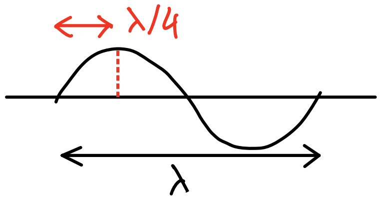
F1

$$\lambda = \frac{c}{f} = 1\,m \Rightarrow d = 0{,}25\,m = \frac{\lambda}{4}$$



$$\Rightarrow \Delta\varphi = \frac{\pi}{2}$$

Általánosan:

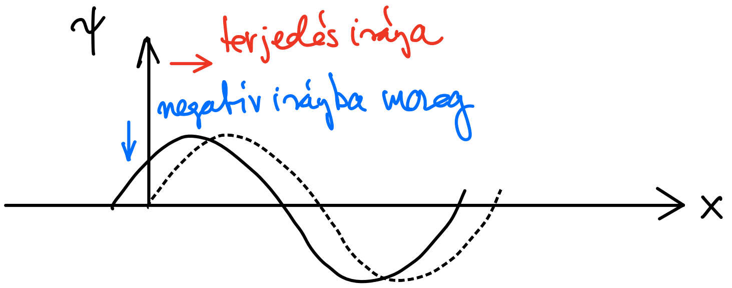
λ távolságra lévő pontok fáziskülönbsége 2π
d távolságra lévő pontok fáziskülönbsége $\Delta\varphi$

$$\Rightarrow \frac{d}{\lambda} = \frac{\Delta\varphi}{2\pi} \Rightarrow \Delta\varphi = 2\pi \cdot \frac{d}{\lambda}$$

F2 Az adatoknak megfelelő hullámfüggvény:

$$\psi(x;t) = A \cdot \sin(\omega t - kx + \alpha),$$

ahol $A = 0{,}5\,m$; $\omega = 2\pi f \approx 12{,}6\ \frac{1}{s}$; $k = \frac{2\pi}{\lambda} = 2\pi \cdot \frac{f}{c} = \frac{\omega}{c} \approx 0{,}628\ \frac{1}{m}$ és



$$\psi(0;0) = A \cdot \sin\alpha = 0{,}25\,m$$

$$\sin\alpha = \frac{1}{2} \Rightarrow \alpha = 30^\circ = \frac{\pi}{6}$$

$$\psi(x = 5\,m;\ t = 2\,s) = 0{,}5 \cdot \sin\left(12{,}6 \cdot 2 - 0{,}628 \cdot 5 + \frac{\pi}{6}\right) \approx -0{,}28\,m$$

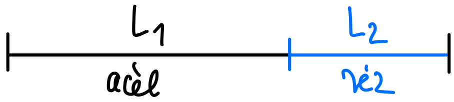
F3

$$\psi(\underline{r};t) = A \sin\left[\omega t - \underbrace{(5x - 2y - z)}_{\underline{k}\,\underline{r}}\right]$$

$$\left.\begin{aligned} \underline{r} &= (x;y;z) \\ \underline{k} &= (k_1;k_2;k_3) \end{aligned}\right\} \Rightarrow \left.\begin{aligned} k_1 &= 5\ \tfrac{1}{m} \\ k_2 &= -2\ \tfrac{1}{m} \\ k_3 &= -1\ \tfrac{1}{m} \end{aligned}\right\} \underline{k} = \begin{pmatrix} 5 \\ -2 \\ -1 \end{pmatrix} \Rightarrow \underline{e}_k = \frac{\underline{k}}{|\underline{k}|} = \frac{1}{\sqrt{30}} \cdot \begin{pmatrix} 5 \\ -2 \\ -1 \end{pmatrix}$$

$$\lambda = \frac{2\pi}{|\underline{k}|} = \frac{2\pi}{\sqrt{30}} \approx 1{,}1\ m$$

F4



terjedési sebesség: $c = \sqrt{\frac{F}{\lambda}}$, ahol

$$\lambda = \frac{m}{L} = \frac{\rho A L}{L} = \rho \frac{d^2}{4}\pi$$

Tehát: $c = \sqrt{\frac{4F}{\rho \pi d^2}}$ → $c_1 = 155\,m/s$, $c_2 = 146\,m/s$

Az idő: $t = \frac{L_1}{c_1} + \frac{L_2}{c_2} \approx 0{,}33\,s$

F5

a) $y_1 = \frac{5}{(3x-4t)^2+2} = f(x-ct)$ jobbra (+x) terjedő pulzus

$y_2 = \frac{-5}{(3x+4t-6)^2+2} = g(x+ct)$ balra (−x) terjedő pulzus

b)–c) kioltás esetén: $y_1 + y_2 = 0$

$$(3x-4t)^2 = (3x+4t-6)^2$$

$$3x-4t = \pm(3x+4t-6)$$

$3x-4t = 3x+4t-6$

$6 = 8t$

$t = \frac{3}{4}\,s$

bármelyik x esetén kioltás

$3x-4t = -3x-4t+6$

$6x = 6$

$x = 1\,m$

bármely időpillanatban kioltás

F6

$$\left.\begin{aligned}\psi_1 &= A\cdot\sin(\omega t - kx)\\ \psi_2 &= A\cdot\sin\left(\omega t - kx + \frac{\pi}{2}\right)\end{aligned}\right\} \Rightarrow \psi = \psi_1 + \psi_2 = A\cdot\sin(\omega t - kx) + A\sin(\omega t - kx)\cdot\cos\frac{\pi}{2} +$$

$$+ A\cos(\omega t - kx)\cdot\sin\frac{\pi}{2} =$$

$$= A\cdot\left[\sin(\omega t - kx) + \cos(\omega t - kx)\right] = A\cdot\sqrt{2}\cdot\left[\underbrace{\frac{1}{\sqrt{2}}}_{\cos\frac{\pi}{4}}\sin(\omega t - kx) + \underbrace{\frac{1}{\sqrt{2}}}_{\sin\frac{\pi}{4}}\cos(\omega t - kx)\right] =$$

$$= A\sqrt{2}\cdot\sin\left(\omega t - kx + \frac{\pi}{4}\right)$$

Az eredő hullám amplitúdója: $A' = A\cdot\sqrt{2} \approx 5{,}7\ m$

komplexen:

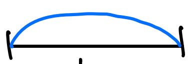
$$\left.\begin{aligned}\psi_1 &= A e^{i(\omega t - kx)}\\ \psi_2 &= A e^{i\frac{\pi}{2}}\cdot e^{i(\omega t - kx)}\end{aligned}\right\} \Rightarrow \psi = A e^{i(\omega t - kx)}\cdot\left(1 + e^{i\frac{\pi}{2}}\right)$$

komplex amplitúdó: $\tilde{A} = A\left(1 + e^{i\frac{\pi}{2}}\right) = A(1 + i)$

A valódi amplitúdó: $A' = \sqrt{|\tilde{A}|^2} = A\sqrt{|1+i|^2} = A\sqrt{(1+i)(1-i)} = A\sqrt{1 - i^2} = A\sqrt{2}$

F7

Alaphang:

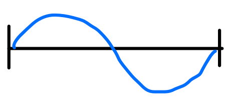


L

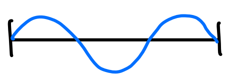
(n=1)

$$\lambda_0 = 2L \Rightarrow f_0 = \frac{c}{\lambda_0} = \frac{c}{2L} = \frac{1}{2L}\sqrt{\frac{F}{\lambda}} =$$

$$= \frac{1}{2L}\sqrt{\frac{FL}{m}} \Rightarrow F = 4 f_0^2\, m\cdot L \approx 160\ N$$



n = 2



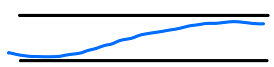
n = 3

$$L = \frac{3}{2}\lambda_3 \Rightarrow \lambda_3 = \frac{2L}{3} \Rightarrow f_3 = \frac{c}{\lambda_3} = 3\cdot\frac{c}{2L} = 3 f_0 = 660\ Hz$$

F8

nyitott:

ℓ

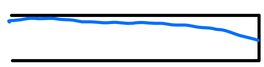


$$\ell = \frac{\lambda}{2}$$

$$f = \frac{c}{\lambda} = \frac{c}{2\ell} \approx 405\ Hz$$

zárt:

ℓ



$$\ell = \frac{\lambda}{4}$$

$$f = \frac{c}{\lambda} = \frac{c}{4\ell} \approx 202\ Hz$$