

# WELCOME

TO Adda247

*"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



**प्रवाह** Batch

## COMMUNICATION

### QUANTIZER IN PCM PART-2

TIME- 9:00PM

RENU SIR



Chapter-2

**Digital Communications**

*In today's lecture we will cover the following Topics :*

1. **QUANTIZER in PCM (Part-2)**



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# GATE 2023 RESULT



**Congratulations**  
**FROM ADDA 247 FAMILY**

<b>AIR</b> <b>03</b> <b>ME</b> KUSHAGRA DUTT	<b>AIR</b> <b>05</b> <b>PI</b> HARSHIT KUMAR	<b>AIR</b> <b>07</b> <b>ME</b> RUSHI PRADIPKUMAR KARIYA	<b>AIR</b> <b>11</b> <b>CE</b> VINEET JAIN	<b>AIR</b> <b>30</b> <b>CE</b> RITIK BANSAL	<b>AIR</b> <b>36</b> <b>ECE</b> SUMIT KUMAR
<b>AIR</b> <b>64</b> <b>CE</b> UTKARSH MISHRA	<b>AIR</b> <b>71</b> <b>EE</b> SONESH SANJAY PAKAR	<b>AIR</b> <b>76</b> <b>CE</b> BIPANKAR DAS	<b>AIR</b> <b>87</b> <b>EC</b> SURAJIT RABI DAS	<b>AIR</b> <b>91</b> <b>EE</b> RISHABH GUPTA	<b>AIR</b> <b>111</b> <b>ES</b> ANIL GUPTA
<b>AIR</b> <b>130</b> <b>EE</b> SAURAV PATEL	<b>AIR</b> <b>136</b> <b>CE</b> RUPESH SACHDEVA	<b>AIR</b> <b>200</b> <b>ECE</b> WASIUZZAMA	<b>AIR</b> <b>212</b> <b>IN</b> WASIUZZAMA	<b>AIR</b> <b>217</b> <b>ME</b> VISHAL KUMAR	<b>AIR</b> <b>219</b> <b>ME</b> NITISH KUMAR
<b>AIR</b> <b>258</b> <b>EE</b> MANAV	<b>AIR</b> <b>348</b> <b>EE</b> AMAN NAMDEV	<b>AIR</b> <b>392</b> <b>EE</b> GAURAV MAHAJAN	<b>AIR</b> <b>403</b> <b>EC</b> MOHAN KUMAR SINGH	<b>AIR</b> <b>567</b> <b>EE</b> SHANKAR JHA	<b>AIR</b> <b>571</b> <b>ME</b> VUENDER MEENA



GATE

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BILINGUAL

# PRACHAND BATCH FREE FOR ALL

ELECTRICAL,  
ELECTRONICS COMMUNICATION ENGINEERING

GATE 2024 & ALL PSU's



Start Apr 11, 2023

7:30 AM to 11:30 PM

Free

# You Tube Classes Schedule



## 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

# FREE APP CLASS SCHEDULE



## EE & ECE ENGINEERING



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

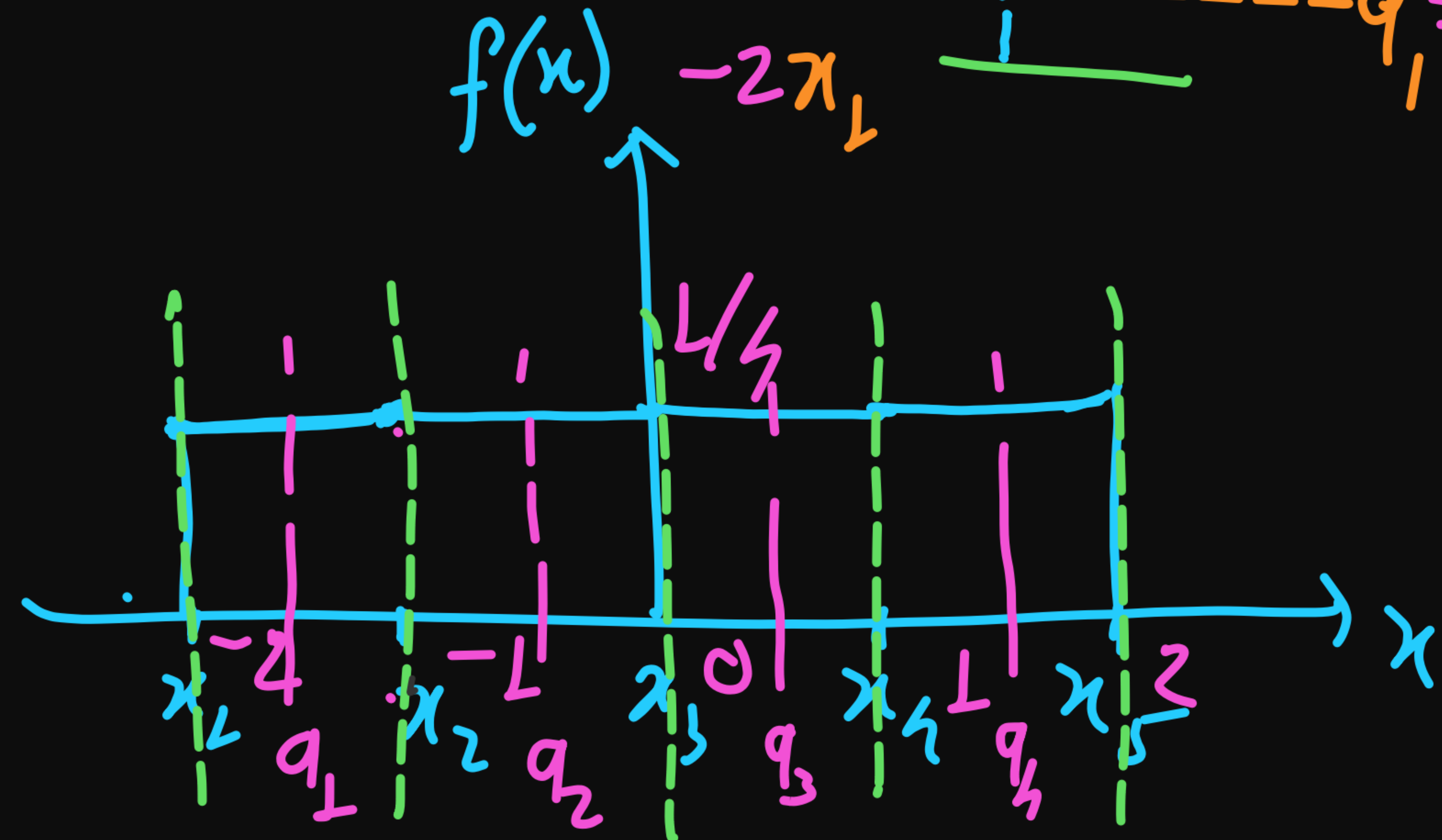
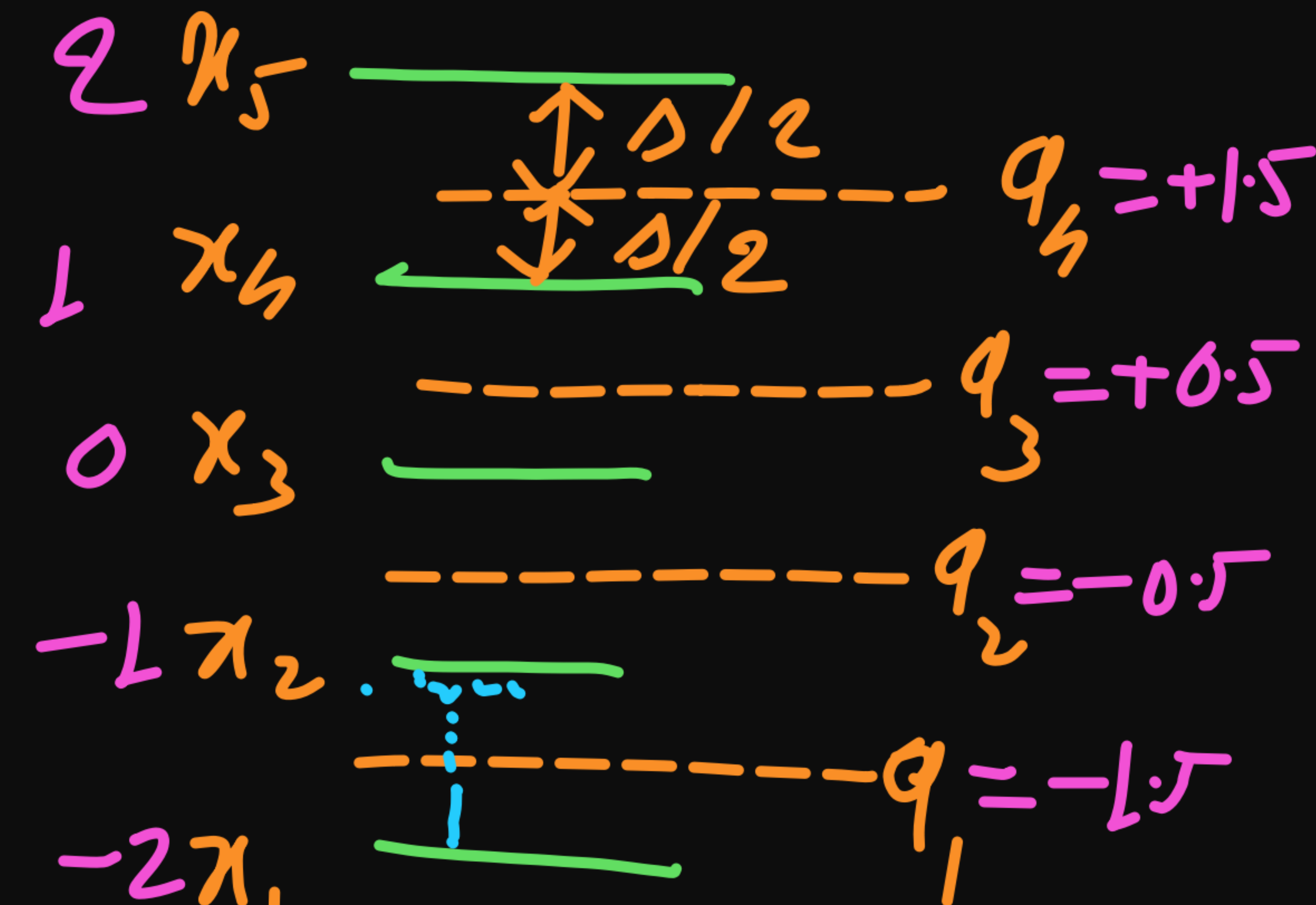
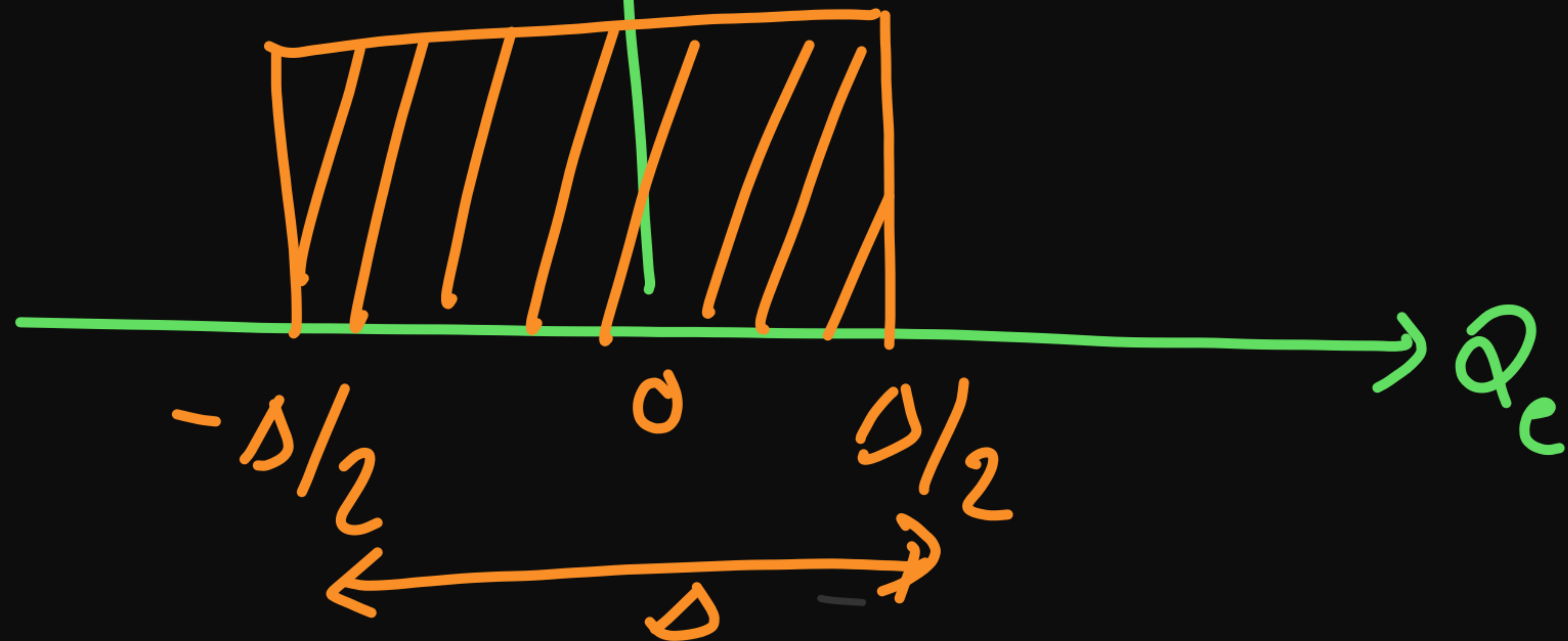


# Quantizer

→ Uniform quantiser:

$\Delta = \text{fixed \& equal} \rightarrow Q_c |_{min} = \pm \Delta/2$

Prob. density  
fn. of  $Q_c \rightarrow f(Q_c)$



$$\Rightarrow mV[\alpha_c] = 0$$

$$\Rightarrow \text{Noise Power} = mSV[\alpha_c] = \text{min}$$

$$\Rightarrow \int_{-\Delta/2}^{\Delta/2} \alpha_c \frac{1}{\Delta} d\alpha_c = \frac{1}{\Delta} \left. \frac{\alpha_c^2}{2} \right|_{-\Delta/2}^{\Delta/2}$$

$$= \frac{1}{2\Delta} \left[ \frac{\Delta^2}{4} - \frac{\Delta^2}{4} \right] = 0$$

$$mV[\alpha_c] = \int_{-\infty}^{\infty} \alpha_c f(\alpha_c) d\alpha_c$$

$$\text{Noise Power} = mSV[\alpha_c]$$

$$= \int_{-\infty}^{\infty} \alpha_c^2 f(\alpha_c) d\alpha_c$$

$$\text{(Noise Power)} = \int_{-\Delta/2}^{\Delta/2} \alpha_c^2 \frac{1}{\Delta} d\alpha_c$$

$$(NP)_Q = \frac{1}{\Delta} \left. \frac{Q_c^3}{3} \right|_{-\Delta/2}^{\Delta/2} = \frac{1}{3\Delta} \left[ \frac{\Delta^3}{8} + \frac{\Delta^3}{8} \right] = \frac{\Delta^2}{12}$$

for Uniform quantiser total noise power (avg) =  $\frac{\Delta^2}{12}$

$$mv[Q_c] \Rightarrow mv[x - q_c] = \int_{x_1}^{x_2} (x - q_1) f(x) dx = \int_{-1}^{1} (x - q_1) \frac{1}{h} dx = 0$$

$$= \frac{1}{4} \left. \frac{x^2}{2} \right|_{-2}^{1} - \frac{q_1}{4} \left. x \right|_{-2}^{1} = 0$$

$$E[x] = \int x f(x) dx$$

$$\Rightarrow \frac{x^2}{2} \Big|_{-2}^{-1} = q_1 \cdot x \Big|_{-2}^{-1}$$

$$\Rightarrow q_1 = \frac{\frac{x^2}{2} \Big|_{-2}^{-1}}{x \Big|_{-2}^{-1}} = \frac{\frac{1}{2} [1-4]}{+1-(-2)} = \frac{\frac{1}{2}(-3)}{1} = \frac{-3}{2} = -1.5$$

= center of  $-2$  &  $-1$

$$q_1 = \frac{x_1 + x_2}{2}$$

$$\text{Mean Power} = m_{SV}[a_c] = m_{SV}[x - q]$$

$$m_{SV}[x] = \int_{-\infty}^{\infty} x^2 f(x) dx$$

$$= \left( \frac{x^3}{3} - \frac{x^2}{2} + \frac{1}{4}x \right) \Big|_0^1$$

$$= \frac{1}{3} - \frac{1}{2} + \frac{1}{4} = \frac{4}{12} - \frac{6}{12} + \frac{3}{12}$$

$$= \frac{1}{12} = \sigma^2/12$$

$$= \int_{-2}^{-1} (x - q_1)^2 f(x) dx + \int_{-1}^0 (x - q_2)^2 f(x) dx$$

$$+ \int_0^1 (x - q_3)^2 f(x) dx + \int_1^2 (x - q_3)^2 f(x) dx$$

$$= 4x \int_0^1 \left(x - \frac{1}{2}\right)^2 \frac{1}{4} dx = \int_0^1 \left(x^2 - x + \frac{1}{4}\right) dx$$

$$= \int_0^{\Delta} (x - q_3)^2 f(x) dx$$

$$= f(x) \int_0^{\Delta} (x^2 - 2xq_3 + q_3^2) dx$$

$$= f(x) \left[ \frac{x^3}{3} - \cancel{2}q_3 \frac{x^2}{\cancel{2}} + q_3^2 x \right]_0^{\Delta}$$

$$= f(x) \left[ \frac{\Delta^3}{3} - q_3 \Delta^2 + q_3^2 \Delta \right]$$

$$q_3 = \Delta/2$$

$$= f(x) \left[ \frac{\Delta^3}{3} - \frac{\Delta^3}{2} + \frac{\Delta^3}{4} \right]$$

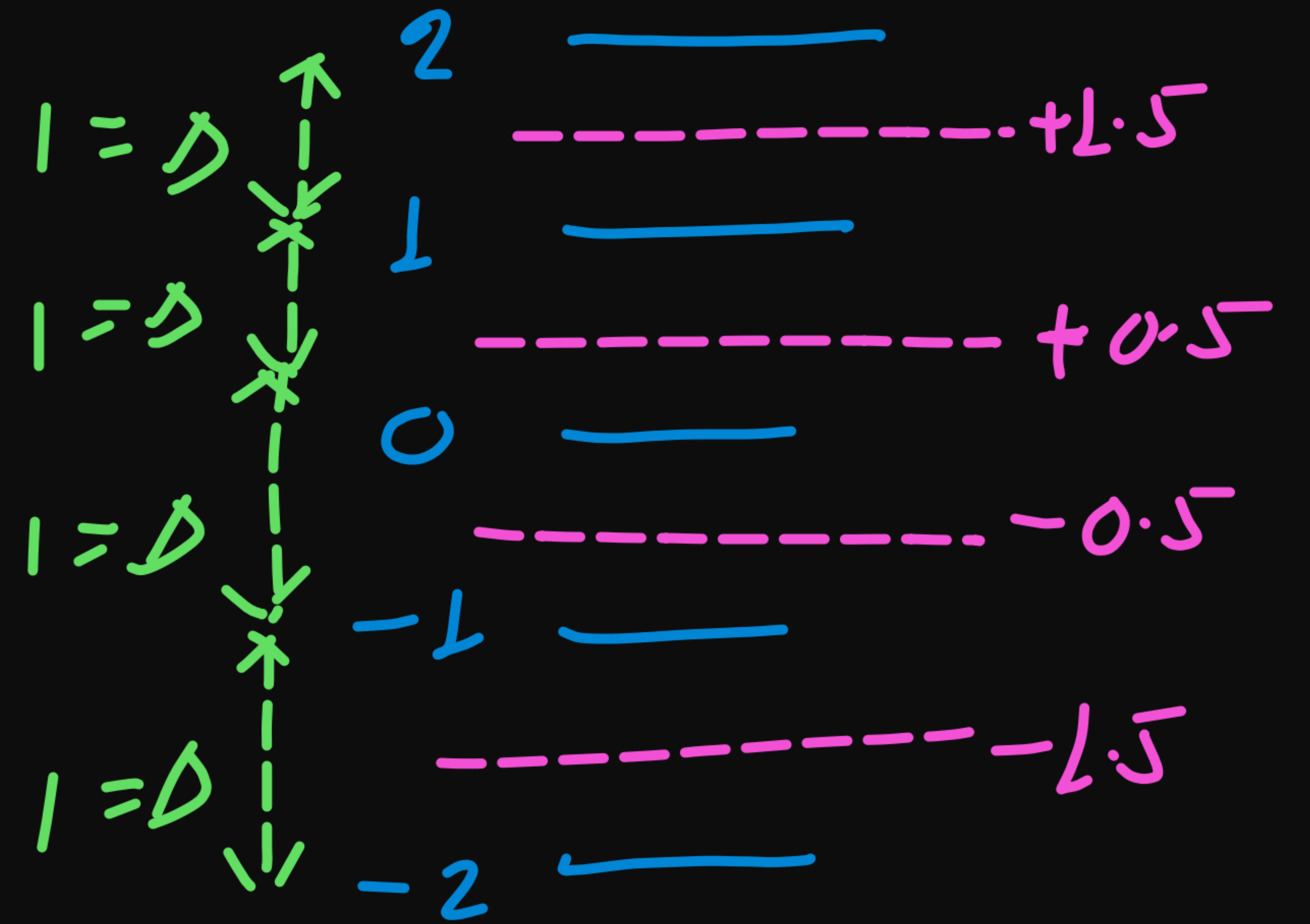
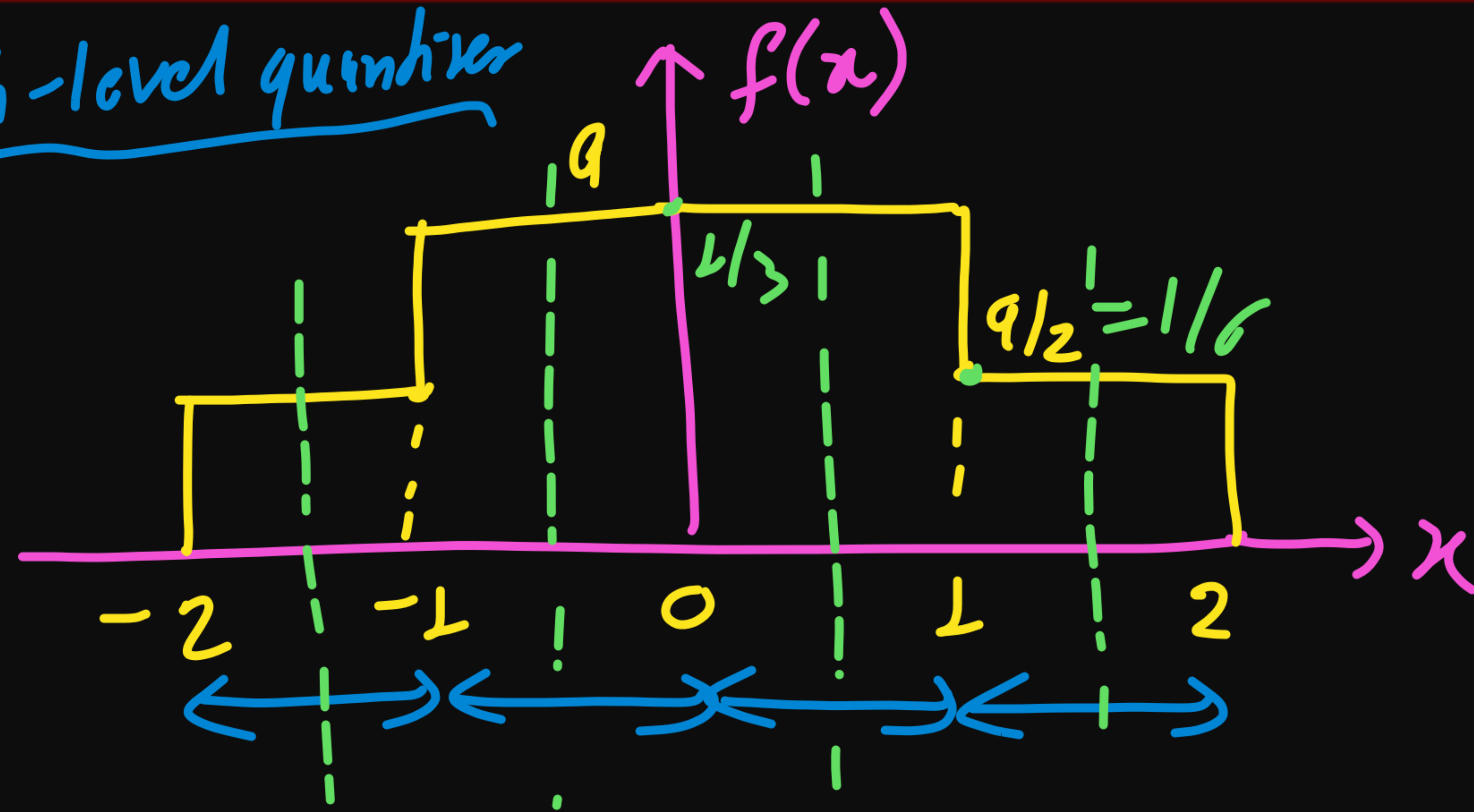
$$= f(x) \left[ \frac{4\Delta^3}{12} - \frac{6\Delta^3}{12} + \frac{3\Delta^3}{12} \right]$$

$$= f(x) \frac{\Delta^3}{12} = \frac{\Delta^2}{12} \times f(x) \Delta$$

$$= \frac{\Delta^2}{12} \times \text{Area of that level}$$

Que.

4-level quantizer



Noise Power = ?

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

$$q + 2q = 1$$

$$3q = 1$$

$$q = \frac{1}{3}$$

$$\text{Noise Power} = \int_{-2}^{-1} (x+1.5)^2 \frac{1}{6} dx + \int_{-1}^0 (x+0.5)^2 \frac{1}{3} dx + \int_0^1 (x-0.5)^2 \frac{1}{3} dx + \int_1^2 (x-1.5)^2 \frac{1}{6} dx$$

$$= \frac{D_1^2}{12} \times A_{\text{req}} L + \frac{D_2^2}{12} \times A_{\text{req}} L + \frac{D_3^2}{12} \times A_{\text{req}} L + \frac{D_4^2}{12} \times A_{\text{req}} L$$

$$= \frac{1}{12} \left[ \underbrace{A_1 L + A_2 L + A_3 L + A_4 L}_L \right] = \frac{1}{12}$$



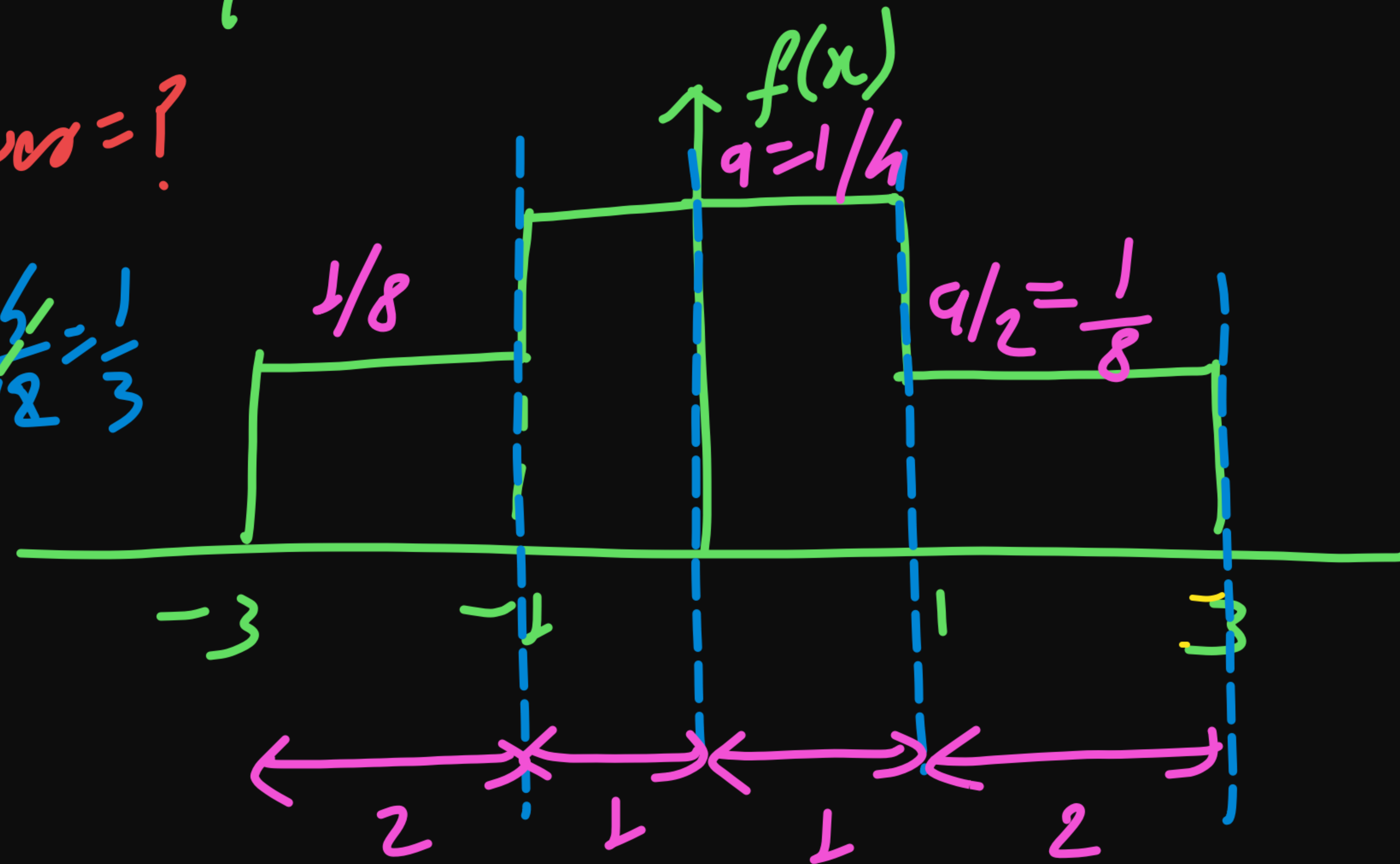
Q.  $h$ -level quantiser:

Noise power = ?

$$\frac{\sigma^2}{12} = \frac{(2)^2}{12} = \frac{4}{12} = \frac{1}{3}$$

$$\frac{\sigma^2}{12} = \frac{1}{12}$$

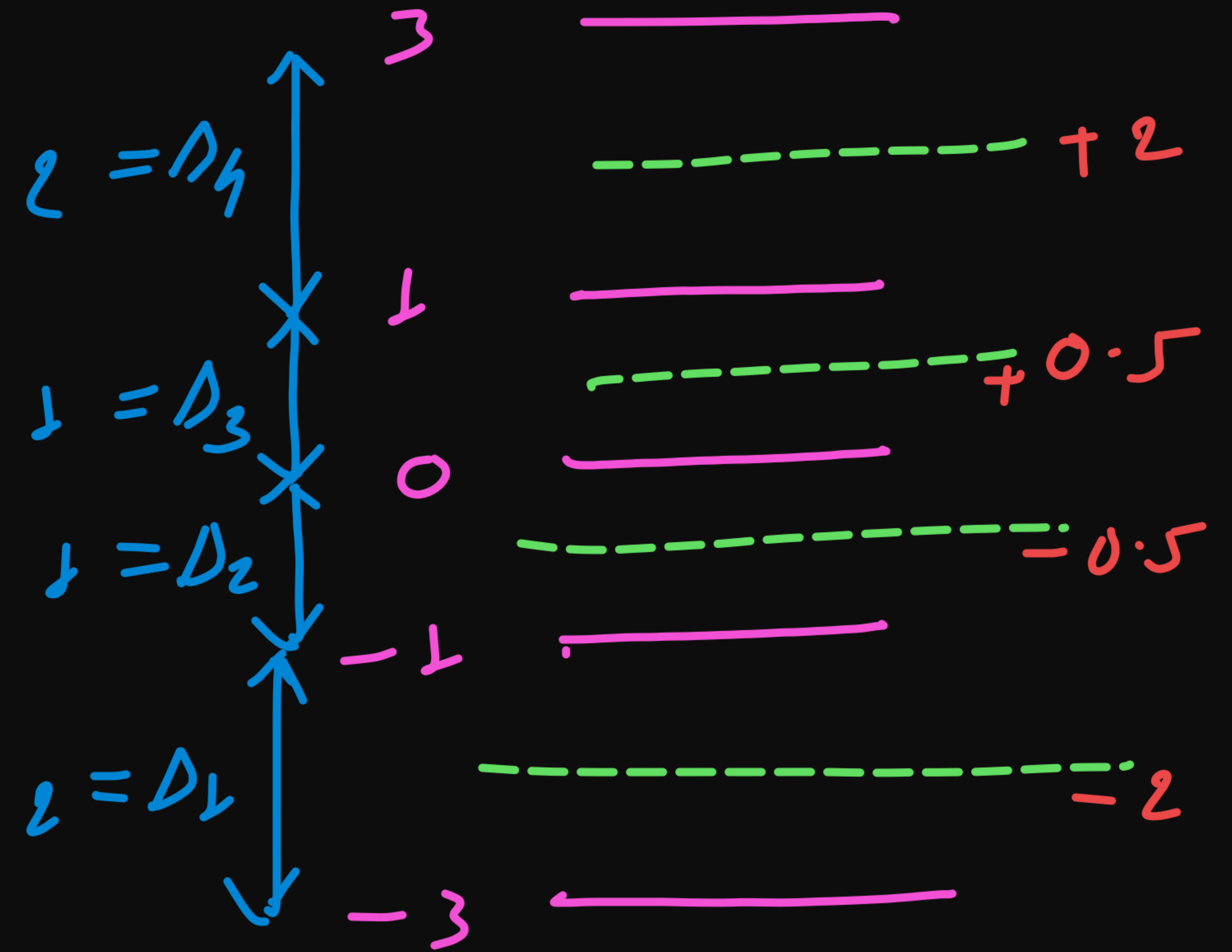
$$\frac{4}{12} + \frac{1}{12} = \frac{5}{12}$$



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

$$h_4 = 1$$

$$q = 1/4$$



$$\begin{aligned}
 \text{Mean Power} &= \int_{-3}^{-1} (x+2)^2 \frac{1}{8} dx + \int_{-1}^0 (x+0.5)^2 \frac{1}{4} dx + \int_0^1 (x-0.5)^2 \frac{1}{4} dx \\
 &\quad + \int_1^3 (x-2)^2 \frac{1}{8} dx \\
 &= \frac{\Delta_1^2}{12} \text{Area}_1 + \frac{\Delta_2^2}{12} \text{Area}_2 + \frac{\Delta_3^2}{12} \times \text{Area}_3 \\
 &\quad + \frac{\Delta_4^2}{12} \times \text{Area}_4 \\
 &= \frac{(2)^2}{12} \times \frac{1}{4} + \frac{(1)^2}{12} \times \frac{1}{4} + \frac{(1)^2}{12} \times \frac{1}{4} + \frac{(2)^2}{12} \times \frac{1}{4} \\
 &= \frac{1}{4} \cdot \frac{1}{12} [4 + 1 + 1 + 4] = \frac{10}{4 \times 12} = \frac{5}{24} \checkmark
 \end{aligned}$$

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