

Física II para IO - 2013
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Ondas



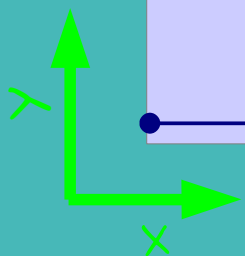
Tentativa de definição

- “Perturbação do equilíbrio local dependente do tempo” ou “Sinal que se propaga no espaço”
- Função de onda: $\vec{\psi}(\vec{r}, t)$
- Valor da perturbação (ou sinal): $\vec{\psi}$
- Local (genérico) da perturbação: $\vec{r} = (x, y, z)$
- Instante (genérico): t

Onda progressiva

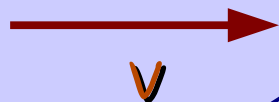
$$y(x, t) = 0$$

Equilíbrio



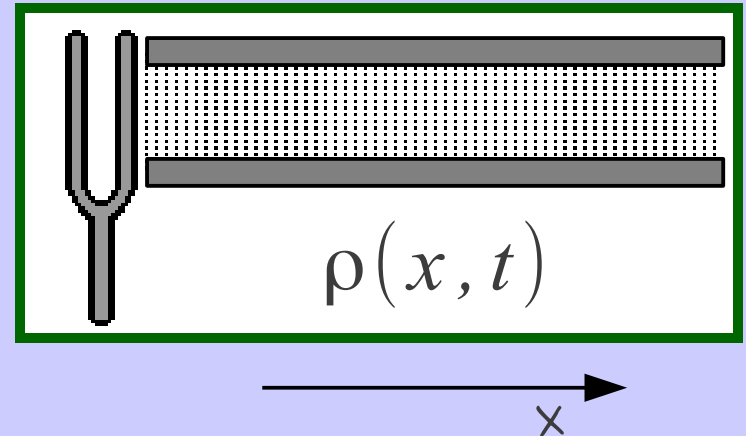
$$y(x, t) = f(x - vt)$$

Onda



Exemplos

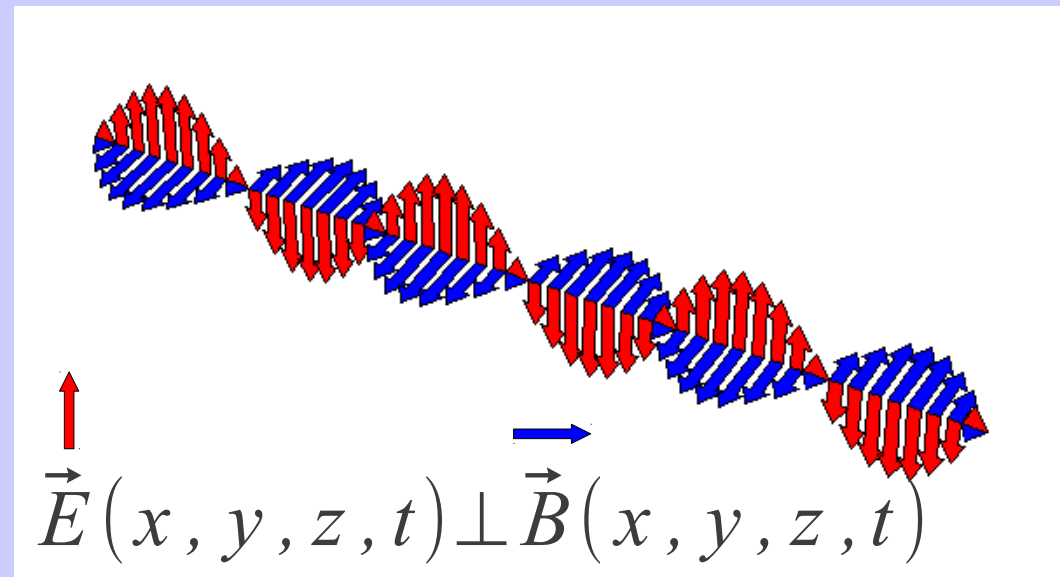
- Escalar em uma dimensão -
Onda sonora no centro
de um tubo longo e
fino - Densidade:



<http://www.physicsclassroom.com/class/sound/tfl.gif>

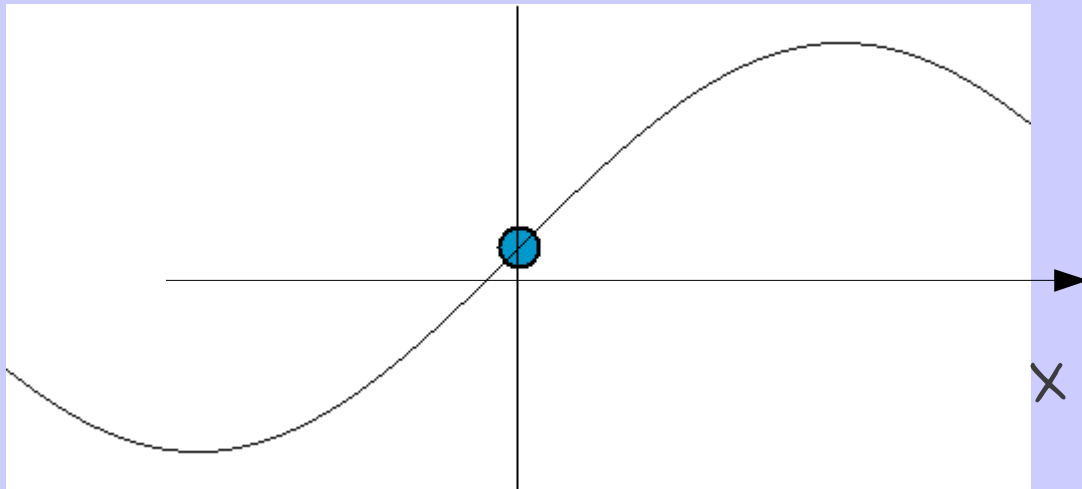
http://www.molphys.leidenuniv.nl/monos/smo/basics/images/wave_anim.gif

- Vetor em 3 dimensões -
Onda eletromagnética no
espaço - Campo elétrico
ou magnético:



Ondas Harmônicas

1 Dimensão (x)

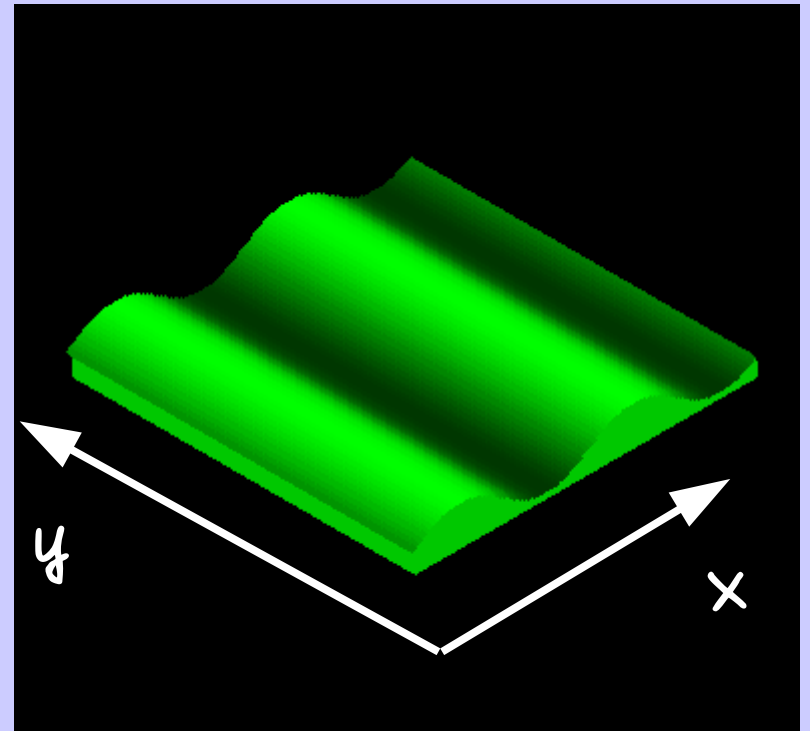


http://en.wikipedia.org/wiki/File:Simple_harmonic_motion_animation.gif

$$h(x, t) = h_0 \text{sen}(kx - \omega t)$$

MHS para cada ponto do espaço
 \vec{r}

2 Dimensões (x, y)

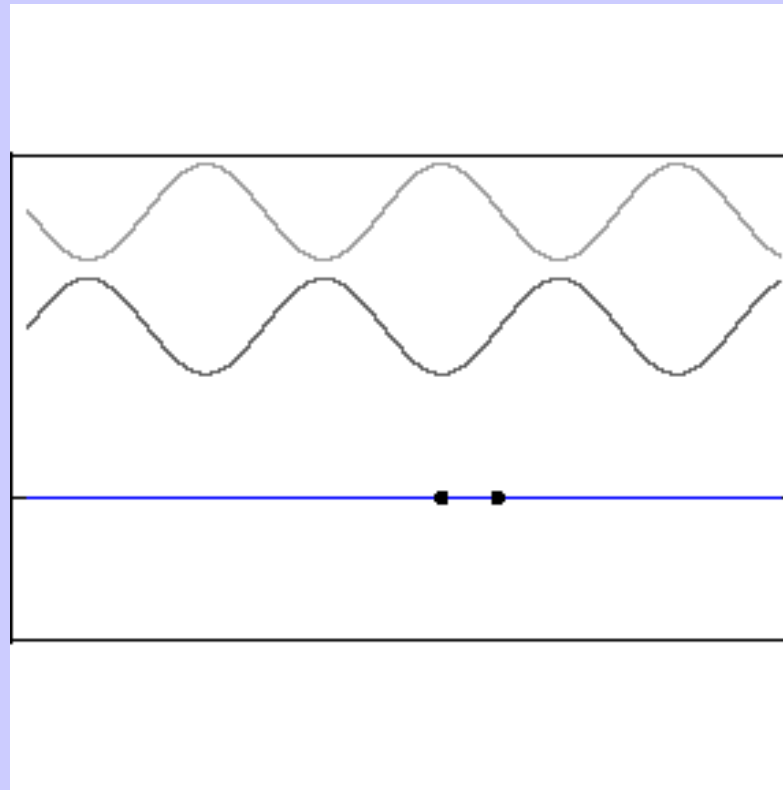


http://etorgerson.net/images/Wave_Animated_by_BlueThen.gif

$$h(x, y, t) = h_0 \text{sen}(kx - \omega t)$$

Ondas harmônicas

- Onda harmônica estacionária como superposição de ondas progressivas para a direita e para a esquerda de mesma amplitude

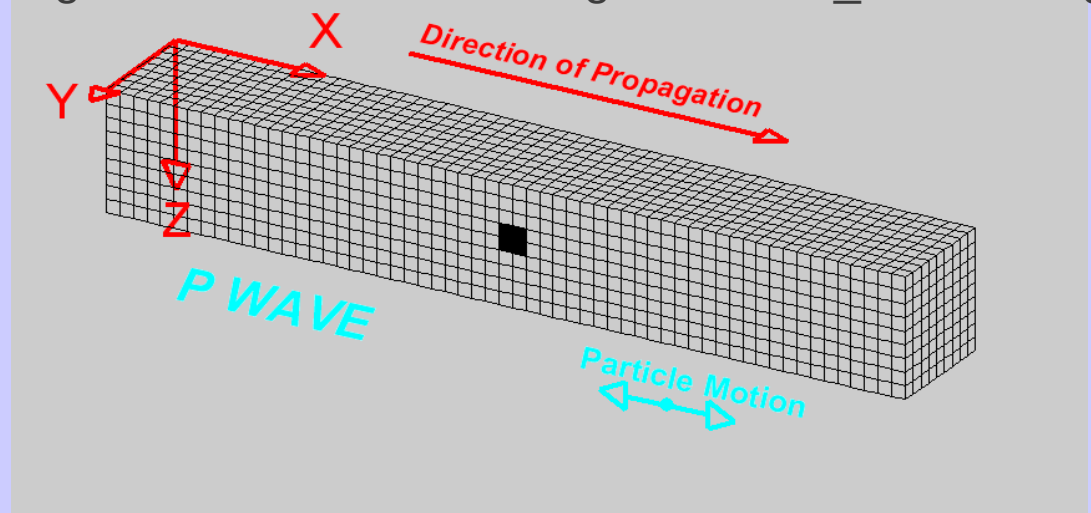


Ondas longitudinais e transversais

http://www.geo.mtu.edu/UPSeis/images/P-wave_animation.gif

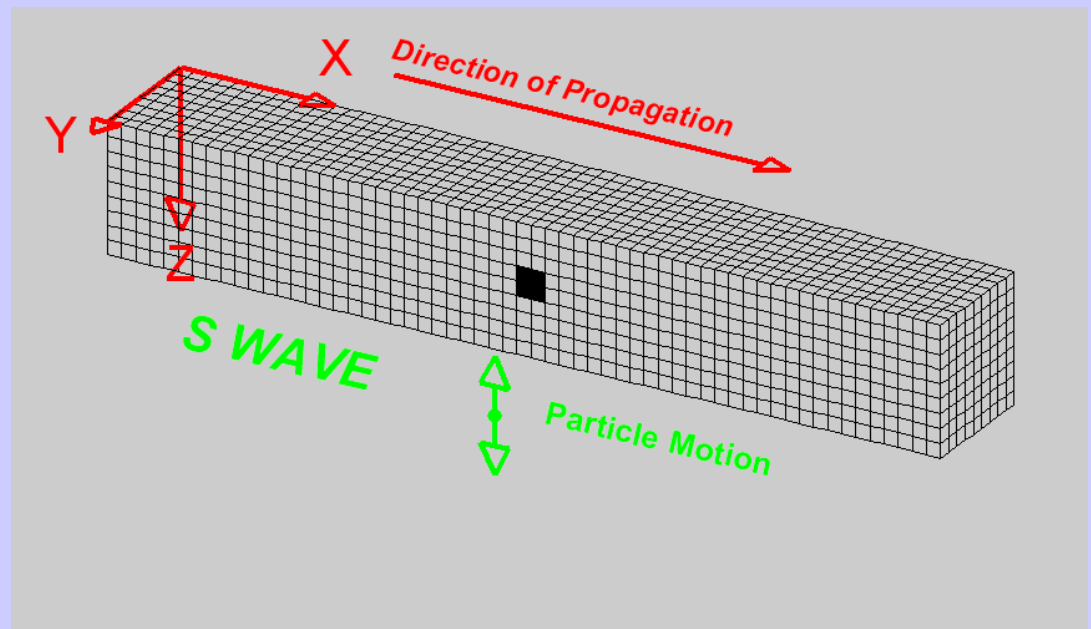
Longitudinal

$$\vec{\psi} \parallel \vec{v}$$



Transversal

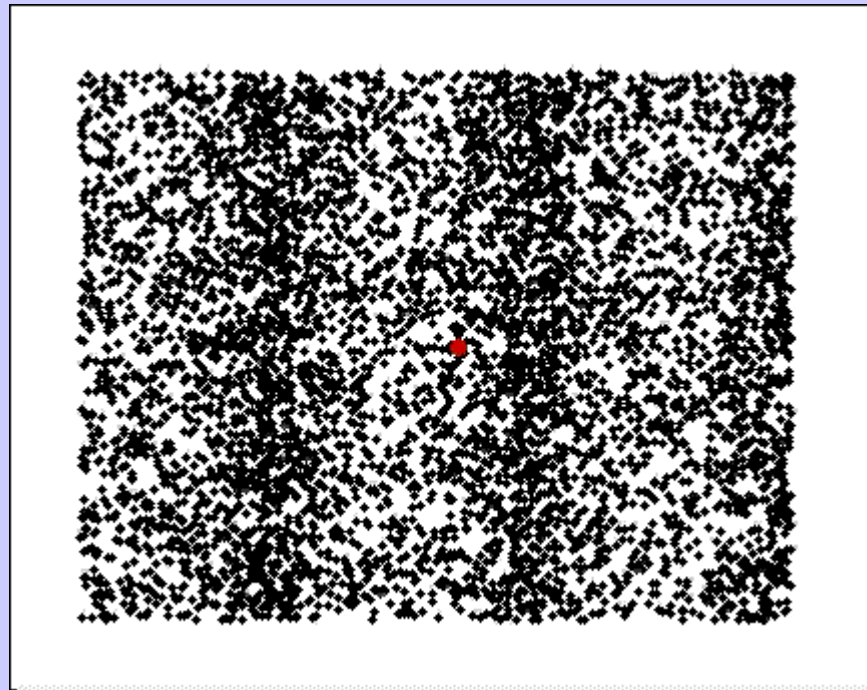
$$\vec{\psi} \perp \vec{v}$$



http://www.geo.mtu.edu/UPSeis/images/S-wave_animation.gif

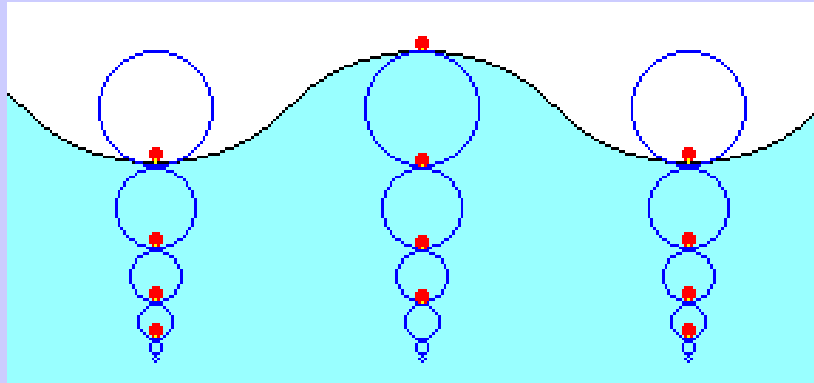
Som

- Transporte de energia sonora, mas sem transporte de matéria (a longas distâncias):

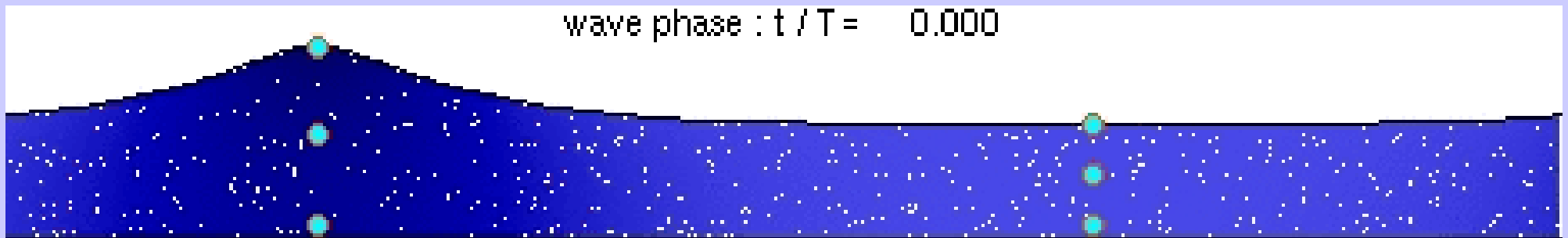


Onda de gravidade no mar Longitudinal E Transversal

Fundo -
Transporte
de energia



http://faculty.gvsu.edu/videticp/wave_animation1.GIF



http://en.wikipedia.org/wiki/File:Shallow_water_wave.gif

Raso - transporte de matéria e energia

Ondas estacionárias

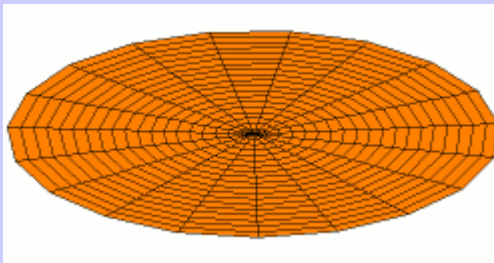
1D

http://en.wikipedia.org/wiki/File:Standing_wave.gif

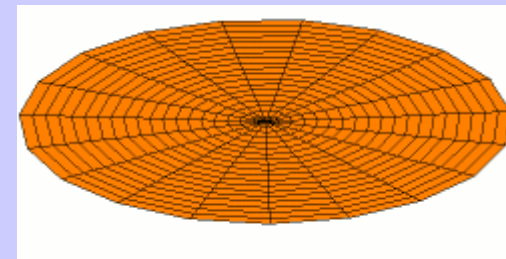


$$h(x, t) = h_0 \text{sen}(kx) \text{sen}(\omega t)$$

2D

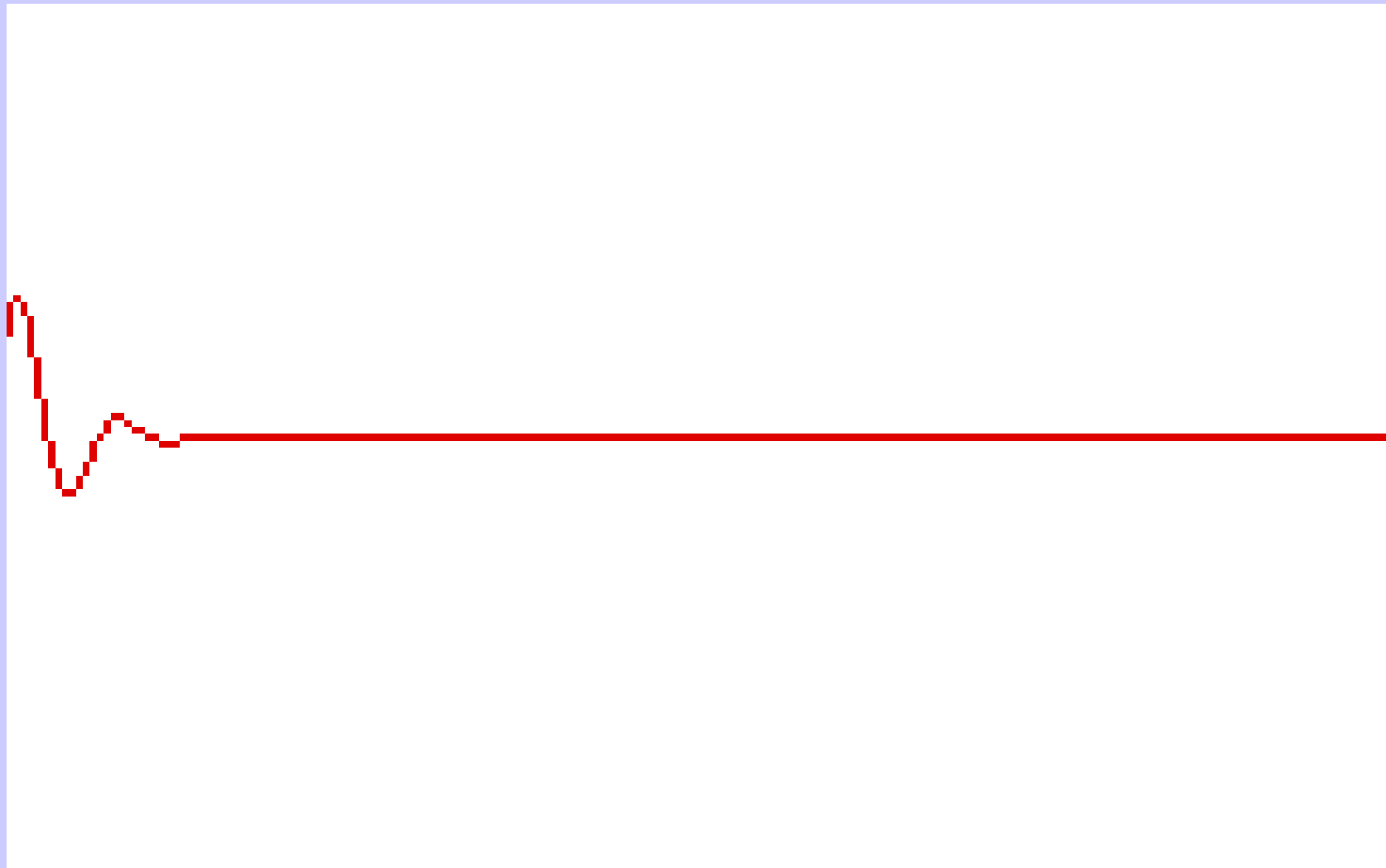


http://en.wikipedia.org/wiki/File:Drum_vibration_mode01.gif



http://en.wikipedia.org/wiki/File:Drum_vibration_mode21.gif

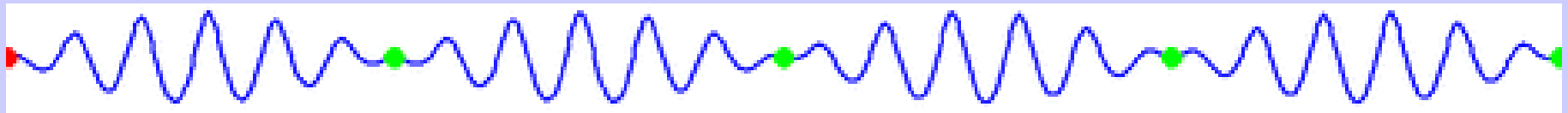
Pacote de onda



[http://en.wikipedia.org/wiki/File:Wave_packet_\(dispersion\).gif](http://en.wikipedia.org/wiki/File:Wave_packet_(dispersion).gif)

Velocidade de fase e de grupo

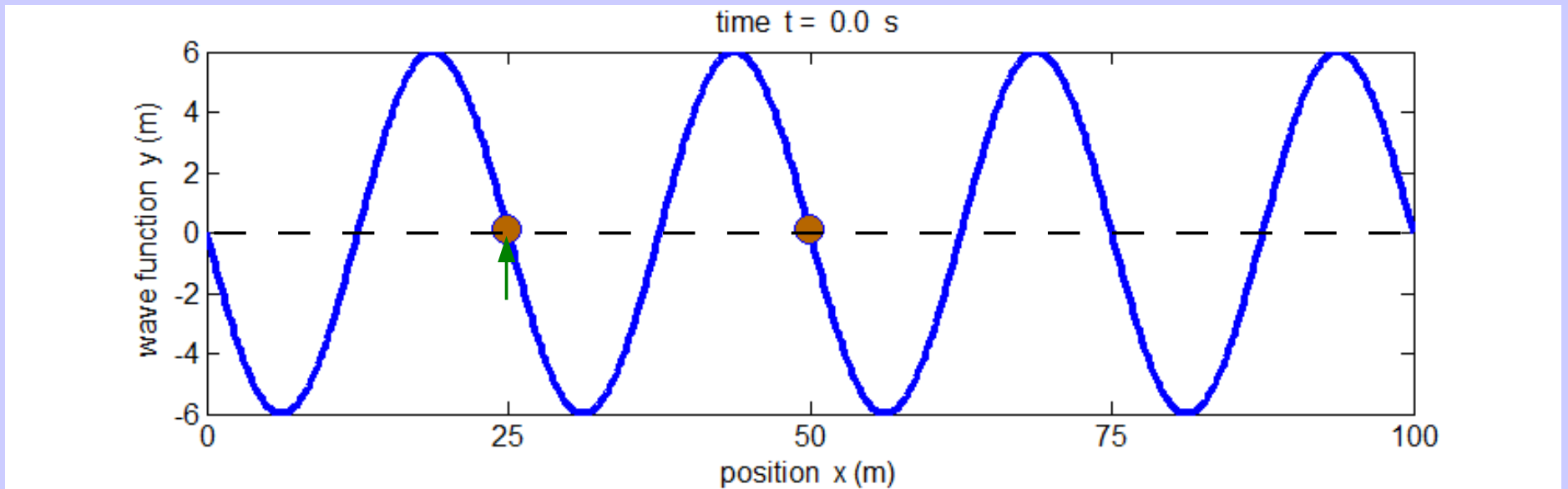
- Meio dispersivo - velocidade depende da frequência
- $v_f \neq v_g$



http://en.wikipedia.org/wiki/File:Wave_group.gif

Onda Harmônica Progressiva

Período T



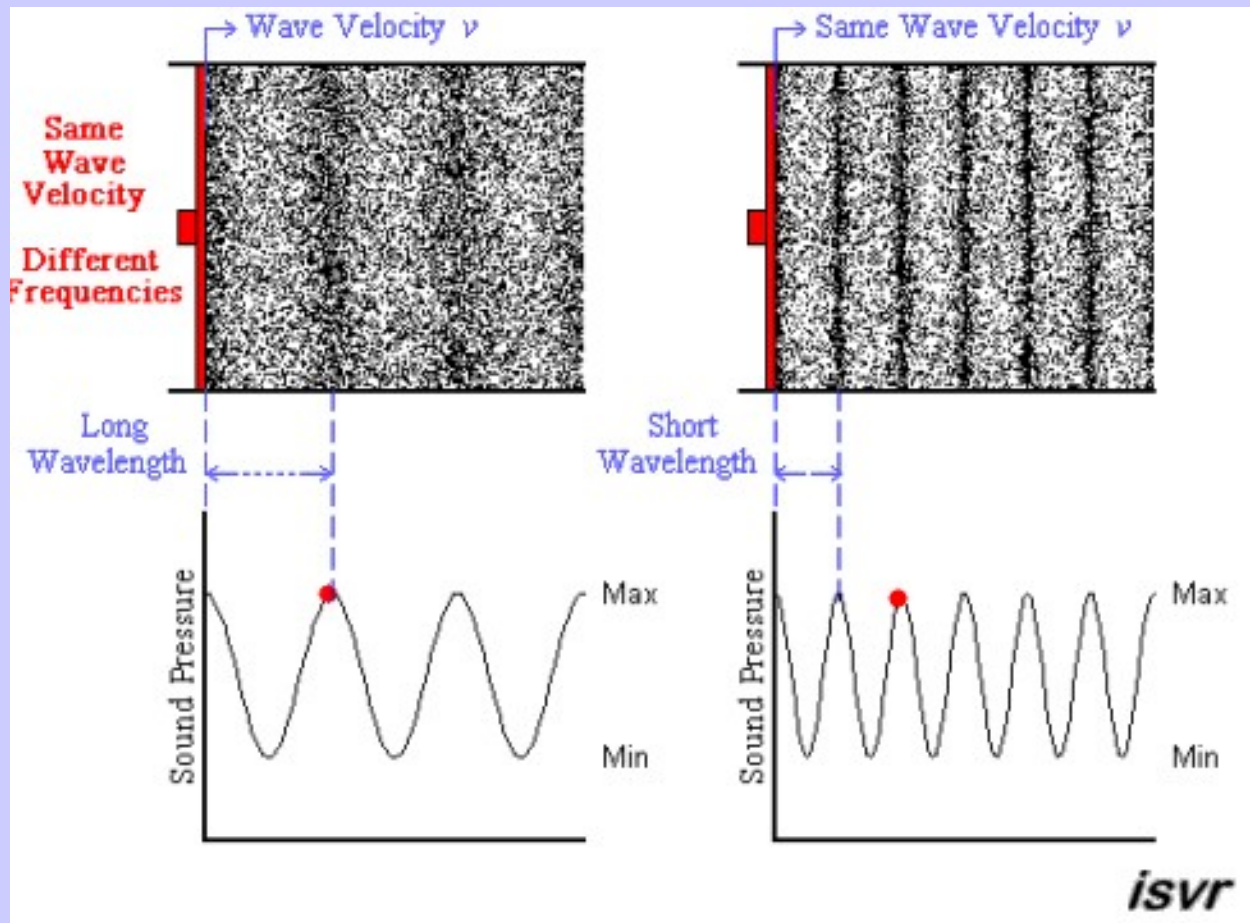
http://www.physics.usyd.edu.au/teach_res/mp/waves/string_1_files/image117.gif

λ



Comprimento de onda

Velocidade de fase



http://resource.isvr.soton.ac.uk/spcg/tutorial/tutorial/Tutorial_files/longitest3bis.gif