Tentamen i Vågfysik
NFYB01, TFYA10, TFYA59
2011-05-26
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Vågfysik
2011-05-26
1.

a) $\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2 \Rightarrow I_2 = I_1\left(\frac{r_1}{r_2}\right)^2 \Rightarrow I = 2 \cdot \frac{1}{r^2}$ $\underline{\underline{B}}$

b) $\frac{I_1}{I_2} = \frac{r_2}{r_1} \Rightarrow I_2 = I_1 \frac{r_1}{r_2} \Rightarrow I = \frac{1}{r}$ $\underline{\underline{C}}$

c) $\beta = 10 \cdot \lg\left(\frac{I}{I_0}\right)$ $\beta_1 = 90\,dB$ vid $r_1 = 1{,}0\,m$

β_2 vid $r_2 = 5{,}0\,m$?

$$I = \frac{P_{av}}{a} = \frac{P_{av}}{2\pi r^2}$$

$$\Delta\beta = \beta_2 - \beta_1 = 10\left(\lg\left(\frac{I_2}{I_0}\right) - \lg\left(\frac{I_1}{I_0}\right)\right) = 10 \cdot \lg\left(\frac{I_2}{I_1}\right) =$$

$$= 10 \cdot \lg\left(\frac{P_{av}/2\pi r_2^2}{P_{av}/2\pi r_1^2}\right) = 10 \lg\left[\left(\frac{r_1}{r_2}\right)^2\right] = 20 \cdot \lg\left(\frac{1}{5}\right) = -13{,}979\ldots\,dB$$

$\therefore \beta_2 = \Delta\beta + \beta_1 = 76{,}020\ldots\,dB$ $\underline{\underline{\text{Svar:}}}$ $\beta_2 = 76\,dB$

d) $I^* = I e^{-kr}$ $\beta^* = 10 \lg\left(\frac{I^*}{I_0}\right) = 10 \lg\left(\frac{I e^{-kr}}{I_0}\right) =$

$$= \underbrace{10 \cdot \lg\left(\frac{I}{I_0}\right)}_{\beta} - 10\,k \cdot r \lg(e)$$

$$\Rightarrow k = \frac{\beta - \beta^*}{10 \cdot r \cdot \lg(e)} \quad \left(\dim(k) = L^{-1}\right)$$

Vid 1,0 m: $k = \frac{90 - 89{,}13}{10 \cdot 1 \cdot \lg(e)} = 0{,}2003\ldots$

Vid 5,0 m: $k = \frac{76{,}020 - 71{,}68}{10 \cdot 5 \cdot \lg(e)} = 0{,}1999\ldots$ ok!

$\underline{\underline{\text{Svar:}}}$ $k = 0{,}20\ m^{-1}$

a, $L = 0{,}80\,m \quad f_m = 315\,Hz,\ f_{m+1} = 420\,Hz$

$$\lambda_m = \frac{2L}{m},\quad f_m = \frac{V}{\lambda_m} = \frac{V}{2L}\cdot m = f_1 \cdot m$$

$$\frac{f_{m+1}}{f_m} = \frac{m+1}{m} \Rightarrow m = \frac{f_m}{f_{m+1} - f_m} = \frac{315}{105} = \underline{3}$$

<u>Svar</u>: 2:a $(m=3)$ och 3:e $(m+1=4)$ övertonen

b, $\frac{f_3}{f_1} = \frac{3}{1} \Rightarrow f_1 = \frac{f_3}{3} = \frac{315}{3} = 105\,Hz$ <u>Svar: 105 Hz</u>

alt: $(f_{m+1} - f_m = f_1(m+1) - f_1 \cdot m = f_1 \Rightarrow f_1 = 420 - 315 = 105\,Hz)$

c, $f_1 = \frac{V}{2L} \quad f_1' = r \cdot f_1 \quad (r = 1{,}25)$

$$f_1' = \frac{V}{2(L-l)} \quad l?$$

$$\frac{f_1'}{f_1} = \frac{L}{L-l} \Rightarrow f_1' = f_1\left(\frac{L}{L-l}\right) \quad \therefore r = \frac{L}{L-l} \Rightarrow l = L\left(1 - \frac{1}{r}\right)$$

$$\Rightarrow l = 0{,}80 \cdot \left(1 - \frac{1}{1{,}25}\right) = 0{,}16\,m$$ <u>Svar</u>: 16 cm

d, $f_{sv} = 4\,Hz \quad f_{sv} = |f_1^A - f_1^B|$ (440 Hz) $\quad f_1 = \underbrace{\sqrt{\frac{T_S}{\mu}}}_{V} \cdot \underbrace{\frac{1}{2L}}_{1/\lambda}$

$$f_1^A = \sqrt{\frac{T_S^A}{\mu}}\,\frac{1}{2L},\quad f_1^B = \sqrt{\frac{T_S^B}{\mu}}\,\frac{1}{2L}$$ T_S^B ska öka $\therefore f_1^B = 444\,Hz$

$$\frac{f_1^B}{f_1^A} = \sqrt{\frac{T_S^B}{T_S^A}} \Rightarrow \frac{T_S^B}{T_S^A} = \left(\frac{f_1^B}{f_1^A}\right)^2 = \left(\frac{444}{440}\right)^2 = 1{,}01826\ldots$$

<u>Svar</u> T_S^B ska öka med 1,8%

Vågfysik
2011-05-26
3.

a) $\lambda = \frac{h}{p} = \frac{h}{mv}$ $V = 100$ m/s $h = 6{,}626 \cdot 10^{-34}$ Js

i) elektron $m = 9{,}109 \cdot 10^{-31}$ kg $\Rightarrow \lambda = 7{,}3\ \mu m$

ii) neutron $m = 1{,}6749 \cdot 10^{-27}$ kg $\Rightarrow \lambda = 3{,}95$ nm

iii) natriumatom $m = \frac{A_r}{N_A} = 3{,}82 \cdot 10^{-26}$ kg $\Rightarrow \lambda = 0{,}17$ nm

PHT-5.1

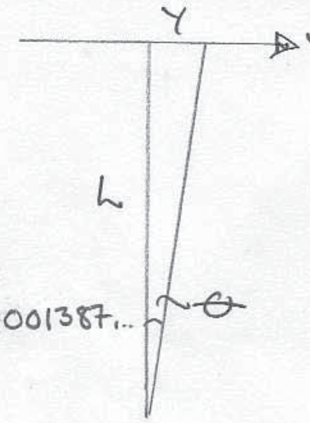
iiii) ärta! $m = 10^{-3}$ kg $\Rightarrow \lambda = 6{,}6 \cdot 10^{-33}$ m

b) laserljus: $\lambda_\ell = 600$ nm, $V = 50$ m/s

Avstånd mellan bukar (noder) $d = \frac{\lambda_\ell}{2} = 300$ nm

Atomernas de Broglievåglängd $\lambda = \frac{h}{mv} = 3{,}4691\ldots \cdot 10^{-10}$ m

max då $d \sin\theta = n \cdot \lambda$ ($n = 0, \pm 1, \pm 2, \ldots$)



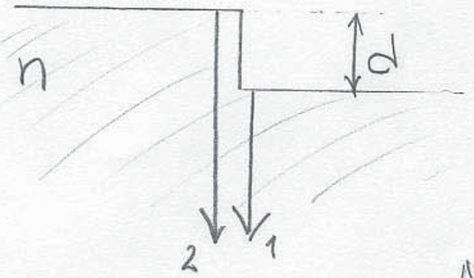
Små vinklar $\sin\theta \approx \tan\theta = \frac{Y}{L}$

Första ordningens topp: $n = 1$

$\therefore d \frac{Y}{L} = \lambda \Rightarrow Y = \frac{L}{d} \cdot \lambda = \frac{1{,}2}{300 \cdot 10^{-9}} \cdot 3{,}4691\ldots \cdot 10^{-10} = 0{,}001387\ldots$

Svar: 1,4 mm

a,



$\lambda_0 = 790\,\text{nm} \quad n = 1{,}8$

$\Phi_1 = k \cdot \underbrace{x_1}_{=0} + \phi_1$

$\Phi_2 = k \cdot \underbrace{x_2}_{2d} + \phi_2 \qquad \phi_1 = \phi_2$

$\Delta\Phi = \Phi_2 - \Phi_1 = k \cdot 2d = \frac{2\pi}{\lambda_f} \cdot 2d$

destruktiv interferens $\Delta\Phi = (m + \frac{1}{2})2\pi \quad m = 0, \pm1, \pm2, \ldots$

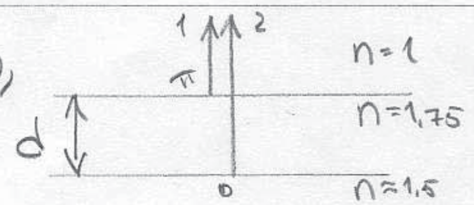
$\Rightarrow \frac{\cancel{2\pi}}{\lambda_f} \cdot 2d = (m + \frac{1}{2})\cancel{2\pi} \Rightarrow d = \frac{(m + \frac{1}{2}) \cdot \lambda_0}{2 \cdot n}$

$\lambda_f = \frac{\lambda_0}{n}$

minsta djup då $m = 0$ $\quad d = \frac{\lambda_0}{4 \cdot n} = \frac{790 \cdot 10^{-9}}{4 \cdot 1{,}8} = 1{,}0972 \ldots \cdot 10^{-7}$

Svar: $0{,}11\,\mu\text{m}$

b,



$\Phi_1 = k_a x_1 + \phi_1 = \overbrace{\phi_1}^{\pi}$ $\quad \lambda_0 = 582{,}4\,\text{nm}$

$\lambda_0' = 588{,}5\,\text{nm}$

$\Phi_2 = k_f x_2 + \underbrace{\phi_2}_{=0} = \frac{2\pi}{\lambda_f} \cdot 2d$

$\Delta\Phi = \Phi_2 - \Phi_1 = \frac{2\pi}{\lambda_f} \cdot 2d - \pi$

destruktiv interferens $\Delta\Phi = (m + \frac{1}{2})2\pi \quad m = (0), \pm1, \pm2, \ldots$

$\Rightarrow \frac{2\pi}{\lambda_f} \cdot 2d - \cancel{\frac{\pi}{2}} = (m + \frac{1}{2})\cancel{2\pi} \Rightarrow d = \frac{m\lambda_0}{2n}$

$\lambda_f = \frac{\lambda_0}{n}$

antag samma ordning (m) för båda fallen

$\Delta d = \frac{m}{2 \cdot n}(\lambda_0' - \lambda_0) = m \cdot 1{,}7428 \ldots \cdot 10^{-9}\,\text{m}$

Svar: $1{,}7\,\text{nm}$ (för $m = 1$)

a) F

b) D

$$D(I) = \frac{10I^{-0,3}+3}{I^{-0,3}+2} = \frac{10+3I^{0,3}}{1+2I^{0,3}} \qquad \lambda = 589 \text{ nm}$$

c) $D = \lim_{I \to 0}\left(\frac{10+3I^{0,3}}{1+2I^{0,3}}\right) = 10 \text{ mm}$ ← pupillens diameter $\qquad d = 0,05 \text{ m}$

$\theta_{min} = \frac{d}{L}$

Rayleighkriterie: $\theta_{min} = \frac{1,22\lambda}{D}$

$\therefore \frac{d}{L} = \frac{1,22\lambda}{D} \Rightarrow L = \frac{d \cdot D}{1,22 \cdot \lambda} = 695,816\ldots \text{ m}$

Svar: 696 m

d) $D = \lim_{I \to \infty}\left(\frac{10I^{-0,3}+3}{I^{-0,3}+2}\right) = 1,5 \text{ mm}$ pupillens "spaltbredd"

Rayleighkriterie: $\theta_{min} = \frac{\lambda}{D}$

$\therefore \frac{d}{L} = \frac{\lambda}{D} \Rightarrow L = \frac{d \cdot D}{\lambda} = 127,33\ldots \text{ m}$

Svar: 127 m

Vågfysik
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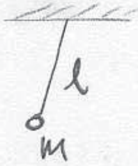
6.

a, $\theta(t) = \theta_0 \cdot \cos(\omega t + \phi_0)$

$\theta(0) = \theta_0 \Rightarrow \phi_0 = 0 \qquad \omega = \sqrt{\frac{g}{l}}$



$\therefore t(\theta) = \sqrt{\frac{l}{g}} \arccos\left(\frac{\theta}{\theta_0}\right)$ $\qquad T_a/4$

$t(\theta_0) = \sqrt{\frac{l}{g}} \arccos(1) = 0 \; ; \; t(0) = \sqrt{\frac{l}{g}} \arccos(0) = \sqrt{\frac{l}{g}} \cdot \frac{\pi}{2}$

Svar: $T_a = 2\pi \sqrt{\frac{l}{g}}$

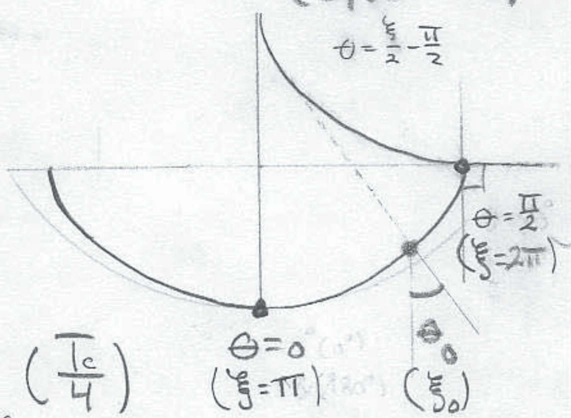
b, $\eta = 0{,}02 \qquad \frac{1}{4} \cdot \underbrace{\sin^2\left(\frac{\theta_0}{2}\right)}_{\gamma} + \frac{9}{64} \underbrace{\sin^4\left(\frac{\theta_0}{2}\right)}_{\gamma^2} = \eta \Rightarrow \gamma^2 + \frac{16}{9}\gamma - \frac{64}{9}\eta = 0$

$\gamma = \dfrac{-\frac{16}{9} \pm \sqrt{\left(\frac{16}{9}\right)^2 + 4 \cdot \frac{64}{9}\eta}}{2} \quad , \quad \theta_0 = 2 \cdot \arcsin\left(\sqrt{\gamma}\right)$

med siffror ... $\theta_0 = 32{,}1544^\circ$ $\qquad$ Svar: $\theta_0 = 32{,}15^\circ$ $(0{,}56 \text{ rad})$

c, $\left(\frac{d\xi}{dt}\right)^2 = \dfrac{2g(\cos\xi_0 - \cos\xi)}{l \cdot \sin^2(\xi/2)}$

$\Rightarrow t = \sqrt{\frac{l}{2g}} \int_{\xi_0}^{\xi} \dfrac{\sin(\xi/2)}{\sqrt{\cos\xi_0 - \cos\xi}} \, d\xi$



Betrakta svängning från $\xi = \xi_0$ till $\xi = \pi$ $\left(\frac{T_c}{4}\right)$

Låt $u = \dfrac{\cos(\xi/2)}{\cos(\xi_0/2)} \qquad \dfrac{du}{d\xi} = -\dfrac{\sin(\xi/2)}{2\cos(\xi_0/2)}$

$u(\xi_0) = 1 \qquad u(\pi) = 0$

$\Rightarrow \frac{T}{4} = -\sqrt{\frac{l}{2g}} \int_1^0 \sqrt{2} \cdot \frac{du}{\sqrt{1-u^2}} = \sqrt{\frac{l}{g}} \left[\arcsin(u)\right]_0^1 = \frac{\pi}{2} \cdot \sqrt{\frac{l}{g}}$

$\therefore T = 2\pi \sqrt{\frac{l}{g}}$

TFYA59 (MED)

Vågfysik
2011-05-26
Uppgift 4.I
(se 4. ovan)

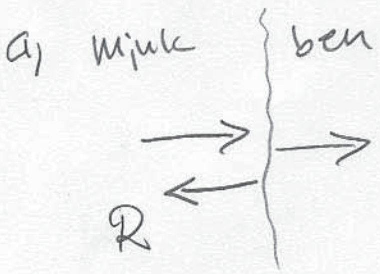
4.II

$$R_1 = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$$

$Z_{ben} = 6.8 \cdot 10^6 \; kg/ms^2$

$Z_{mjuk} = 1,5 \cdot 10^6 \; kg/ms^2$

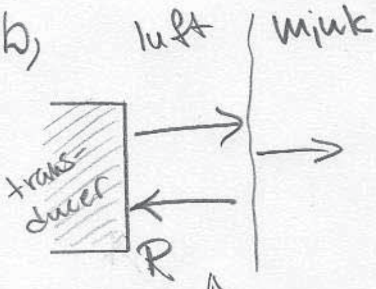
a)



$$R = \left(\frac{Z_{ben} - Z_{mjuk}}{Z_{ben} + Z_{mjuk}}\right)^2 = \left(\frac{6,8 - 1,5}{6,8 + 1,5}\right)^2 = 0,4077$$

Svar: 41 % reflekteras

b)



blir alltid en luft ficka mellan trans. och mjukdel

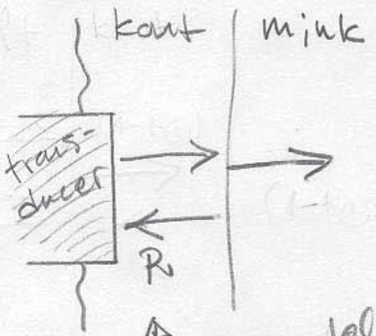
$$Z_{luft} = \rho \cdot v = \underbrace{1,2929}_{kg/m^3} \cdot \underset{m/s}{343} = 443,4647 \; \frac{kg}{ms^2}$$

(20°)

$$R = \left(\frac{Z_{mjuk} - Z_{luft}}{Z_{mjuk} + Z_{luft}}\right)^2 = \left(\frac{1,5 \cdot 10^6 - 443,5}{1,5 \cdot 10^6 + 443,5}\right)^2 = 0,99881\ldots$$

Svar: 99,9 % reflekteras

c)



kontaktmedel innesluter trancducer (ingen luftficka)

$Z_{kont} = 2 \cdot 10^5 \; \frac{kg}{ms^2}$

$$R_{1} = \left(\frac{Z_{kont} - Z_{mjuk}}{Z_{kont} + Z_{mjuk}}\right)^2 = 0,5848$$

Svar: Med kontaktmedium enligt fig sänks reflektansen till 58,5 %.