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"If you can think, you can Achieve"
So start thinking..

Renu Raj Garg
M.Tech (VLSI Design)
13 Year of Teaching Experience
Worked 10 Year in NTRO

GATE 2024

प्रचण्ड Batch

COMMUNICATION

QUANTIZER IN PCM

PART-3

TIME- 9:00PM

RENU SIR

Chapter-2

Digital Communications

In today's lecture we will cover the following Topis :

1. *QUANTIZER in PCM (Part-3)*

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GATE 2023 RESULT

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AIR 348 EE AMAN NAMDEV

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AIR 571 ME VIJENDER MEENA

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Free

YouTube Classes Schedule

ENGINEERS

EE & EC ENGINEERING

EXAM TARGET	SUBJECT	TIME	FACULTY
ALL PSUs	ENGINEERING MATHS	11:00 AM	ANANT SIR
GATE 2024-25	NETWORK THEORY	6:00 PM	RAVI SIR
GATE 2024-25	ELECTRICAL MACHINE	7:30 PM	SANTAN SIR
GATE 2024-25	COMMUNICATION	9:00 PM	RENU SIR

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CLASS SCHEDULE

EE & ECE ENGINEERING

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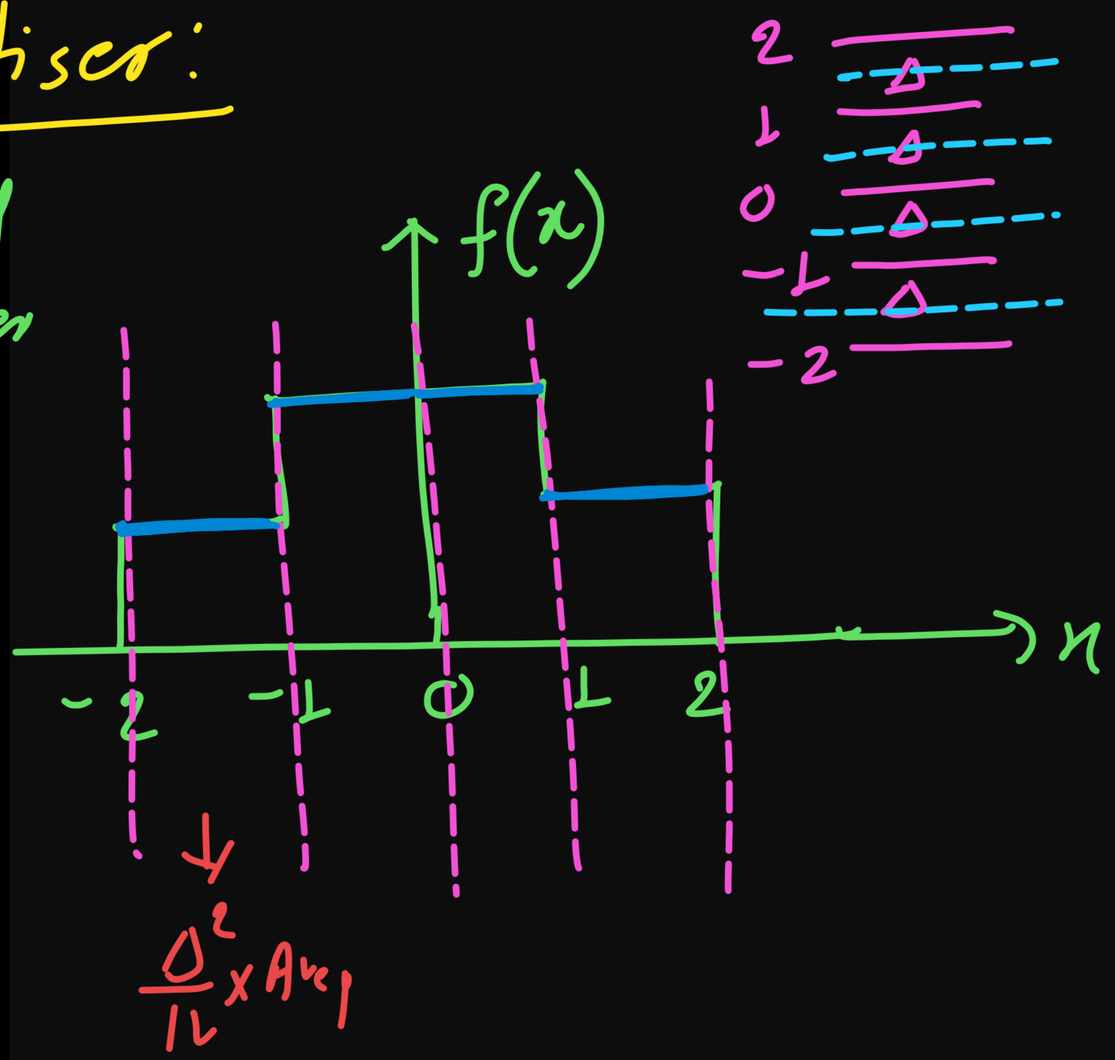
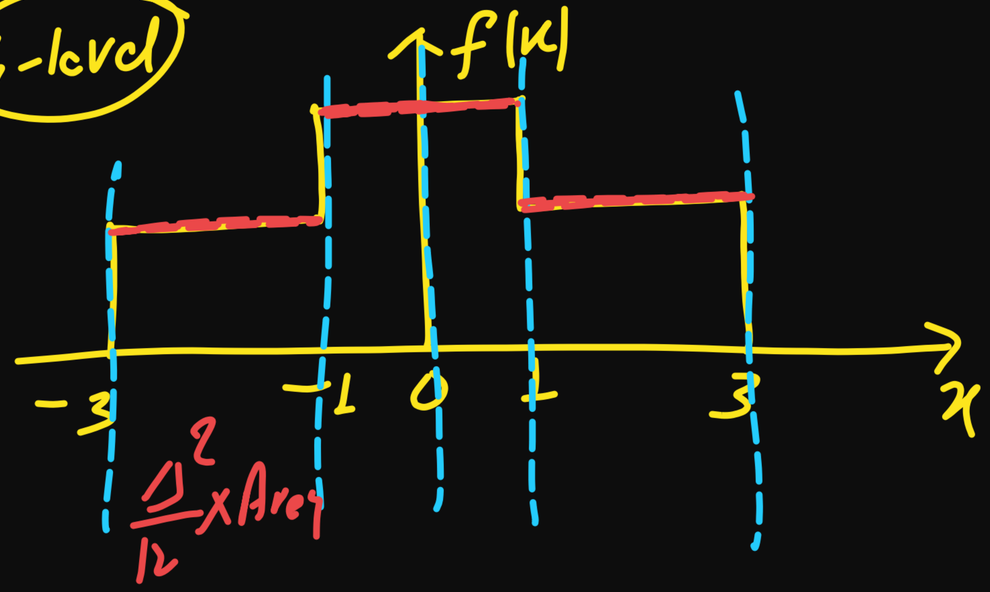
NETWORK THEORY	SATURDAY Live @11AM	RAVI SIR
COMMUNICATION	WEDNESDAY Live @8PM	RENU SIR
ANALOG ELECTRONICS	THURSDAY Live @8PM	LAWRENCE SIR
ENGINEERING MATHEMATICS	FRIDAY Live @11AM	ANANT SIR
ELECTRICAL MACHINE	MONDAY Live @8PM	SANTAN SIR

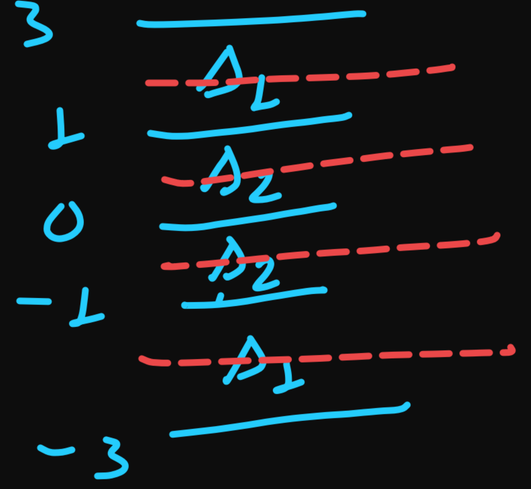
Quantiser:

4-level quantiser



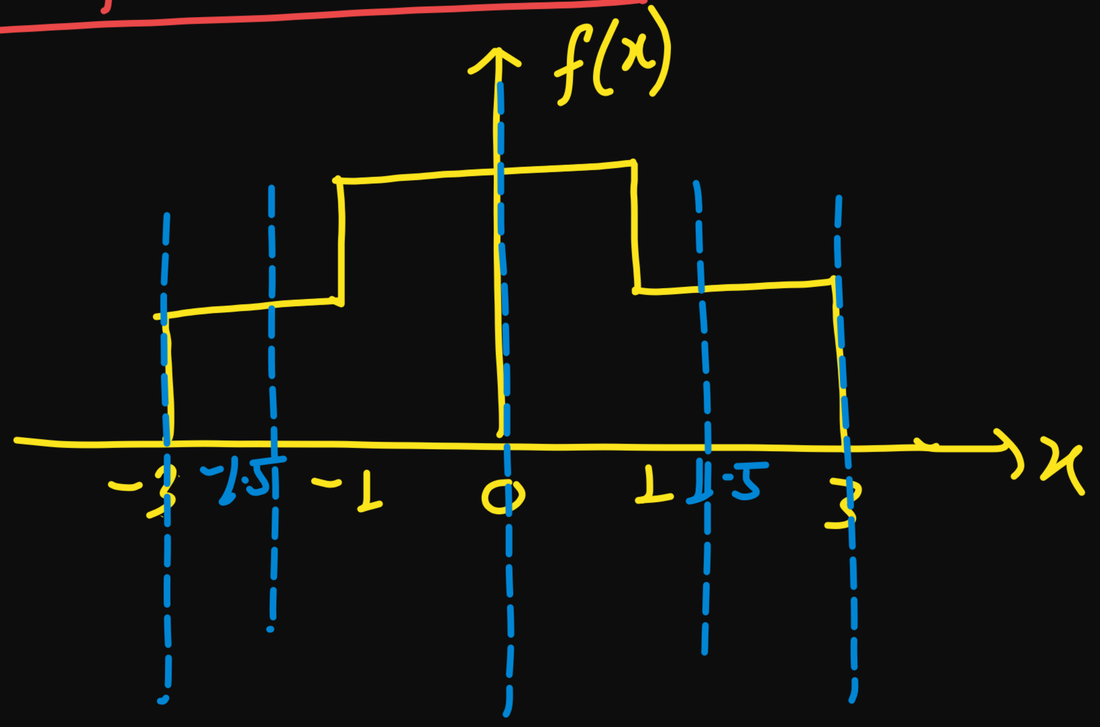
4-level

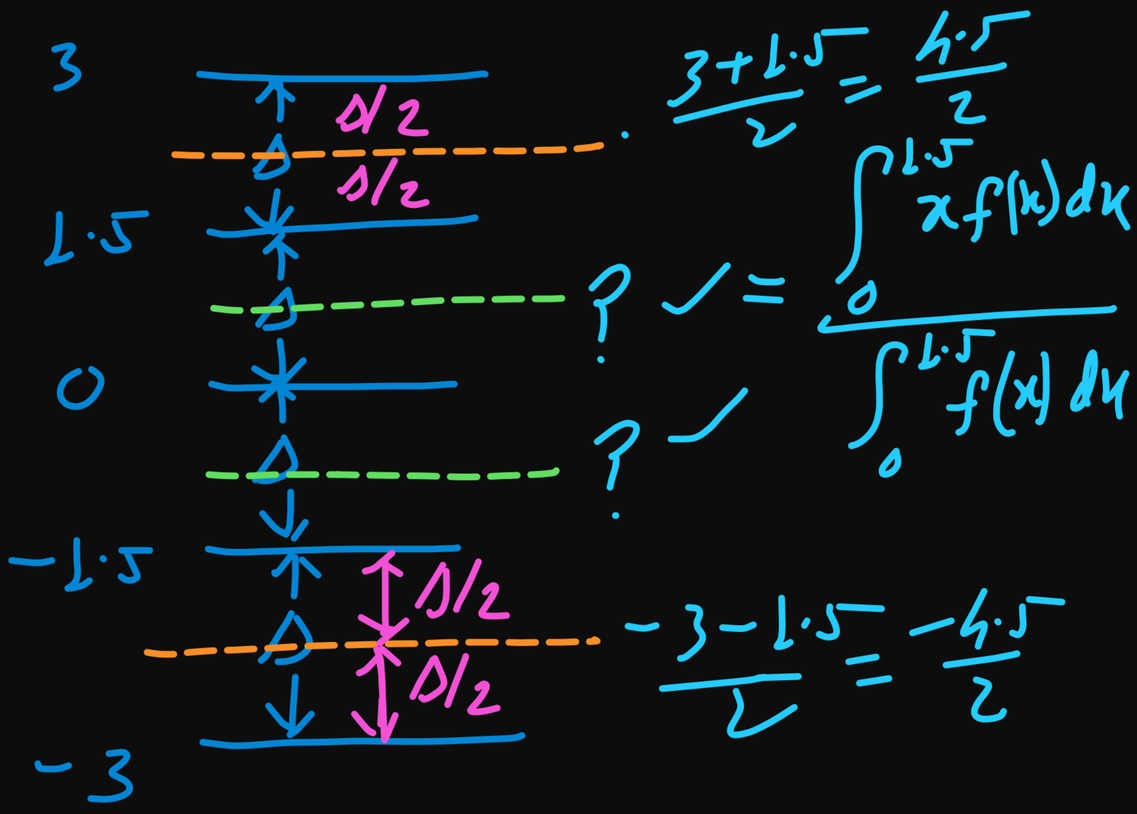


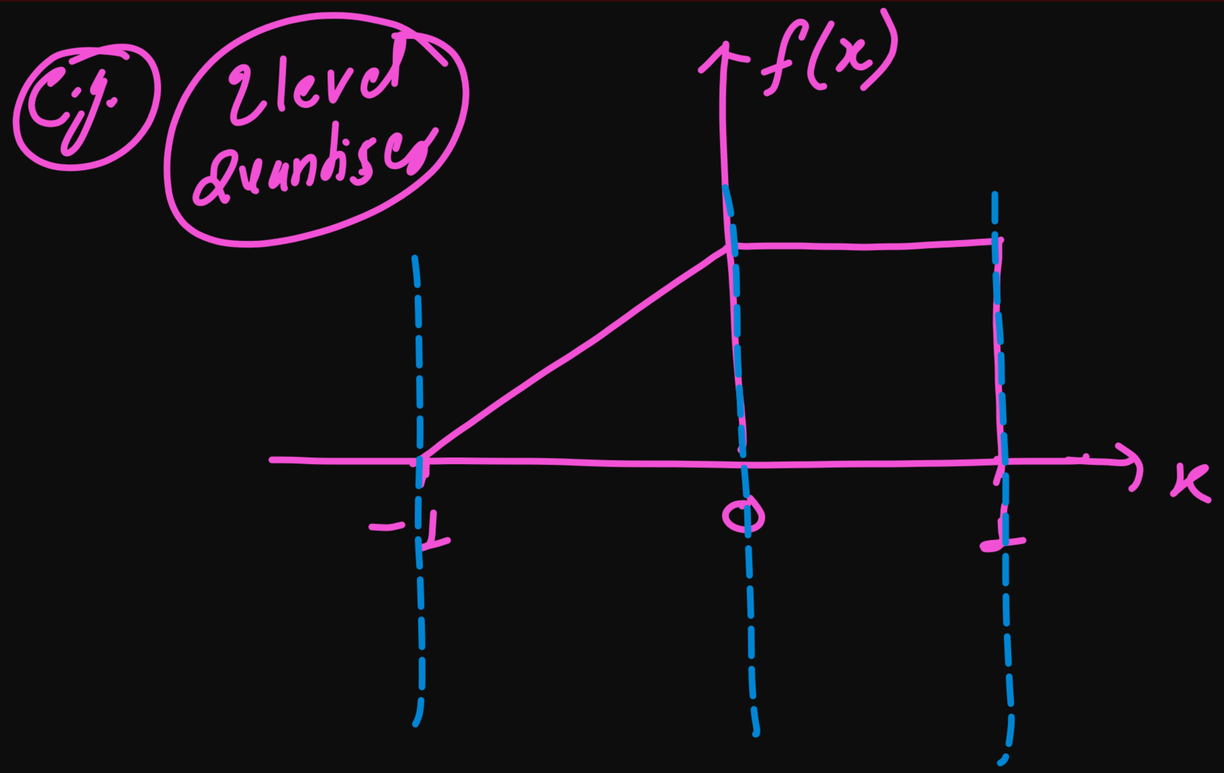


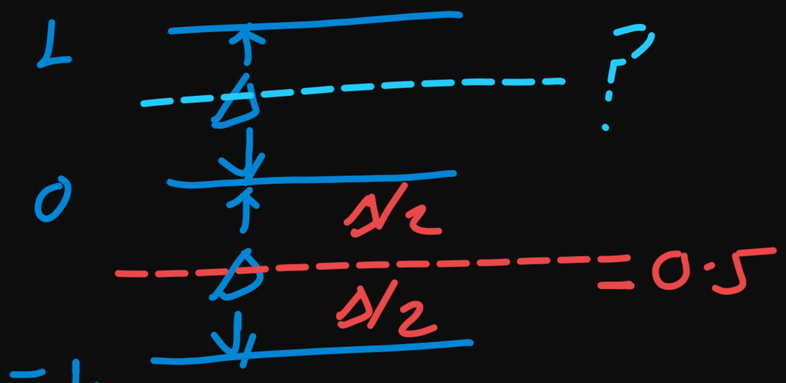
Non Uniform Quantiser:

Eg:






c.f.
2 level quantiser
f(x)
x
-1
0
1


1
?
0
Δ/2
=0.5
Δ/2
-1

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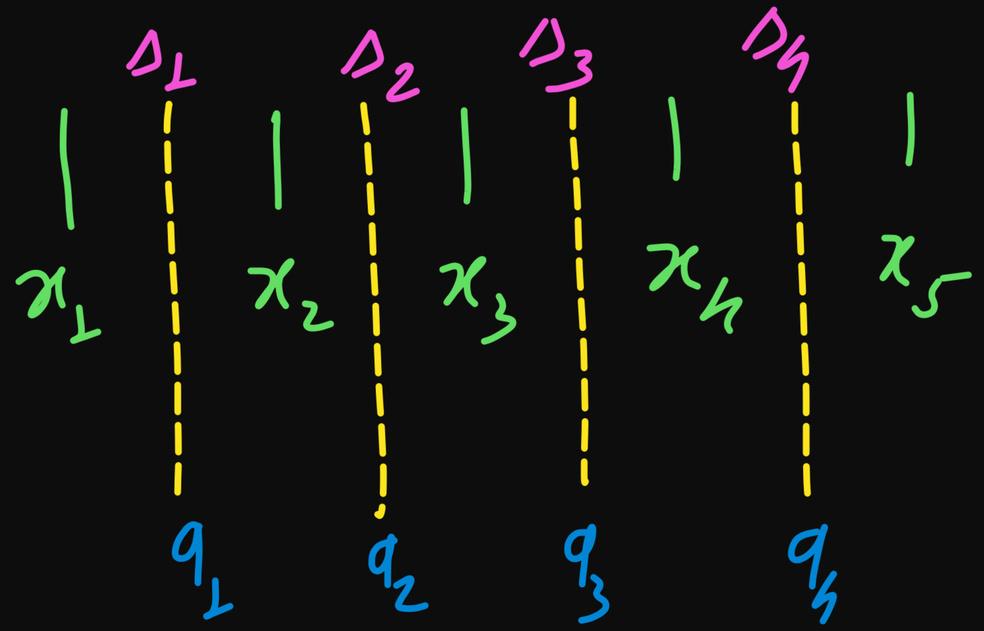
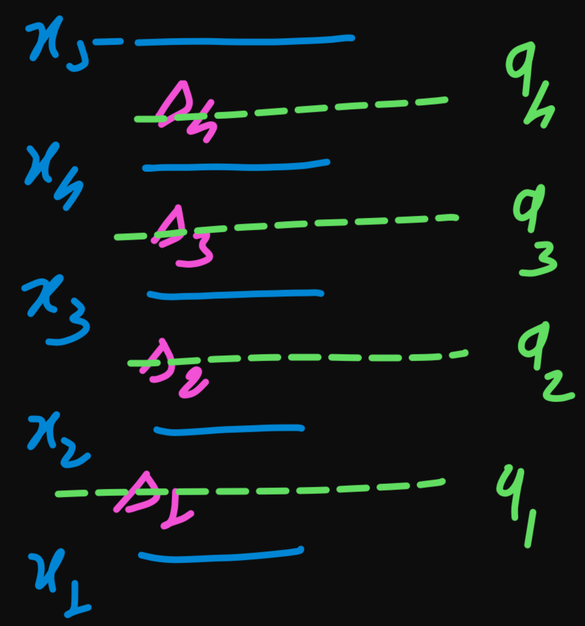
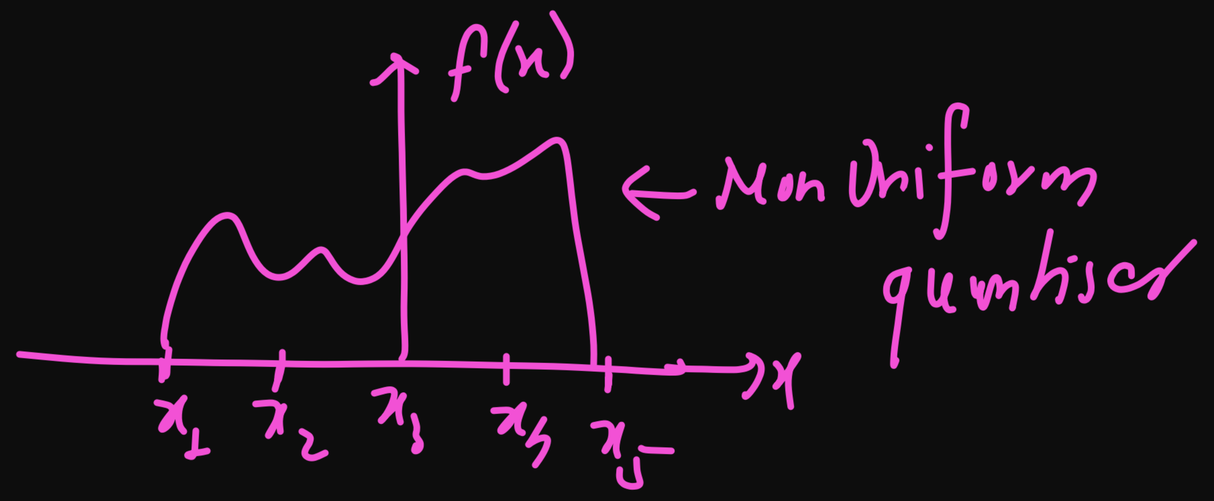
Lloyd Max Quantiser







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Condition for best Quantizer:

① Mean (avg.) value of quantization Error = 0

$$E[q_c] = 0, \quad E[x - q_1] = 0 \Big|_{\text{in one level}}$$

$$E[x] = \int_{-\infty}^{\infty} x f(x)\, dx \Bigg\} \quad E[q_c] = mu[q_c] = E[x - q_1] = \int_{x_1}^{x_2} (x - q_1) f(x)\, dx = 0$$

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For level-I :

$$\int_{x_1}^{x_2} (x - q_1) f(x)\, dx = 0$$

$$\Rightarrow \int_{x_1}^{x_2} x f(x)\, dx = q_1 \int_{x_1}^{x_2} f(x)\, dx$$

$$q_1 = \frac{\int_{x_1}^{x_2} x f(x)\, dx}{\int_{x_1}^{x_2} f(x)\, dx}$$

$$q_2 = \frac{\int_{x_2}^{x_3} x f(x)\, dx}{\int_{x_2}^{x_3} f(x)\, dx}$$

for uniform Pdf of $f(x)$

$$q_2 = \frac{f(x) \int_{x_2}^{x_3} \frac{x^2}{2}\, dx}{f(x) \int_{x_2}^{x_3} dx}$$

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$$q_2 = \frac{\int_{x_2}^{x_3} x\,dx}{\int_{x_2}^{x_3} dx} = \frac{\frac{x^2}{2}\Big|_{x_2}^{x_3}}{x\Big|_{x_2}^{x_3}} = \frac{\frac{1}{2}(x_3^2 - x_2^2)}{(x_3 - x_2)} = \frac{(x_3 - x_2)(x_3 + x_2)}{2(x_3 - x_2)}$$

$$\boxed{q_2 = \frac{x_2 + x_3}{2}} = \text{center point}$$

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Condition (II) $\quad mse[q_c] = \min$

$$E[q_c^2] = \min$$

$$E[(x-q_1)^2] = \int_{x_1}^{x_2} (x-q_1)^2 f(x)\,dx$$

$$q_1 = \frac{\int_{x_1}^{x_2} x f(x)\,dx}{\int_{x_1}^{x_2} f(x)\,dx}$$

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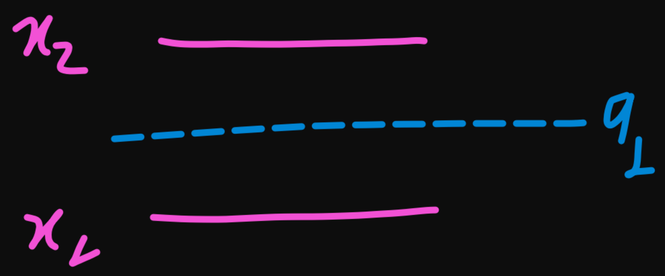
Lloyd Max Criteria :

$$q_l = \frac{\int_{x_l}^{x_2} x f(x)\,dx}{\int_{x_l}^{x_2} f(x)\,dx}$$



for uniform Pdf

$$q_l = \frac{x_l + x_2}{2}$$

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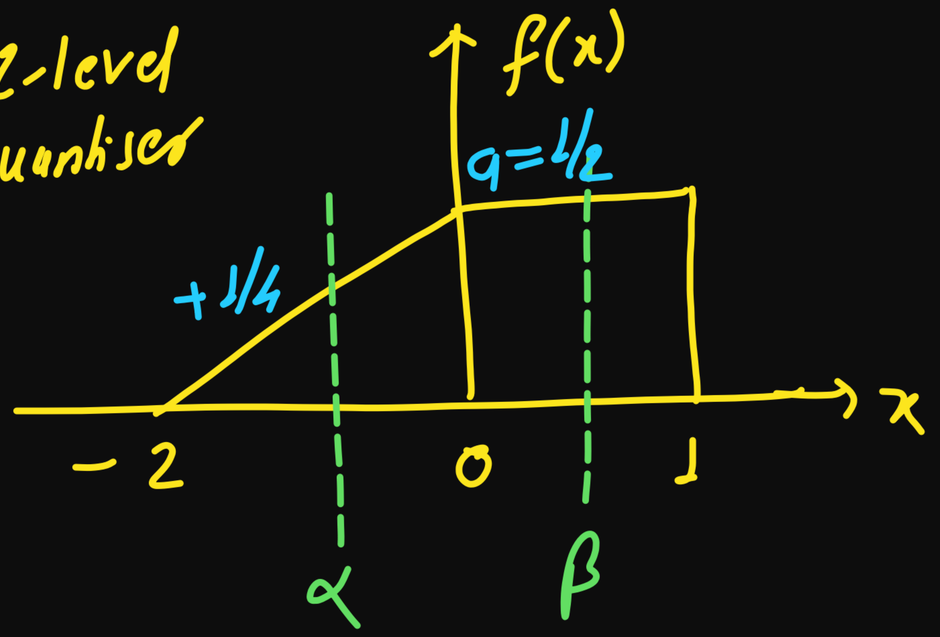
(Q.) 2-level quantiser



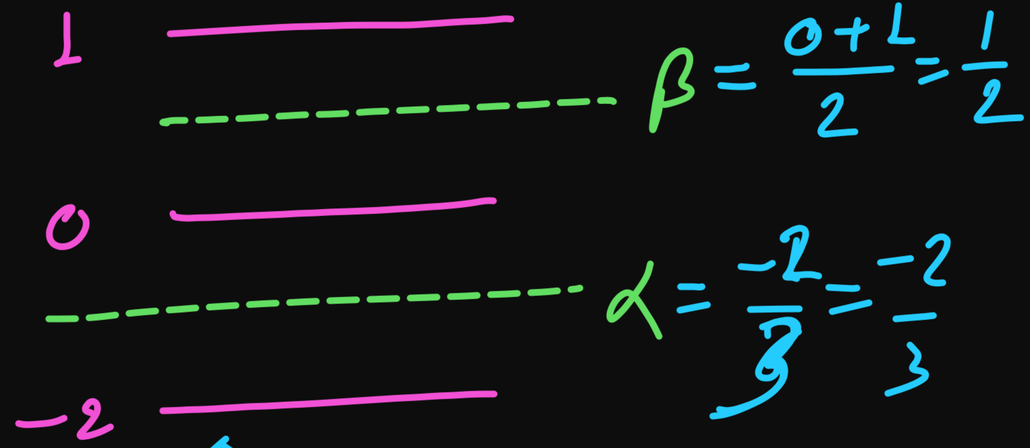
$\alpha = ?$

$\beta = ?$

$1 \cdot q + \frac{1}{2} \times 2 \times q = 1$

$q + q = 1$

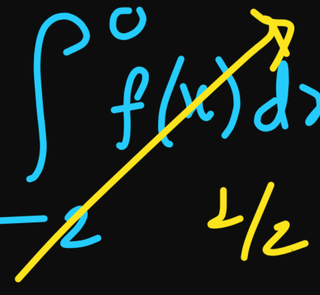
$q = 1/2$



$\beta = \frac{0+1}{2} = \frac{1}{2}$

$\alpha = \frac{-2}{3} = \frac{-2}{3}$

$$\alpha = \frac{\int_{-2}^{0} x f(x)\,dx}{\int_{-2}^{0} f(x)\,dx} = \frac{\int_{-2}^{0} x\left(\frac{1}{4}x + \frac{1}{2}\right)dx}{1/2}$$



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$$\alpha = 2\left[\frac{1}{4}\frac{x^3}{3}\Big|_{-2}^{0} + \frac{1}{2}\frac{x^2}{2}\Big|_{-2}^{0}\right]$$

$$\alpha = 2\left[\frac{1}{12}[0+8] + \frac{1}{4}[0-4]\right]$$

$$\alpha = 2\left[\frac{8}{12} - 1\right] = 2\left[\frac{-4}{12}\right] = 2\left[\frac{-1}{3}\right] = \frac{-2}{3}$$

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