

Engineering Tripos Part IIA, 3F3: Statistical Signal Processing, 2018-19

Module Leader

[Dr S.S. Singh](#) [1]

Lecturers

Dr S.S. Singh

Lab Leader

[Dr S.S. Singh](#) [2]

Timing and Structure

Michaelmas term. 16 lectures.

Prerequisites

3F1

Aims

The aims of the course are to:

- Study more advanced probability theory, leading into random process theory.
- Study random process theory and focus on discrete time methods.
- Introduce inferential methodology, including maximum likelihood and Bayesian procedures, and examples drawn from signal processing. Objectives

Objectives

As specific objectives, by the end of the course students should be able to:

- By the end of the course students should be familiar with the fundamental concepts of statistical signal processing, including random processes, probability, estimation and inference.

Content

Lectures 1-8: Advanced Probability and Random Processes

- **Probability and random variables**
 - Sample space, events, probability measure, axioms.
 - Conditional probability, probability chain rule, independence, Bayes rule.

- Random variables (discrete and continuous), probability mass function (pmf), probability density function (pdf), cumulative distribution function, transformation of random variables.
- Bivariate: conditional pmf, conditional pdf, expectation, conditional expectation.
- Multivariate: marginals, Gaussian (properties), characteristic function, change of variables (Jacobian.)
- **Random processes**
 - Definition of a random process, finite order densities.
 - Markov chains.
 - Auto-correlation functions.
 - Stationarity—strict sense, wide sense. Examples: iid process, random-phase sinusoid.
 - Ergodicity, Central limit theorem.
 - Spectral density.
 - Response of linear systems to stochastic inputs – time and frequency domain.
 - Time series models: AR, MA, ARMA

Lectures 9-16: Detection, Estimation and Inference

- Basic linear estimation theory: BLUE, MMSE, bias, variance
- Wiener filters
- Matched filters
- Least squares, maximum likelihood, Bayesian inference.
- The ML/Bayesian linear Gaussian model
- Maximum likelihood and Bayesian estimation

- Example inference models: frequency estimation, AR model, Estimation of parameters for discrete Markov chain.

Coursework

Random variables and random number generation

Learning objectives:

- Understand random variables and functions of random variables and their simulation
- To study the Jacobian as used with random variables
- To experiment with methods for non-uniform random number generation

Practical information:

- Sessions will take place in [Location], during week(s) [xxx].
- This activity involves preliminary work.

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the [Booklist for Part IIA Courses](#) [3] for references for this module.

Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [4].

UK-SPEC

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [5] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the ['Accreditation of Higher Education Programmes' \(AHEP\) document](#) [6] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [7] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links

[1] <mailto:sss40>

[2] <mailto:sss40@cam.ac.uk>

[3] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=48941>

[4] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[5] <http://www.engc.org.uk/ukspec.aspx>

[6] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahp/>

[7] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>