# BIOMEDICAL SIGNAL PROCESSING

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**PRE-REQUISITES :** Signals and Systems, Familiarity with the basic definition of probability,Familiarity with MATLAB

**INTENDED AUDIENCE :** Electronics, Electrical, Instrumentation

**INDUSTRIES APPLICABLE TO :** Philips Research, GE Global Research, Siemens Research, TCS, Wipro, Conduent Labs India

**COURSE OUTLINE :**

This course is prepared for the engineering students in their final year of undergraduate studies or in their graduate studies. Electrical Engineering students with a good background in Signals and Systems are prepared to take this course. Students in other engineering disciplines, or in computer science, mathematics, geo physics or physics should also be able to follow this course. While a course in Digital Signal Processing would be useful, it is not necessary for a capable student. The course has followed problem solving approach as engineers are known as problem solvers. The entire course is presented in the form of series of problems and solutions.

**ABOUT INSTRUCTOR :**

Prof. Sudipta Mukhopadhyay is a graduate from JU (1988), MTech (1991) and PhD (1996) from IIT Kanpur. After serving a decade in industry, serving the Department of Electronics and Electrical Communication Engineering for more than a decade. The last two companies served are Philips medical Systems and GE Global Research, Bangalore. Written more than 100 articles in referred journals and international conferences. Guided more than 81 MTech and 10 PhD scholars.

**COURSE PLAN :**

**Week 1:** Preliminaries, Biomedical signal origin & dynamics (ECG), Biomedical signal origin & dynamics (EEG, EMG etc.)
**Week 2:** Filtering for Removal of artifacts: Statistical Preliminaries, Time domain filtering (Synchronized Averaging, Moving Average), Time domain filtering (Moving Average Filter to Integration, Derivative-based operator), Frequency Domain Filtering (Notch Filter), Optimal Filtering: The Weiner Filter.
**Week 3:Filtering for Removal of artifacts contd.:** Optimal Filtering: The Weiner Filter, Adaptive Filtering Selecting Appropriate Filter
**Week 4:Event Detection:** Example events (viz. P, QRS and T wave in ECG), Derivative based Approaches for QRS Detection Pan Tompkins Algorithm for QRS Detection, Dicrotic Notch Detection Correlation Analysis of EEG Signal
**Week 5:Waveform Analysis:** Illustrations of problem with case studies, Morphological Analysis of ECG, Correlation coefficient, The Minimum phase correspondent.
**Week 6:Waveform Analysis contd.:** Signal length, Envelop Extraction, Amplitude demodulation, The Envelogram, Analysis of activity, Root Mean Square value, Zero-crossing rate, Turns Count, Form factor.
**Week 7:Frequency-domain Analysis:** Periodogram, Averaged Periodogram, Blackman-Tukey Spectral Estimator, Daniell's Spectral Estimator, Measures derived from PSD.
**Week 8:Modelling of Biomedical Systems:** Motor unit firing pattern, Cardiac rhythm, Formants and pitch of speech, Point process, Parametric system modelling, Autoregressive model, Autocorrelation method, Application to random signals, Computation of model parameters, Levinson-Durbin algorithm, Computation of gain factor, Covariance method, Spectral matching and parameterization, Model order selection, Relation between AR and Cepstral coefficients.
**Week 9:bModelling of Biomedical Systems & Tutorials:** ARMA model, Sequential estimation of poles and zeros, Tutorial 1.1: Notch filter design, Tutorial 1.2: Synchronized averaging, Tutorial 1.3: Design Butterworth low pass filter.
**Week 10:Tutorials:** Tutorial 2.1: Design derivative-based filter, Tutorial 2.2: Design Butterworth high pass filter, Tutorial 2.3: Design Wiener filter, Tutorial 3.1: Implement the Pan-Tompkins method for QRS detection.
**Week 11:Tutorials:** Tutorial 3.2: Use cross-correlation to detect alpha rhythm, Tutorial 3.3: Design a matched filter, Tutorial 3.4: Pan-Tompkins method for QRS detection and the Lehner and Rangayyan method to detect dicrotic notch, Tutorial 4.1: Half wave and full wave rectification, Tutorial 4.2: RMS value calculation, Tutorial 4.3: Turns count calculation, Tutorial 4.4: RMS, Turns count and Zero-crossing rate calculations
**Week 12: Tutorials:** Tutorial 4.5: Derive the Envelogram, Tutorial 4.6: RR interval and Form Factor calculations, Tutorial 5.1: Power spectrum calculations using different windows, Tutorial 5.2: Mean frequency and variance of PSD, Tutorial 5.3: Compute PSDs of Voiced, Unvoiced and Silent portion of sound signal, Tutorial 5.4: Compute mean frequency of PSDs and ratio of energies, Tutorial 5.5: Study the changes in the PSDs by varying window width, number of segments averaged, and type of the window used.