CMP4101 Digital Signal Processing

Period per Week			Contact Hour per Semester	Weighted Total Mark	Weighted Exam Mark	Weighted Continuous Assessment Mark	Credit Units
LH	PH	TH	CH	WTM	WE	WCM	CU
45	30	00	60	100	60	40	4

Rationale

Computer Engineering benefits from Digital signal processing, through its application in the transformation, synthesis and analysis of data. For example, when modelling a communication channel, filters, generators and analyzers can be used to remove, add or measure noise in processing audio, images and video. The computer engineer to-be therefore has to have a thorough introduction to Digital signal processing.

Course Content

1. History and Overview

- Indicate some reasons for studying digital signal processing and multimedia
- Highlight some people that influenced or contributed to the area of digital signal processing and multimedia
- Indicate some important topic areas such as digital audio, multimedia, wave tables, digital filters, image display, chromatic and achromatic lighting, and thresholds
- Contrast the meanings of analog and digital signals
- Explain the need for using transforms and why they are different for analog and discrete situations
- Indicate how the subject relates to simple graphics
- Contrast image processing from computer graphics
- Mention some techniques used in transformations such as Fourier, Laplace, and wavelet transforms
- Explore some additional resources associated with digital signal processing and multimedia

- Explain the purpose and role of digital signal processing and multimedia in computer engineering

2. ***Theories and concepts***
   - The sampling theorem
   - Nyquist frequency
   - Aliasing
   - Relationship between time and frequency domain
   - Principle of causality such as discrete and continuous spectra
3. ***Discrete Fourier transform***
   - Definition of the Discrete Fourier Transform (DFT)
   - Relationship between original and transformed domains
   - Algorithms of the DFT
   - Linear convolutions
   - Contrast DFT with the Fourier Transform and the Fast Fourier Transform (FFT)
   - Filtering using DFT
   - Filtering of long data sequences
4. ***Digital spectra analysis***
   - Spectral views
   - Spectrum analysis
   - Spectra of periodic signals
   - Spectra of the impulse and a square wave
   - Filtering
   - Interpolation
5. ***Sampling***
   - Implications of assumptions of repeated time series
   - Group sampling of time signals
   - Size of group and how it affects spectra
   - Sampled signals
   - Periodic signals
   - Non-periodic signals
   - Spectrograms
6. ***Transforms***
   - Concept and properties of the z–transform
   - Inverse z–transforms
   - Difference equations
   - The Discrete Fourier Transform
   - The Inverse DFT
   - The Fast Fourier Transform Class
   - The Inverse FFT method
   - Fast Convolution using the FFT
   - Power Spectral Density
   - Frequency shifting using the FFT
   - Filtering using FFT
   - Additive and subtractive synthesis
7. ***Digital filters***
   - Frequency response of discrete – time systems

- Recursive filter design
- Nonrecursive filter design
- Windowing
- FIR filters, frequency and phase response, time domain multi-tap filters, surface acoustic wave filters
- Poles and zeros in the z plane
- IIR filters, frequency and phase response
- Design of IIR Filters

8. Discrete time signals

- Representation of signals
- Sampling of signals
- Quantizing
- Aliasing
- Difference Equations

9. Window functions

- Definition of a window function
- Purpose of a window function
- Signal compression and transform properties
- Window functions and their impact on the spectra
- Window functions and the DFT

10. Convolution

- Impulse response
- Convolution integral
- Physically realizable systems
- Graphical methods

Learning Outcomes

- Identify some contributors to digital signal processing and multimedia and relate their achievements to the knowledge area.
- Know the difference between analog and discrete signals.
- Describe how computer engineering uses or benefits from digital signal processing and multimedia.
- Explain the purpose of a Fourier transform in signal processing.
- Describe the advantage of the FFT.
- Contrast how group size affects signal spectra.
- Understand the concept, properties and uses of the z–transform.
- Understand the relationship between z–transform and the conformal map
- Understand the Discrete Fourier transform and its significance.
- Understand frequency selective filters in the z–transform domain.
- Understand the definition of a window function.
- Understand the discrete-time representation of signals.
- Use the convolution technique to analyze circuits.

Recommended and Reference Books

[1] Emmanuel C. Ifeachor, Barrie W. Jervis, *Digital Signal Processing; A practical Approach*, 2nd Edition, Prentice Hall, 2002.

[2] Richard G. Lyons, *Understanding Digital Signal Processing*, 2nd Edition, Pearson Education, 2004.

[3] John G. Proakis, Dimitris G. Manolakis, *Digital Signal Processing; Principles, Algorithms and Applications*, 4th ed., Prentice Hall, 2006.

[4] S. Salivahanan, A. Vallararaj, C. Gnanapriya, *Digital Signal Processing*, Tata McGraw-Hill Publishing Company Limited, 2006.

[5] A.V. Oppenheim and R.W. Schafer, *Digital Signal Processing*, Prentice Hall, Englewood Cliffs NJ, 1975.

[6] Sanjit K. Mitra, *Digital Signal Processing*, 3rd ed., 2006

[7] Boaz Porat, *A course in digital signal processing*, John Wiley & Sons Inc., 1997.

[8] Alan V. Oppenheim, Ronald W. Schafer, *Discrete-time Signal Processing*, Prentice- Hall, International ed., 1989.

[9] Lawrence R. Rabiner, Bernard Gold, *Theory and application of digital signal processing*, Prentice-Hall Inc., 1975.