{1 - \frac{m_1^2\lambda^2}{d}} + \cos\vartheta\,\frac{m_1\lambda}{d}$

$d\sin\varphi = \lambda$

$d\sin\varphi\cos\Delta\vartheta + d\cos\varphi\sin\Delta\vartheta = 2\lambda$

$\sin\varphi = \frac{\lambda}{d}\quad \lambda\cos\Delta\vartheta + d\sqrt{1 - \frac{\lambda^2}{d^2}}\sin\Delta\vartheta = 2\lambda$

$d^2\left(1 - \frac{\lambda^2}{d^2}\right)\sin^2\Delta\vartheta = 4\lambda^2 + \lambda^2\cos^2\Delta\vartheta - 4\lambda^2\cos\Delta\vartheta$

$d^2 - \lambda^2\sin^2\Delta\vartheta = 4\lambda^2 + \lambda^2\cos^2\Delta\vartheta - 4\lambda^2\cos\Delta\vartheta$

$d^2 = 4\lambda^2 + \lambda^2 - 4\lambda^2\cos\Delta\vartheta$

$\lambda^2(5 - 4\cos\Delta\vartheta) = d^2$

$\lambda = \sqrt{\frac{d^2}{5 - 4\cos\Delta\vartheta}}$

3.17

λ_2, m_1, m_2

λ_1

$d\sin\varphi = m_1\lambda_1 = m_2\lambda_2$

$\lambda_1 = \frac{m_2}{m_1}\lambda_2 =$

$= \frac{4}{3} \cdot 4861 = 6481\ \text{Å}$

~~3.18~~

~~$d, b, m_{max} = 0$~~

~~условие.~~

~~$\frac{\lambda m}{d} = \frac{k\lambda}{b} \Rightarrow \frac{k}{m} = \frac{b}{d} \Rightarrow m = \frac{d}{b}k$~~

3.19

$\lambda = 0{,}4\text{мкм}$

$\sin\varphi_1 = 0{,}2$

$\sin\varphi_2 = 0{,}3$

$m - ?$

$d\sin\varphi_1 = m\lambda$

$d\sin\varphi_2 = (m+1)\lambda$

$\frac{m+1}{m} = \frac{\sin\varphi_2}{\sin\varphi_1}$

$m = \frac{1}{\frac{\sin\varphi_2}{\sin\varphi_1} - 1}$

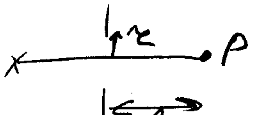
$m = \frac{\sin\varphi_1}{\sin\varphi_2 - \sin\varphi_1} = \frac{0{,}2}{0{,}1} = 2$

Наблюдается второй и третий

3.5

$r, \lambda, b, \min$

$\Delta b_{min} - ?$



$r_m = \sqrt{\frac{\lambda(2m+1)}{2}b}$

$b = \frac{2r_m^2}{\lambda(2m+1)}\quad b + \Delta b = \frac{2r_m^2}{\lambda(2m-1)}$

$\Delta b = \frac{2r^2}{\lambda}\left(\frac{1}{2m-1} - \frac{1}{2m+1}\right) =$

$= \frac{2r^2 \cdot 2}{\lambda(4m^2-1)}\quad m = \left(\frac{2r_m^2}{\lambda b} - 1\right)\Big/2$

3.18.

$d, b,$

условие?

$I = I_0 \cdot \operatorname{sinc}^2\left(\frac{kb\sin\varphi}{2}\right) \cdot \operatorname{sinc}^2\left(\frac{kd\sin\varphi N}{2}\right)$

$\sin\varphi = \frac{m\lambda}{d}$

$\operatorname{sinc}^2\left(\frac{kb}{2}\frac{m\lambda}{d}\right) = 0; \Rightarrow \frac{kb}{2}\frac{m\lambda}{d} = \pi n$

$\Rightarrow \pi\frac{b}{d}m = \pi n; \Rightarrow m = \frac{d}{b}n.$

4.1

$\Delta n = 0{,}025$
$\lambda = 544$ нм
d_{min} - ?

$$\frac{2\pi}{\lambda}(n_o - n_e)d = \frac{\pi}{4}$$

$$\cos\frac{\delta}{2} = \pm\sin\frac{\delta}{2}$$

$$2\frac{\delta}{2} = \pm\frac{\pi}{4} + \pi k$$

$$\delta = \pm\frac{\pi}{2} + 2\pi k$$

$$\frac{2\pi}{\lambda}(n_o - n_e)d = \delta \Rightarrow d = \frac{\lambda}{4\Delta n} =$$

$$= \frac{544}{4\cdot 0{,}025} = 5440 \text{ нм.}$$

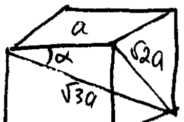
4.2.

$n_o = 1{,}658$
$n_e = 1{,}486$
v - ?

$$v_o = \frac{c}{n_o} \quad v_e = \frac{c}{n_{\parallel}}$$

$$v_x = v_e \quad v_y = v_z = v_o.$$

$$\frac{1}{n_{\parallel}^2} = \frac{\sin^2\alpha}{n_e^2} + \frac{\cos^2\alpha}{n_o^2}$$



$$\sin\alpha = \frac{\sqrt{2}}{\sqrt{3}}$$

$$\cos\alpha = \frac{1}{\sqrt{3}}.$$

$$\frac{1}{n_{\parallel}} = \sqrt{\frac{2}{3n_e^2} + \frac{1}{3n_o^2}}$$

$$v_e = \frac{c}{\sqrt{\frac{2}{3n_e^2} + \frac{1}{3n_o^2}}}$$

4.3

α, $\lambda/2$
$\frac{I_3}{I_2}$ - ?

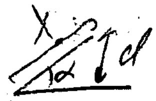
$$I_2 = I_1\cos^2\alpha$$

$$I_3 = I_2\cos^2\left(\frac{\pi}{2} - \alpha\right) = I_1\sin^2\alpha$$

$$\frac{I_3}{I_2} = \sin^2\alpha$$

4.4

$\alpha = 3{,}5^\circ$
$\beta = 45^\circ$
$\lambda = 550$ нм
$\Delta x = 1$ мм
Δn - ?



$$d\Delta n = \lambda \quad d = x\alpha.$$

$$\Delta d\Delta n = \lambda \quad \Delta d = \Delta x\alpha$$

$$\Delta x\alpha\Delta n = \lambda$$

$$\Delta n = \frac{\lambda}{\Delta x\alpha}$$

4.5

$\alpha = 45^\circ$
$\Delta n = 0{,}009$
$\lambda_1 = 564$ нм
$\lambda_2 = 643$ нм
h - ?

$$h\Delta n = m\lambda$$

$$\begin{cases} h\Delta n = 2m\frac{\lambda_2}{2} \\ h\Delta n = (2m \pm 1)\frac{\lambda_1}{2} \end{cases}$$

$$m = \frac{h\Delta n}{\lambda_2}$$

$$h\Delta n = \left(\frac{2h\Delta n}{\lambda_2} + 1\right)\frac{\lambda_1}{2}$$

$$2\lambda_2 h\Delta n = 2h\Delta n\lambda_1 + \lambda_1\lambda_2$$

$$h = \frac{\lambda_1\lambda_2}{2\Delta n(\lambda_2 - \lambda_1)}$$

4.6

$\varphi = 60^\circ$
$n = 3$
P - ?

$$P = \frac{I_n}{I_n + I_e}$$

$$I_n' = I_n\cos^2\varphi$$

$$I_e' = \frac{I_e}{2}.$$

$$P = \frac{I_n}{I_n + I_e}$$

$$n = \frac{I_n + I_e/2}{I_n\cos^2\varphi + I_e/2}$$

$$\frac{I_n}{I_e} = \frac{n-1}{2(1 - n\cos^2\varphi)}$$

$$P = \frac{1}{1 + \frac{2(1 - n\cos^2\varphi)}{n-1}} = \frac{n-1}{n+1-2n\cos^2\varphi} =$$

$$= \frac{2}{4 - \ \cdot\frac{1}{4}} = \frac{4}{5}$$

4.7

$n_o = 1{,}5941$
$n_e = 1{,}5887$
$\lambda = 5000$ Å
h_{min} - ?

$$h\Delta n = \frac{\lambda}{4}$$

$$h = \frac{\lambda}{4(n_o - n_e)}$$

4.8

$\varphi = 45^\circ.$
$\lambda = 500 \div 600$ нм
$d = 0{,}5$ мм
$\Delta n = 0{,}009$
λ_1, λ_2 - ?

$$d\Delta n = m\frac{\lambda}{4}$$

$$500\cdot 10^{-9} < \frac{4d\Delta n}{m} < 600\cdot 10^{-9}$$

$$2m_1 = 30 \quad 2m_2 = 36$$

$$\lambda_1 = \frac{4d\Delta n}{2m_1 + 1} = \cancel{600}\ 581 \text{ нм}$$

$$\lambda_2 = \frac{4d\Delta n}{2m_2 + 1} < 500 \text{ нм.}$$

Ответ: $\lambda = 581$ нм.

4.9

$\Delta n = 0{,}009$
$d = 0{,}25$ мм
$\lambda = 0{,}53$ мкм
$\lambda_x - ?$

$\Delta n \cdot d = \frac{\lambda}{2} m + \frac{\lambda}{4}$

~~$4\Delta n d = 0{,}25 \cdot 0{,}009 \cdot 4 = 0{,}009$ мм~~

$0{,}4 m \cdot 10^{-6} < 9 \cdot 10^{-6} < 0{,}75 m \cdot 10^{-6}$

~~$\lambda = 0{,}999$~~ $\quad m = \frac{4d\Delta n - \lambda}{2\lambda} \in \mathbb{Z}$

~~$\lambda = 0{,}474$~~ $\quad \lambda = 0{,}69$ мкм $\quad \lambda = 0{,}43$ мкм

~~$\lambda = 0{,}450$~~ .. ~~и так далее~~

4.10

$\lambda = 5000$ Å
$\alpha = 90°/$мм
$\Delta n - ?$

$\psi = \frac{\pi L \Delta n}{\lambda} = \alpha L$

$\Delta n = \frac{\alpha \lambda}{\pi}$

4.11

$\Delta = 0{,}2$
$\frac{I_n}{I_e} - ?$

$\Delta = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$

$I_{max} = I_n + \frac{I_e}{2} \quad I_{min} = \frac{I_e}{2}$

$\Delta = \frac{I_n}{I_e + I_n} = \frac{I_n / I_e}{1 + \frac{I_n}{I_e}} = 0{,}2.$

$0{,}8 \frac{I_n}{I_e} = 0{,}2$

$\frac{I_n}{I_e} = \frac{1}{4}$

4.12

λ, пл $\frac{\lambda}{2}$
поляр-?

Поляризован по левому кругу

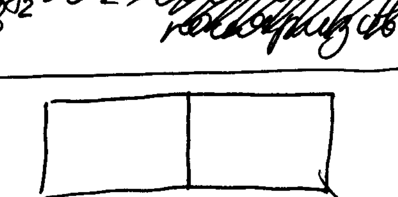
$\Delta = \frac{\lambda}{2} \Rightarrow \varphi = \pi$

$\frac{E_x^2}{a^2} + \frac{E_y^2}{b^2} - 2\frac{E_x E_y}{ab}\cos\varphi = \sin^2\varphi$

$\frac{E_x^2}{a^2} + \frac{E_y^2}{b^2} = 0 \Rightarrow$ ~~свет линейно поляризован~~ правая круговая поляриз.

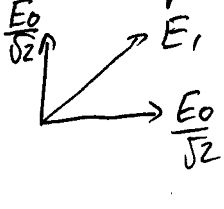
4.13

I_0
I_1



пропускает $\frac{E_0}{\sqrt{2}}$ от естественного света в одном направлении

пропускает $\frac{E_0}{\sqrt{2}}$ от естественного света в $\perp$ первому направлению



$E_1 = E_0 \Rightarrow I_1 = I_0.$

4.14.

пл. $\frac{\lambda}{4}$
$m = 3$
$\frac{I_e}{I_{кр}} - ?$

$I = I_{кр} + I_e.$

$\frac{I_{max}}{I_{min}} = 3.$

$\Delta = \frac{\lambda}{4} \Rightarrow \varphi = \frac{\pi}{2}$

$\Delta = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{3-1}{3+1} = \frac{1}{2} = \frac{I_n}{I_n + I_e}$

$\frac{1}{2} I_n - I_n = -\frac{1}{2} I_e$

$I_n = I_e \Rightarrow \frac{I_e}{I_{кр}} = 1$

4.15

α, k
$\frac{I_2}{I_0} - ?$

~~I_0 / I_1 | I_1 / I_2~~

~~$E_1 = \frac{E_0}{\sqrt{2}} k^2 \cos\alpha$~~

~~$E_2 = E_1 k = \frac{E_0}{\sqrt{2}} k^3 \cos\alpha \Rightarrow$~~

~~$\Rightarrow I_2 = \frac{I_0}{2} k^6 \cos^2\alpha$~~

~~$\frac{I_2}{I_0} = \frac{k^6 \cos^2\alpha}{2}$~~

4.15

α, k
$\frac{I_3}{I_0} - ?$

После 1-го: $I_1 = \frac{I_0}{2} k$

После 2-го: $I_2 = I_1 \cos^2\alpha \, k = \frac{I_0}{2} k^2 \cos^2\alpha.$

После 3-го: $I_3 = I_2 \cos^2\alpha \, k = \frac{I_0}{2} k^3 \cos^4\alpha$

$\frac{I_3}{I_0} = \frac{k^3 \cos^4\alpha}{2}$

5.11

$u = 2v_\varphi$

$v_\varphi(\lambda) - ?$

$u = \frac{d\omega}{dk} = v + k\frac{dv}{dk} = v - \lambda\frac{dv}{d\lambda} = 2v$

$-\lambda\frac{dv}{d\lambda} = v$

$\frac{dv}{v} = -\frac{d\lambda}{\lambda}$

$\ln v = -\ln\lambda + \ln c$

$v = \frac{c}{\lambda} \quad c = const.$

5.12.

$v \sim 1/\omega\lambda$

$u(v)$

$u = \frac{d\omega}{dk} \quad dk = -\frac{2\pi\, d\lambda}{\lambda^2}$

$u = -\frac{\lambda^2 d\omega}{2\pi\, d\lambda} = -\frac{\lambda^2 dv}{d\lambda} = \frac{\lambda^2}{\omega\lambda^2} = \frac{1}{\omega}$

$v = \frac{\omega}{k} \quad \omega = vk$

$u = \frac{1}{vk}.$

5.3 Дано:

$R_1 = 10\,см$

$R_2 = 5\,см$

$d = 3\,см$

$f - ?$

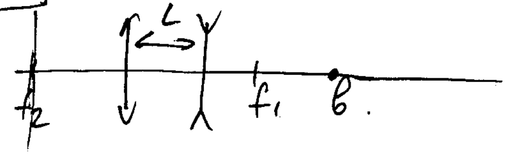
$\Phi = \Phi_1 + \Phi_2 - \frac{d}{n}\Phi_1\Phi_2 =$

$x = \frac{d}{n}\frac{\Phi_2}{\Phi} = 5{,}0\,см$

$x' = -\frac{d\Phi_1}{n\Phi} = 2{,}5\,см$

5.1

1)



$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}.$

$f = f_2 = -|f_2|$

$a = f_1 - L$

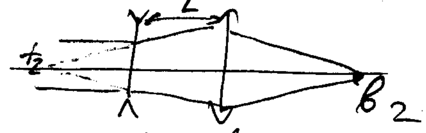
$b = b.$

$\frac{1}{L - f_1} + \frac{1}{b} = -\frac{1}{|f_2|}$

$\frac{1}{b} = \frac{1}{f_1 - L} - \frac{1}{|f_2|} = \frac{|f_2| - f_1 + L}{(f_1 - L)|f_2|}$

$b_1 = \frac{(f_1 - L)|f_2|}{|f_2| - f_1 + L}$

2)



$\frac{1}{|f_2| + L} + \frac{1}{b} = \frac{1}{f_1}$

$\frac{1}{b} = \frac{1}{f_1} - \frac{1}{|f_2| + L} = \frac{|f_2| + L - f_1}{f_1(|f_2| + L)}$

$b_2 = \frac{f_1(|f_2| + L)}{|f_2| - f_1 + L}$

$b_2 - b_1 = \frac{f_1|f_2| + f_1 L - f_1|f_2| + |f_2|L}{|f_2| - f_1 + L} = \frac{L(f_1 + |f_2|)}{|f_2| - f_1 + L}.$

~~**5.2**~~

~~$d = 4см$~~

~~$\Phi_1 = 10\,дптр$~~

~~$\Phi_2 = 10\,дптр$~~

~~$b - ?$~~

~~$\frac{1}{f_1} = \Phi_1 \quad \frac{1}{f_2} = \Phi_2$~~

~~$\frac{1}{b} = \frac{1}{f_1} - \frac{1}{|f_2| + d}$~~

~~$\frac{f_1(|f_2| + L)}{|f_2| - f_1 + L} = \frac{10 \cdot 14}{4} = 35\,см.$~~

5.2

$\Phi_1 = 10\,дптр$

$\Phi_2 = 10\,дптр$

$d = 4\,см$

$b - ?$

$\Phi = \Phi_1 + \Phi_2 - d\Phi_1\Phi_2.$

$\Phi = 4 \quad f_1 = \frac{1}{\Phi_1}$

[redacted] [redacted]

$b = \frac{1}{\Phi} + f_1 = 0{,}25 + 0{,}1 = 0{,}35\,м$

5.4

$\lambda = 500$ нм
$L = 50$ см
$R - ?$

$R = m_{max} \cdot N$

$N = \frac{L}{d}$

$d = m_{max} \cdot \lambda$

$R = \frac{d \cdot L}{\lambda d} = \frac{L}{\lambda} = \frac{5 \cdot 10^{-1}}{500 \cdot 10^{-9}} = 10^6$

5.5

h_{max}?
$\Delta\lambda = 0{,}6$ нм
$\lambda = 600$ нм

$\begin{cases} (m+1)\lambda = 2h \\ m(\lambda + \Delta\lambda) = 2h \end{cases}$

$m\lambda + \lambda = m\lambda + m\Delta\lambda$

$m = \frac{\lambda}{\Delta\lambda}$

$h = \frac{(m+1)\lambda}{2} = \frac{\left(\frac{\lambda}{\Delta\lambda} + 1\right)\lambda}{2} =$

$= \frac{\left(\frac{600}{0{,}6} + 1\right) \cdot 600}{2} = 3 \cdot 10^{-4}\,м = 0{,}3\,мм$

5.6

$\lambda_1 = 5000{,}00$ Å
$\lambda_2 = 5000{,}02$ Å
$d = 1$ см
$n = 1{,}5$
$N - ?$

$(m+1)\lambda_1 = m\lambda_2$

$m = \frac{\lambda_1}{\lambda_2 - \lambda_1}$

$m\lambda_2 = h(n-1)(N-1)$

$N = \frac{\lambda_1 \lambda_2}{(\lambda_2 - \lambda_1) d(n-1)} + 1 =$

$= \frac{5000 \cdot 5000{,}02 \cdot 10^{-20}}{(0{,}02) \cdot 10^{-10} \cdot 0{,}01 \cdot 0{,}5} + 1 = 26$

Ответ: $N < 26$.

5.7

$\lambda = 0{,}6$ мкм
$d = 25$ мкм
$\delta\varphi_2 = 11''$
$R_3 - ?$

$R_3 = \frac{\lambda_{cp}}{\delta\lambda} = \frac{\lambda_{cp}}{\delta\varphi_3 F}$

$R_2 = \frac{\lambda_{cp}}{\delta\varphi_2 F}$

$d\delta\varphi_2 \cos\varphi_2 = m_2 \delta\lambda$

$R = mN$

$\frac{R_3}{R_2} = \frac{3}{2} = \frac{m_3}{m_2}$

$R_2 = \frac{m_2 \lambda}{d\sqrt{\left(1 - \frac{2\lambda}{d}\right)^2}\,\delta\varphi_2}$

$R_3 = \frac{m_3 \lambda}{m_2 d\sqrt{1 - \frac{2\lambda}{d}}\,\delta\varphi_2}$

5.8.

$m = 3$
$n = 4 \cdot 10^3\,см^{-1}$
$\lambda = 500$ нм
$D\varphi - ?$

$D\varphi = \frac{\delta\varphi}{\delta\lambda} = \frac{m}{d\sqrt{1 - \left(\frac{m\lambda}{d}\right)^2}} =$

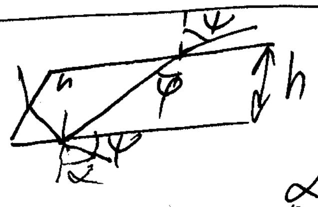
$= \frac{m}{\frac{L}{N}\sqrt{1 - \left(\frac{m\lambda N}{L}\right)^2}} =$

$= \frac{mn}{\sqrt{1 - (mn\lambda)^2}} = \frac{12 \cdot 10^3 \cdot 10^{-1}}{\sqrt{1 - (12 \cdot 10^2 \cdot 500 \cdot 10^{-9})^2}} =$

$\approx 1200.$

5.9

$\lambda = 5000$ Å
$n = 1{,}5$
$h = 1$ см
$G - ?$



$n_1 \sin\varphi = n_2 \sin\alpha \approx 1$

$\sin\varphi = \frac{1}{n}$

$\cos\varphi = \sqrt{1 - \frac{1}{n^2}} = \frac{\sqrt{n^2 - 1}}{n}$

$2dn\cos\varphi = m\lambda$

$m = \frac{2d\sqrt{n^2-1}}{\lambda}$ $\quad G = \frac{\lambda}{m}$

$G = \frac{\lambda^2}{2d\sqrt{n^2 - 1}}$

5.10

$\varepsilon = 1 - a/\nu^2$
$v_{гр}(v_\varphi) - ?$

$v_\varphi = \frac{\omega}{k} = \frac{c}{n} = \frac{c}{\sqrt{\varepsilon}} = \frac{c}{\sqrt{1 - \frac{a}{\nu^2}}}$

$v_{гр} = \frac{d\omega}{dk} = v_\varphi + k\frac{dv_\varphi}{dk}$

$\frac{dv_\varphi}{dk} = \frac{c\,dn}{dk} = \frac{dn}{d\omega}$ $\quad k\frac{v_\varphi}{dk} = \frac{\omega\,dn}{c\,d\omega}$

$v_{гр} = \frac{c}{n + \frac{dn}{d\omega}\omega} = \frac{c}{\sqrt{\varepsilon} + \frac{2\pi\nu\, d\sqrt{\varepsilon}}{2\pi\, d\nu}} =$

$= \frac{c}{\sqrt{\varepsilon} + \nu\frac{2a/\nu^3}{2\left(1 - \frac{a}{\nu^2}\right)^{1/2}}} =$

$= \frac{c}{\sqrt{\varepsilon} + \frac{a/\nu^3}{\sqrt{1 - a/\nu^2}}} = \frac{v_\varphi (1 - a/\nu^2)}{1 - a/\nu^2 + a/\nu^2} = v_\varphi\,\varepsilon$

2.23

d, θ, λ

$L - ?$

$V = \mathrm{sinc}\left(\frac{kd\theta}{2L}\right) = 0$

$\frac{kd\theta}{2L} = m\pi$

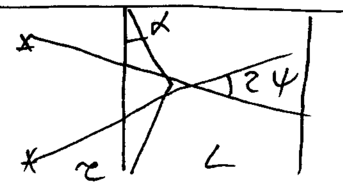
$m = 1.$

$\frac{d\theta}{L\lambda} = \pi \Rightarrow L = \frac{d\theta}{\pi\lambda}$

2.24

$r = 20$ см,
$\lambda = 5000$ Å
$\alpha = 5\cdot10^{-2}$ рад
$n = 1{,}5$
$L = 4$ м

$\Delta N - ?$



$\varphi = \alpha(n-1)$

$\Delta = \frac{xd}{r+L} \quad \Delta x = \frac{\lambda(r+L)}{d}$

$N = \frac{X}{\Delta x}. \quad X = \frac{\lambda(r+L)}{2r\,tg\varphi} \quad X = 2L\,tg\varphi$

$N = \frac{2L\,tg^2\varphi \cdot 2r}{\lambda(r+L)} = \frac{4Lr\,tg^2\varphi}{\lambda(r+L)}$

$\Delta N = \frac{4L_1 r\,tg^2\varphi}{\lambda(r+L_1)} - \frac{4Lr\,tg^2\varphi}{\lambda(r+L)} =$

$= \frac{4r\,tg^2\varphi}{\lambda}\left(\frac{2L}{r+2L} - \frac{L}{r+L}\right) =$

$= \frac{4r^2\,tg^2\varphi\,L}{\lambda(r+2L)(r+L)}$

2.25

m, λ

d

$\Delta = 2d = m\lambda$

$d = \frac{m\lambda}{2}$

5.13

n, α

$R - ?$

$n = tg\varphi$

$r_\parallel = \frac{tg(\varphi-\theta)}{tg(\varphi+\theta)}$

$r_\perp = \frac{\sin(\varphi-\theta)}{\sin(\varphi+\theta)}$

$r_\parallel = 0 \quad \theta = \frac{\pi}{2} - \varphi$

$r_\perp = \frac{\sin(2\varphi - \frac{\pi}{2})}{\sin\pi/2} = \cos2\varphi =$

$= 2\cos^2\varphi - 1 = \frac{2}{1+tg^2\varphi} - 1 =$

$= \frac{1-tg^2\varphi}{1+tg^2\varphi} = \frac{1-n^2}{1+n^2}$

$r = r_\parallel\cos\alpha + r_\perp\sin\alpha =$

$= r_\perp\sin\alpha = \sqrt{R}$

$R = \left(\frac{1-n^2}{1+n^2}\right)^2\sin^2\alpha$

5.14.

n

r

см. 13. $r_\parallel = 0 \quad r_\perp = \frac{1-n^2}{1+n^2}$

$r = \frac{1}{2}(r_\parallel + r_\perp) = \frac{1}{2}\left(\frac{1-n^2}{1+n^2}\right)$

5.15.

$n = 3/2$

$P - ?$

$P = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$

$I_{max} = t_\perp^2 I_0 \quad \theta = \frac{\pi}{2} - \varphi$

$I_{min} = t_\parallel^2 I_0$

$t_\perp = \frac{2\cos\theta\sin\theta}{\sin(\varphi+\theta)} = \frac{2}{1-n^2}$

$t_\parallel = \frac{2\cos\varphi\sin\theta}{\sin(\varphi+\theta)\cos(\varphi-\theta)} = \frac{1}{n}$

$P = \frac{\frac{4}{(1-n^2)^2} - \frac{1}{n^2}}{\frac{4}{(1-n^2)^2} + \frac{1}{n^2}}$