SIO 207A: Fundamentals of Digital Signal Processing
Class 9

Florian Meyer

Scripps Institution of Oceanography
Electrical and Computer Engineering Department
University of California San Diego

SCRIPPS INSTITUTION OF OCEANOGRAPHY

UC San Diego
JACOBS SCHOOL OF ENGINEERING

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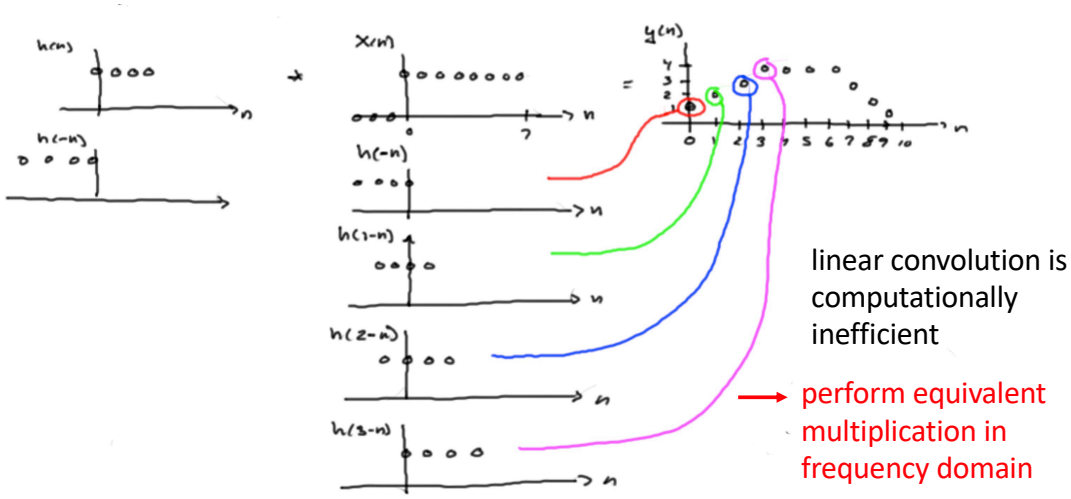
Time Domain Convolution

- By implementing a time domain convolution via multiplication in the frequency domain computational savings can be achieved



linear convolution is computationally inefficient

→ perform equivalent multiplication in frequency domain

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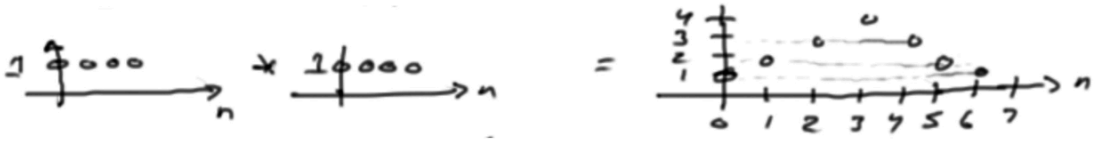
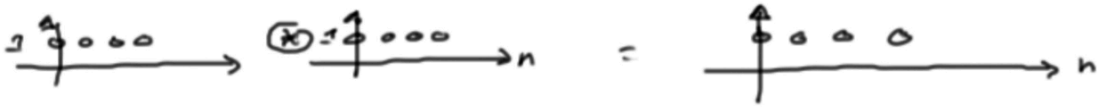
Linear Convolution vs Circular Convolution

- Sampling in one domain implies periodicity in the other domain. Thus by representing the signals using a DFT (or FFT) we imply that the underlying signals are periodic
- Recall that multiplication of DFTs/FFTs implies the resulting convolution to be circular and not linear

Linear Convolution



Circular Convolution (via 4-point DFTs/FFTs)



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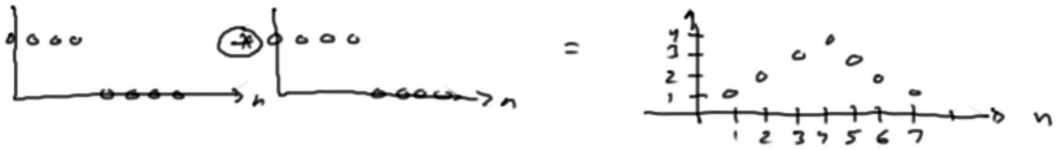
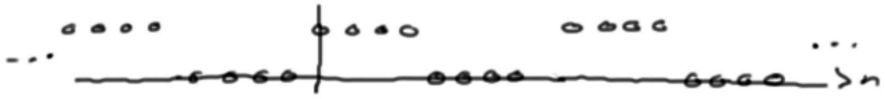
Convolution via Multiplication in Frequency Domain

- Convolution via multiplication in frequency domain using 8-point DFTs/FFTs by zero padding of the sequences



- DFT/FFT implies periodic extension of sequence



- Recall thinking of circular convolution as if one is painting the two functions on circular cans which are stacked on top of each other and rotated

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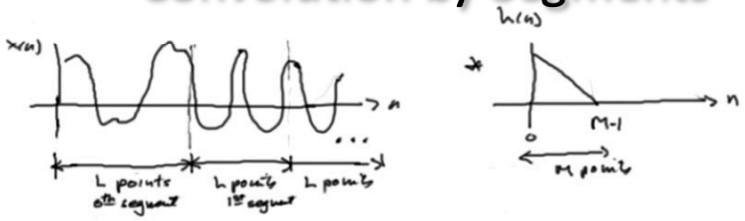
Convolution by Segments



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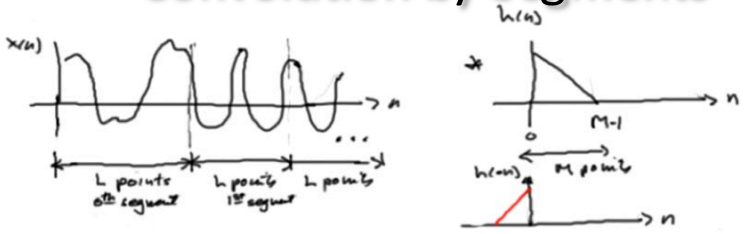
Convolution by Segments



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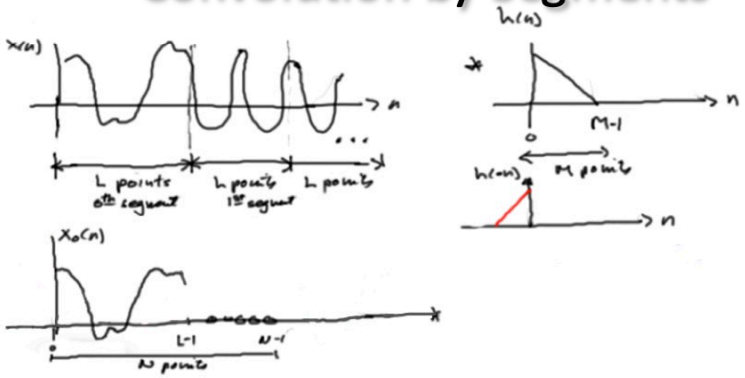
Convolution by Segments



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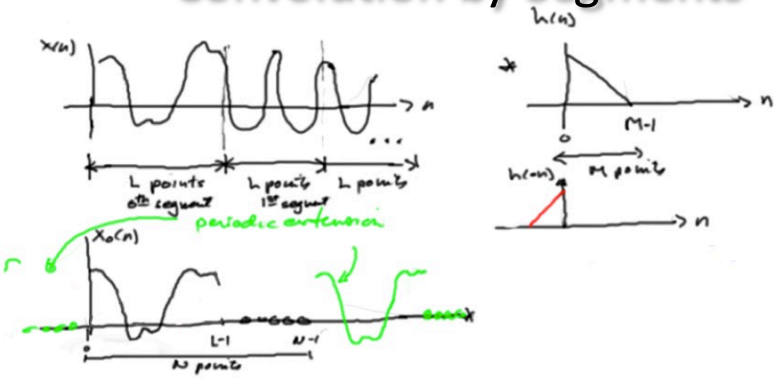
Convolution by Segments



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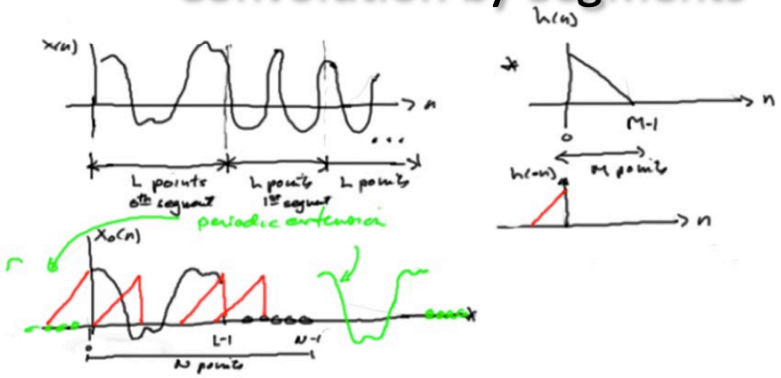
Convolution by Segments



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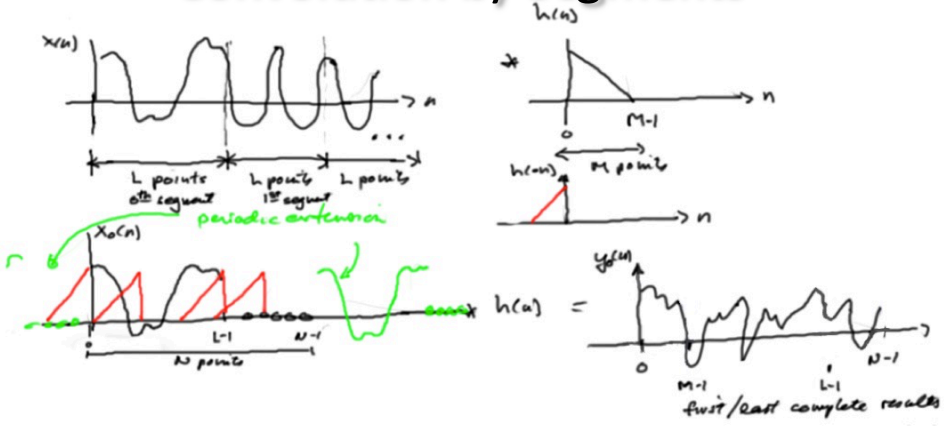
Convolution by Segments



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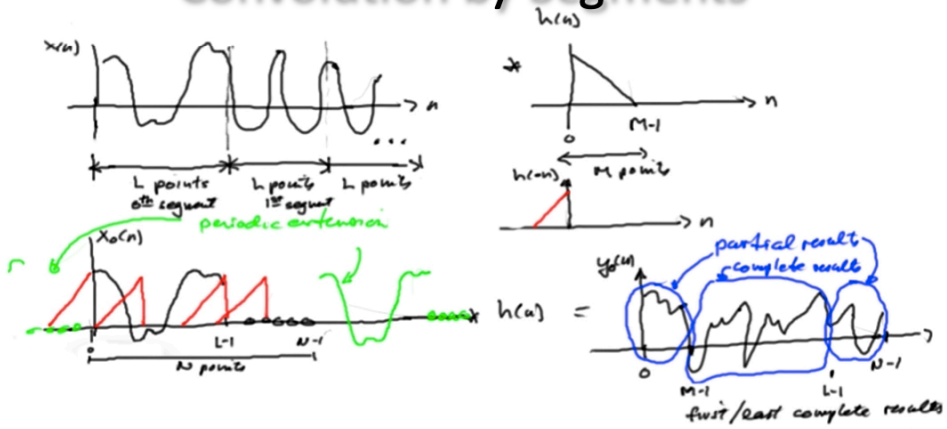
Convolution by Segments



- Similar pictures describe the circular convolution from the 1st segment, 2nd segment, etc; where each segment has a length of L points
- Partial results at the end of one segment are completed by the partial results at the beginning of the next segment. $y[n]$ is obtained by adding together the overlapped segment convolutions

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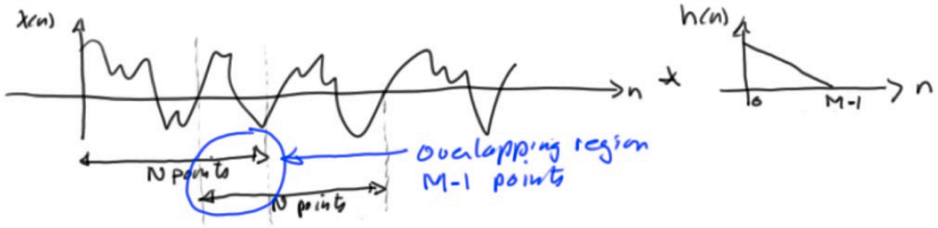
Convolution by Segments (Alternative Method)



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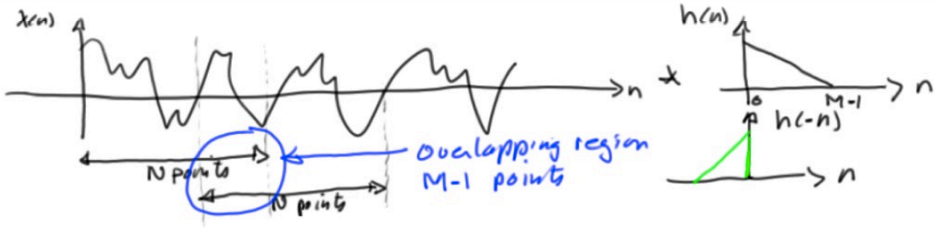
Convolution by Segments (Alternative Method)



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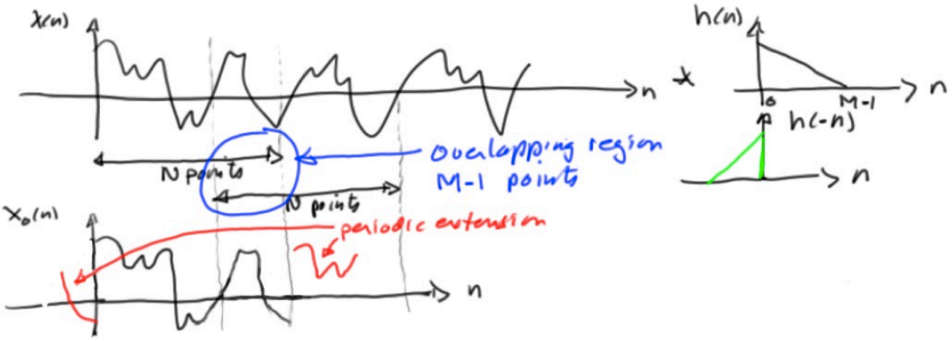
Convolution by Segments (Alternative Method)



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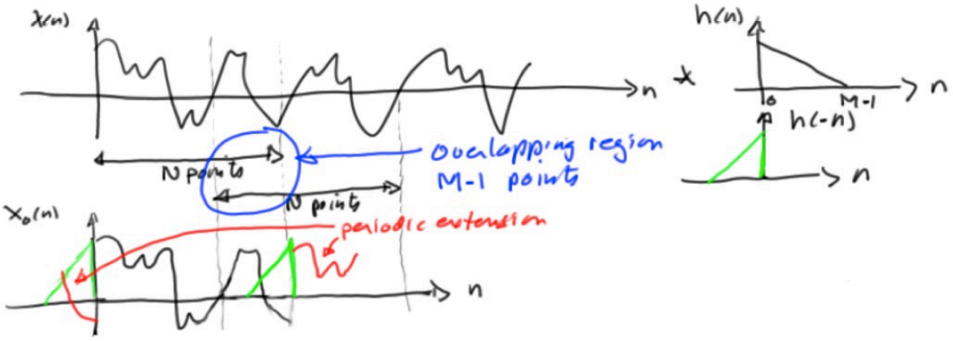
Convolution by Segments (Alternative Method)



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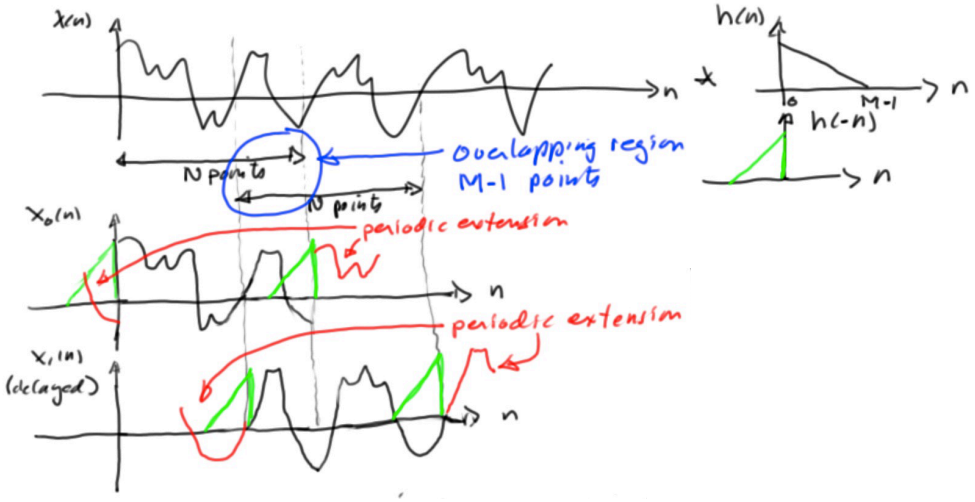
Convolution by Segments (Alternative Method)



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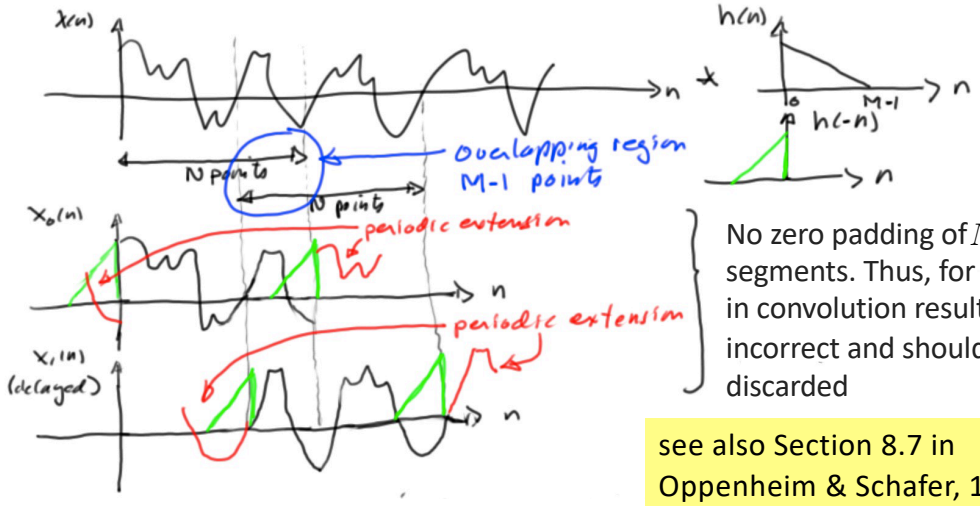
Convolution by Segments (Alternative Method)



No zero padding of N-point segments. Thus, for $M-1$ points in convolution result will be incorrect and should be discarded

see also Section 8.7 in Oppenheim & Schafer, 1999

- $y[n]$ is obtained by discarding the first $M-1$ points in each segment convolution and then concatenating the resulting time series together