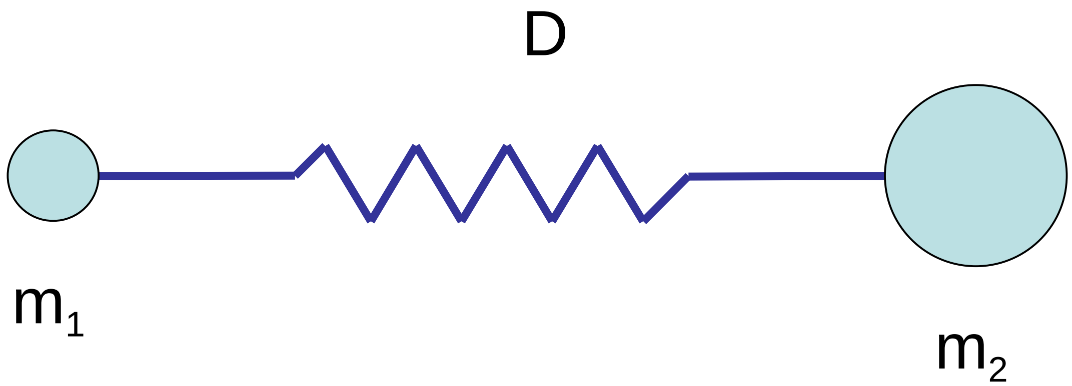
Fizika i

Rezgések, hullámok

Molekula rezgés:

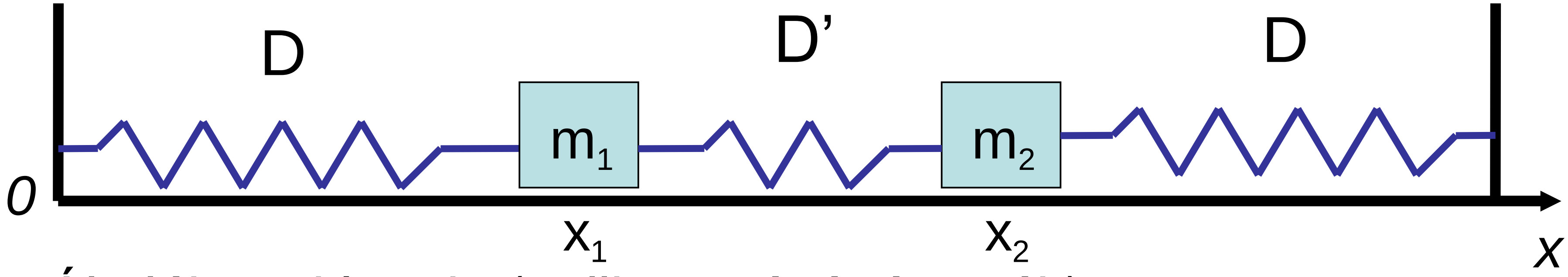


$\omega = ?$

$D' = ?$

$m' = ?$

Csatolt rezgés:



Általában: k’ << k (nullhosszúságú rugók)

$$m_1\ddot{x}_1 = -Dx_1 + D'(x_2 - x_1)$$

$$m_2\ddot{x}_2 = D(l - x_2) - D'(x_2 - x_1)$$

$m_2 = m_1$ $\quad \omega_0^2 = \dfrac{D}{m}$

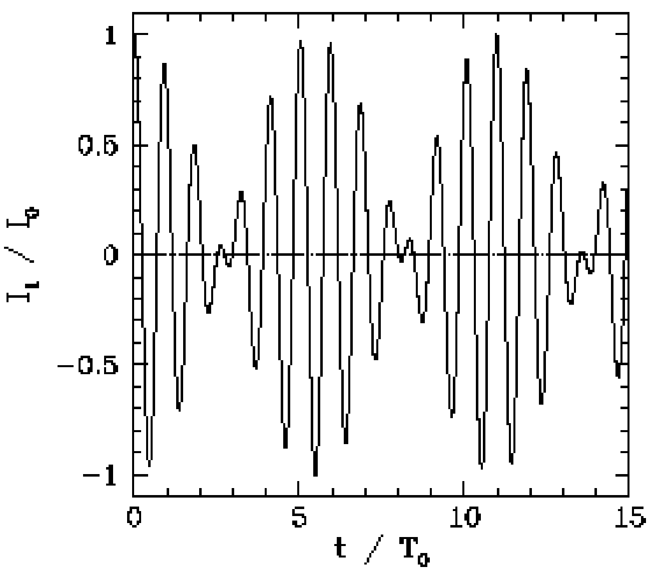
$$\boxed{\begin{aligned}\ddot{x}_1 &= -\omega_0^2 x_1 + \frac{D'}{m}(x_2 - x_1)\\ \ddot{x}_2 &= -\omega_0^2(l - x_2) + \frac{D'}{m}(x_2 - x_1)\end{aligned}}$$

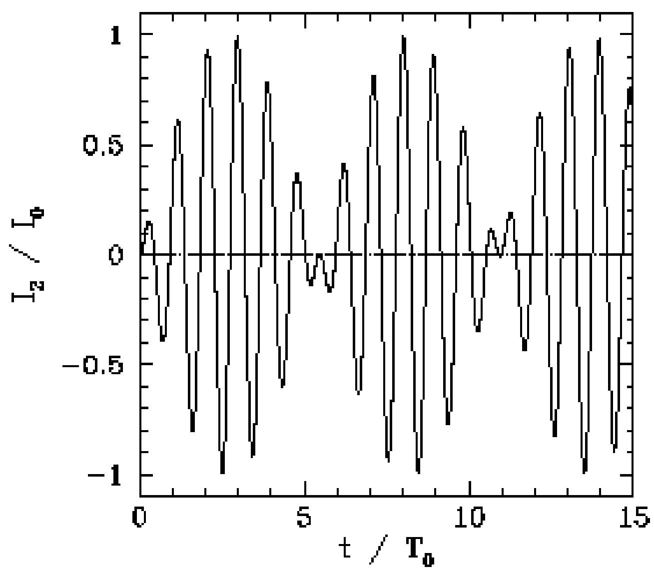
megoldás:

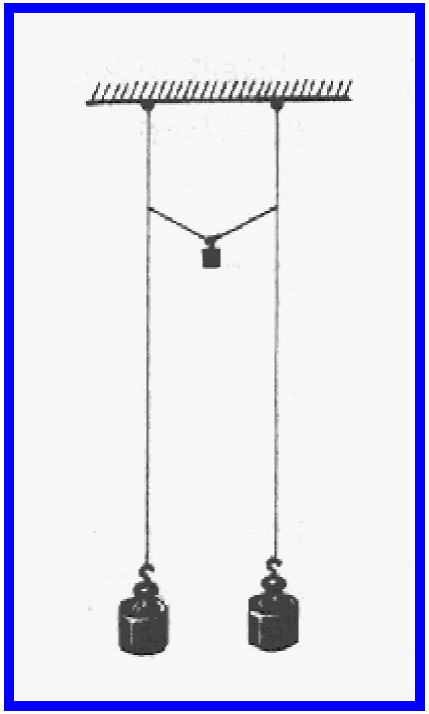
$$\omega = \sqrt{\omega_o^2 + 2\kappa} \quad \text{ahol} \quad \kappa = \frac{D'}{m}$$

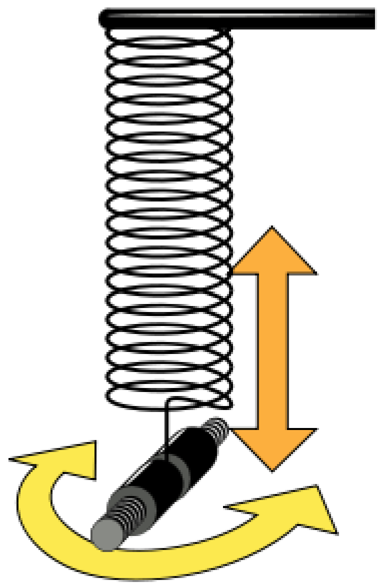
$$x_1 = C\cos\left(\frac{\omega - \omega_o}{2}t\right)\cos\left(\frac{\omega + \omega_o}{2}t\right)$$

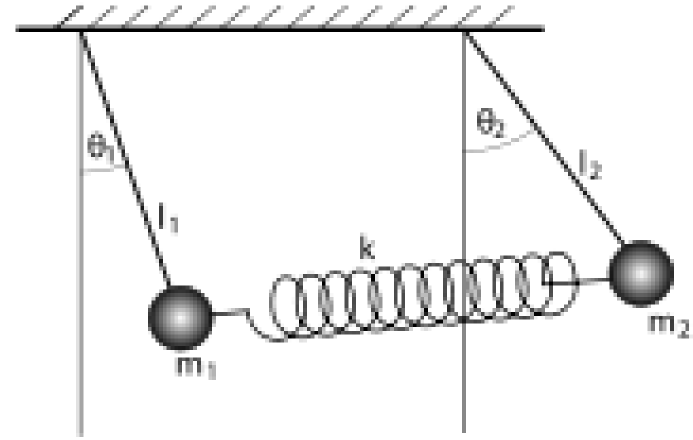
$$x_2 = C\sin\left(\frac{\omega - \omega_o}{2}t\right)\sin\left(\frac{\omega + \omega_o}{2}t\right)$$

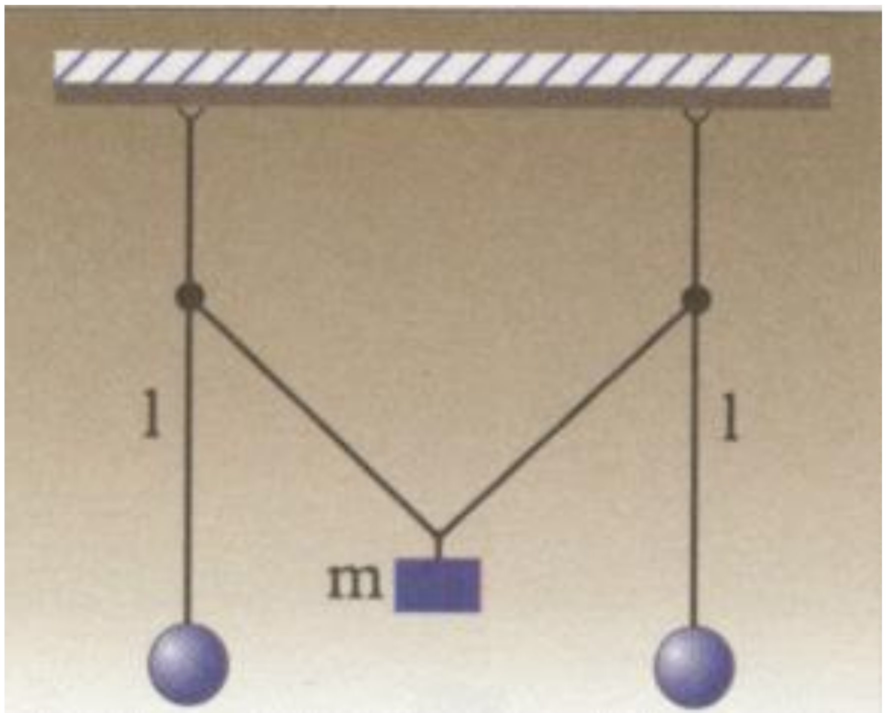




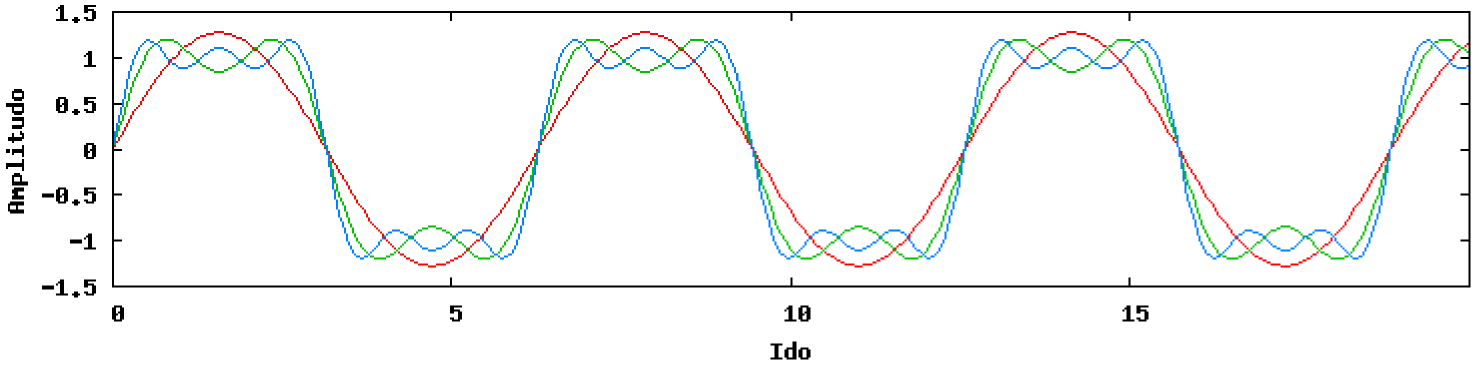





θ1
l1
k
m1
θ2
l2
m2


l
l
m

Rezgések Fourier-felbontása:

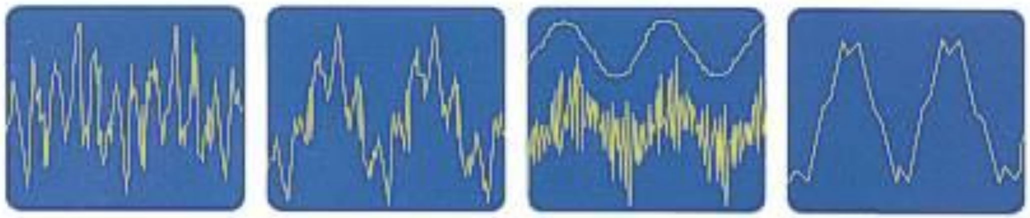


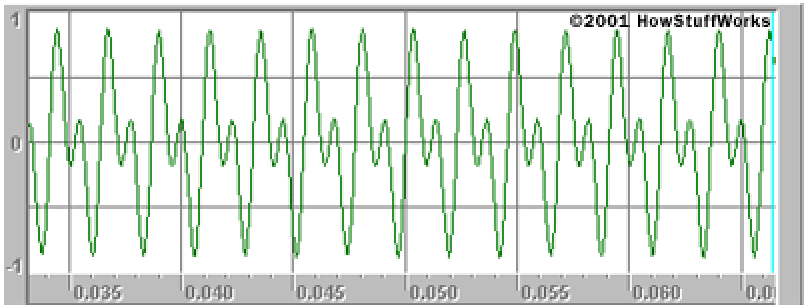
Tehát a Fourier transzformáció:

$$f(t) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} F(j\omega)\, e^{j\omega t}\, d\omega$$

$$F(j\omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(t)\, e^{-j\omega t}\, dt$$

$$a_n = \frac{2}{T}\int_0^T f(t)\cos\left(2\pi n\frac{t}{T}\right)dt \longrightarrow f(t) = c_0 + \sum_{n=1}^{\infty}\left[a_n \cdot \cos\left(2\pi n\frac{t}{T}\right) + b_n \cdot \sin\left(2\pi n\frac{t}{T}\right)\right]$$





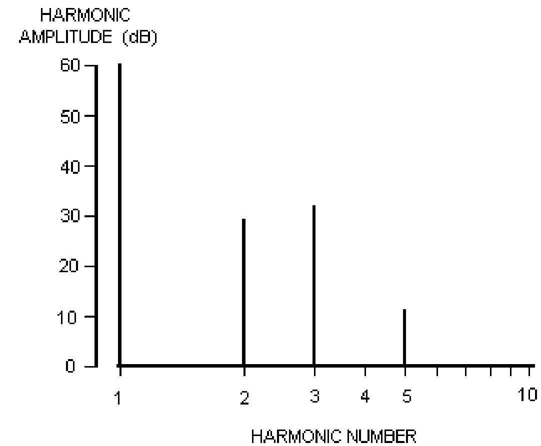
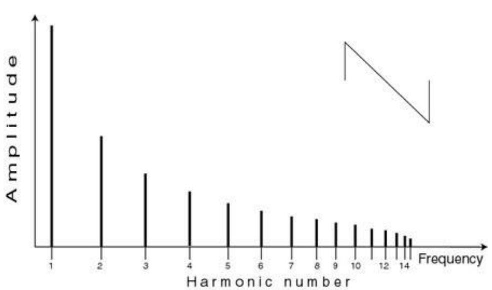
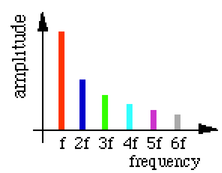
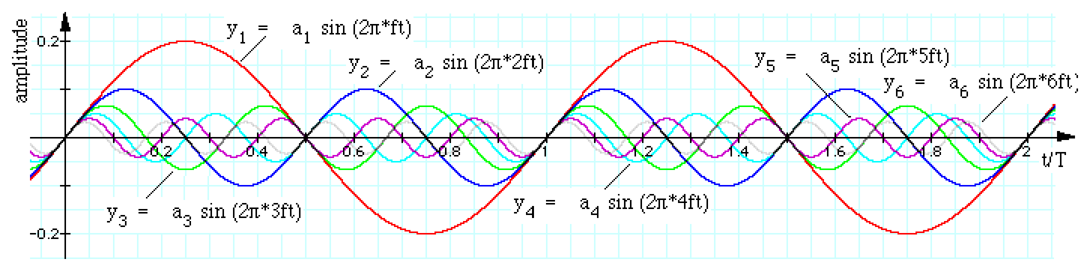
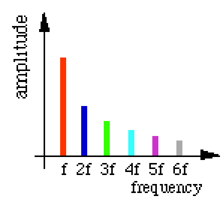


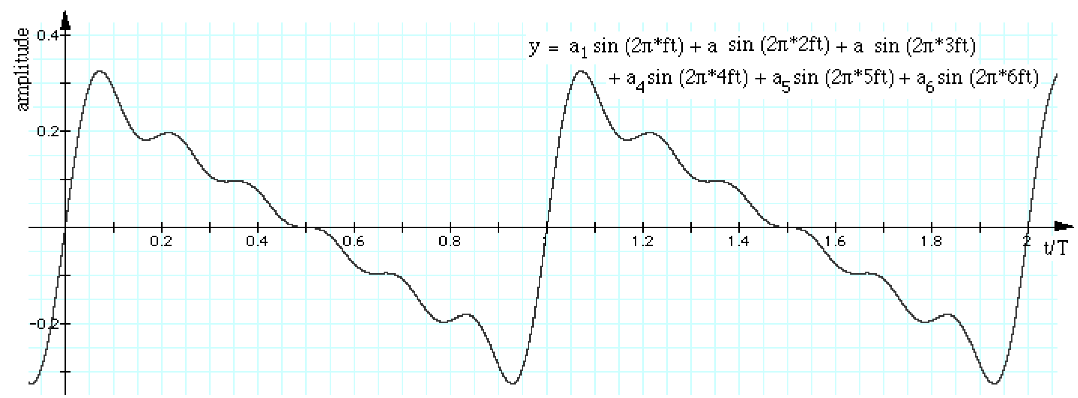
Figure 7 Harmonic Flute spectrum

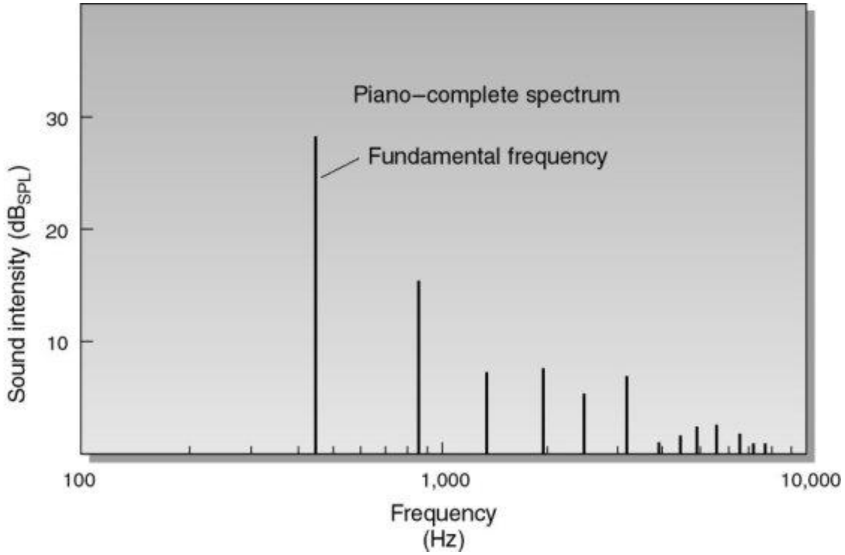


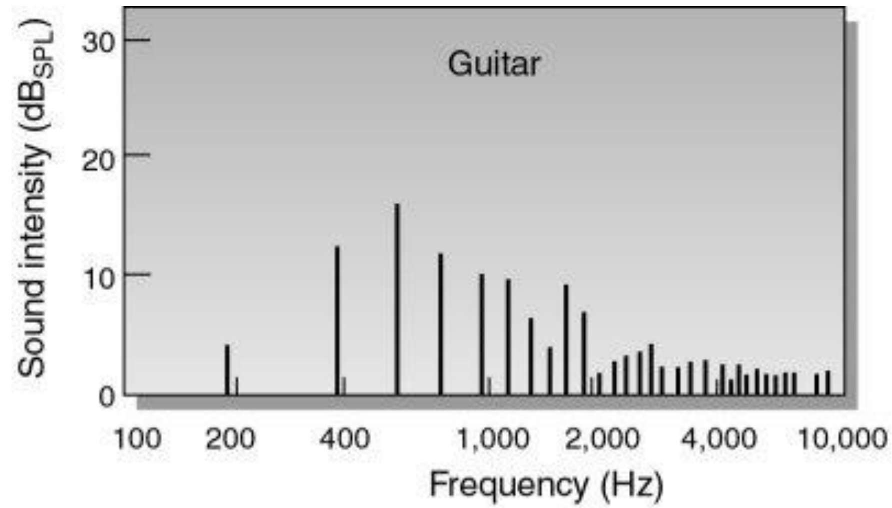












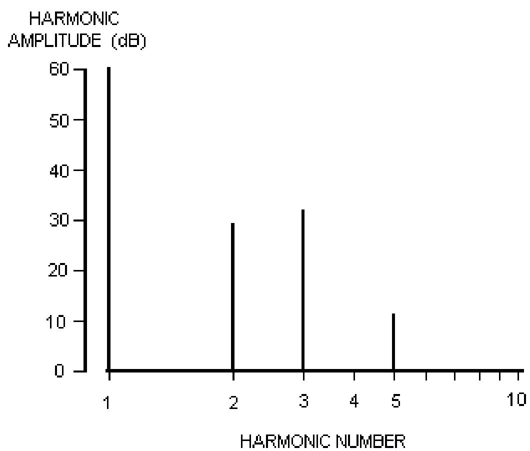
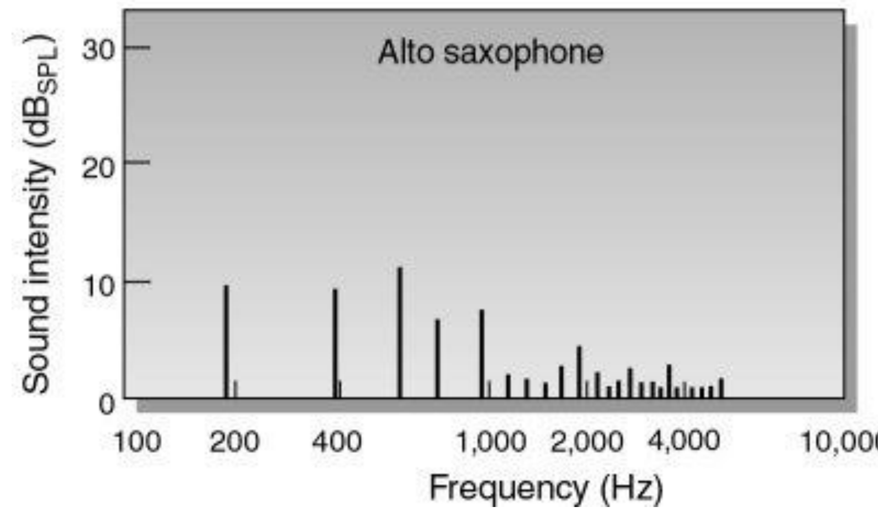


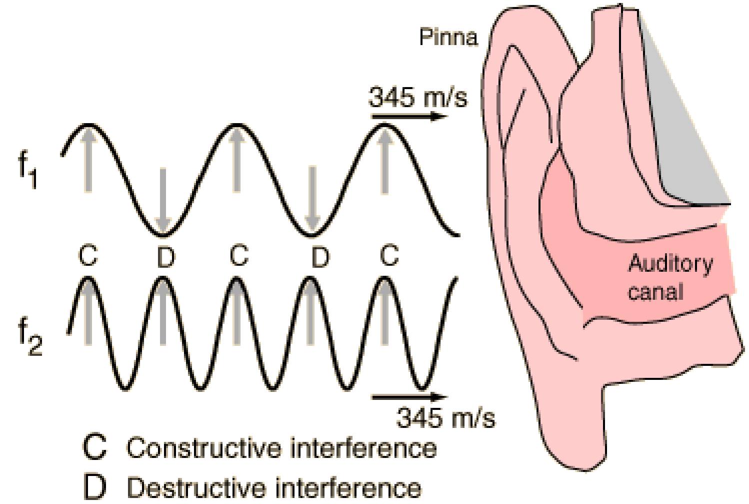
Figure 7 Harmonic Flute spectrum



A lebegés jelensége:

$$y_1(t) = A\cos(\omega_1 t)$$

$$y_2(t) = A\cos(\omega_2 t)$$

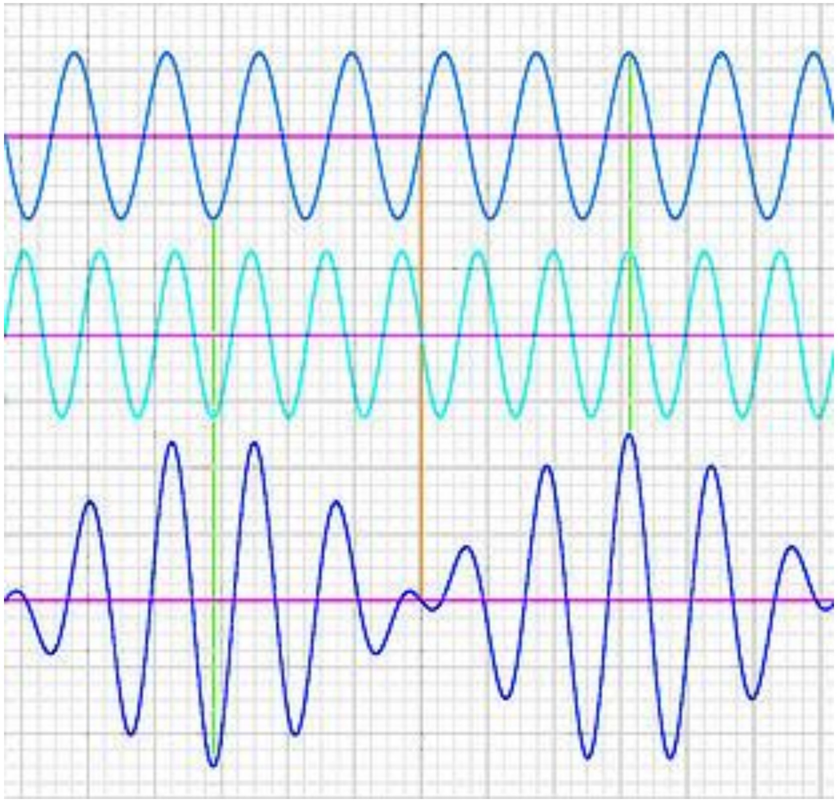


$$y(t) = y_1(t) + y_2(t)$$

$$y(t) = A\cos(\omega_1 t) + A\cos(\omega_2 t)$$

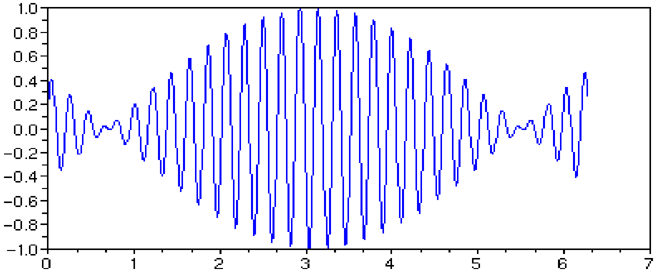
$$y(t) = 2A\cos\left(\frac{\omega_1 + \omega_2}{2} t\right)\cos\left(\frac{\omega_2 - \omega_1}{2} t\right)$$

$$y(t) = 2A\cos\left(2\pi \frac{f_1 + f_2}{2} t\right)\cos\left(2\pi \frac{f_2 - f_1}{2} t\right)$$



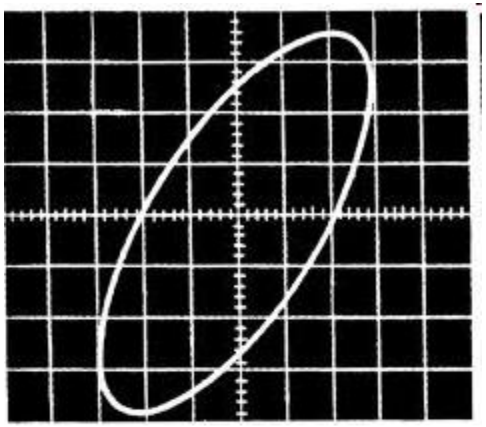
$$f_{lebegés} = \Delta f$$

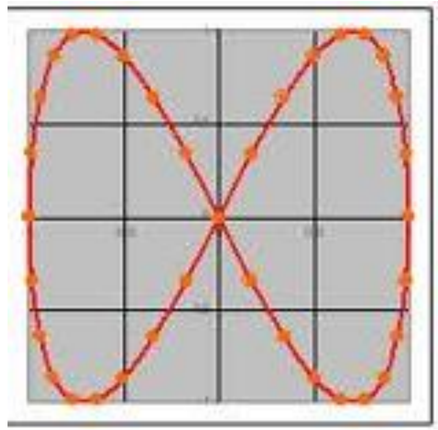
!

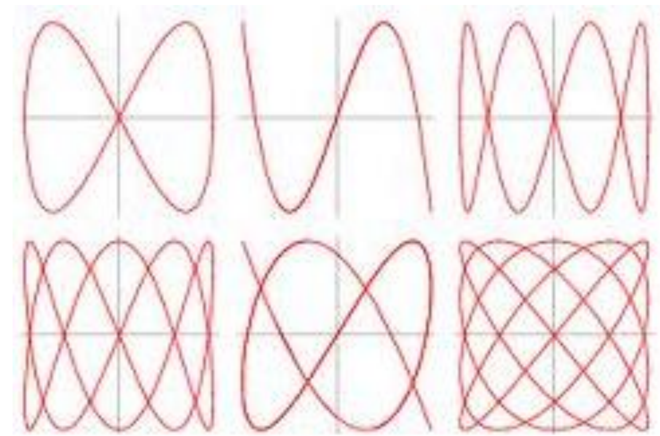


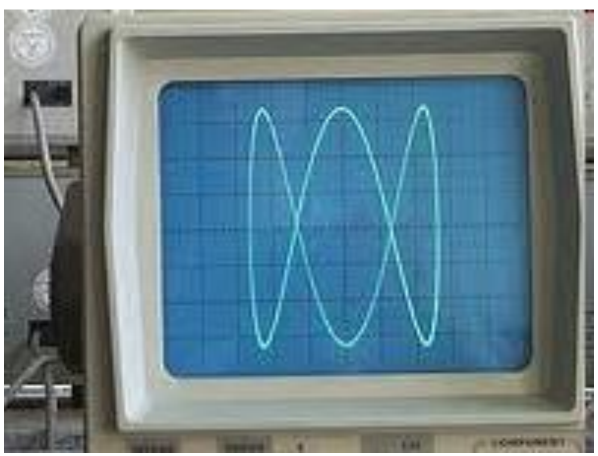
Egymásra merőleges rezgések összetétele – Lissajou görbék

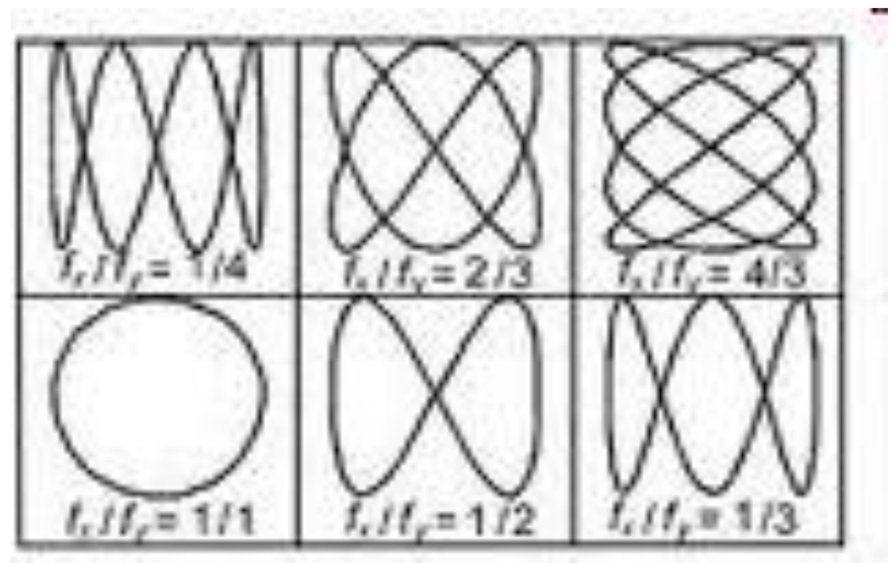
$$x(t) = A\sin(\omega t) \qquad y(t) = A\sin(\omega t + \varphi)$$



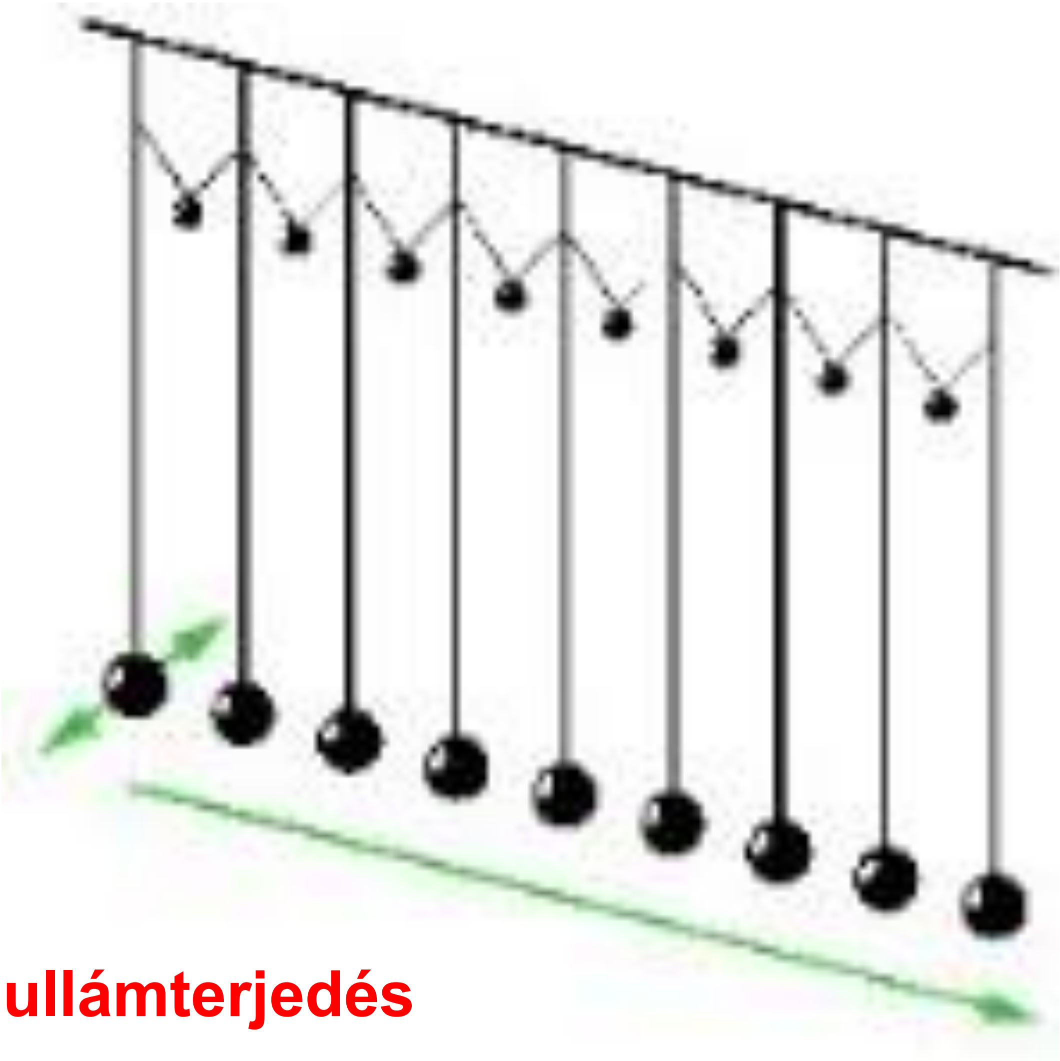








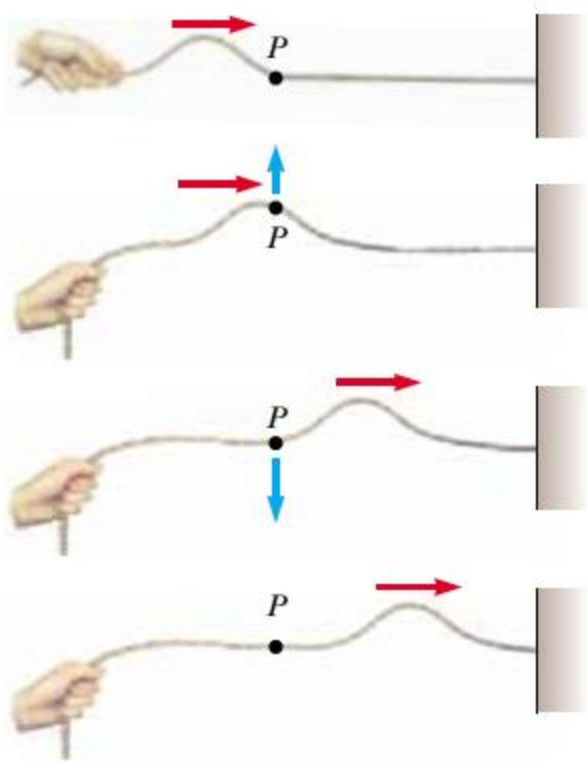
Csatolt rezgés még egyszer

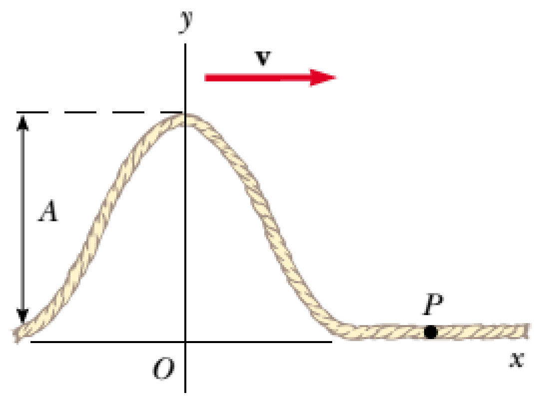


Hullámterjedés

Hullámterjedés

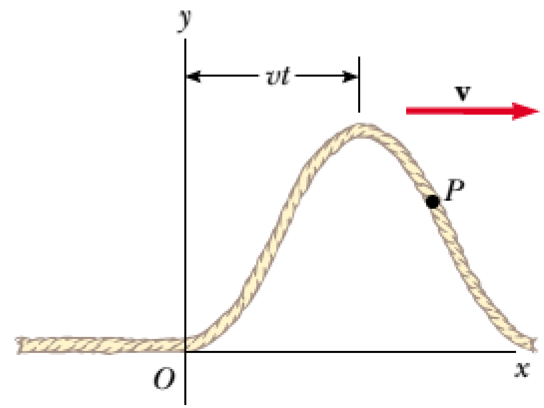
(Hullámmozgás)





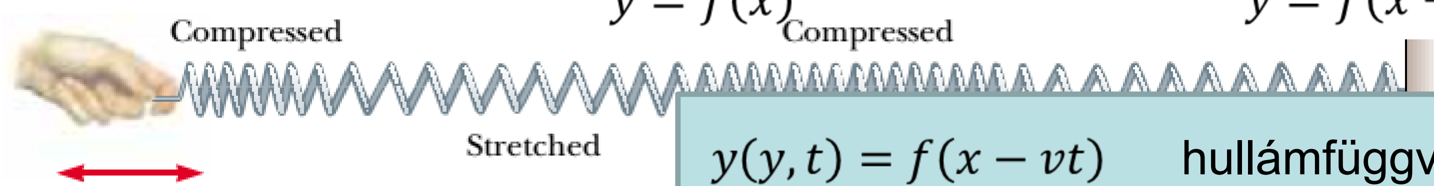
t = 0

$y = f(x)$



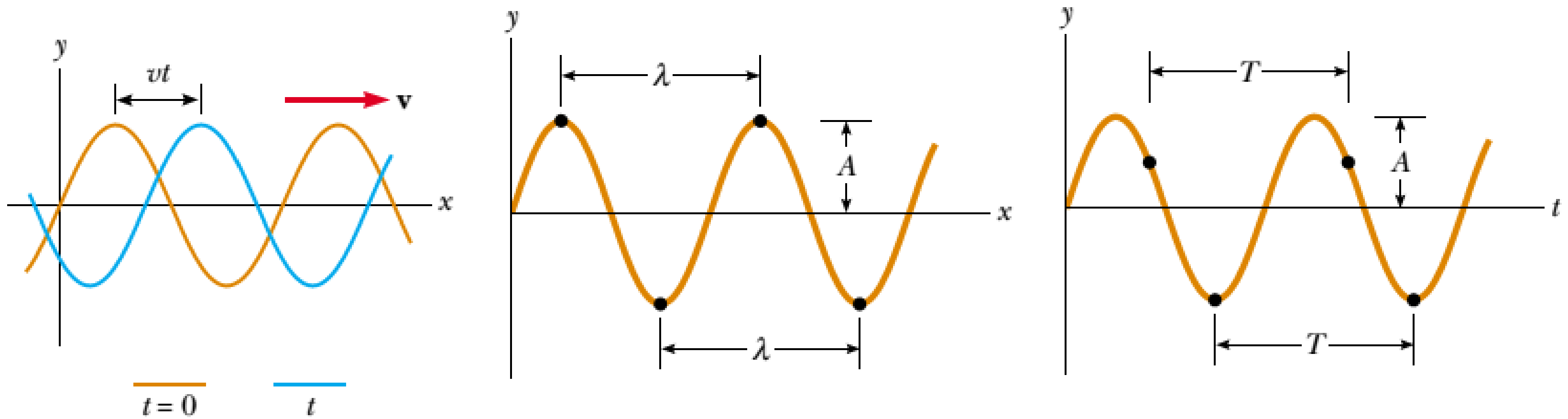
t = *t*

$y = f(x - vt)$



$y(y, t) = f(x - vt)$ hullámfüggvény

Szinusz(os) hullám



Hullámszám: $k = \dfrac{2\pi}{\lambda}$ $\quad v = \dfrac{\lambda}{T}$ és $T = \dfrac{1}{f} \rightarrow f \cdot \lambda = v$

$$y(x, t = 0) = A \sin\left(\frac{2\pi}{\lambda} x\right)$$

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

$$y(x, t) = A \sin\left(\frac{2\pi}{\lambda}(x - vt)\right)$$

$$\frac{2\pi}{\lambda} vt = \frac{2\pi}{\lambda/v} t = \frac{2\pi}{T} t = \omega t$$

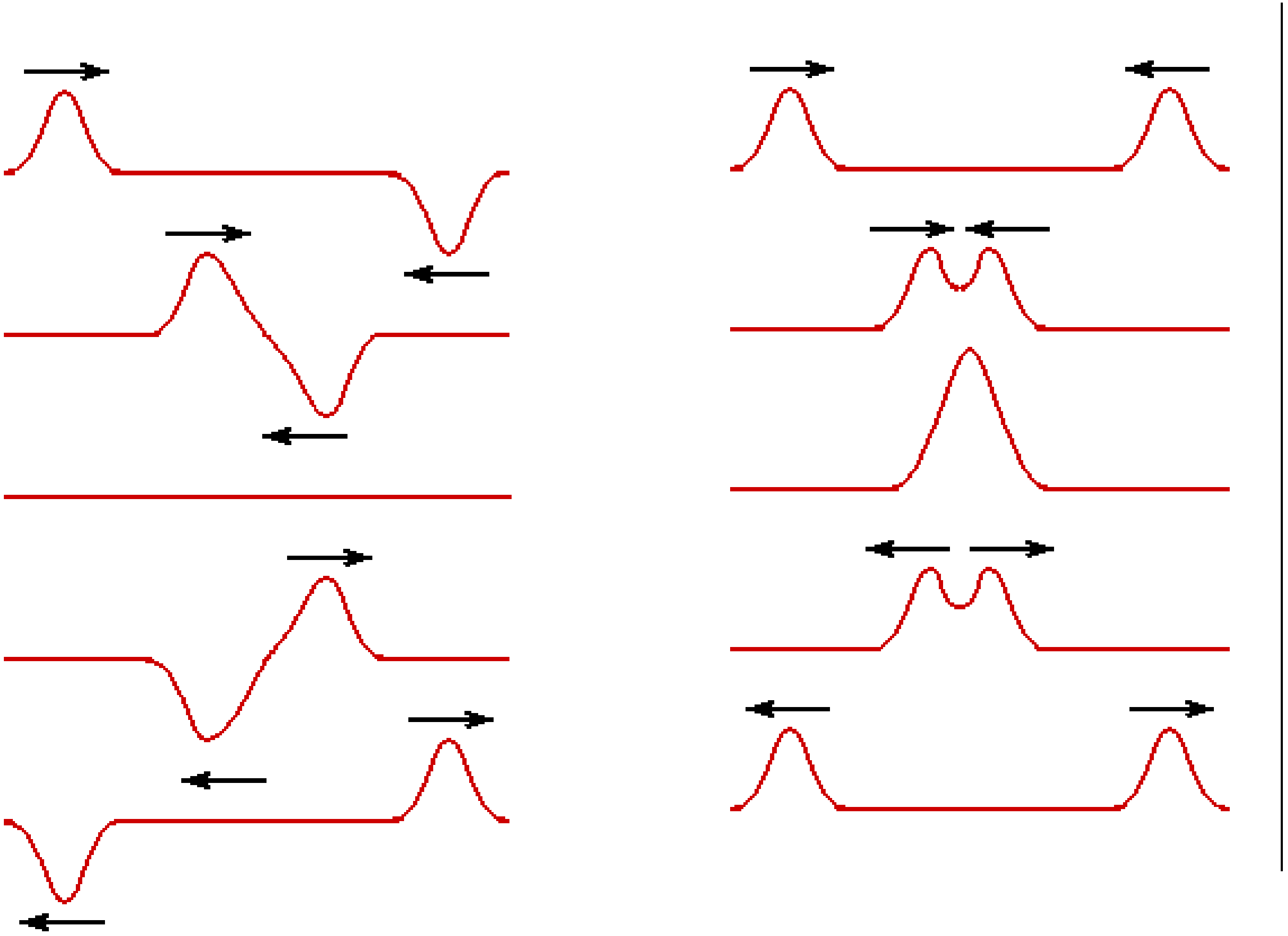
$$y(x, t) = A \sin(kx - \omega t + \varphi)$$

Hullámegyenlet:

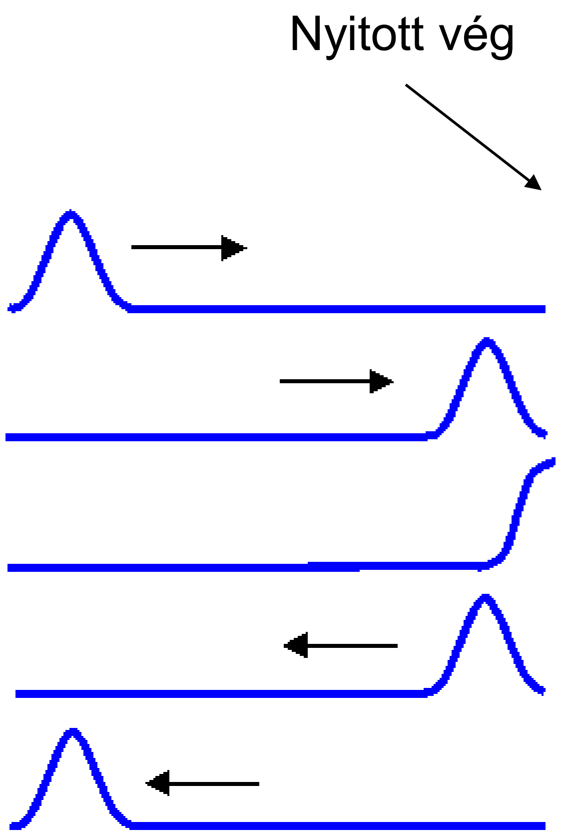
$$\boxed{\frac{\partial^2 y(x,t)}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y(x,t)}{\partial t^2}}$$

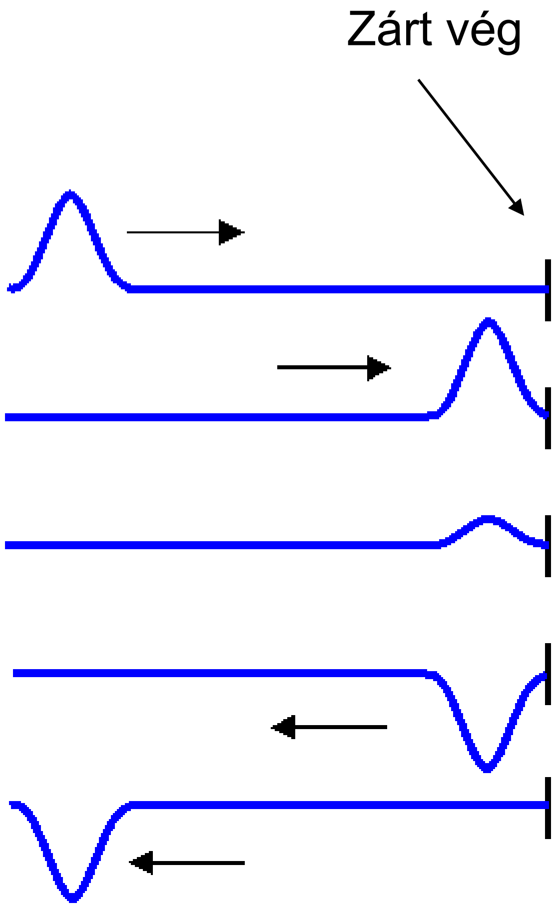
Szuperpozíció

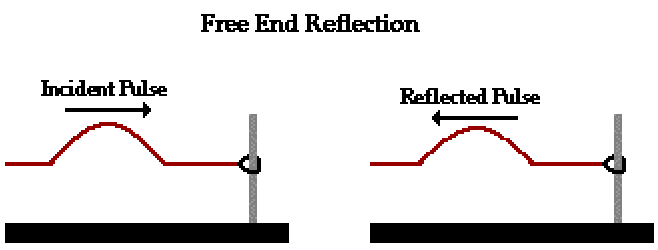
Linearitás!!!

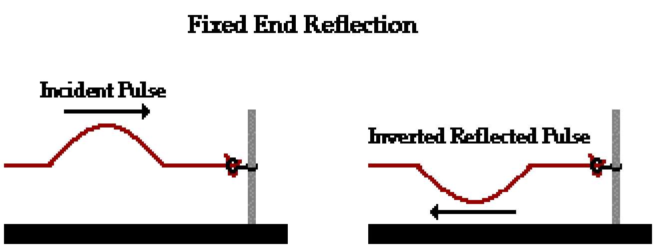


Hullámok visszaverődése, reflexiója:









Állóhullám

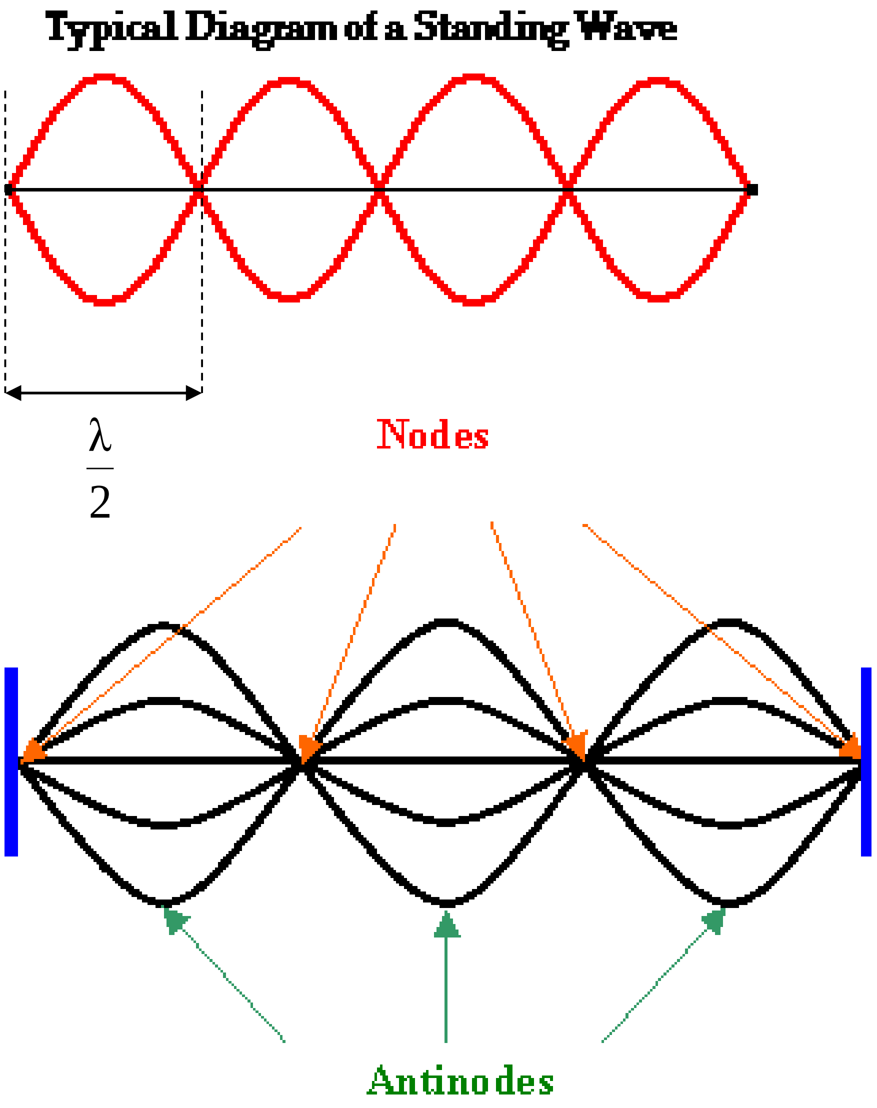
$$y_1(x,t) = A\cos(kx - \omega t) \qquad y_2(x,t) = A\cos(kx + \omega t)$$

$$y = y_1 + y_2$$

$$y(x,t) = 2A\cos(\omega t)\cos(kx)$$

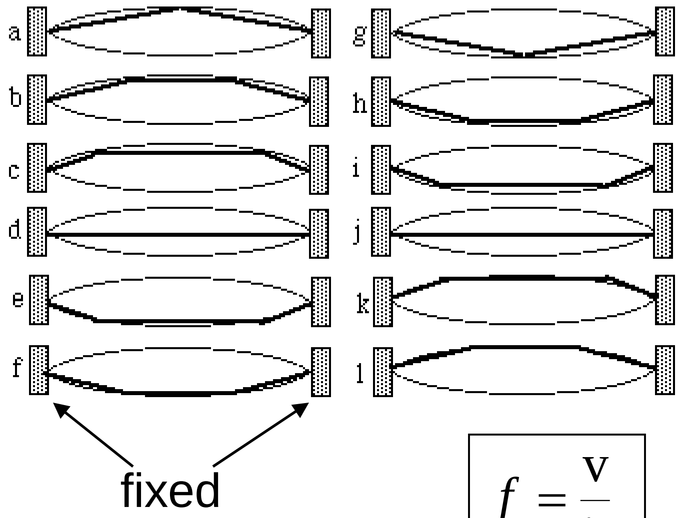
$$\omega = \frac{2\pi}{T} \qquad \mathrm{k} = \frac{2\pi}{\lambda}$$

Állóhullám:

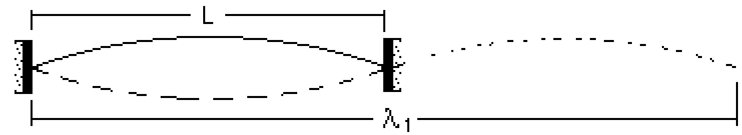


Typical Diagram of a Standing Wave
$\frac{\lambda}{2}$
Nodes
Antinodes

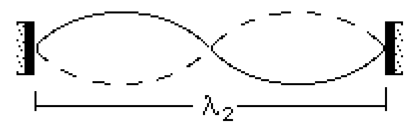
Alap és felharmónikusok (mindkét vég zárt)



$$f = \frac{v}{\lambda}$$

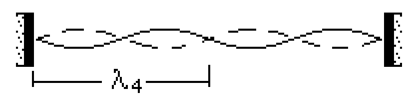


$$\lambda_1 = 2L$$



$$2 \cdot \frac{\lambda_2}{2} = L \rightarrow \lambda_2 = L$$

$$3 \cdot \frac{\lambda_3}{2} = L \rightarrow \lambda_3 = 2 \cdot \frac{L}{3}$$



$$4 \cdot \frac{\lambda_4}{2} = L \rightarrow \lambda_4 = 2 \cdot \frac{L}{4}$$

$$f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$$

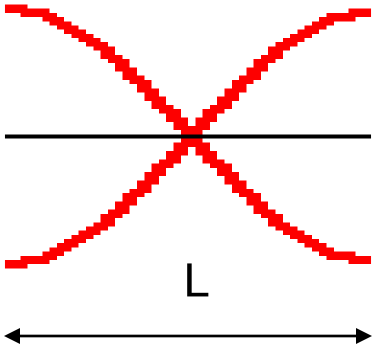
$$f_2 = \frac{v}{\lambda_2} = 2 \cdot \frac{v}{2L} = 2 \cdot f_1$$

$$f_3 = \frac{v}{\lambda_3} = 3 \cdot \frac{v}{2L} = 3 \cdot f_1$$

∘
∘
∘

$$\boxed{f_n = n \cdot f_1}$$

Mindkét vég nyitott

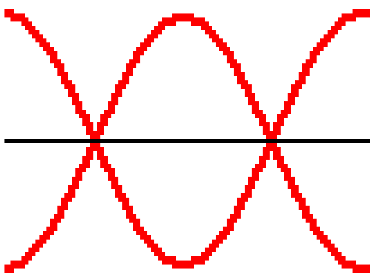


$$\lambda_1 = 2L$$

$$f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$$

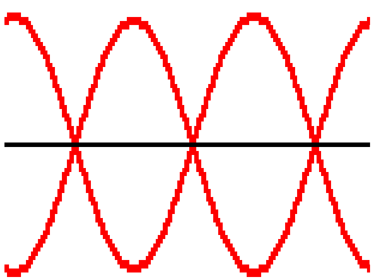
$$f_2 = \frac{v}{\lambda_2} = 2 \cdot \frac{v}{2L} = 2 \cdot f_1$$

$$f_3 = \frac{v}{\lambda_3} = 3 \cdot \frac{v}{2L} = 3 \cdot f_1$$



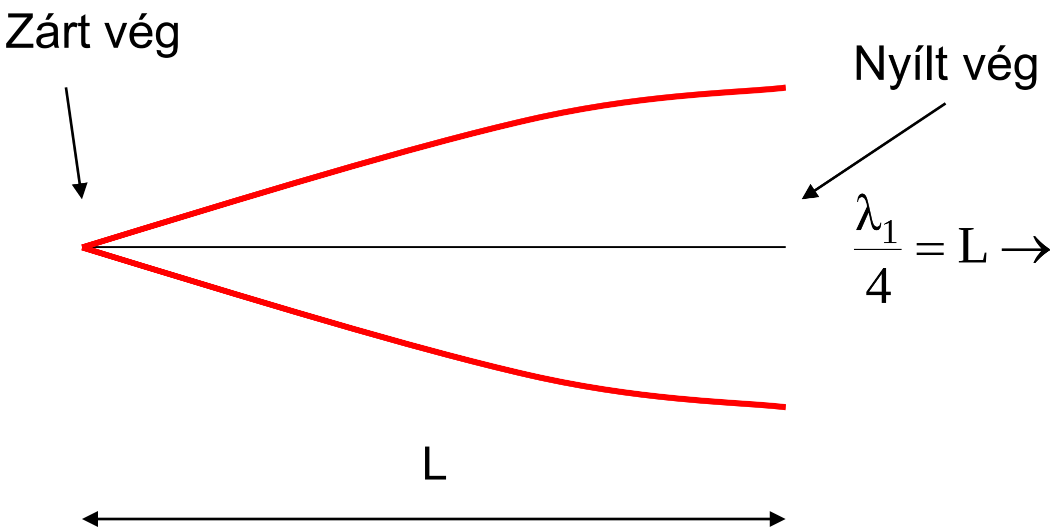
$$\lambda_2 = \frac{2L}{2}$$

$$\boxed{f_n = n \cdot f_1}$$

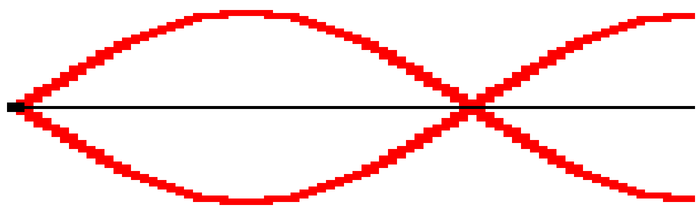


$$\lambda_3 = \frac{2L}{3}$$

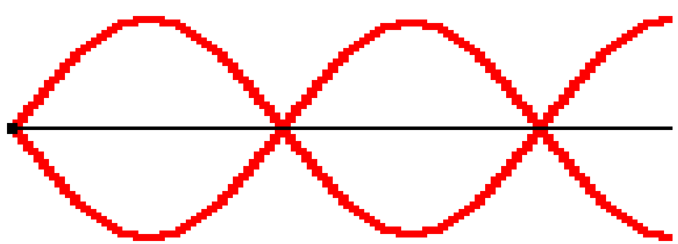
Egyik vég nyitott



$$\frac{\lambda_1}{4} = L \rightarrow \lambda_1 = 4L \longrightarrow f_1 = \frac{v}{\lambda_1} = \frac{v}{4L}$$



$$3 \cdot \frac{\lambda_2}{4} = L \rightarrow \lambda_2 = \frac{4L}{3} \longrightarrow f_2 = \frac{v}{\lambda_2} = 3 \cdot \frac{v}{4L}$$



$$5 \cdot \frac{\lambda_3}{4} = L \rightarrow \lambda_3 = \frac{4L}{5} \longrightarrow f_3 = \frac{v}{\lambda_3} = 5 \cdot \frac{v}{4L}$$

∘

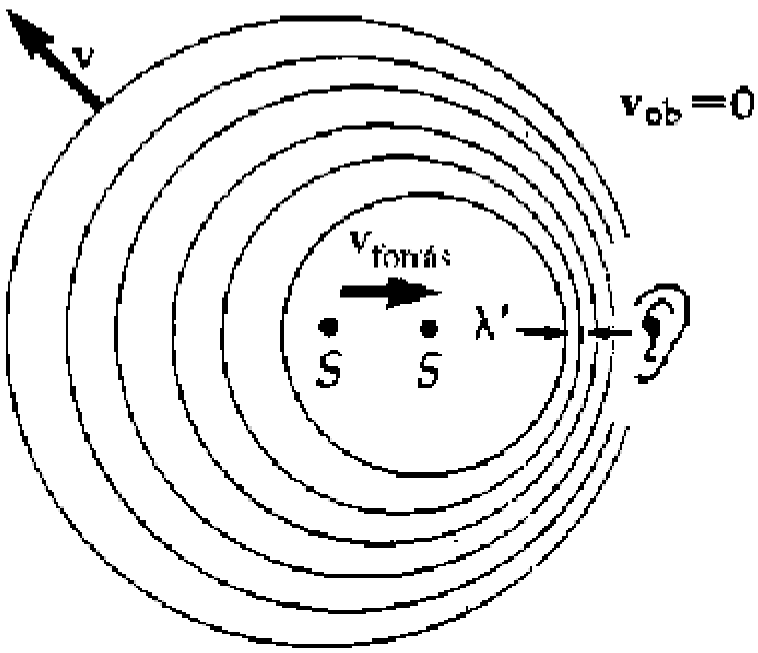
∘

∘

$$\boxed{f_n = (2n - 1) \cdot f_1}$$

Doppler effektus 1.

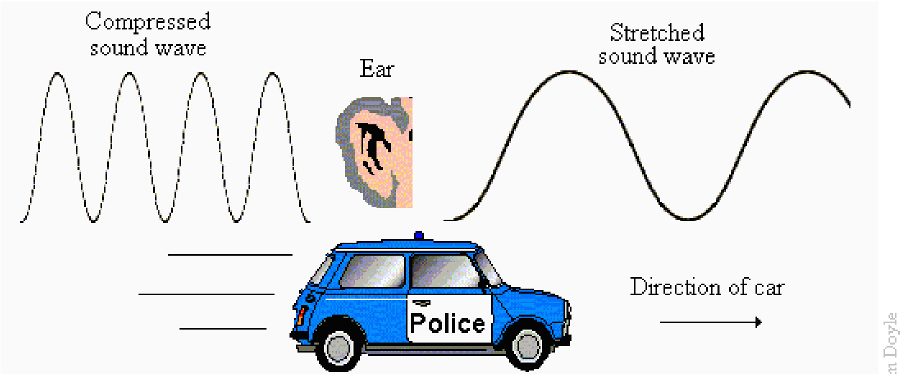
Forrás mozog, a megfigyelő áll



Egy másodperc alatt a $(v-v_{forrás})$t hosszú távolságon f rezgés.

$$\lambda' = \frac{(v - v_{forrás})}{f}$$

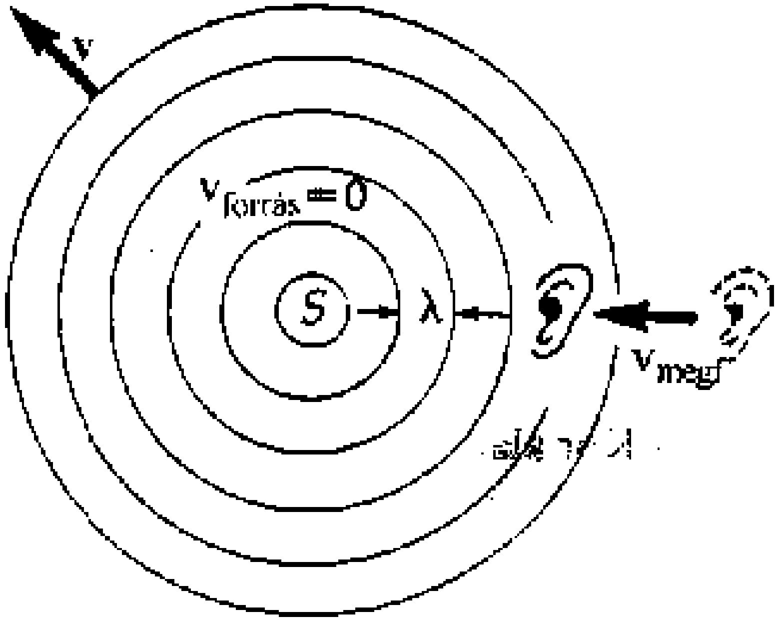
$$f' = \frac{v}{\lambda'} = f\left(\frac{v}{v - v_{forrás}}\right)$$



The Doppler effect:
As the police car approaches the sound waves are compressed and the pitch rises.
As it recedes the sound waves are stretched and the pitch decreases.

Doppler effektus 2.

Forrás áll, a megfigyelő mozog

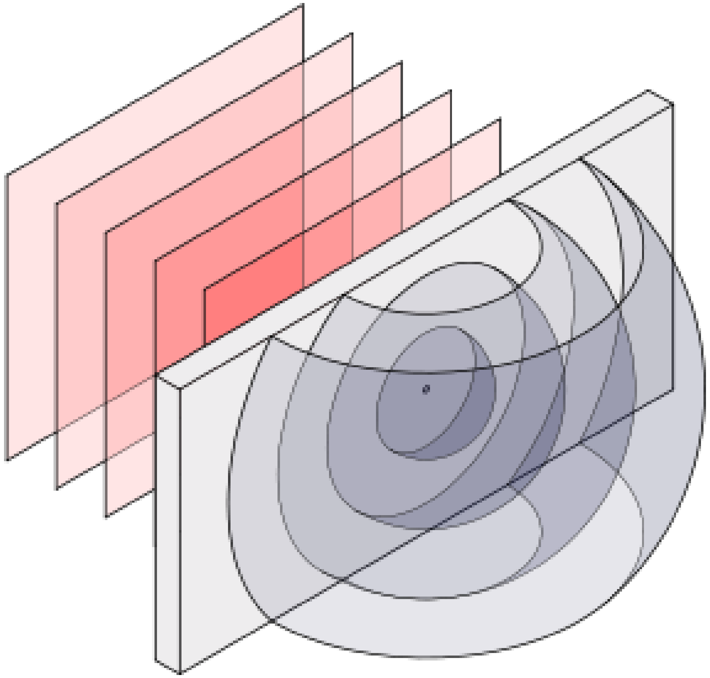


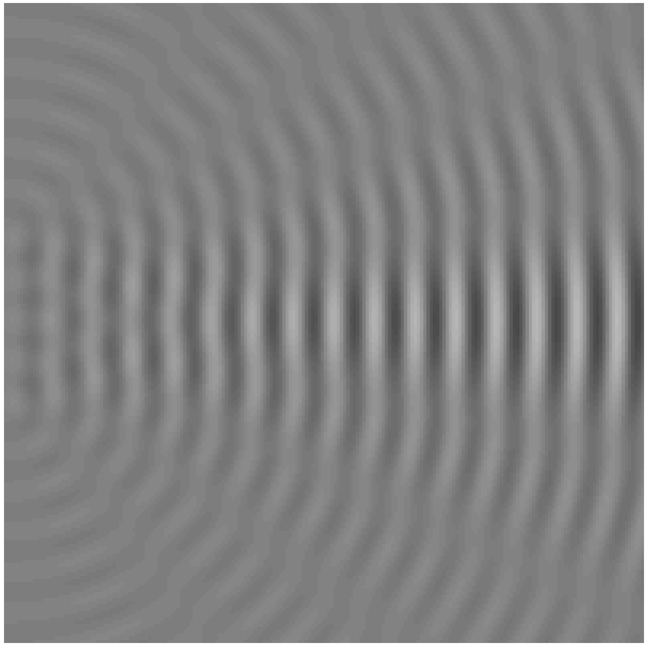
$$f' = \left(\frac{v}{\lambda} + \frac{v_{megf}}{\lambda}\right) = f\left(\frac{v + v_{megf}}{v}\right)$$

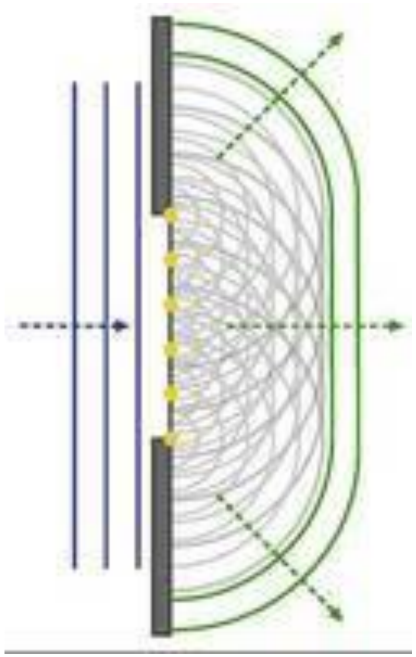
$$f' = f\left(\frac{v \pm v_{megf}}{v \mp v_{forrás}}\right)$$

… és ha a szél fúj?

Huygens elv 1.

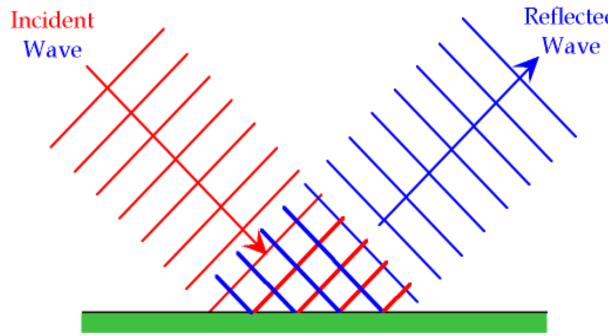


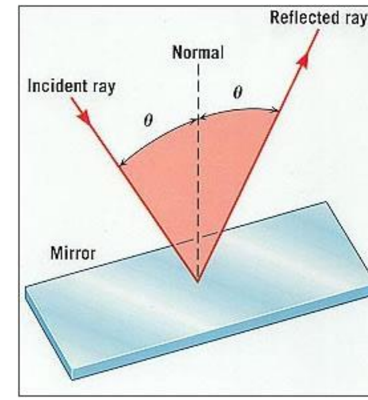




Huygens elv 2.

reflexió





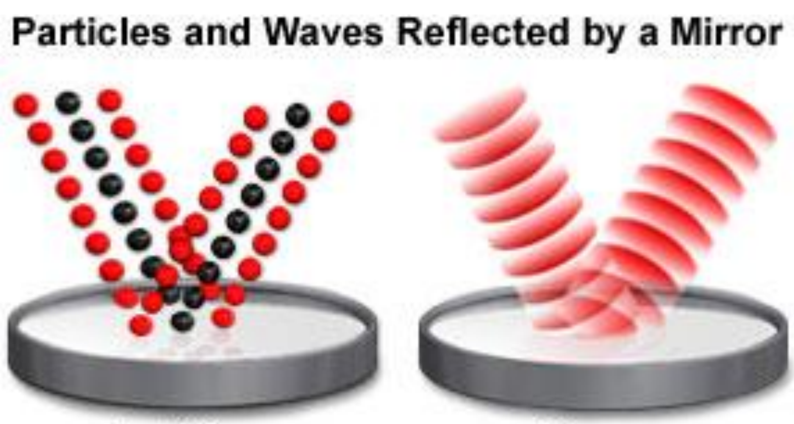
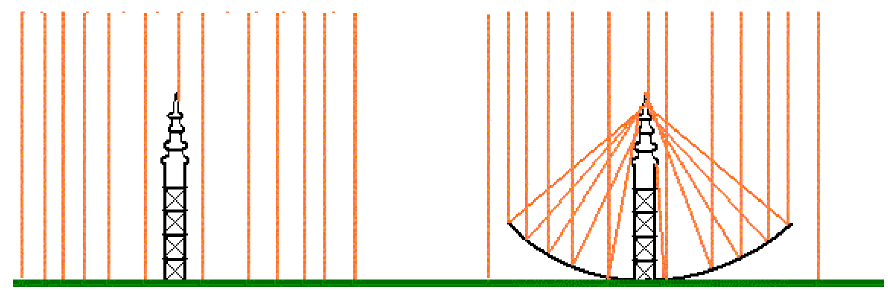
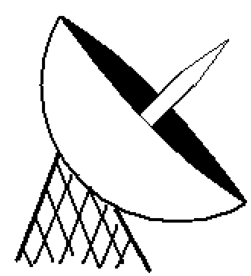


Figure 1



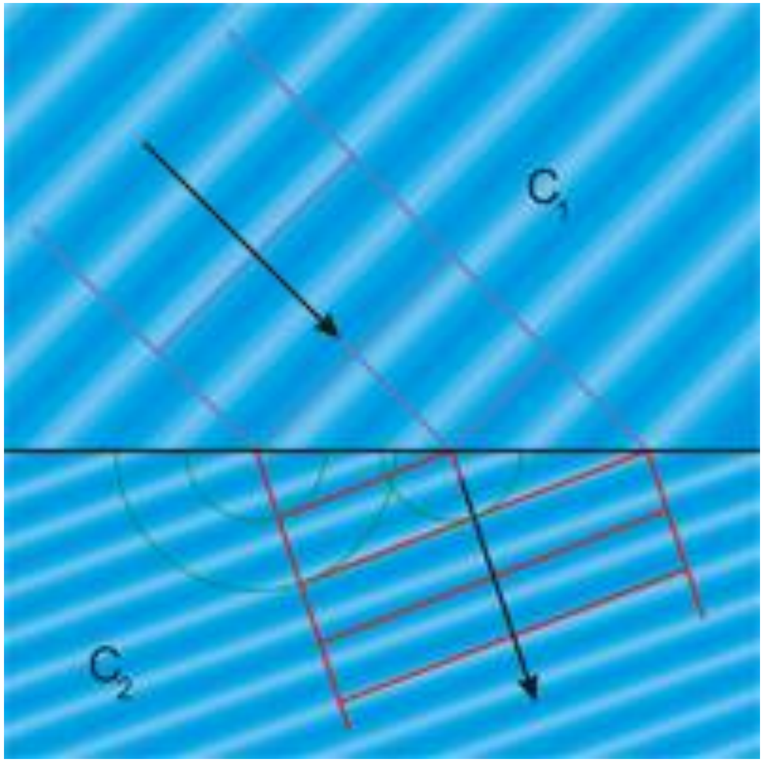
An antenna can only receive radio waves that hit it directly.

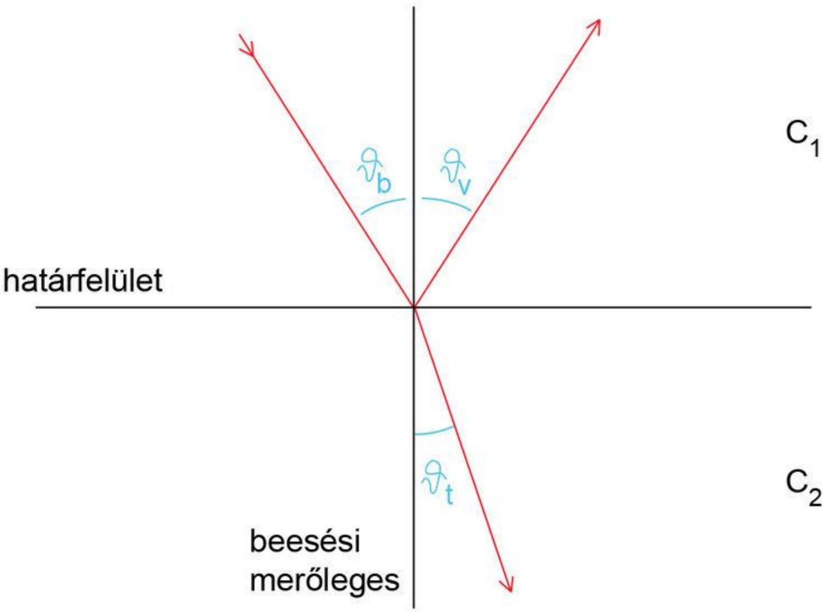
Putting a curved surface beneath the antenna allows radio waves hitting near the antenna to be reflected to the antenna.



This is the reason for this characteristic shape for items that receive radio waves or other transmissions from space. This particular radio receiver is pointed at a certain part of the sky so it can receive transmissions from a particular sattelite.

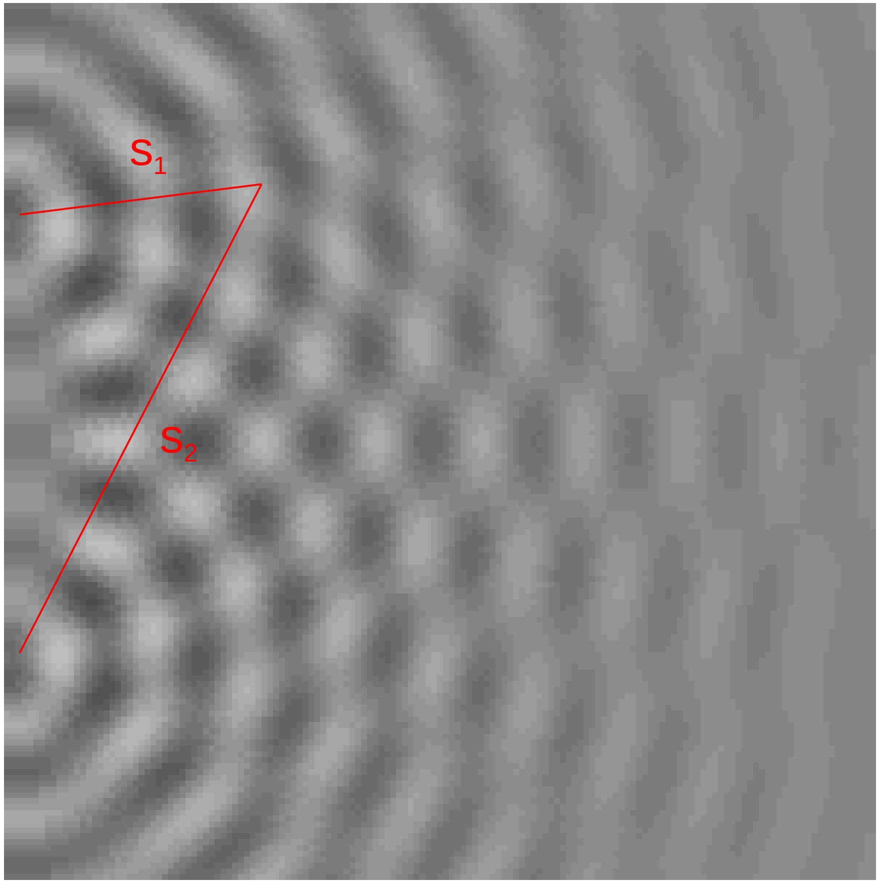
Huygens elv 3.

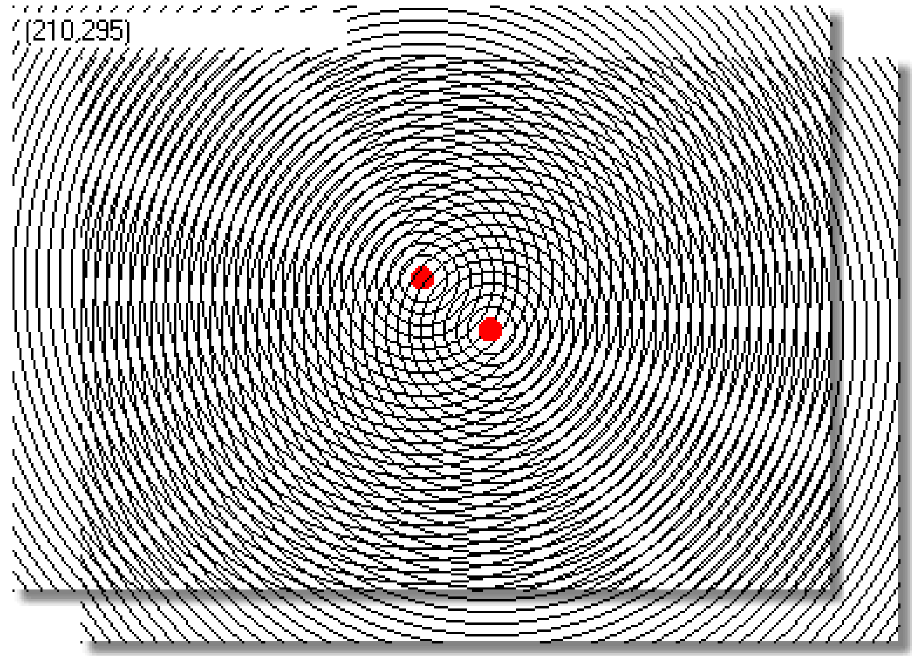




Fénytörés (hullámtörés)

Interferencia





Kioltás: $$\Delta s = s_2 - s_1 = (2n+1)\frac{\lambda}{2}$$

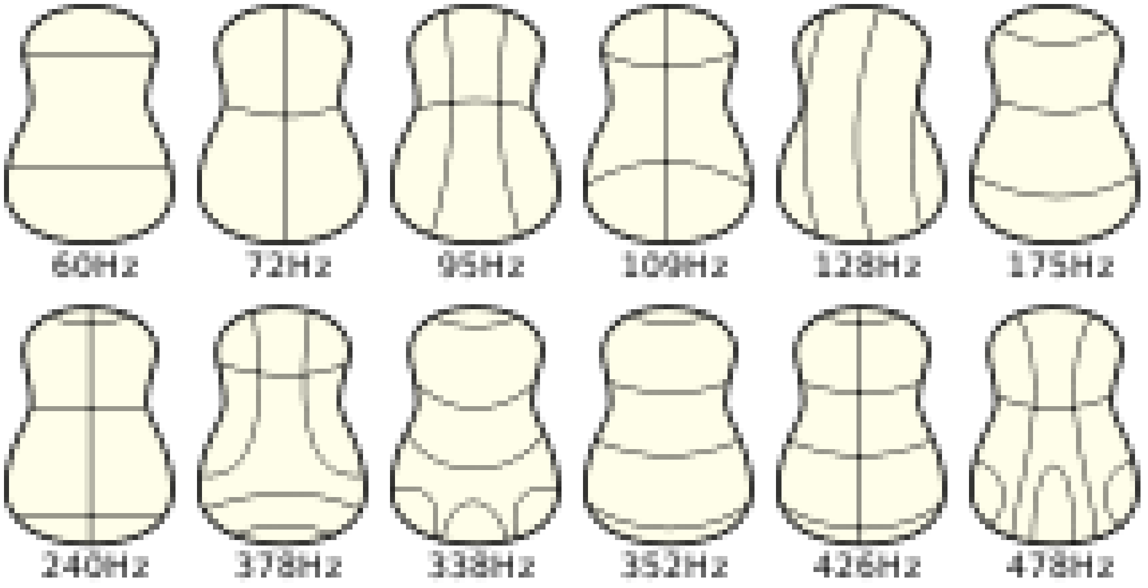
$$\Delta\varphi = (2n+1)\pi$$

Erősítés: $$\Delta s = s_2 - s_1 = n\lambda$$

$$\Delta\varphi = n(2\pi)$$

$$n = 1, 2, 3 \ldots$$

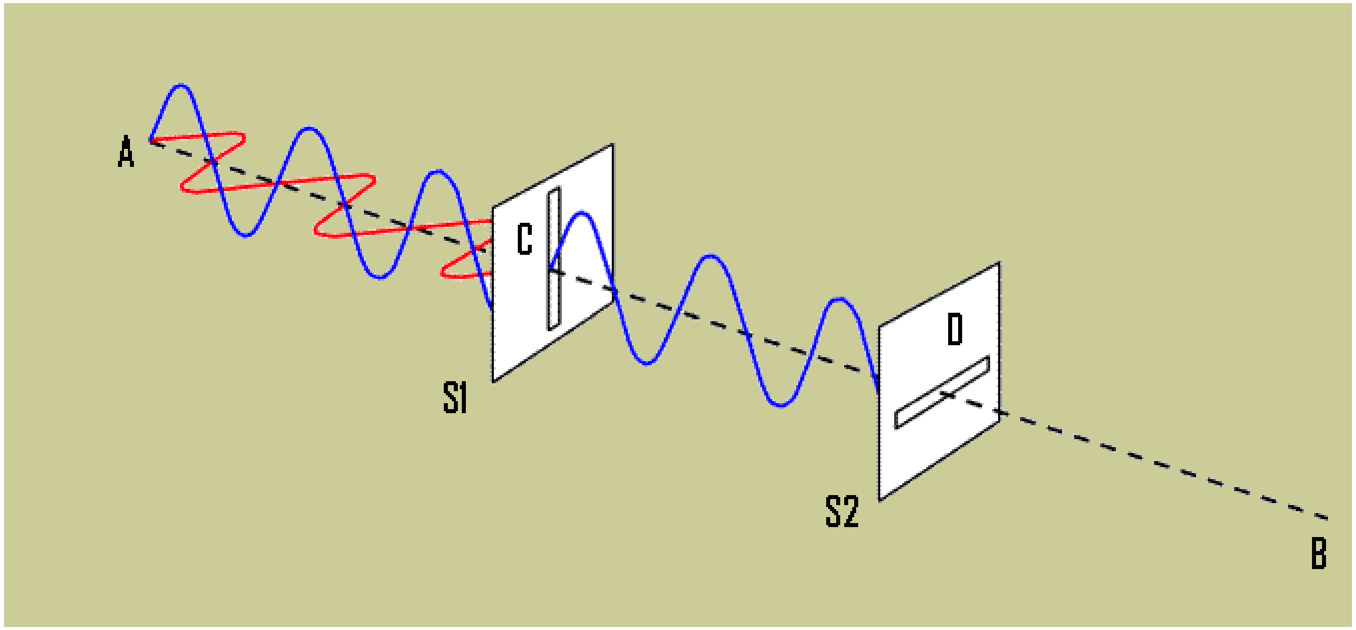
Chladny ábrák

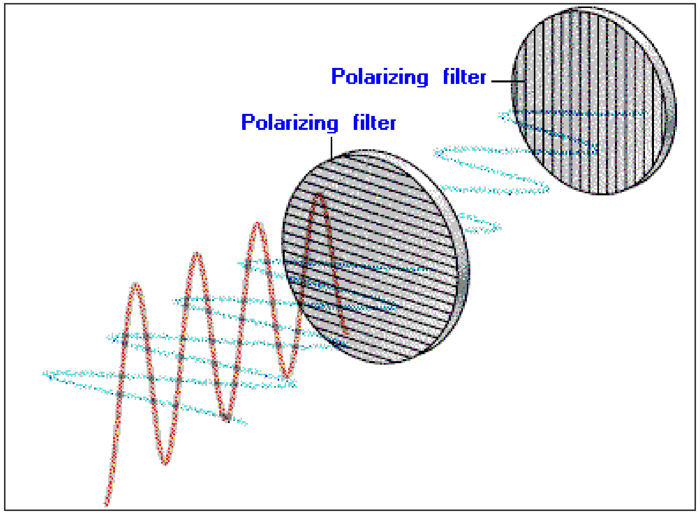


gitár

Polarizáció (hullám)

kötél:





fény