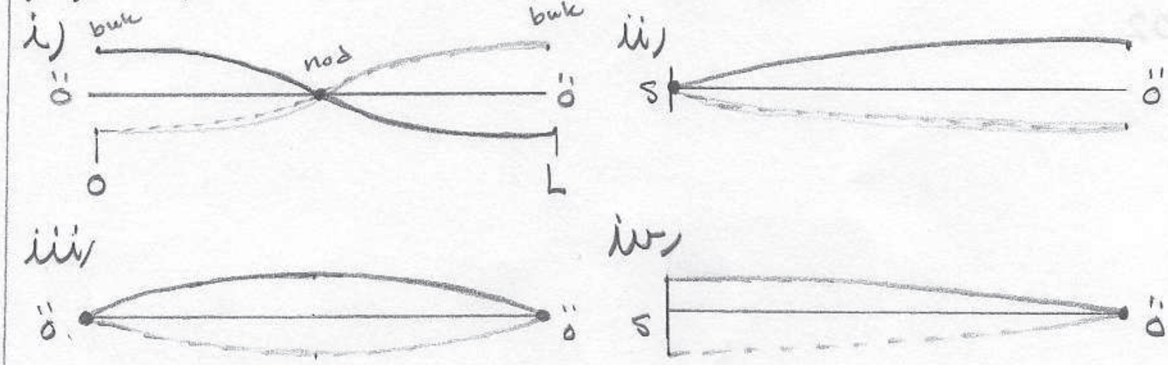
a) $\lambda = 2L$ $\qquad\qquad\qquad$ $\lambda = 4L$



b) Partikelsv: bukar i båda ändar (i, ovan) $L = 0{,}7$ m

bukar vid $x = m \cdot \frac{\lambda}{2}$, buk vid $x = L$ $\quad V = 343$ m/s

$$L = m\frac{\lambda}{2} = \frac{m}{2}\frac{V}{f_m} \Rightarrow f_m = \frac{V}{2 \cdot L} \cdot m \quad (m = 1, 2, 3, \ldots)$$

Tentamen i Vågfysik
NFYB01, TFYA10, TFYA59
2012-08-13
K. Järrendahl, IFM LiU

Grundton $f_1 = \frac{V}{2L} = \frac{343}{2 \cdot 0{,}7} = \underline{\underline{245 \text{ Hz}}}$

1:a överton $f_2 = \frac{V}{L} = \frac{343}{0{,}7} = \underline{\underline{490 \text{ Hz}}}$

c) Partikelsv. Nod i ena änden (ii, ovan)

bukar vid $x = (2m-1)\frac{\lambda}{4}$, buk vid $x = L$

$$L = (2m-1)\frac{\lambda}{4} = \frac{(2m-1)}{4}\frac{V}{f_m} \Rightarrow f_m = \frac{V}{4L}(2m-1) \quad (m = 1, 2, 3, \ldots)$$

Grundton $f_1 = \frac{V}{4 \cdot L} = \underline{\underline{122{,}5 \text{ Hz}}}$

1:a överton $f_2 = \frac{3V}{4 \cdot L} = \underline{\underline{367{,}5 \text{ Hz}}}$

a) $\beta = 10 \cdot \lg\left(\frac{I}{I_0}\right)$ där $I_0 = 10^{-12}\,W/m^2$

Vid hörseltröskel $I = I_0$ $\quad \beta = 10 \cdot \lg\left(\frac{I_0}{I_0}\right) = \underline{\underline{0\ dB}}$

Vid smärtgräns $I = 10\,W/m2$ $\quad \beta = 10 \cdot \lg\left(\frac{10^1}{10^{-12}}\right) = \underline{\underline{130\ dB}}$

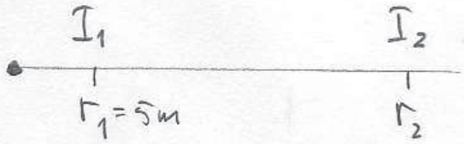
b) $\Delta\beta = \beta_5 - \beta_1 = 10\lg\left(\frac{5 \cdot I}{I_0}\right) - 10\lg\left(\frac{I}{I_0}\right) = 10\lg(5) = 6{,}989\ldots dB$

$\underline{\underline{\text{Svar}}}$ $\Delta\beta = 7dB$

c) $\Delta\beta = \underbrace{2 \cdot 10(\lg 5)}_{\approx 14dB} \Rightarrow 10\lg\left(\frac{n \cdot I}{I}\right) = 20 \cdot \lg 5 \Rightarrow n = 10^{2 \cdot \lg 5} = 25$

$\underline{\text{Svar}}$: 25 st.

d) $\Delta\beta = \beta_1 - \beta_2 = 14\,dB$



$\Delta\beta = 10 \cdot \lg\left(\frac{I_1}{I_2}\right) \Rightarrow \frac{I_1}{I_2} = 10^{\Delta\beta/10} \approx 25$

$P = A_1 I_1 = A_2 I_2$ ger $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$ (inv. sq. law)

$\Rightarrow r_2 = \sqrt{10^{\Delta\beta/10}} \cdot r_1 = 25{,}059\ldots$ $\quad \underline{\text{Svar}}$: 25 m från källan

e) En ökning från 86 till 100 dB (+14 dB) kräver återigen en ökning från 1 till ca 25 signalhorn.
(25,118... st)

$\underline{\text{Svar}}$: 25 st

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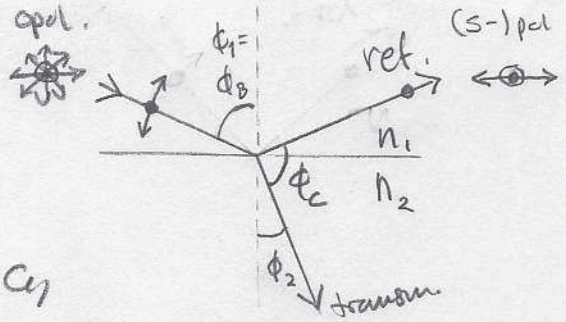


$n_1 = 1$

$n_2 = 1{,}33$

a)

Brewstervinkeln söks $\tan\phi_B = \frac{n_2}{n_1} \Rightarrow$

$$\phi_B = \arctan\left(\frac{n_2}{n_1}\right) = \arctan(1{,}33) = \underline{\underline{53{,}0612\ldots^\circ}}$$

Snells lag ger brytningsvinkeln $n_1 \sin \underbrace{\phi_1}_{=\phi_B} = n_2 \cdot \sin\phi_2$

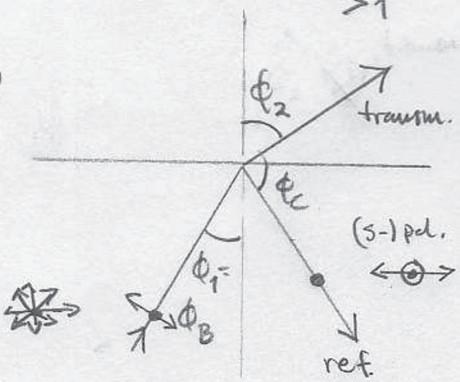
$$\Rightarrow \phi_2 = \arcsin\left(\frac{n_1}{n_2}\cdot \sin\phi_1\right) = \arcsin\left(\frac{\sin\phi_B}{1{,}33}\right) = \underline{\underline{36{,}9387\ldots^\circ}}$$

Totalref. då $\phi_2 = 90^\circ$ $\phi_1 \equiv \phi_g$

$$\Rightarrow \phi_g = \arcsin\Big(\underbrace{\frac{n_2}{n_1}}_{>1}\Big)$$ <u>ej möjligt</u>

<u>Svar:</u>
$\phi_B = 53{,}1^\circ$
$\phi_2 = 36{,}9^\circ$
ϕ_g —

b)



$$\phi_B = \arctan\left(\frac{1}{1{,}33}\right) = 36{,}9387\ldots^\circ$$

$$\phi_2 = \arcsin(1{,}33 \cdot \sin\phi_B) = 53{,}0612\ldots^\circ$$

$$\phi_g = \arcsin\left(\frac{1}{1{,}33}\right) = 48{,}7534\ldots$$

<u>Svar:</u> $\phi_B = 36{,}9^\circ$, $\phi_2 = 53{,}1^\circ$
$\phi_g = 48{,}8^\circ$

c) Vinkel mellan ref. och transm. strålar ϕ_c

$$\phi_c + \phi_B + \phi_2 = 180^\circ \Rightarrow \phi_c = 180^\circ - \underbrace{(\phi_B + \phi_2)}_{90^\circ \text{ enl. uppg. a) och b)}} = 90^\circ$$

Visa att $\phi_B + \phi_2 = 90^\circ$ (oberoende av n_1, n_2)

Brewster: $\tan\phi_B = \frac{n_2}{n_1} \Rightarrow \frac{\sin\phi_B}{\cos\phi_B} = \frac{n_2}{n_1} \Rightarrow n_1 \sin\phi_B = n_2 \cos\phi_B$

Snell: $n_1 \cdot \sin \overset{=\phi_B}{\phi_1} = n_2 \cdot \sin\phi_2$

$\cos\phi_B = \sin\phi_2 \Rightarrow \cos\phi_B = \cos(90^\circ - \phi_2)$

$\therefore \phi_B + \phi_2 = 90^\circ \Rightarrow \phi_c = 90^\circ$ <u>VSV.</u>

a) $E_n = -\underbrace{\left(\frac{me^4}{8\varepsilon_0^2 h^2}\right)}\frac{1}{n^2} = -\left(\frac{1}{4\pi\varepsilon_0}\frac{e^2}{2a_B}\right)\frac{1}{n^2}$

$$\frac{9{,}109\cdot 10^{-31}\cdot(1{,}602\cdot 10^{-19})^4}{8\,(8{,}854\cdot 10^{-12})^2\cdot(6{,}626\cdot 10^{-34})^2} = 2{,}1789\ldots\cdot 10^{-18}\,\mathrm{J}$$

$$= 13{,}601\ldots\,\mathrm{eV}$$

i) $\underline{\underline{E_1 = -13{,}6\ \mathrm{eV}}}$

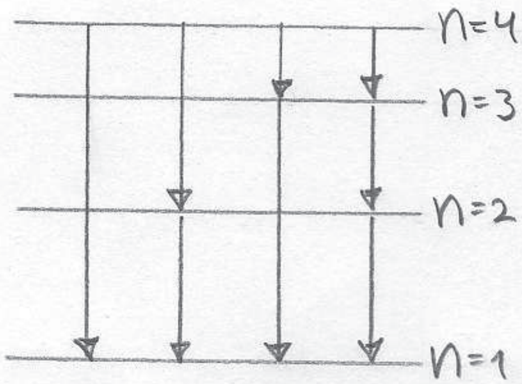
$$\frac{me^{\cancel{4}\,2}}{\cancel{8}\varepsilon_0^{\cancel{2}}h^2} = \frac{1}{4\pi\cancel{\varepsilon_0}}\frac{\cancel{e^2}}{\cancel{2}a_B} \Rightarrow a_B = \frac{\varepsilon_0 h^2}{\pi m e^2} = 5{,}292\ldots 10^{-11}\,\mathrm{m}$$

ii) $\underline{\underline{a_B = 0{,}0529\ \mathrm{nm}}}$

b) $E_4 = -13{,}6\cdot\frac{1}{16}$ $\quad \Delta E = E_4 - E_1 = -13{,}6\left(\frac{1}{16}-1\right) = \underline{\underline{12{,}75\,\mathrm{eV}}}$

$2{,}04\cdot 10^{-18}\,\mathrm{J}$

c)



$\Delta E_{4\to1} = -13{,}6\left(\frac{1}{16}-1\right) = 12{,}75\ \mathrm{eV}$

$\Delta E_{3\to1} = -13{,}6\left(\frac{1}{9}-1\right) = 12{,}1\ \mathrm{eV}$

$\Delta E_{2\to1} = -13{,}6\left(\frac{1}{4}-1\right) = 10{,}2\ \mathrm{eV}$

$\Delta E_{4\to2} = -13{,}6\left(\frac{1}{16}-\frac{1}{4}\right) = 2{,}55\ \mathrm{eV}$

$\Delta E_{3\to2} = -13{,}6\left(\frac{1}{9}-\frac{1}{4}\right) = 1{,}89\ \mathrm{eV}$

$\Delta E_{4\to3} = -13{,}6\left(\frac{1}{16}-\frac{1}{9}\right) = 0{,}66\ \mathrm{eV}$

d) $\lambda(\mathrm{nm}) = \frac{h\cdot c}{e}\cdot 10^9\,\frac{1}{E(\mathrm{eV})} \approx \frac{1240}{E(\mathrm{eV})}$

$\lambda_{4\to1} = \frac{1240}{12{,}75} = 97{,}3\,\mathrm{nm}$ Lyman (UV)

$\lambda_{3\to1} = \frac{1240}{12{,}1} = 102{,}5\,\mathrm{nm}$ Lyman (UV)

$\lambda_{2\to1} = \frac{1240}{10{,}2} = 121{,}6\,\mathrm{nm}$ Lyman (UV)

$\lambda_{4\to2} = \frac{1240}{2{,}55} = 486{,}3\,\mathrm{nm}$ Balmer (vis, cyan)

$\lambda_{3\to2} = \frac{1240}{1{,}89} = 656{,}1\,\mathrm{nm}$ Balmer (vis, röd)

$\lambda_{4\to3} = \frac{1240}{0{,}66\ldots} = 1876\,\mathrm{nm}$ Paschen (ir)

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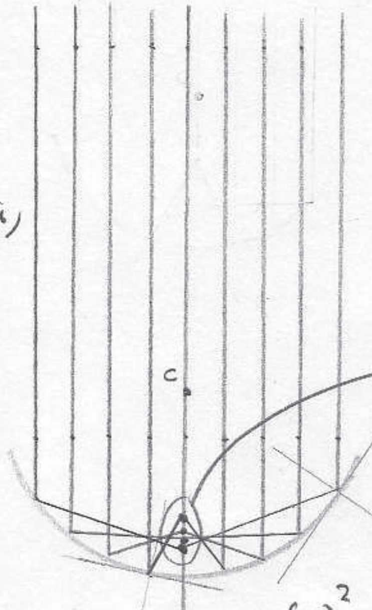
a)

i)

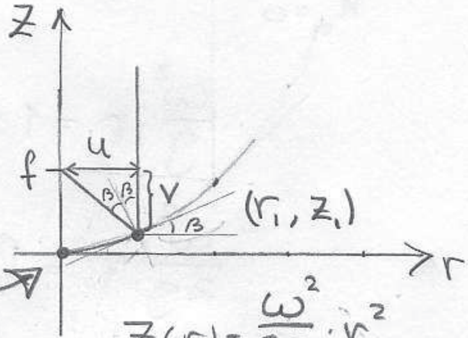


ii, Felet kallas <u>sfärisk aberration</u>

ej samma fokus.

b) $z(r) = h_0' + \frac{\omega^2}{2g} r^2$ $\omega(f)$?

kan sätta $h_0' = 0$



$z(r) = \frac{\omega^2}{2g} \cdot r^2$

<u>PH M-3</u>
par $(y - y_0) = \frac{1}{4d}(x - x_0)^2$
har fokus i pkt $x_0, y_0 + d$
med $y_0 = 0$, $x_0 = 0$, $y \equiv z$, $x \equiv r$
$\frac{1}{4d} = \frac{\omega^2}{2g} \Rightarrow d = f = \frac{g}{2\omega^2} \Rightarrow \omega = \pm\sqrt{\frac{g}{2f}}$

enligt fig: $u = r_1$, $v = f - z_1 = f - \frac{\omega^2}{2g} \cdot r_1^2$

$$\frac{u}{v} = \tan 2\beta = \frac{2\tan\beta}{1 - \tan^2\beta}$$

I pkten (r_1, z_1) kan kurvans lutning beskrivas med $\tan\beta$ alt. $\left.\frac{dz}{dr}\right|_{r=r_1} = \frac{\omega^2}{g} r_1$

$$\Rightarrow \frac{\cancel{r_1}}{f - \frac{\omega^2}{2g} \cdot r_1^2} = \frac{2\frac{\omega^2}{g} \cdot \cancel{r_1}}{1 - \frac{\omega^4}{g^2} \cdot r_1^2} \Rightarrow f \cdot \frac{2\omega^2}{g} - \cancel{\frac{r_1^2}{g^2}\omega^4} = 1 - \cancel{\frac{r_1^2}{g^2}\omega^4} \Rightarrow$$

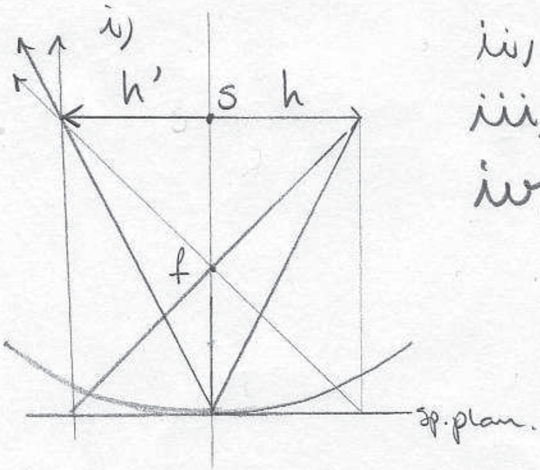
Skivspelare?

$\Rightarrow \omega = \pm\sqrt{\frac{g}{2 \cdot f}}$ $\omega = \pm\sqrt{\frac{9.8}{2 \cdot 0{,}22}} \cdot \frac{60}{2\pi} = \underline{\underline{\pm 45 \text{ varv/min}}}$

$4{,}72 \text{ rad/s}$

c, Anv. vanlig grafisk strålspårning

i)



ii, bilden är reell

iii, bilden är inverterad

iv, m=1 (h'=h), ingen förstoring/förminskning

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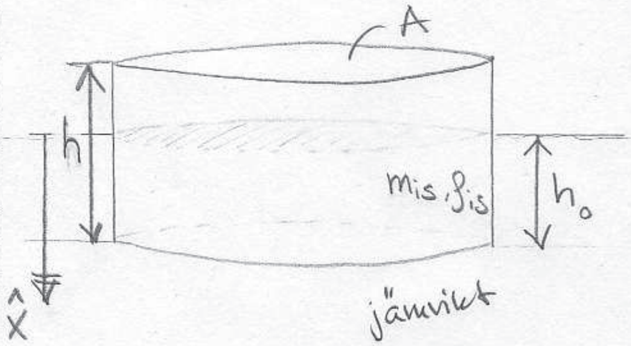
6.



ρ_{is}, m_{is} isens densitet, massa

ρ_v vattnets densitet

$h_0 = \frac{\rho_{is}}{\rho_v} \cdot h$ undanträngda vattnets massa

a, $\bar{F}_{tot} = \bar{F}_g + \bar{F}_l = 0 \Rightarrow m_{is} g \hat{x} - m_v g \hat{x} = 0$

Utan pingviner $m_{is} - m_v = A \cdot h \rho_{is} - A h_0 \rho_v = 0 \Rightarrow h_0 = \frac{\rho_{is}}{\rho_v} \cdot h$ ok!

med pingviner $m_{is} + m_p - m_v' = 0 \Rightarrow \cancel{Ah\rho_{is}} + m_p - \cancel{Ah_0\rho_v} - Ax_0\rho_v = 0$

enl. ovan

$\Rightarrow x_0 = \frac{m_p}{A \cdot \rho_v}$

b, Då pingvinerna har lämnat isberget

$\bar{F}_{tot} = \bar{F}_g + \bar{F}_l \Rightarrow m_{is} - m_v'' = \cancel{Ah\rho_{is}} - \cancel{Ah_0\rho_v} - A\underset{x(t)}{x}\rho_v$

$\therefore \bar{F}_{tot} = -Ax\rho_v \cdot g\hat{x}$ Newton II: $\bar{F}_{tot} = m_{is}\ddot{x}\hat{x} = Ah\rho_{is}\ddot{x}\hat{x}$

$\Rightarrow -\cancel{A}x\rho_v g\hat{x} = \cancel{A}h\rho_{is}\ddot{x}\hat{x} \Rightarrow \ddot{x} + \underbrace{\frac{\rho_v}{\rho_{is}} \frac{1}{h}}_{1/h_0} \cdot gx = 0$

$\therefore \ddot{x} + \frac{g}{h_0} x = 0$

c, $x(0) = x_0$ och $\dot{x}(0) = 0$ ger lösningen

$x(t) = x_0 \cdot \cos\left(\sqrt{\frac{g}{h_0}} \cdot t\right)$

$d(t) = h_0 + x \Rightarrow d(t) = \frac{\rho_{is}}{\rho_v} \cdot h + \frac{m_p}{A\rho_v} \cdot \cos\left(\sqrt{\frac{\rho_v}{\rho_{is}} \cdot \frac{g}{h}} \cdot t\right)$

d, $\omega = \sqrt{\frac{\rho_v}{\rho_{is}} \cdot \frac{g}{h}}$ $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{\rho_{is}}{\rho_v} \cdot \frac{h}{g}}$

PH T-1.3 -1.6

$\rho_v = 0{,}997 \cdot 10^3\ kg/m^3$, $\rho_{is} = 0{,}917 \cdot 10^3\ kg/m^3$, $g = 9.8\ m/s^2$

$h = 100$ m ger

$T = 19{,}2488...$ s

Svar: $T = 19$ s