$$\frac{I_2}{I_1} = \frac{\frac{k}{r_2^2}}{\frac{k}{r_1^2}} = \frac{r_1^2}{r_2^2} \Leftrightarrow I_2 = \frac{r_1^2}{r_2^2} I_1 = \frac{(9{,}0\,m)^2}{(15\,m)^2} \cdot 1{,}99526 \cdot 10^{-7}\,\frac{W}{m^2} \approx 7{,}18294 \cdot 10^{-8}\,\frac{W}{m^2}$$

$$\Rightarrow L_2 = 10\,lg\,\frac{I_2}{I_0} = 10\,lg\,\frac{7{,}18294 \cdot 10^{-8}\,\frac{W}{m^2}}{10^{-12}\,\frac{W}{m^2}} \approx 48{,}5630\ dB \approx \underline{49\ dB}$$

d) $I_3 = I_0 \cdot 10^{\frac{L_3}{10}} = 10^{-12}\,\frac{W}{m^2} \cdot 10^{0} = 10^{-12}\,\frac{W}{m^2}$

$$\frac{I_3}{I_1} = \frac{r_1^2}{r_3^2} \Leftrightarrow r_3 = \sqrt{\frac{I_1}{I_3}}\, r_1 = \sqrt{\frac{1{,}99526 \cdot 10^{-7}\,\frac{W}{m^2}}{10^{-12}\,\frac{W}{m^2}}} \cdot 9{,}0\,m \approx 4020{,}15\,m \approx \underline{4{,}0\,km}$$

Huom. Cje d-kohdisse on oletettu että äänі ei heikkene absorption tai esteiden takia. Siten erityisesti d-kohdan tulos on turhan iso.

10. a)

$r = \frac{1}{2} \cdot 51\,cm$, $m = 37\,g$

NII : $\sum \vec{F} = \vec{N} + \vec{G} = m\vec{a} \Rightarrow N + mg = m a_n = m\frac{v^2}{r}$ $\quad | \cdot \frac{r}{m} \quad | \sqrt{\ }$

Rajatilanteessa $N = 0$

$$\Rightarrow v = \pm\sqrt{gr} = \sqrt{9{,}81\,\frac{m}{s^2} \cdot \frac{1}{2} \cdot 0{,}51\,m} \approx 1{,}58163\,\frac{m}{s} \approx \underline{1{,}6\,\frac{m}{s}}$$

b) Tarkastellaan tilannetta d_1:n hetkellä (kohta 1) d_2:n hetkellä (kohta 2).

$$E_{k1} + E_{p1} + W = E_{k2} + E_{p2}$$

$$\Leftrightarrow \frac{1}{2} m v_1^2 + mgd_1 + W = \frac{1}{2} m v_2^2 + mgd_2$$

$$\Leftrightarrow W = \frac{1}{2} m v_2^2 + mgd_2 - \frac{1}{2} m v_1^2 - mgd_1 \qquad (v = \sqrt{gr} \Rightarrow v^2 = gr)$$

$$= 0{,}037\,kg\left(\frac{1}{2} \cdot 9{,}81\,\frac{m}{s^2} \cdot \frac{0{,}38\,m}{2} + 9{,}81\,\frac{m}{s^2} \cdot 0{,}38\,m - \frac{1}{2} \cdot 9{,}81\,\frac{m}{s^2} \cdot \frac{0{,}51\,m}{2} - 9{,}81\,\frac{m}{s^2} \cdot 0{,}51\,m\right)$$

$$\approx -0{,}0589826\ J$$

$$W = F \cdot s = F\left(\frac{1}{2}\pi d_1 + \frac{1}{2}\pi d_2\right) \Leftrightarrow F = \frac{W}{\frac{1}{2}\pi(d_1 + d_2)} \approx \frac{-0{,}0589826\,J}{\frac{1}{2}\pi(0{,}51\,m + 0{,}38\,m)}$$

$$\approx -0{,}0421905\,N$$

Tarkastellaan tilannetta d_2:n hetkellä d_3:n hetkellä jolloin lisäreostusvoima $F \approx -0{,}0421905\,N$ ja matka $s = \frac{1}{2}\pi d_2 + \frac{1}{2}\pi d_3$

$$E_{k2} + E_{p2} + W = E_{k3} + E_{p3}$$

$$\Leftrightarrow \frac{1}{2} m v_2^2 + mgd_2 + Fs = \frac{1}{2} m v_3^2 + mgd_3$$

$$\Leftrightarrow \frac{1}{2} m g \frac{d_2}{2} + mgd_2 + Fs = \frac{1}{2} m v_3^2 + mgd_3$$

$$\Leftrightarrow v_3^2 = \frac{\frac{5}{4} mgd_2 + F \cdot \frac{1}{2}\pi(d_2 + d_3) - mgd_3}{\frac{1}{2} m} = \ldots \approx 2{,}15765\,\frac{m^2}{s^2}$$

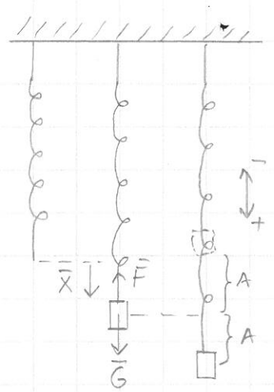
Vaadittava nopeuden neliö arvo d_3:n hetkellä:

$$v_3^2 = g r_3 = g\frac{d_3}{2} = 9{,}81\,\frac{m}{s^2} \cdot \frac{0{,}25\,m}{2} \approx 1{,}22625\,\frac{m^2}{s^2}$$

Koska d_3:n hetkellä $v_3^2 \approx 2{,}15765\,\frac{m^2}{s^2} > 1{,}22625\,\frac{m^2}{s^2}$, lelukiinto pääsee myös 3. silmukan läpi

FY5 26.3.2026

1.



$k = 15\,\frac{N}{m}$, $m = 51\,g$, $A = 2{,}0\,cm$

Punnus on tasapainossa: $\sum \vec{F} = \vec{F} + \vec{G} = \vec{0} \Rightarrow G - F = 0$

Harmoninen voima: $\vec{F} = -k\vec{x}$

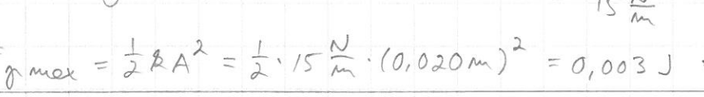
$\Rightarrow F = -G = -mg = -kx$

$$\Leftrightarrow x = \frac{mg}{k} = \frac{0{,}051\,kg \cdot 9{,}81\,\frac{m}{s^2}}{15\,\frac{N}{m}} \approx 0{,}033354\,m \approx \underline{3{,}3\,cm}$$

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0{,}051\,kg}{15\,\frac{N}{m}}} \approx 0{,}366370\,s \approx \underline{0{,}37\,s}$$

$$E_{p\,max} = \frac{1}{2} k A^2 = \frac{1}{2} \cdot 15\,\frac{N}{m} \cdot (0{,}020\,m)^2 = 0{,}003\,J = \underline{3{,}0\,mJ}$$

2. a)



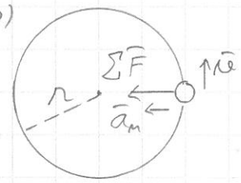
$f_0 = 623\,Hz$, $v_h = 15\,\frac{m}{s}$, $v = 340\,\frac{m}{s}$ (oletus)

Dopplerin ilmiö:

i) $f_1 = f_0\,\frac{v + v_h}{v} = 623\,Hz \cdot \frac{340\,\frac{m}{s} + 15\,\frac{m}{s}}{340\,\frac{m}{s}} \approx 650{,}485\,Hz \approx \underline{650\,Hz}$

ii) $f_2 = f_0\,\frac{v - v_h}{v} = 623\,Hz \cdot \frac{340\,\frac{m}{s} - 15\,\frac{m}{s}}{340\,\frac{m}{s}} \approx 595{,}515\,Hz \approx \underline{600\,Hz}$

b)



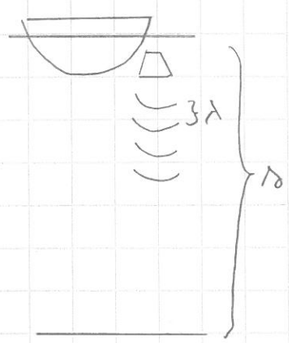
$m = 5{,}8\,kg$, $r = 4{,}2\,m$, $v = 2{,}3\,\frac{m}{s}$

Kappale on tasaisessa ympyrälikkeessä, joten kiihtyvyys on kohti ympyrän keskipistettä olevaa normaalikiihtyvyyttä

$$a_n = \frac{v^2}{r} = \frac{\left(2{,}3\,\frac{m}{s}\right)^2}{4{,}2\,m} \approx 1{,}25952\,\frac{m}{s^2} \approx \underline{1{,}3\,\frac{m}{s^2}}\ \text{kohti keskipistettä}$$

NII : $\sum \vec{F} = m\vec{a} \Rightarrow \sum F = 5{,}8\,kg \cdot 1{,}25952\,\frac{m}{s^2} \approx 7{,}30524\,N \approx \underline{7{,}3\,N}$ — " —

3.



$v = 1500\,\frac{m}{s}$ (oletus) , $f = 50\,kHz$, $t = 0{,}64\,s$

a) Kaltaliikkeen pituus:

$v = \lambda f$

$$\Leftrightarrow \lambda = \frac{v}{f} = \frac{1500\,\frac{m}{s}}{50 \cdot 10^3\,\frac{1}{s}} = \underline{0{,}03\,m}$$

b) Ultraäänen edestakainen matka:

$2s = vt \quad | : 2$

$$\Leftrightarrow s = \frac{vt}{2} = \frac{1500\,\frac{m}{s} \cdot 0{,}64\,s}{2} = \underline{480\,m}$$