Subject Description Form

Subject Code	EIE4413
Subject Title	Digital Signal Processing
Credit Value	3
Level	4
Pre-requisite	EIE3312 Linear Systems
Co-requisite/ Exclusion	Nil
Objectives	This is an essential subject to provide fundamental digital signal processing (DSP) techniques important to many communications and multimedia subjects. Both theory and practical realisation are stressed.
Intended Subject Learning Outcomes	**Upon completion of the subject, students will be able to:** Category A: Professional/academic knowledge and skills 1. Understand the basic concepts of Fourier analysis of digital signals and apply them to practical problems. 2. Design and realize simple digital filters for practical applications. 3. Understand the importance of random signal processing in DSP, and its application in statistical measures, prediction and data modelling. 4. Design and simulate simple DSP systems. Category B: Attributes for all-roundedness 5. Think critically. 6. Learn independently.
Subject Synopsis/ Indicative Syllabus	**Syllabus:** 1. Introduction 1.1 Why DSP? Typical DSP system. Typical steps to construct a DSP system. 2. Discrete Fourier Transform and Convolution 2.1 Fourier series and continuous-time Fourier transform, Gibbs phenomenon, Shannon sampling theorem. Discrete Fourier transform (DFT), properties of DFT, Fourier analysis using DFT. The fast Fourier transform (FFT) algorithm. 2.2 DSP systems. Linear convolution and its implementation. Convolution theorem. Convolution by section. 3. Design of Finite Impulse-response (FIR) and Infinite Impulse-response (IIR) Digital Filters 3.1 Design stages for FIR filters. Design method – Windowing. Designing low-pass, band-pass, and high-pass FIR filters. Linear phase response filters and their design. 3.2 Difference equation, impulse response and transfer function of IIR filters. IIR filter implementation. Poles, zeros and stability of IIR filters. Frequency response of IIR filters. Case study: first and second order IIR filter design. Designing higher order IIR filters. 4. Random Signal Processing 4.1 Revision on Random Processes, probability distribution function, expected values, variance and standard derivation. Application – Finding correlation: covariance, cross correlation, unbiased cross correlation, auto-correlation. Application – Denoising: white and coloured noises, power spectral density, periodogram, Welch's method.

5. <u>Advanced DSP and Applications</u>
   To discuss not less than one of the following topics:
   5.1 Architectures of digital signal processors and DSP chips.
   5.2 Denoising using the Wiener filter: Basic Wiener filter theory, Wiener filter in frequency domain. Application example.
   5.3 Multirate digital signal processing: Concepts of multirate signal processing, design of practical sampling rate converters. Application examples.

Laboratory Experiments:

The student will carry out at least three laboratory exercises on the topics below:
1. Laboratory 1: MATLAB for DSP laboratory exercises.
2. Laboratory 2: FIR filter analysis and design.
3. Laboratory 3: IIR filter analysis and design.
4. Laboratory 4: Properties of DFT and the fast Fourier transform.
5. Laboratory 5: Statistical digital signal processing.

Teaching/ Learning Methodology

Teaching and Learning Method	**Intended Subject Learning Outcome**	**Remarks**
Lectures	1, 2, 3, 5	Fundamental principles and key concepts of the subject are delivered to students
Tutorials	1, 2, 3, 5	Supplementary to lectures, tutorials are conducted with smaller class size. Students will be able to clarify concepts and to have a deeper understanding of the lecture material; problems and application examples are given and discussed.
Laboratory sessions	1, 2, 3, 4, 5, 6	Students will make use of the software tool to simulate the various theories and visualize the results.

Assessment Methods in Alignment of Assessment and Intended Subject Learning Outcomes

Specific Assessment Methods/Tasks	**% Weighting**	**Intended Subject Learning Outcomes to be Assessed (Please tick as appropriate)**					
		1	**2**	**3**	**4**	**5**	**6**
1. Continuous Assessment (total 40%)							
• Short exercises	5%	✓	✓	✓		✓	
• Tests	20%	✓	✓	✓		✓	
• HW Assignment	5%	✓	✓	✓		✓	✓
• Laboratory sessions	10%	✓	✓	✓	✓	✓	✓
2. Examination	60%	✓	✓	✓		✓	
Total	100%						

The continuous assessment will consist of a number of assignments, laboratory reports, short exercises, and two tests.

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Specific Assessment Methods/Tasks	Remark
Short exercises	Small exercises conducted to measure the students' basic understanding of the theories, concepts and physical meanings of subject materials during the lectures or tutorial classes.
Tests and examination	End-of chapter type problems used to evaluate students' ability in applying concepts and skills learnt in the classroom, and their comprehension of subject materials. Students need to think critically in order to come with a good solution for the problem given.
Assignment	Students have to learn independently, to search, digest and analyze data.
Laboratory sessions	Each student is required to produce a report on the laboratory work they conduct. Each student also needs to make a demonstration on the open-ended question set out in each laboratory work.

Student Study Effort Expected

Class contact (time-tabled):	
• Lecture	26 Hours
• Tutorial/Laboratory/Practice Classes	13 Hours
Other student study effort:	
• Lecture: preview/review of notes; homework/ assignment; preparation for tests/examination	36 Hours
• Tutorial/Laboratory/Practice Classes: preview of materials, revision and/or reports writing	30 Hours
Total student study effort:	**105 Hours**

Reading List and References

Textbooks:

1. S.K. Mitra, *Digital Signal Processing*, McGraw-Hill Education (Asia), 3^{rd} ed., 2009.
2. E.C. Ifeacher and B.W. Jervis, *Digital Signal Processing - A Practical Approach,* Prentice-Hall (Pearson Education), 2002.

Reference Books:

1. J.G. Proakis and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 4/e., Pearson International Edition, 2007.
2. *Ulrich Karrenberg, An Interactive Multimedia Introduction to Signal Processing,* 2^{nd} ed., Springer, 2007.

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