Module Code | EEU5M04
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Module Name | OPTIMISATION & CONTROL
ECTS Weighting | 5 ECTS
Semester taught | Semester 2
Module Coordinator/s | PROF BISWAJIT BASU

**Module Learning Outcomes with reference to the Graduate Attributes and how they are developed in discipline**

On successful completion of this module, students should be able to:

- **LO1.** Use the Kalman filter to solve state estimation problems
- **LO2.** Implement nonlinear programming in Matlab and solve problems in optimization
- **LO3.** Map a problem in combinatorial optimization onto a graph for solving hard problems
- **LO4.** Assess critically, methodologies for combinatorial problems
- **LO5.** Assess critically the state of the art in modern variational approach to control and optimization
- **LO6.** Assess critically the relative performance of different control algorithms
- **LO7.** Analyse the performance of optimization tools within to solve specific problems
- **LO8.** Design and deploy competency in control algorithms in applications related to energy systems, image smoothing, network flows and PDEs

**Graduate Attributes: levels of attainment**

- To act responsibly - Enhanced
- To think independently - Enhanced
- To develop continuously - Enhanced
- To communicate effectively - Enhanced

**Module Content**

Algorithms in optimisation and control underpin many of the new technologies in automation that have disrupted so much of the modern world. This includes robotics, deep learning and automated trading to name a few. The course considers theoretical development and applications - oriented problem solving in the areas of: estimation, detection, analysis of stochastic systems; controllers for dynamical systems; stochastic and deterministic optimal control; multivariate optimization and control; variational principles. The course will emphasize the interplay between theory and application with practical problem solving.

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1. [An Introduction to Module Design](#) from AISHE provides a great deal of information on designing and re-designing modules.
2. [TEP Glossary](#)
Teaching and Learning Methods

The module contains a mixture of tutorials and conventional lab sessions where students will be able to seek assistance on their development assignments. There will be approximately 20 lecture hours which will be run twice a week from the start of the semester. The guideline for a 5 ECTS module is for 125 hours of student effort including class hours.

ASSESSMENT MODE(S)

Assessment will be based on 30% Continuous Assessment and 70% final exam. Continuous Assessment will be a mixture of algorithm design assignments and in-class tests. The students on the course will be guided through adapting assignments to complement their chosen project if possible.

SYLLABUS

Dynamical Systems
State Estimation
Kalman Filter, Unscented Kalman Filter
Gradient Descent and Backpropagation for NNs
Optimisation and Control on Graphs
Graph cuts
Smoothing algorithms, PDEs
Spectral Theory
Variational Principles, Energy Minimization
Belief propagation
Markov Random Fields
Control of PDEs
Introduction to Quantum Computing
Applications to Dynamical Systems, Energy Applications, Network Flow Control, Computer Vision, Geophysical Fluid Dynamics
### Assessment Details

Please include the following:

- Assessment Component
- Assessment description
- Learning Outcome(s) addressed
- % of total
- Assessment due date

<table>
<thead>
<tr>
<th>Assessment Component</th>
<th>Assessment Description</th>
<th>LO Addressed</th>
<th>% of total</th>
<th>Week due</th>
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<tbody>
<tr>
<td>Class Test 1</td>
<td>Estimation theory</td>
<td>1, 2</td>
<td>5</td>
<td>2</td>
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<tr>
<td>Assignment</td>
<td>Estimation problem, Comparison of Two Control Algorithms</td>
<td>1, 2, 3, 4</td>
<td>15</td>
<td>6</td>
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<tr>
<td>Class Test 2</td>
<td>PDEs, Markov fields</td>
<td>5, 6</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Final Exam</td>
<td>3 hour written exam</td>
<td>1-8</td>
<td>70</td>
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### Reassessment Requirements

**Contact Hours and Indicative Student Workload**

- **Contact hours:** 44 (2 hours lectures + 2 hours lab per week)
- **Independent Study (preparation for course and review of materials):** 40
- **Independent Study (preparation for assessment, incl. completion of assessment):** 41

### Recommended Reading List

- Numerical Recipes in C CUP
- Optimal State Estimation: Kalman, H Infinity, and Nonlinear Approaches by Dan Simon, Wiley, 2006
- Introductory Optimization Dynamics by Pierre Ninh Van Tu Spinger, 1984
- Understanding Belief Propagation and its Generalizations, Jonathan S. Yedidia, William T. Freeman, and Yair Weiss, Mitsubishi Electric Research Laboratories,

### Module Pre-requisite

Digital Signal Processing

### Module Co-requisite


### Module Website


### Are other Schools/Departments involved in the delivery of this module?

If yes, please provide details.

### Module Approval Date

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3 [TEP Guidelines on Workload and Assessment](#)
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<td>Academic Start Year</td>
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