Mobile Systems

Revision Problems

COMP28512

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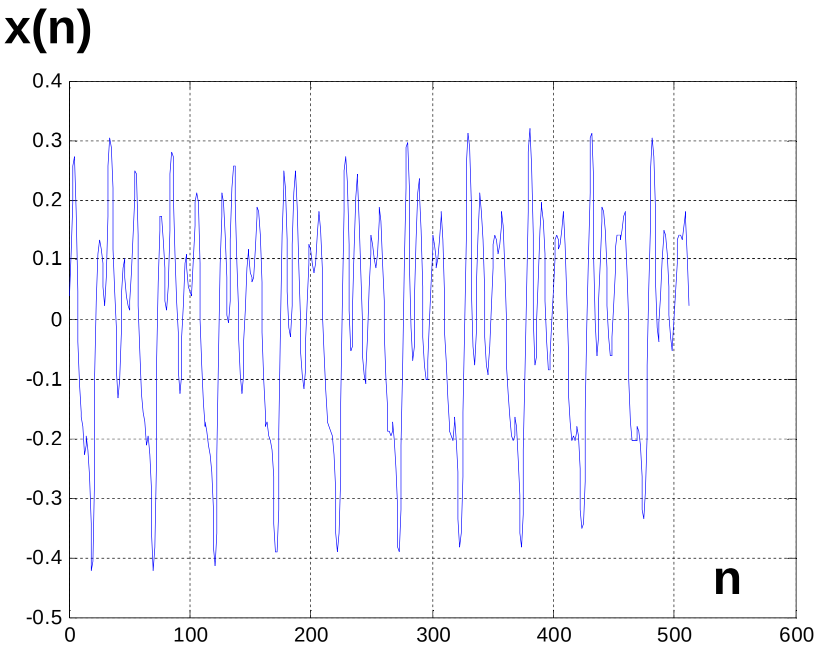
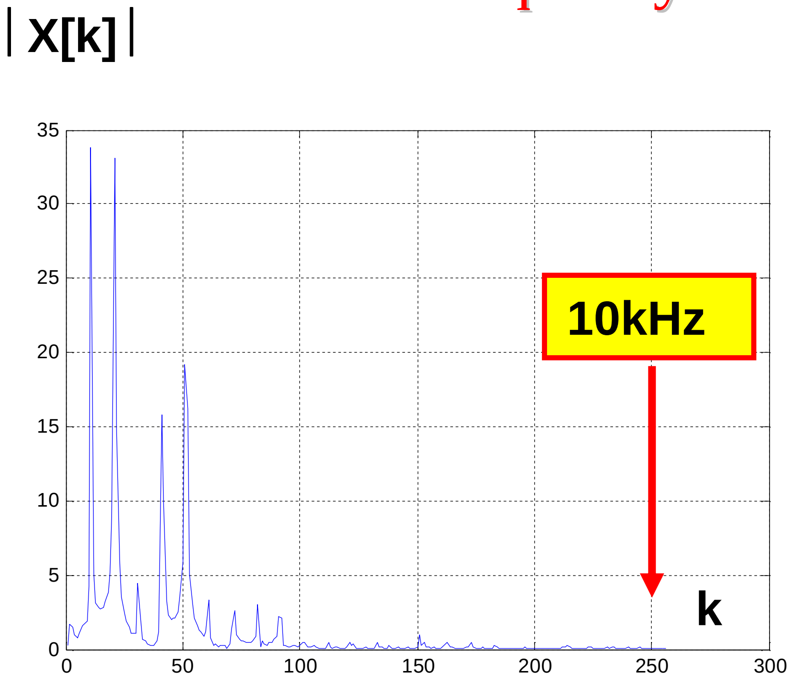
Question 1: If the sampling frequency Fs is 20 kHz, what is the frequency of the musical note whose sampled time-domain waveform is shown below in figure (a)?

If Fs = 20kHz, & the 512 point FFT of a musical note gives the magnitude spectrum in figure (b), what is the note's frequency?

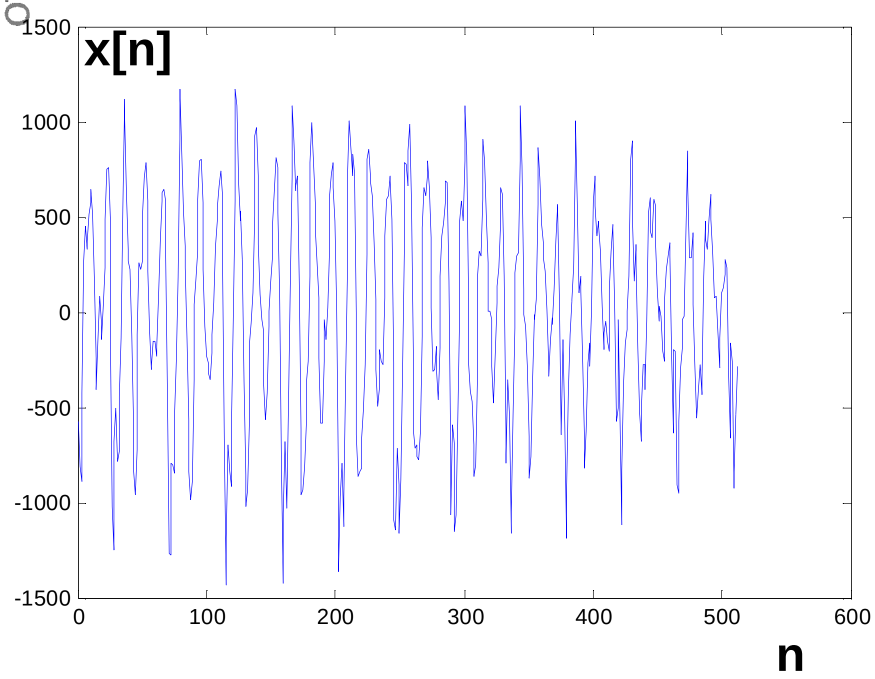


(a) 10 cycles in 500 samples: 400 Hz



(b) 5 peaks in 2kHz: 400 Hz

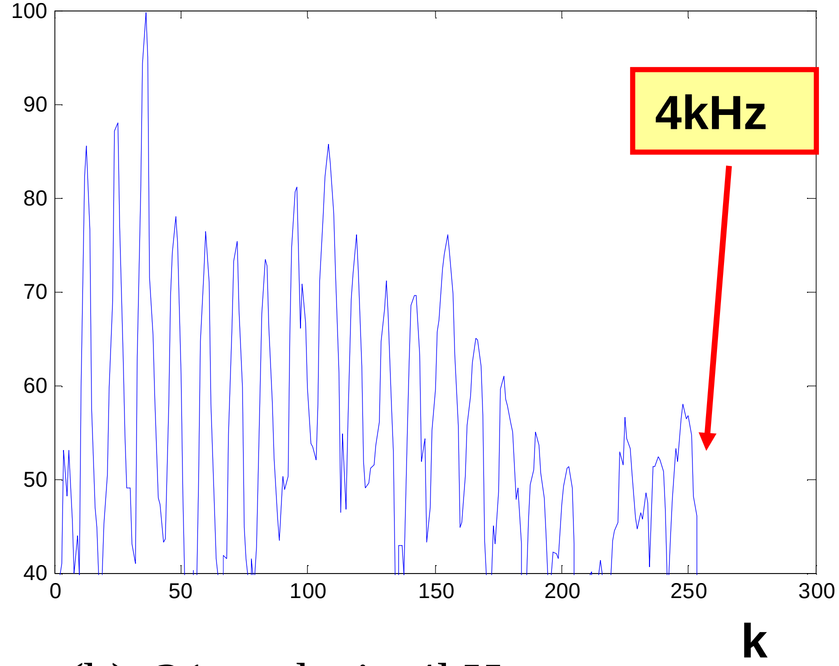
Question 2: Same, except that now Fs = 8kHz



(a) 12 cycles in 500 samples (1/16 s)

16 x 12 = 192 Hz

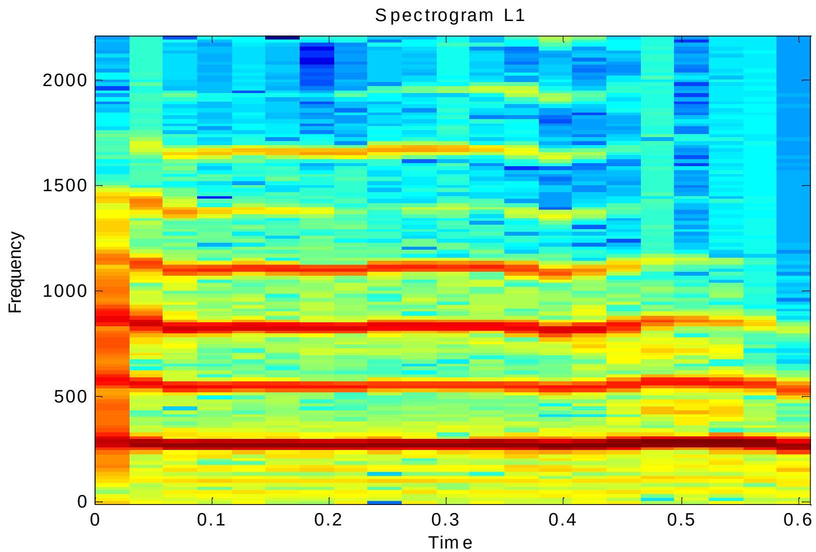
512 pt FFT amplitude

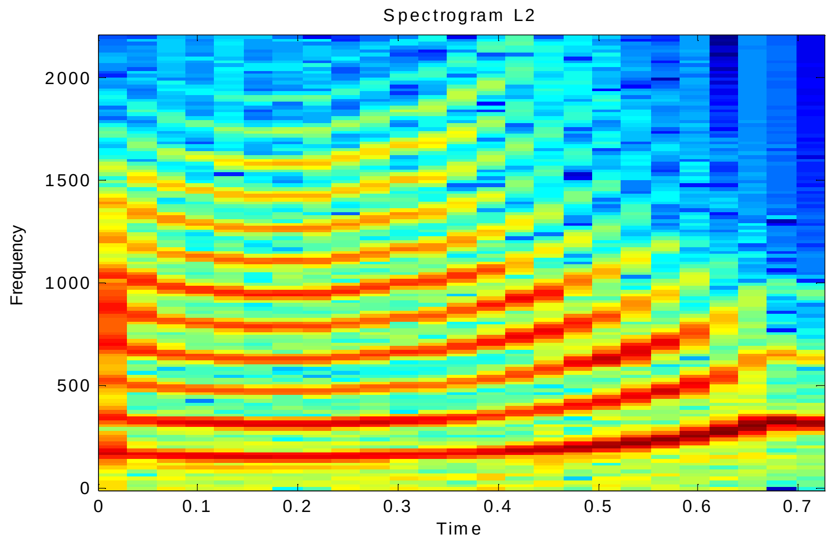


(b) 21 peaks in 4kHz

1st peak (fundamental): 190 Hz

Question 3: Examine the following spectrograms of speech & explain how the pitch of the voice is changing over time





(a) Stays fixed at ≈ 300 Hz

(b) Starts at 1000/6 ≈ 167 Hz & rises to about 250 Hz

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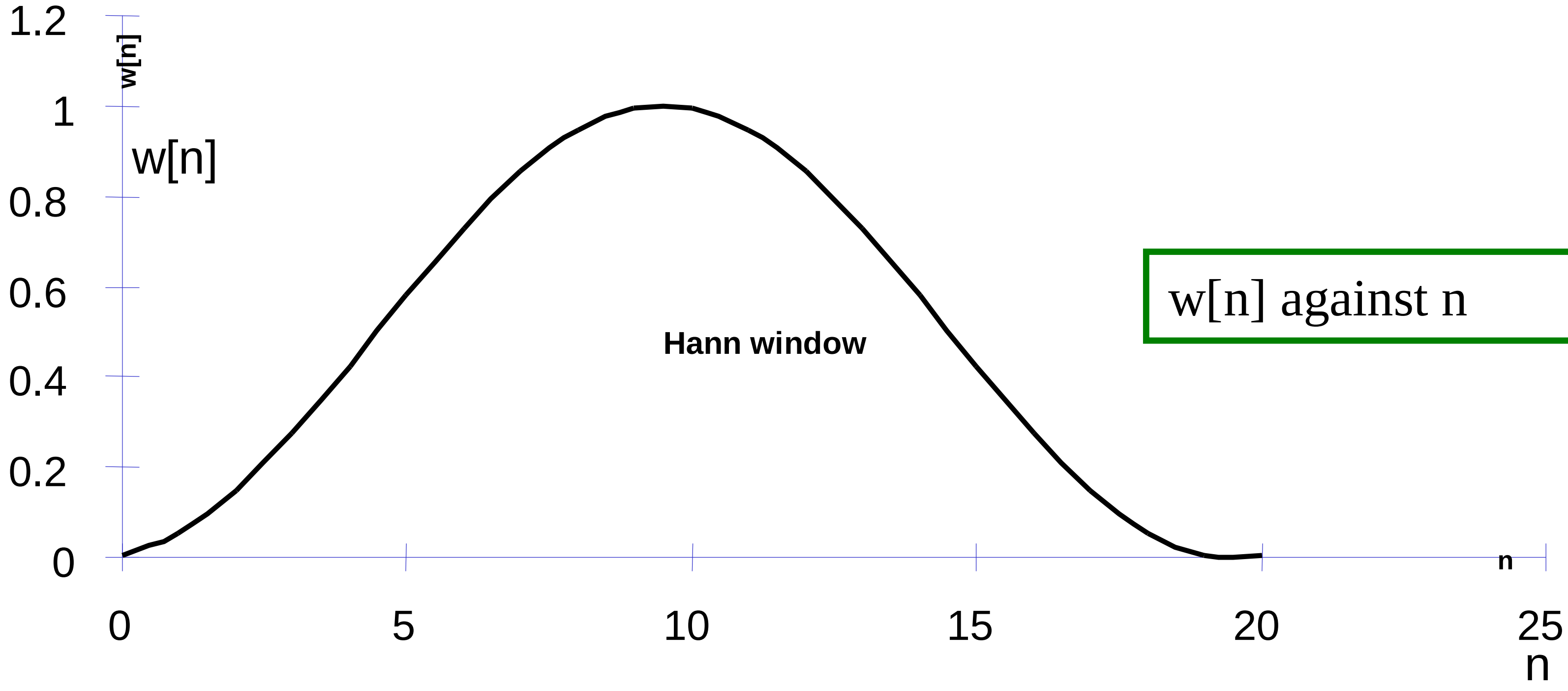
Question 4: Why is non-rectangular windowing normally used when using the FFT for spectral analysis



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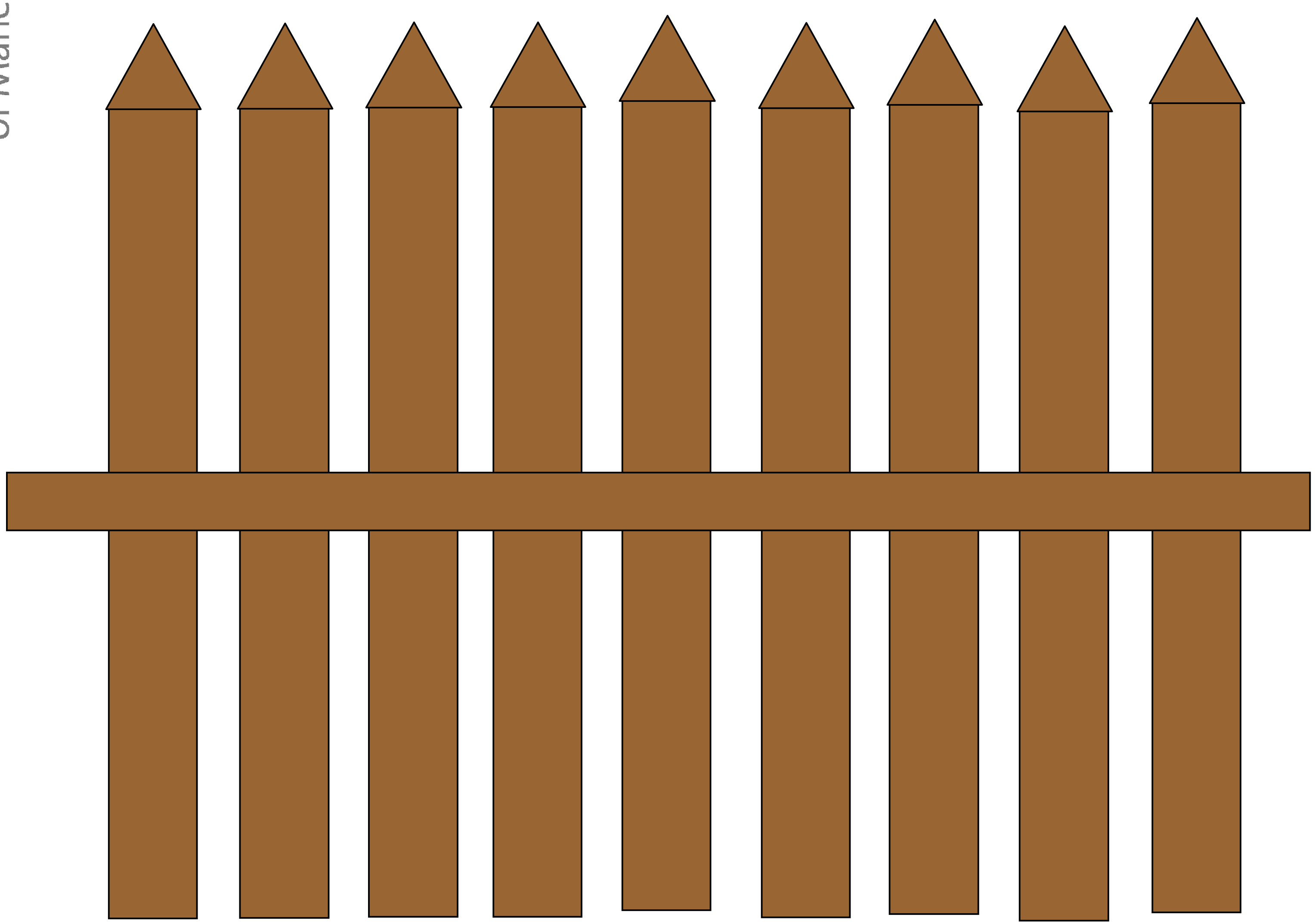
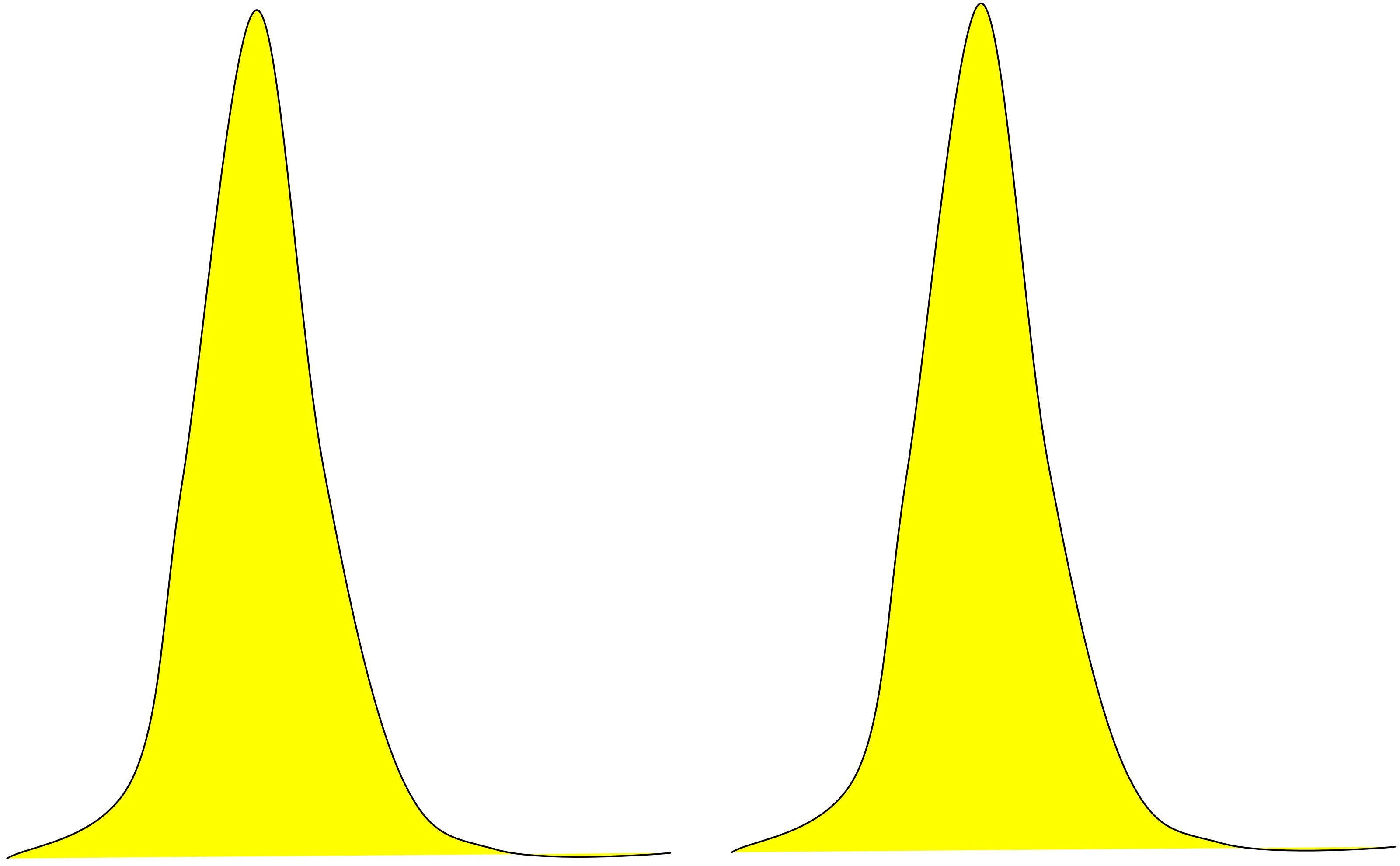
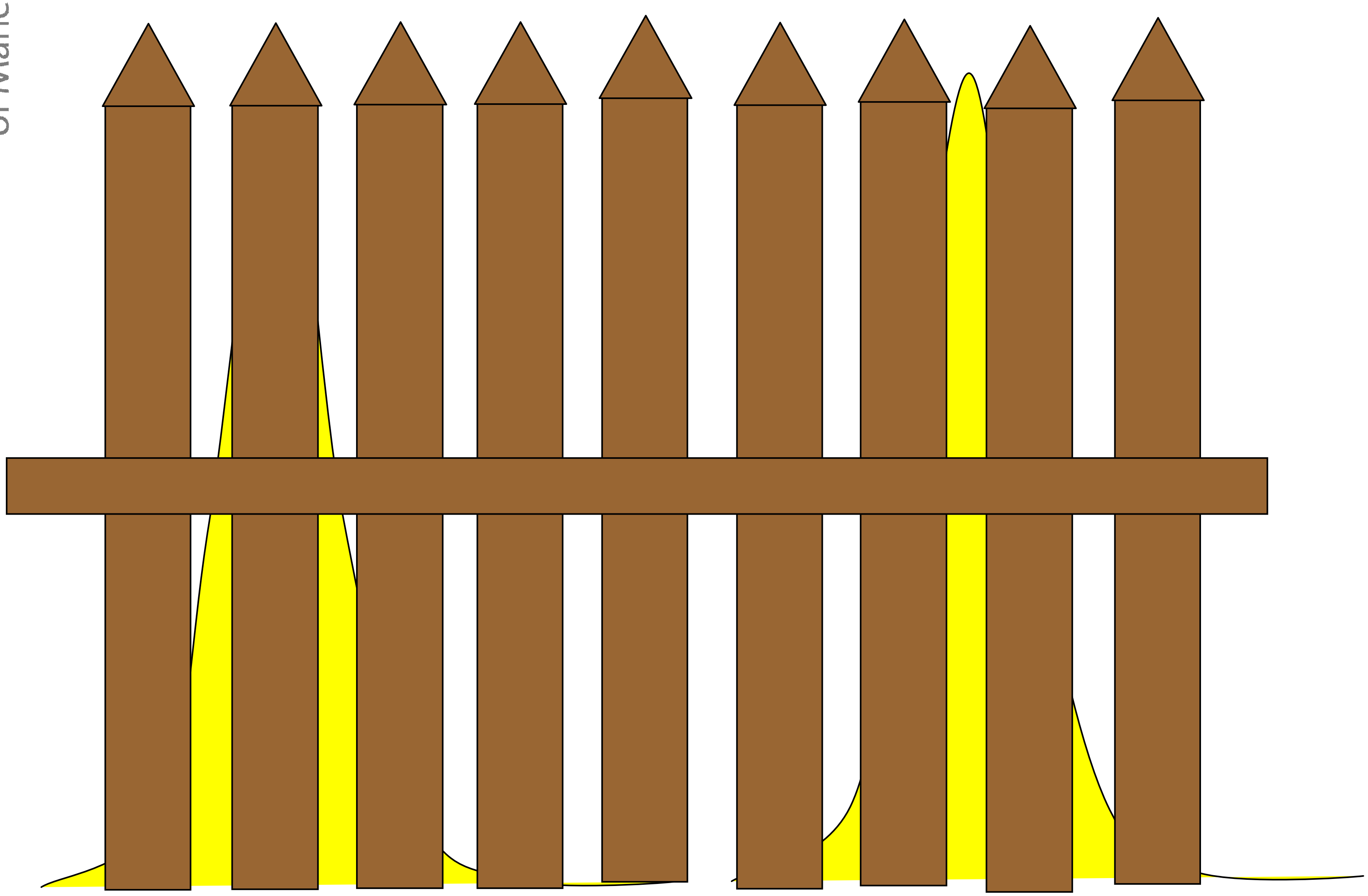
Qn 4: Picket fence effect (a)



Qn 4: Picket fence effect (b)



Qn 4: Picket fence effect (c)



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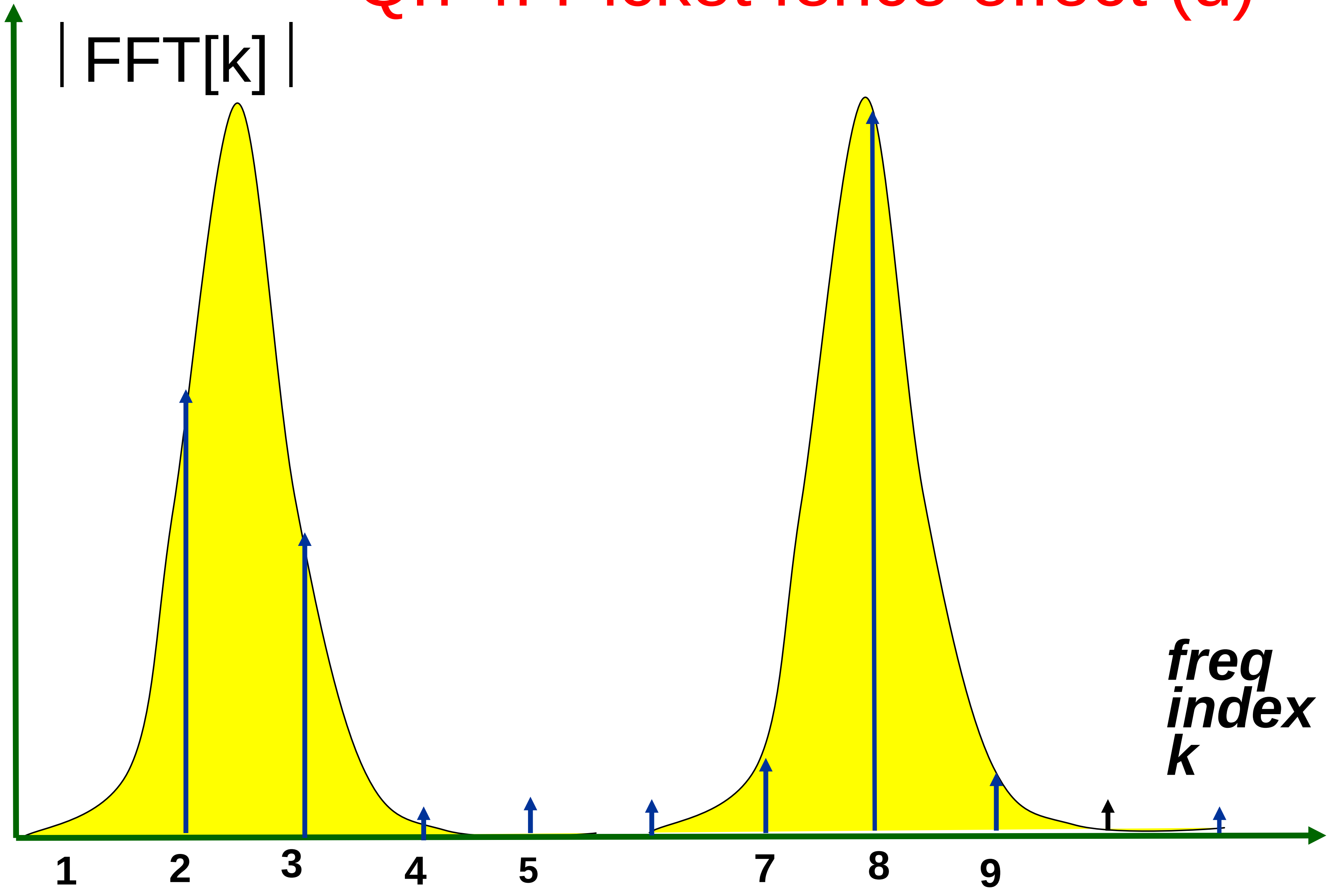
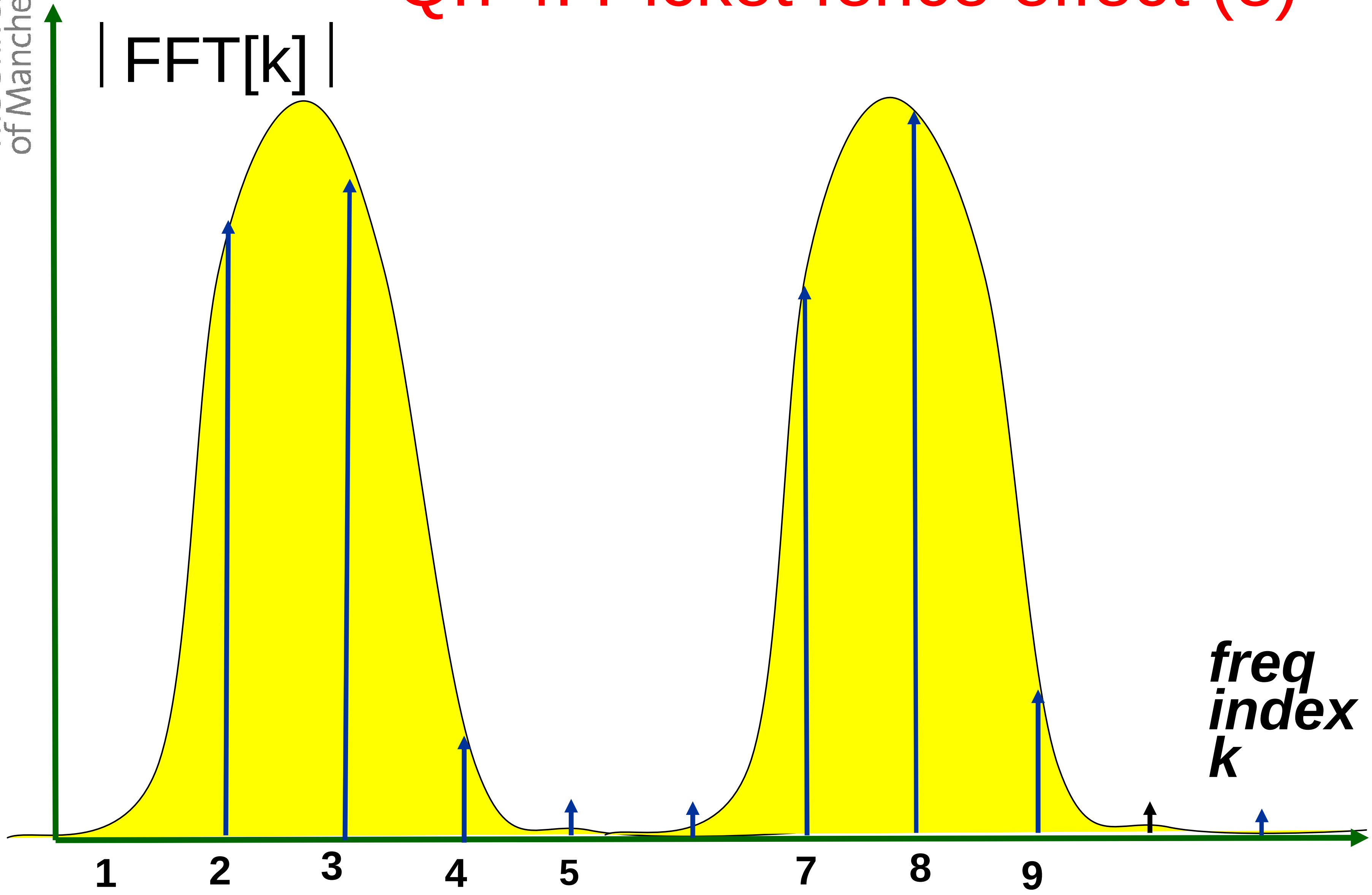
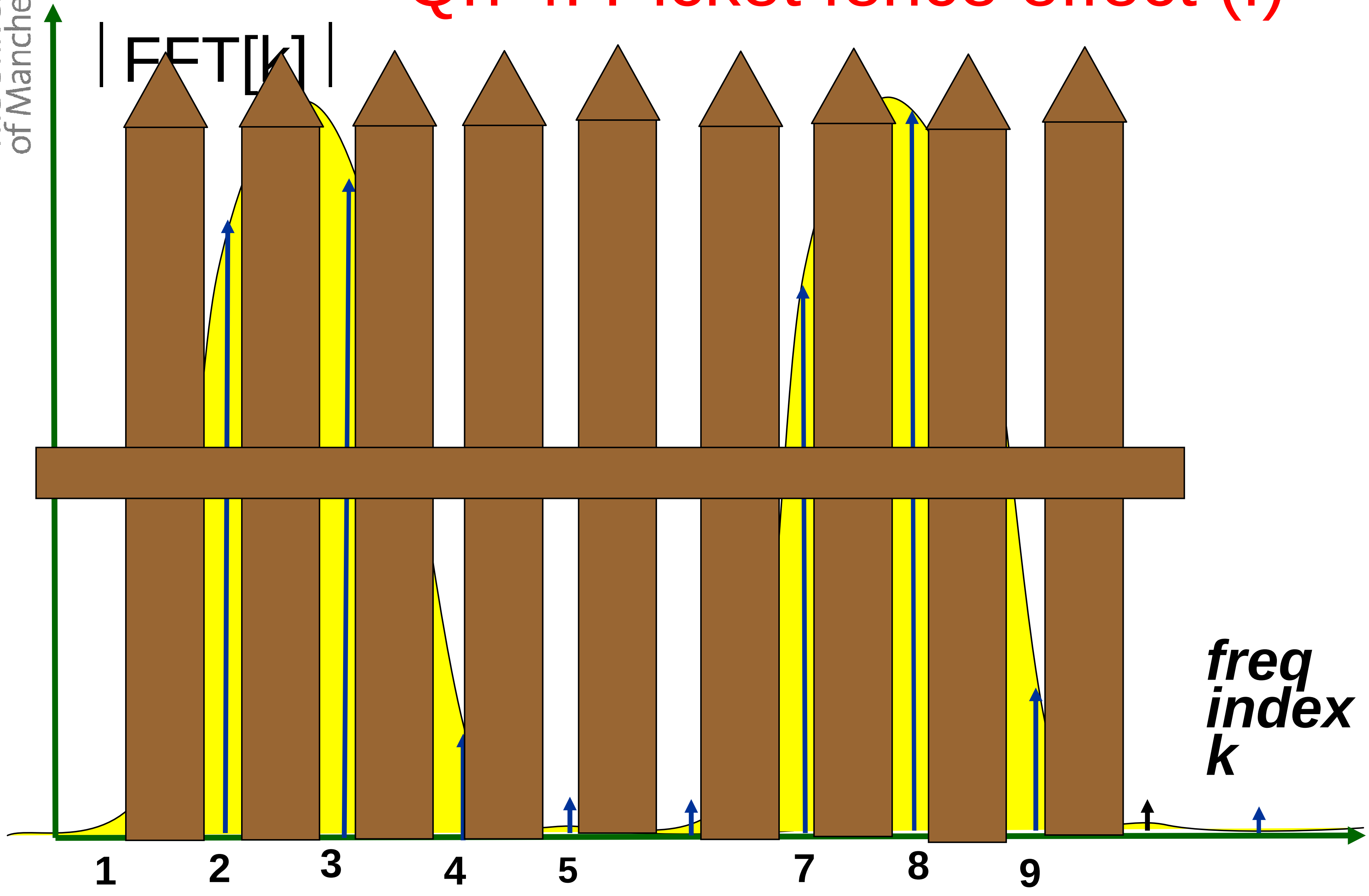
Qn 4: Picket fence effect (d)



Qn 4: Picket fence effect (e)



Qn 4: Picket fence effect (f)



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Question 5 (more on the FFT)

(a) What is the difference between the DFT and the FFT?

(b) What is the DCT and how is it related to the DFT?

(c) How does zero-padding affect an FFT?

(d) Why do we plot only first 256 points of a 512 pt FFT?

(e) What does ‘stationary’ mean?

(a) FFT is faster

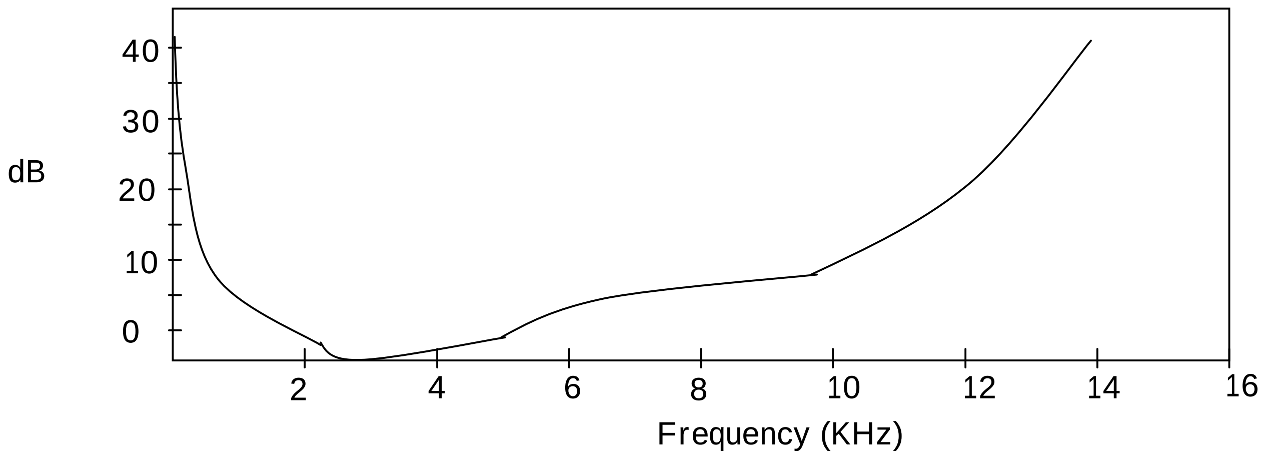
(b) Discrete cosine transform: DFT of symmetrically extended

(c) Increases no. of freq domain samples & resolution.

(d) Plot up half sampling rate (e) Spectrum does not change.

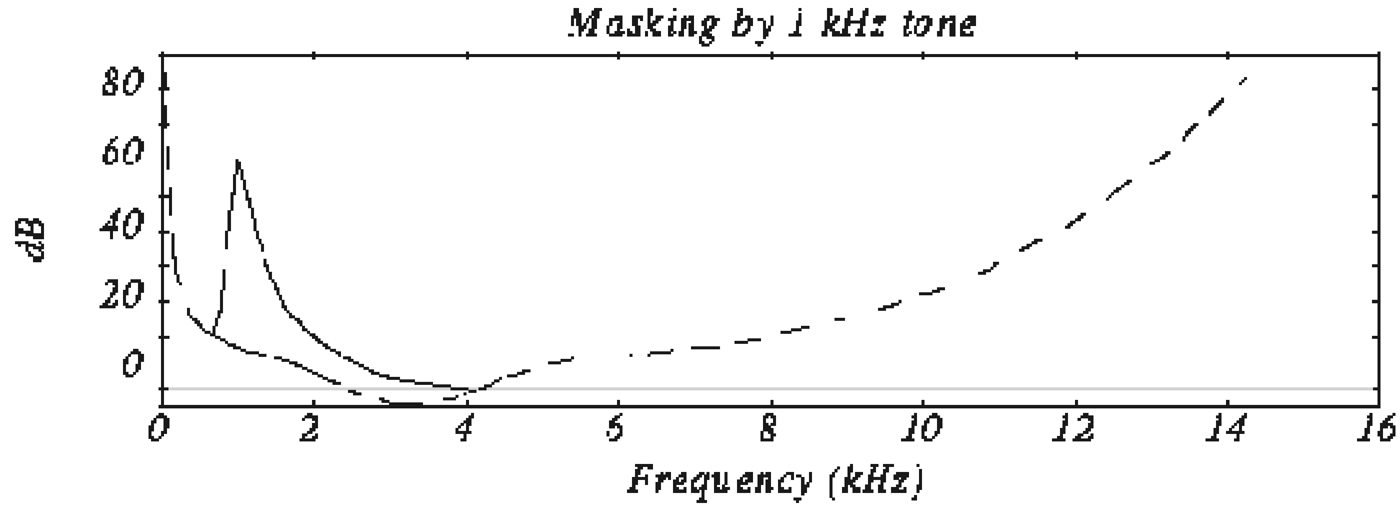
Question 6

(a) What is meant by masking contour in quiet as sketched below?



Masking contour 'in quiet'

(b) Explain frequency masking by referring to the diag below



Question 7

(a) Why would you expect a JPEG compressed image more sensitive to the effect of bit-errors than an uncompressed image such as a bit-map?

(b) Symbols A,B,C,D E,F have probabilities:

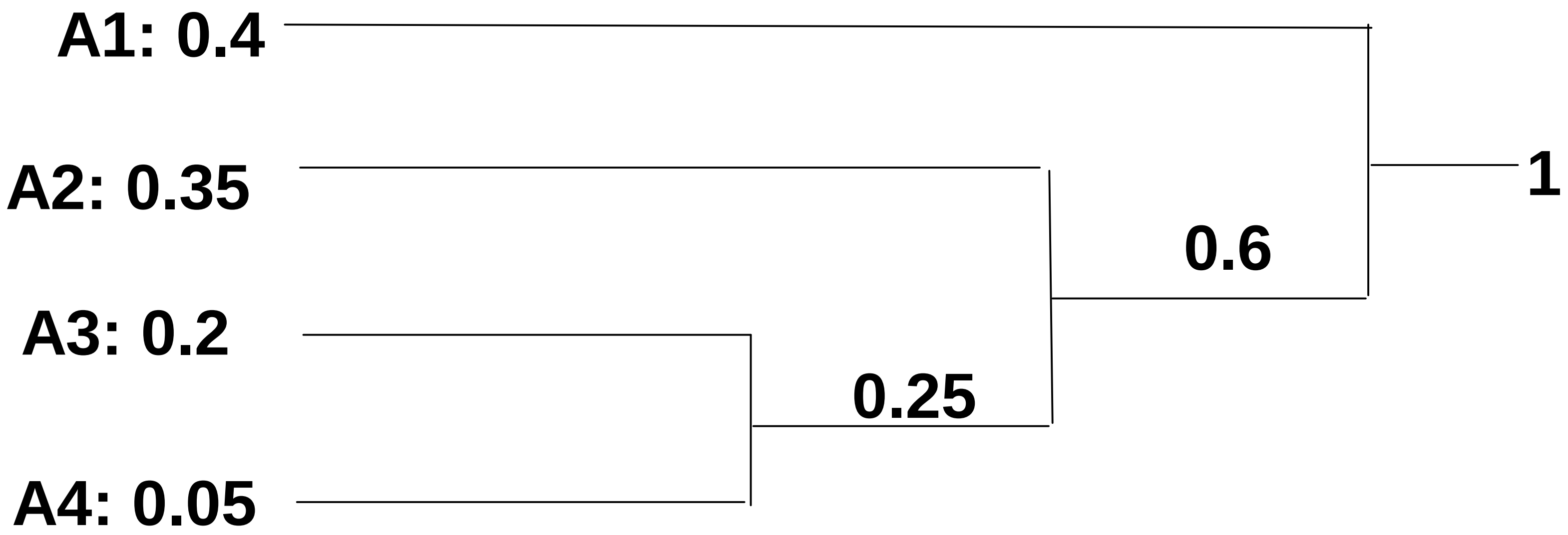
0.12, 0.13, 0.1, 0.1, 0.4, 0.15

Devise a Huffman code & consider how it would be decoded.

Consider simpler example in notes:-

Huffman coding (a)

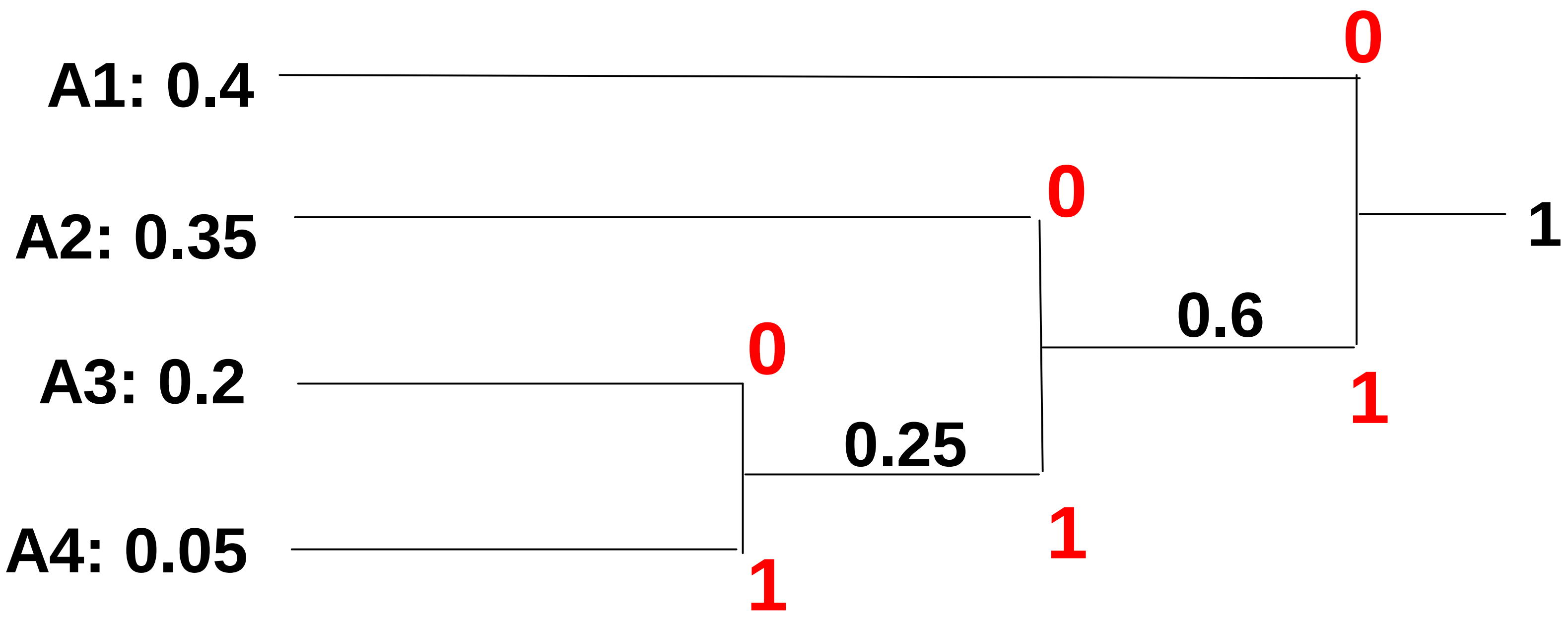
- Variable length, self terminating codes.
- Given 4 numbers A1, A2, A3, A4 occurring with probabilities: 0.4, 0.35, 0.2, 0.05



- Arrange in decreasing order of probabilities
- Then link two with lowest probability.
- Add probs & repeat. Sometimes ordering changes (not here).

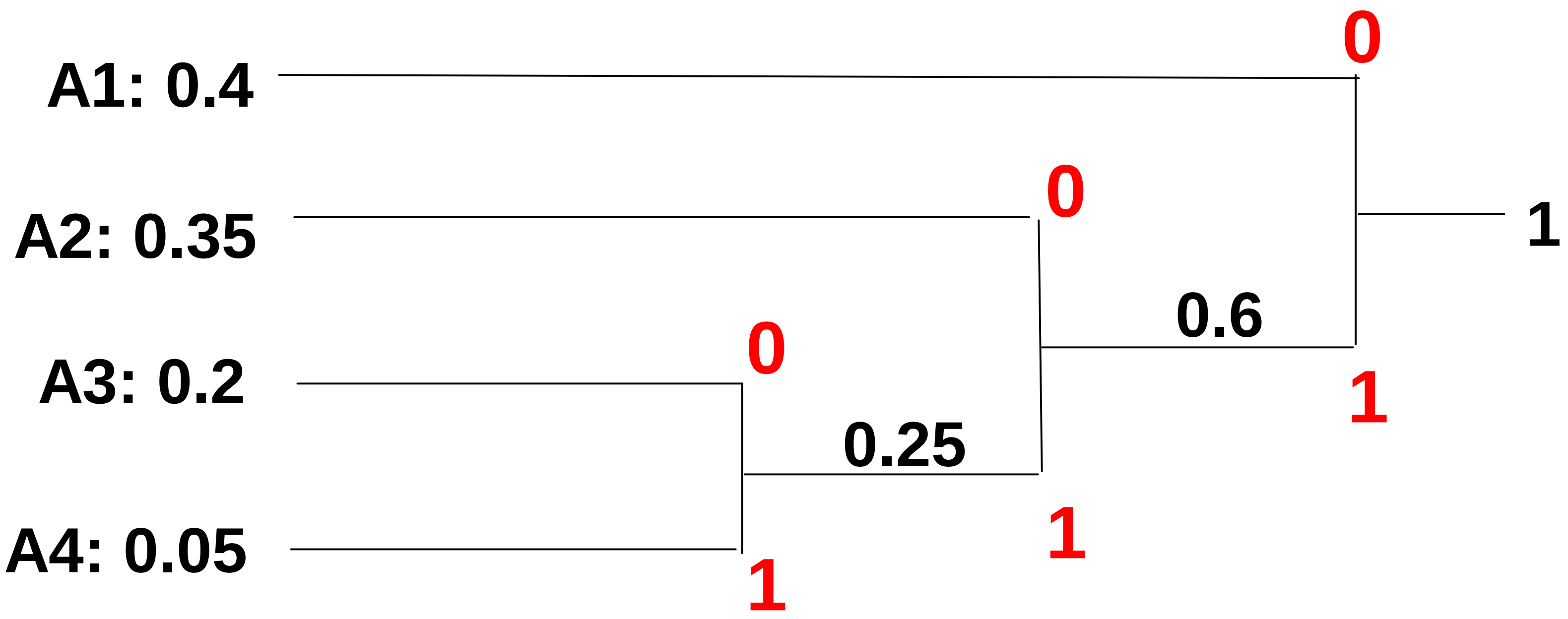
Huffman coding (b)

- Label corners 0 or 1 as shown below:



Huffman coding (c)

- Read backwards from end of tree to each of A1, A2, A3, A4



A1: 0 A2: 10 A3 110 A4: 111

Huffman coding result

- A1 0
- A2 10
- A3 110
- A4 111
- Self terminating & more efficient than:
- A1 00
- A2 01
- A3 10
- A4: 11

for the given probabilities.

But more difficult to decode. See [wiki]

Question 8

(a) What is the main difference between block coding and convolutional coding for FEC?

(b) Is it true that <u>even</u> parity detects an <u>even</u> number of bit-errors, & <u>odd</u> parity detects an <u>odd</u> number?

(c) With respect to Hamming codes, why will 4 parity bits support up to 11 message bits?

(d) What is meant by interleaving & why is it beneficial when using FEC?

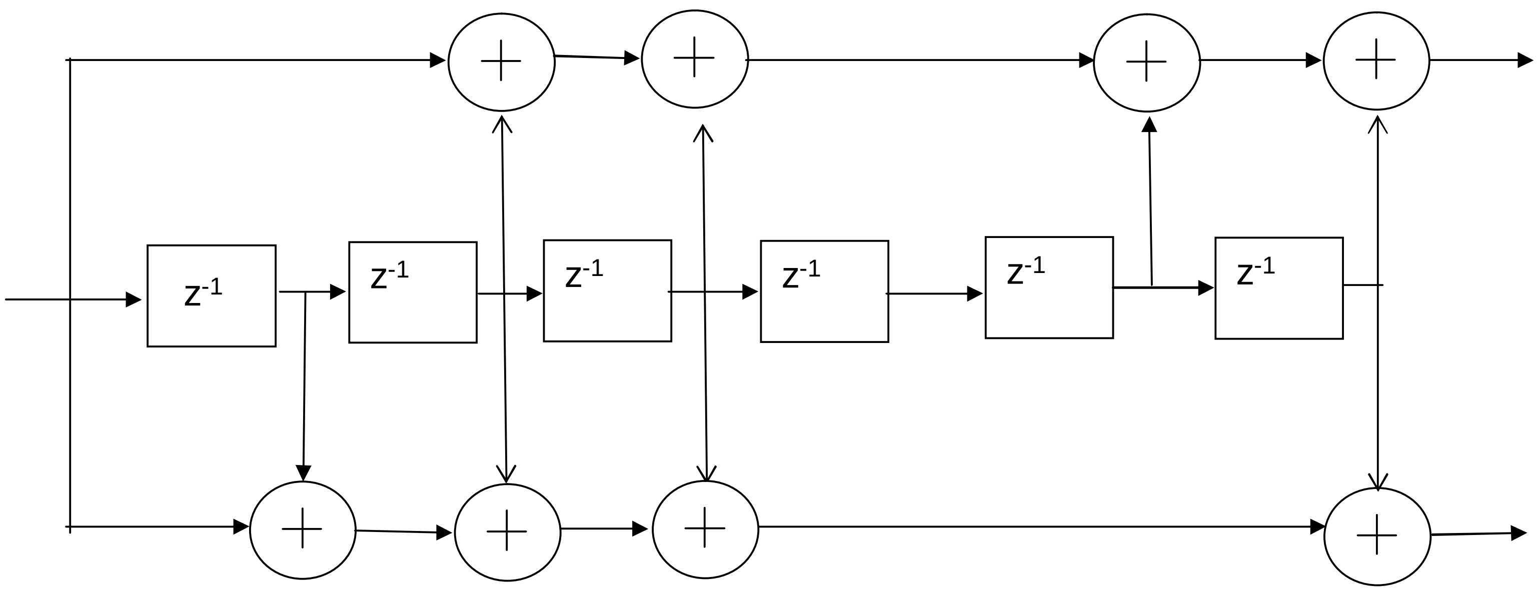
Question 9

(a) Why is the convolutional coder below referred to as a (171, 133) coder?

(b) Why is it 'non-systematic' & what is its constraint length?

(c) Why is it a 'half rate coder?

(d) If the input bit stream is '10101' what is the output bit-stream?



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Question 10

(a) According to the Shannon-Hartley Law, what is meant by channel capacity C?

Ans: C is maximum bit-rate achievable over a channel with arbitrarily small bit-error rate.

(b) What is the channel capacity over a channel of bandwidth 3 kHz affected by AWGN, when the signal-to-noise ratio (SNR) is 50 dB? Ans: 50 kbits/second

(c) What SNR is needed to convey 54 Mb/s over a channel of bandwidth 20MHz ? Ans: ≈8.1 dB.

(d) How can the use of FEC increase the channel capacity?

Ans: Not at all.

Question 11

(a) Define bandwidth efficiency in bits/second per Hz.

(b) With a bandwidth B Hz, what is the maximum number of pulses per second that can be transmitted without inter symbol interference (ISI)? (Ans: 2B)

(c) With a bandwidth B Hz, what is the maximum bit-rate achievable at base-band with binary signalling? (2B)

(d) With a bandwidth B Hz, what is the maximum bit-rate achievable at base-band with 4-level signalling? (4B)

(e) With a bandwidth B Hz, what is the maximum bit-rate achievable at base-band with 64-level signalling? (16B)

Question 12

(a) Give example to show that CDMA can work (see slide 12)

(b) What are the advantages of CDMA?

(c) What is difference between uniform & non-unif quantisation?

(d) What is quantisation noise?

(e) What is meant by the power of a signal?

(f) Why is uniform quantisation noise referred to as $\Delta^2/12$ noise?

(g) What does ‘white’ noise sound like?

(h) What does ‘white’ mean when describing noise?

Question 13

(a) What is meant by SQNR?

(b) What is the max SQNR achievable when an m-bit uniform quantiser is applied to sinusoidal waveforms?

(c) Define ‘dynamic range’.

(d) Estimate the dynamic range of a CD recording assuming that the minimal acceptable SNR is 30 dB.

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Question 14

(a) What is meant by instantaneous companding & how is it generally applied?

(b) What is meant by 'differential encoding' & why is this technique considered to be appropriate for speech coding?

(c) Explain the principle of linear predictive coding (LPC).

(d) Explain the difference between waveform coding & parametric coding as applied to speech compression.

(e) What is 'comfort noise'?

Question 15

a) Describe the roles of anti-aliasing, sampling and quantization in accepting an analogue signal into a digital system.

b) What is the Nyquist frequency?

c) Estimate the data capacity of a CD that can hold 1 hour of uncompressed stereo music sampled at 44kHz with 16-bit resolution.

d) Estimate the data capacity of a voicemail flash memory that can hold 20 minutes of telephone quality (300Hz to 3.4kHz) speech.

e) What is meant by “frequency domain”?

Question 16

a) What is the distinction between “hard” and “soft” real-time systems?

b) Describe and compare the merits of handling external events through the use of polling, interrupts and DMA.

c) Sketch the arrangement of an IO system that is double-buffered in main memory.

d) What is a watchdog timer?

e) What is an event-driven system?

Question 17

a) Describe the principles of carrier sense multiple access (CSMA) communications.
b) Compare 1-persistent, p-persistent and non-persistent CSMA protocols.
c) Describe the MACA (multiple access with collision avoidance) protocol and explain why it is useful.
d) How does error correction help reduce transmit power in radio communications? What are the trade-offs?

Question 18

a) Describe the operation of a real-time streaming media system, in particular sketching the buffer arrangements at the receiver and the role of the buffer's low- and high-water marks.

b) How are packet errors handled in real-time streaming media communications, and how may their effects be ameliorated?

c) Describe how feedback might be used to optimise the performance of a radio communications channel.

Question 19

a) The Manchester Baby computer used 3.5kW of electrical power while executing 700 instructions per second. A recent mobile phone processor might use 20mW while executing 200 MIPS. How much more energy-efficient than Baby is the modern processor?

b) Why is CMOS a good technology for mobile applications?

c) CMOS power is given by $P = {}^{1}/_{2} \times C_{total} \times f_{clock} \times V_{DD}^{2} \times \alpha$.
Why does reducing the clock frequency not directly improve energy-efficiency?
What other measure can exploit a reduced clock frequency to deliver improved energy-efficiency?

d) For each of the variables in the above CMOS power equation describe a design approach that improves energy-efficiency by reducing that variable.

e) What is CMOS leakage power and why is it a growing problem?