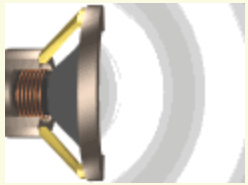
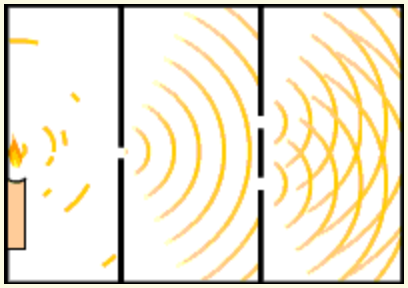
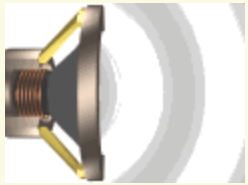


Aula 16: Ondas estacionárias

1. Efeito de Doppler
2. Ondas elásticas estacionárias
3. Interferência de ondas harmónicas
4. Interferência de duas ondas sonoras



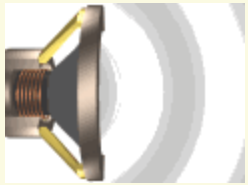


1. Efeito de Doppler

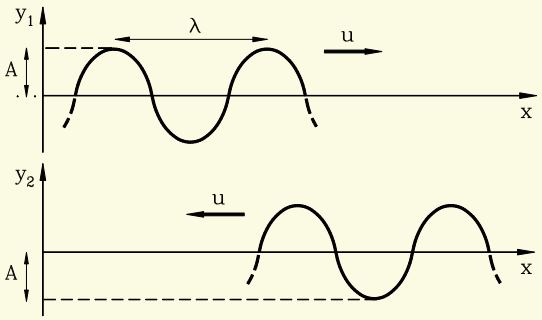
$$\nu = \nu_0 \frac{u \pm v}{u \pm v_0}$$

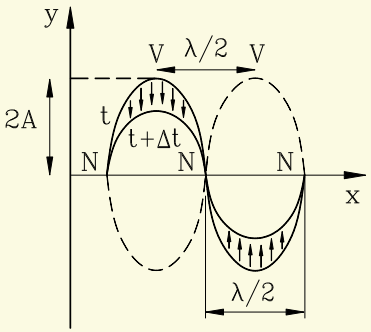
Simulação: ondas estacionárias numa corda

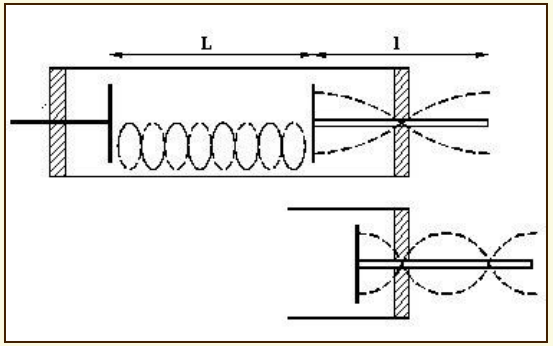
Ondas estacionárias: animação



2. Ondas estacionárias



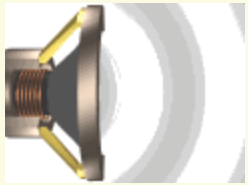




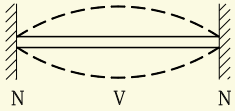
$$\Psi(x) = 2A\,\mathrm{sen}\,kx\cos\omega t = A(x)\cos\omega t$$

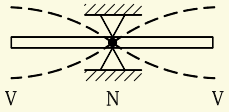
Modos normais na corda elástica: animação

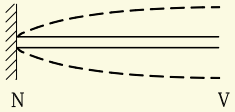
Modos normais na vara elástica: animação



Modos normais

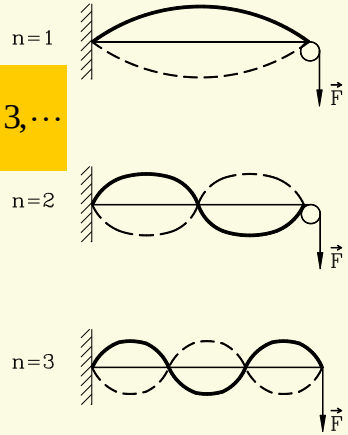






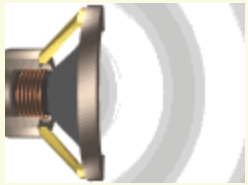
$$l = n\frac{\lambda_n}{2} = \frac{n}{2}\frac{u}{\nu_n} \quad \Rightarrow \quad \nu_n = \frac{n}{2l}\sqrt{\frac{F}{\mu}} \quad , \quad n = 1,2,3,\cdots$$

$$l = (2n-1)\frac{\lambda_n}{4} = \frac{2n-1}{4}\frac{u}{\nu_n} \quad \Rightarrow \quad \nu_n = \frac{2n-1}{4l}\sqrt{\frac{E}{\rho}} \quad , \quad n = 1,2,3,\cdots$$



Representação da sobreposição de ondas: animação

Simulação: interferência de duas ondas circulares

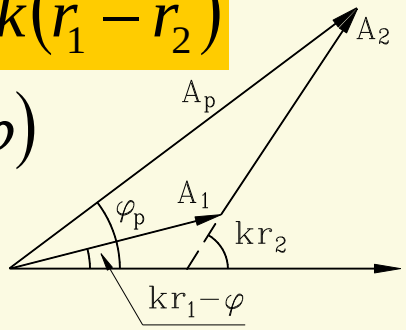


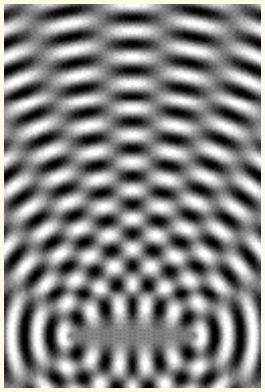
3. Interferência de ondas harmónicas

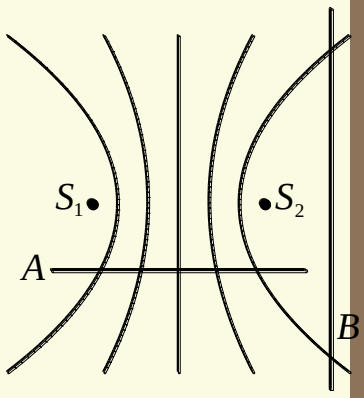
$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos k(r_1 - r_2)$$

$$\Psi_1 = A_1 \operatorname{sen}(kr_1 - \omega t + \Delta\varphi)$$

$$\Psi_2 = A_2 \operatorname{sen}(kr_2 - \omega t)$$

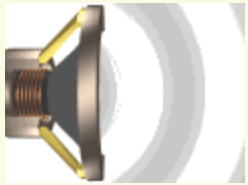






Simulação: interferência de duas ondas escalares

Padrão de interferência: animação



4. Interferência de duas ondas sonoras