Tentamen i Vågfysik
NFYB01, TFYA10
2011-01-07
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1.

$V = 340 \text{ m/s}$

a) Linus sändare, Linnea observatör

$V_S = 0,\ f_0 = 400 \text{ Hz}$ ← $V_{ob} = 10 \text{ m/s}$

(S) + → (Ob)

Linus Linnea

Linnea uppfattar frekvensen $f_{ob} = \frac{V + V_{ob}}{V - V_S} \cdot f_0$

$\therefore f_{ob} = \frac{340+10}{340} \cdot 400 = 411{,}7647...$

Svar: För att inte uppfatta några svävningar blåser Linnea en ton med frekvensen $f_{ob} = 412 \text{ Hz}$

b) $f_{ob} = \frac{V + V_{ob}}{V} \cdot f_0 \Rightarrow V_{ob} = \left(\frac{f_{ob}}{f_0} - 1\right) \cdot V$

enl. uppg. a) $f_{ob} = 411{,}7647...$ ger $V_{ob} = 10 \text{ m/s}$ ok.

$f_{ob_{max}} = 500 \text{ Hz} \Rightarrow V_{ob} = \left(\frac{500}{400} - 1\right) \cdot 340 = 85 \text{ m/s}$

$f_{ob_{min}} = 80 \text{ Hz}$ ger neg V_{ob} (Linnea närmar sig inte Linus)

Svar: Linnea kan närma sig Linus med farten 85 m/s (snabbt!) och fortfarande ha möjlighet att eliminera svävningar.

c) Linus hör svävningar. Linus obs. Linnea sändare

$V_{ob} = 0$ ← V_S

(Ob) ← + (S)

$f_{ob} = \frac{V - V_{ob}}{V - V_S} \cdot f_0 = \left(\frac{V}{V - V_S}\right) f_0$

enl. a) $f_{ob} = \frac{340}{330} \cdot 411{,}7647... = 424{,}242... \Rightarrow f_{sv} = |400 - 424.242| = 24.242...$

enl. b) $f_{ob} = \frac{340}{255} \cdot 500 = 666{,}66... \Rightarrow f_{sv} = |400 - 666{,}66...| = 266{,}66...$

Svar $f_{sv} = 24 \text{ Hz}$ och 267 Hz.

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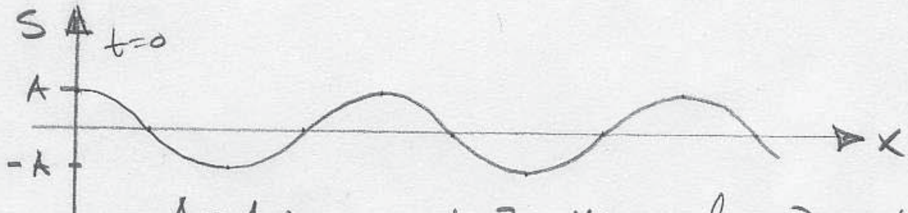
2.



$A = 1{,}0\,cm$, $v = 7{,}0\,m/s$, $f = 5{,}0\,Hz$

$$s(x,t) = A \cdot \sin(\omega t - kx + \phi)$$

$$s(0,0) = A \cdot \sin(\phi) = A \Rightarrow \sin(\phi) = 1$$

$\therefore \phi = \frac{\pi}{2}, \frac{5\pi}{2}, \ldots$ Väljer $\phi = \frac{\pi}{2}$

a) Elongationen $s(0,0) = A = 1{,}0\,cm = 0{,}01\,m$

Farten $\dot{s}(0,t) = A\omega \cos(\omega t + \phi)$

$$\Rightarrow \dot{s}(0,0) = A\omega \cos(\phi) = 0$$

Accelerationen $\ddot{s}(0,t) = -A\omega^2 \sin(\omega t + \phi)$

$$\Rightarrow \ddot{s}(0,0) = -A\omega^2 \underbrace{\sin(\phi)}_{=1} = -A\omega^2$$

$$\omega = 2\pi f = 10 \cdot \pi$$

$\therefore \ddot{s}(0,0) = -0{,}01 \cdot (10 \cdot \pi)^2 = -9{,}86960\ldots\ m/s^2$ $\quad (-\pi^2\ m/s^2)$

Svar: $s = 0{,}01\,m$, $\dot{s} = 0\ m/s$, $\ddot{s} = -9{,}91\ m/s^2$

b) $s(x,t) = A \cdot \sin(\omega t - kx + \overset{\frac{\pi}{2}}{\phi})$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{v} \cdot f$$

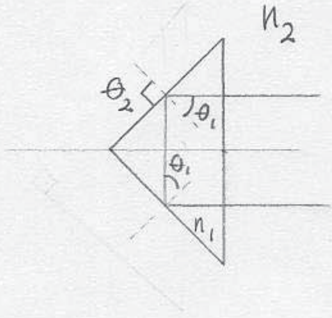
$$\therefore s(2, 0.15) = 0.01 \cdot \sin\left(2 \cdot \pi \cdot 5 \cdot 0.15 - 2\pi \frac{5}{7} \cdot 2 + \frac{\pi}{2}\right) =$$

$$= -4{,}339 \cdot 10^{-3}\ m$$

Svar: $-0.43\ cm$

se tex. PH T-4.3

a)



Totalreflektion då $\theta_2 = 90°$

$\theta_1 = 45°$, $n_2 = 1$

Snellius:

$$n_1 \cdot \sin\theta_1 = n_2 \cdot \sin\theta_2$$

$$\Rightarrow n_1 = \frac{n_2}{\sin\theta_1} = \sqrt{2} = 1,41\ldots$$

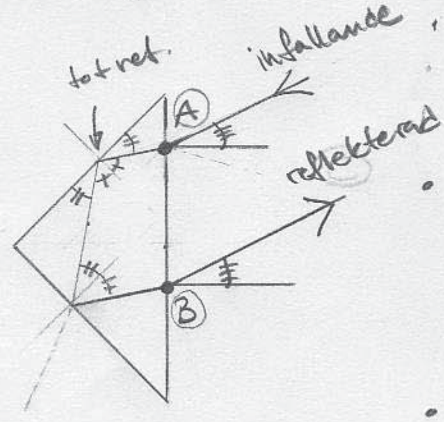
Svar: $n_1 \geq \sqrt{2}$ krävs för totalref.
Något typ av glas kan användas

b) Som i a) men med $n_2 = 1,3$

$$n_1 = 1,3 \cdot \sqrt{2} = 1,8384\ldots$$

Svar: $n_1 \geq 1,84$ krävs för totalreflektion.
Använd tex diamant (2,4 @ 589.3 nm)
eller glas av typ "flint SF51" (> 1,9 @ 486–656 nm)

c)



- Den infallande strålen bryts enl. Snell's lag i pkt. (A).
- Vinkelkonstruktionen inne i prismat visar att inkommande stråle mot (B) är parallell med den refrakterade strålen vid (A).
- Den reflekterade strålen måste då vara parallell med den infallande strålen.

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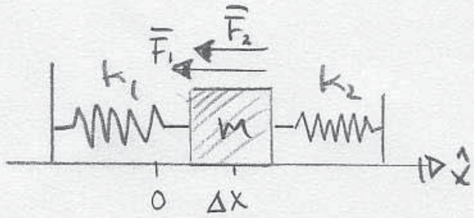
a)



$$\omega = \sqrt{\frac{k}{m}} = 2\pi f \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

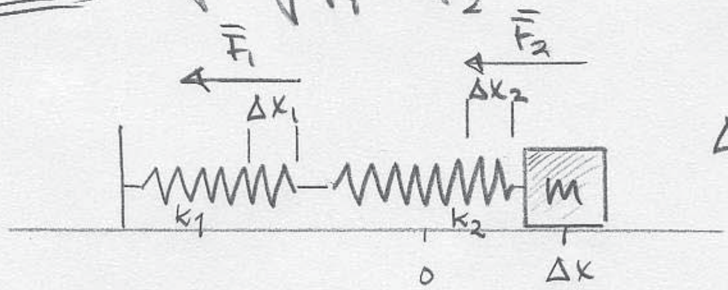
$$\bar{F}_{net} = \bar{F}_1 + \bar{F}_2 \Rightarrow F_{net} = -k_1 \cdot \Delta x - k_2 \Delta x = -\underbrace{(k_1 + k_2)}_{k_{eff}} \Delta x$$

$$k_{eff} = k_1 + k_2 \qquad f = \frac{1}{2\pi}\sqrt{\frac{k_{eff}}{m}} = \frac{1}{2\pi}\sqrt{\frac{k_1 + k_2}{m}} =$$

$$= \sqrt{\frac{k_1}{4\pi^2 m} + \frac{k_2}{4\pi^2 m}} = \sqrt{f_1^2 + f_2^2}$$

Svar: $f = \sqrt{f_1^2 + f_2^2}$

b)



$$\Delta x = \Delta x_1 + \Delta x_2$$

$$\bar{F}_{net} = \bar{F}_1 = \bar{F}_2 \Rightarrow F_{net} = -k_1 \Delta x_1 = -k_2 \Delta x_2$$

$$\Delta x = \Delta x_1 + \Delta x_2 = -\frac{F_{net}}{k_1} - \frac{F_{net}}{k_2} = -\left(\frac{1}{k_1} + \frac{1}{k_2}\right) F_{net}$$

$$\Rightarrow F_{net} = -\left(\frac{1}{\frac{1}{k_1} + \frac{1}{k_2}}\right) \Delta x = -\overbrace{\left(\frac{k_1 \cdot k_2}{k_1 + k_2}\right)}^{k_{eff}} \Delta x$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k_{eff}}{m}} = \sqrt{\frac{\left(\frac{k_1 \cdot k_2}{k_1 + k_2}\right)}{4\pi^2 m}} = \sqrt{\frac{\frac{k_1}{4\pi^2 m} \cdot \frac{k_2}{4\pi^2 m}}{\frac{k_1}{4\pi^2 m} + \frac{k_2}{4\pi^2 m}}} = \sqrt{\frac{f_1^2 \cdot f_2^2}{f_1^2 + f_2^2}}$$

Svar: $f = \sqrt{\frac{f_1^2 f_2^2}{f_1^2 + f_2^2}}$

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5.

a) $I = I_0 e^{-\alpha \cdot x}$

$I = \frac{I_0}{2}$ då $x = x_{\frac{1}{2}}$ $\Bigg\} \frac{I_0}{2} = I_0 e^{-\alpha x_{\frac{1}{2}}} \Rightarrow$

$\Rightarrow \ln \frac{1}{2} = -\alpha \cdot x_{\frac{1}{2}}$

$\Rightarrow \alpha = \frac{\ln 2}{x_{\frac{1}{2}}} = \frac{\ln 2}{1,88} = 0,3686\ldots$

Svar: $\alpha =$ 0,37 cm^{-1}

b) $I = I_0 e^{-1} \Rightarrow \alpha \cdot x = 1 \Rightarrow x = \frac{1}{\alpha} = 2,7122\ldots$

Svar: $x = 2,71$ cm

c) $\alpha = \frac{\ln 2}{x_{\frac{1}{2}}} = \frac{\ln 2}{3,84} = 0,1805\ldots$

Svar: $\alpha = 0,18$ cm^{-1}

d) $x = \frac{1}{\alpha} = 5,5399\ldots$ Svar: $x = 5,54$ cm

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(6)

a) Om $\cos\delta = -1 \Rightarrow$

$$\Rightarrow r_{01}^2 + r_{12}^2 + 2r_{01}r_{12}\cos\delta = r_{01}^2 + r_{12}^2 - 2r_{01}r_{12} =$$

$$= (r_{01} - r_{12})^2$$ dvs $\mathbb{R} = 0$ om $\delta = (2m+1)\pi$, $m \in \mathbb{Z}$

och $r_{01} = r_{12}$

Ingen absorption $N_1 = n_1$, $N_2 = n_2$ $(k=0)$

Omgivning luft $N_0 = 1$

$$\Rightarrow r_{01} = \frac{1-n_1}{1+n_1}, \quad r_{12} = \frac{n_1 - n_2}{n_1 + n_2} \Rightarrow$$

$$\Rightarrow (1-n_1)(n_1+n_2) = (1+n_1)(n_1-n_2) \Rightarrow$$

alt. $n_1 = \sqrt{n_0 n_2}$

$$\Rightarrow \cancel{n_1} + n_2 - n_1^2 - \cancel{n_1 n_2} = \cancel{n_1} - n_2 + n_1^2 - \cancel{n_1 n_2} \Rightarrow n_1 = \sqrt{n_2}$$

Svar:

$$\left.\begin{aligned} \delta &= (2m+1)\pi \\ \delta &= \frac{4\pi d}{\lambda} \cdot n_1 \end{aligned}\right\} \quad d = \frac{(2m+1)\lambda}{4n_1} \qquad m \in \mathbb{Z}$$

Svar:

b) $\lambda = 620\,\text{nm}$

$N_2 = 1.58 + i0 \Rightarrow n_2 = 1.58$

$600 \leq d \leq 650\,\text{nm}$

$\therefore n_1 = \sqrt{1.58} = 1,2569\ldots$

$$d = \frac{2m+1}{4 \cdot 1,2569} \cdot 620 = 123.3\ ;\ 369,9\ ;\ 616,6\ \text{nm}$$

($m=0$; $m=1$; $m=2$)

Svar: $n_1 = 1,26$ $\quad d = 617\,\text{nm}$