

Consider a sequence of i.i.d. random variables  $\{X_n\}$  with common p.d.f.

$$f_X(x) = \begin{cases} |x|/9 & \text{if } |x| < 3 \\ 0 & \text{if } |x| \geq 3 \end{cases} .$$

We design a three-level scalar quantizer for  $\{X_n\}$  with thresholds:  $(T_0, T_1, T_2, T_3) = (-3, -1, +1, +3)$ , and quantization levels  $(y_1, y_2, y_3) = (-2, 0, +2)$ .

1. **(2 pt)** What is the minimum number of bits needed to represent four consecutive quantized samples:  $[Q(X_1), Q(X_2), Q(X_3), Q(X_4)]$ ?
2. **(3 pt)** Suppose that this SQ is used as part of an ECSQ system with a first-order Huffman code. What is the average rate? Provide the correct unit.
3. **(3 pt)** Repeat part 2 if we use instead a second-order Huffman code.
4. **(2 pt)** Suppose  $D_1$  is the average distortion of the system when we use a first-order Huffman code and  $D_2$  is the average distortion of the system when we use a second-order Huffman code. Is  $D_1$  equal to, greater than, or less than  $D_2$ ?