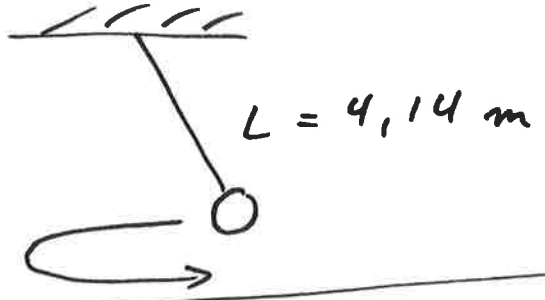
VIRHEANALYYSIÄ

KE
TE FY 1 | KEM
MA 2 |

ESIM.



$$T = 4{,}168 \pm 0{,}002 \text{ s}$$

MITTAUSTEN KA

VIRHEIDEN ITSEISARVOJEN KA

MITTAUKSET

T_1, T_2, T_3

$$T = \frac{T_1 + T_2 + T_3}{3}$$

$$T = \frac{\sum_{j=1}^{n} T_j}{n}$$

M ↑

- JOS MITTAAJA 3 OLISI EPÄTARKKA

$$T = \frac{T_1 + T_2 + T_3 \cdot 0{,}5}{2{,}5}$$

PAINOTETTU KESKIARVO?

- TAI $T = (T_1 \cdot T_2 \cdot T_3)^{\frac{1}{3}}$

$$S = \frac{|T_1 - T| + |T_2 - T| + |T_3 - T|}{3}$$

$$S = \frac{\sum_{j=1}^{n} |T_j - T|}{n}$$

σ ↑

KÄTEVÄ TAPA ARVIOIDA VIRHETTÄ

↑

HIENOISTUNEEMPIA TAPOJA?

$$S = \frac{\sum_{j=1}^{n} |T_j - T|}{n}$$

DEVIATION

TAPA II

OTOS VARIANSSI = OV = σ^2

$$= \frac{\sum_{j=1}^{n} (T_j - T)^2}{n-1} \quad [S^2]$$

MIKSI EI n ?

OTOSHAJONTA

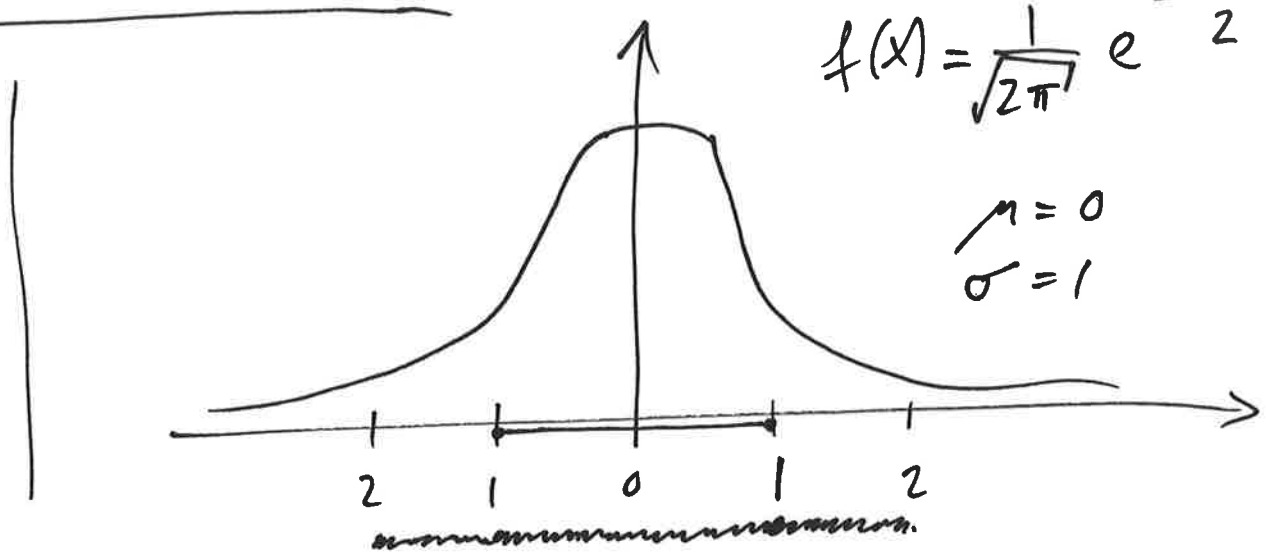
STANDARD DEVIATION $SD = \sqrt{OV} = \sigma$ $[S^2]$

OTOSHAJONTA $SEM = \frac{SD}{\sqrt{n}} = \frac{\sigma}{\sqrt{n}}$

↳ LASKETTAVA VIRHERAJA AINEISTOSTA

NORMAALI JAKAUMA

$$f(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$



$\mu = 0$

$\sigma = 1$

$-\infty \to \infty$ KOKO ALA $1 = 100\,\%$ KAIKKI

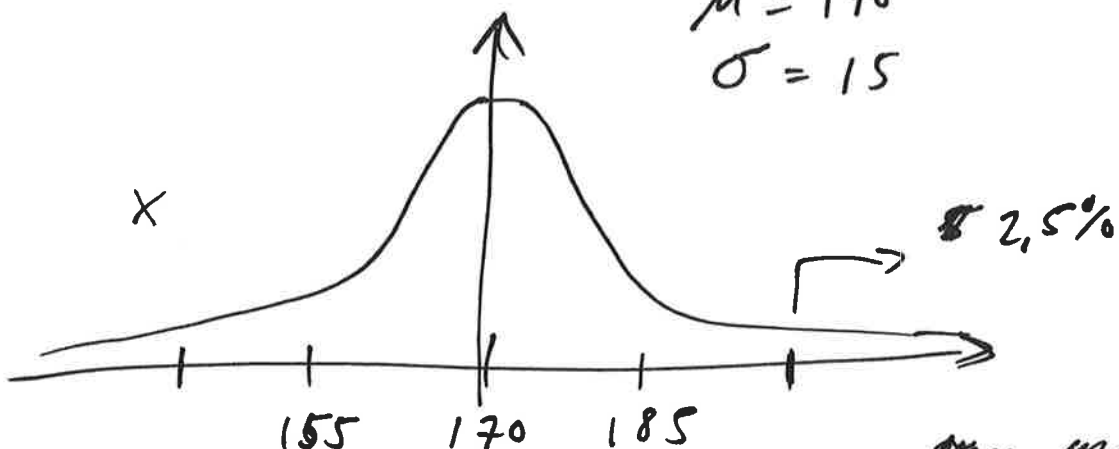
$-1 \to 1$ $68{,}27\%$

$-1{,}92 \to 1{,}92$ 95%

ESIM. OLETETAAN MIEHIÄ IHMISTÄ

$\mu = 170$

$\sigma = 15$



MIEHIÄ 140 $\mu =$ $\sigma = 15$ 200

NORMEERATTU -2 -1 $\tilde{\mu} = 0$ $\tilde{\sigma} = 1$ 2

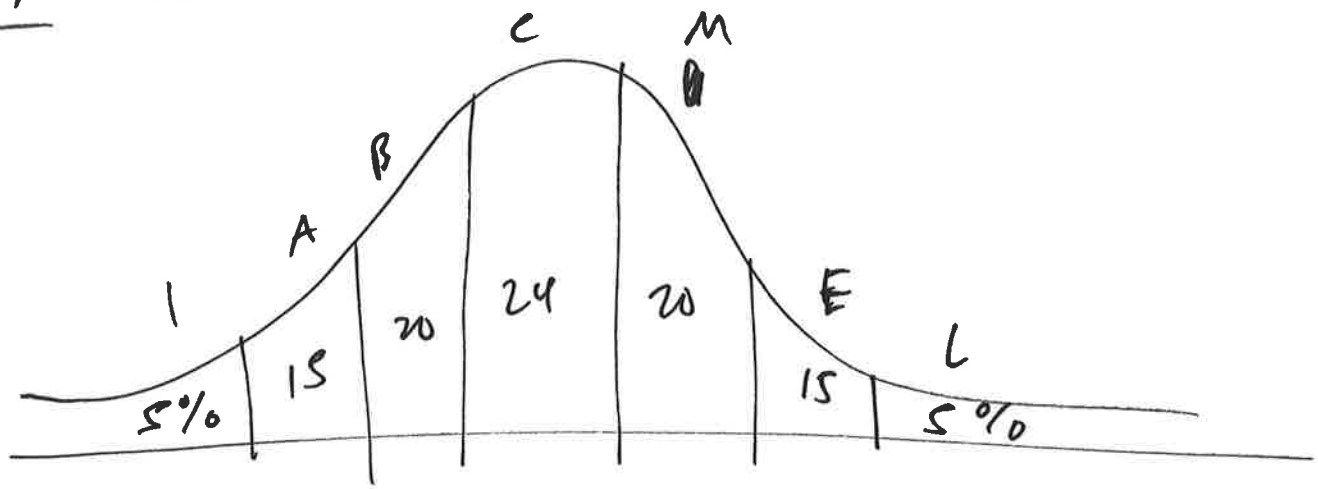
68,27 %

PITUUS VÄLILLÄ 155 – 185 cm

$$\tilde{x} = \frac{x - \mu}{\sigma}$$

2,5% PITUUS YLI 2 m

ESIM, 40 - KOE

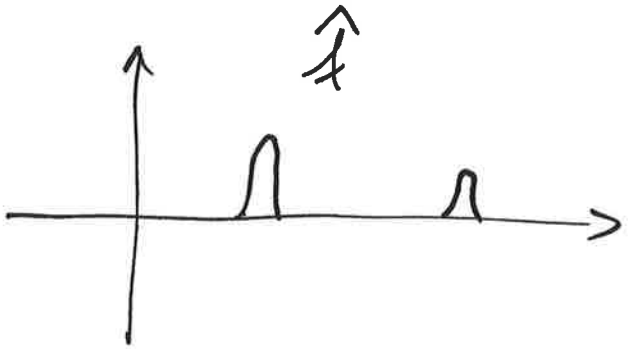


MIKSI LUONTO NOUDATTAA NORMAALIJAKAUMAA ?

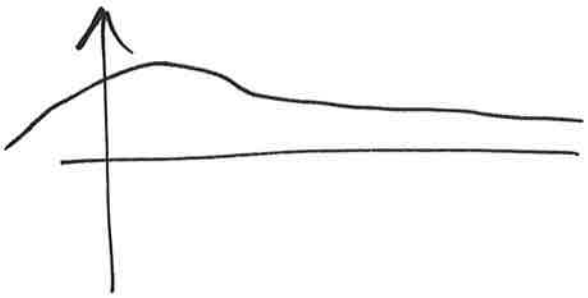
VÄRÄHTELY

FOURIER M.

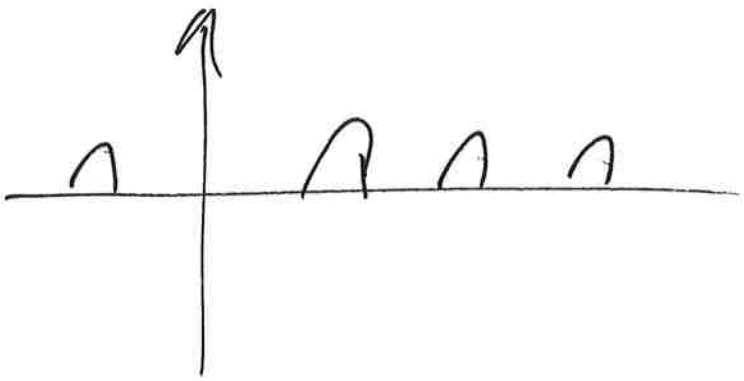
TAAJUUDET



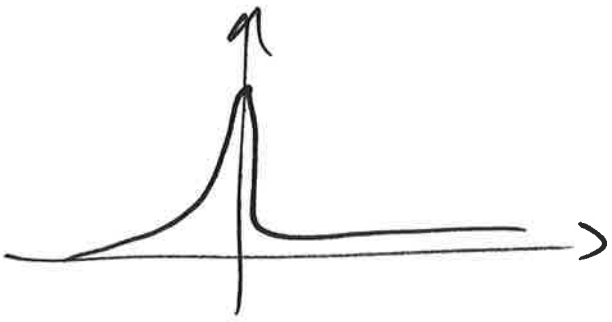
LAVEA PULSSI



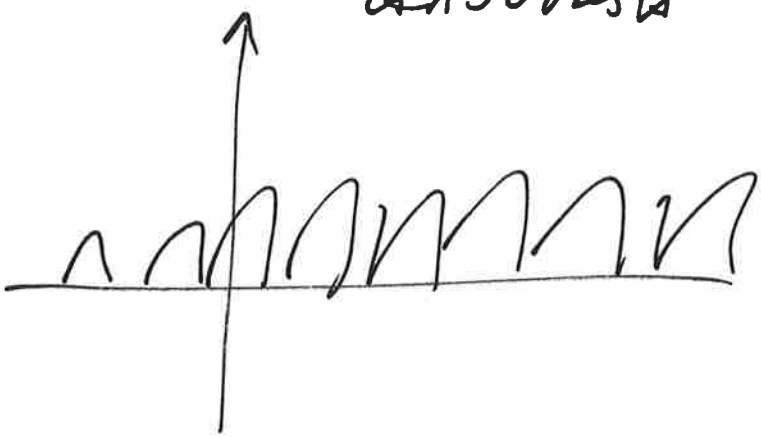
PARI TAAJUUTTA



TARKKA PULSSI



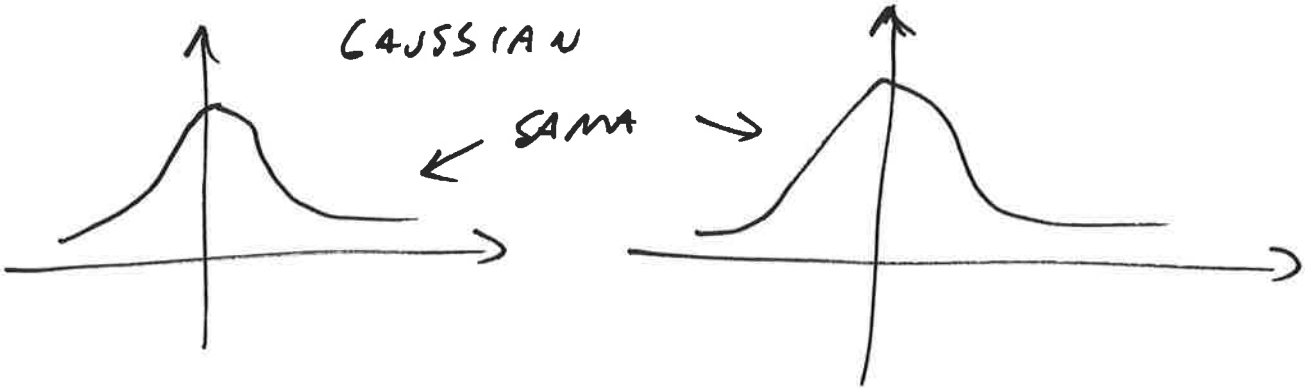
TAAJUUKSIA



OPTIMI "

CAUSSIAN

SAMA



KÄY ILMI

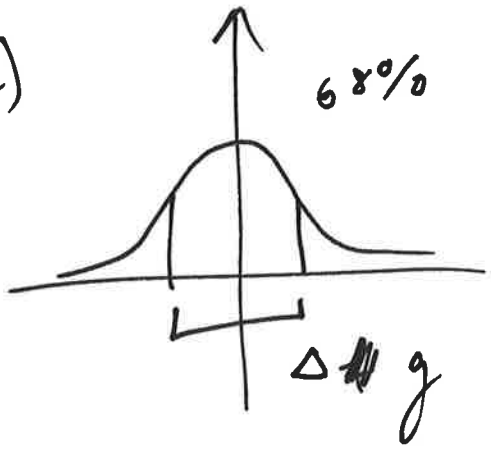
FUNKTIO f — FOURIER MUUNNOS $F\{f\}$ $(= \hat{f})$

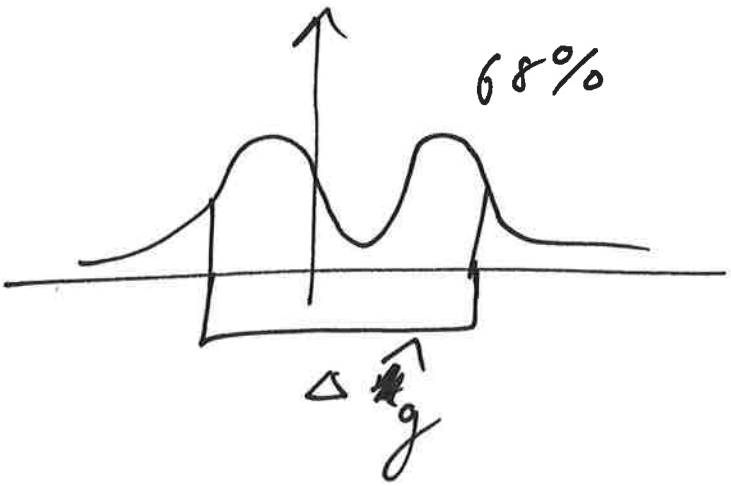
1) JOS $f(x) = e^{-x^2}$, NIIN

$F(f) = \text{VAKIO} \cdot f$

$\rightarrow f$ ON MUUNNOKSEN OMINAISFUNKTIO

2)





KAIKILLE FUNKTIOILLE

$\Delta g \cdot \Delta \hat{g} \geq \text{VAKIO}$ $\Delta f \Delta \hat{f}$

$= \text{MINIMIEPÄMÄÄRITYKSEN} = \delta$

HEISENBERGIN EPÄTARKKUUS PERIAATE !

JOS MITATAAN TOSI PIENIÄ HIUKKASIA,

ESIM. ELEKTRONEJA 3) JNE.

Δ PAIKKA Δ NOPEUS $\geq \delta$

Δ ENERGIA Δ LIIKEMÄÄRÄ $\geq \delta$

DERIVOINTIA / INTEGROINTIA

$$\frac{d}{dx} F(x) = f(x) \qquad F(x) = \int_{-\infty}^{x} f(t)\,dt$$

$$F'(x)$$

$$\frac{d}{dx}\frac{d}{dx}\frac{d}{dx} F(x) = F'''(x)$$

x PAIKKA $[m]$

$$\frac{d}{dt} x(t) = x'(t) = v(t) \quad \text{NOPEUS} \left[\frac{m}{s}\right]$$

$$\frac{d}{dt}\frac{d}{dt} x(t) = x''(t) = v'(t) = a(t)$$

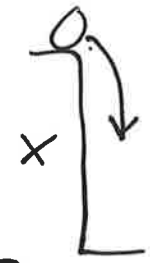
KIIHTYVYYS $\left[\frac{m}{s^2}\right]$

ESIM. PUTOAMINEN

$$a(t) = g = 9{,}81 \ \text{m/s}^2$$

$$\rightarrow v(t) = gt$$

$$\rightarrow \boxed{x(t) = \frac{1}{2} g t^2}$$



$$\rightarrow t^2 = \frac{2x}{g} \qquad x = 7\ \text{m}$$

$$\rightarrow t = \sqrt{\frac{2x}{g}} = \sqrt{\frac{2 \cdot 7}{9{,}81}} = \sqrt{1{,}427}$$

$$= \underline{1{,}1946\ \text{s}}$$

ET RIIPU MASSASTA ? KOTITEHTÄVÄ

PUIJON TORNI $x = 75$ m

$$t = \sqrt{\frac{2 \cdot 75}{9{,}81}} = \underline{3{,}91\ \text{s}}$$

3,6

300 m/s → 1080 km/h

$v_{RAJA} = 270$ km/h

$= 500$ km/h