Aims
The aims of this unit are to:
1. Provide an introduction to numerical optimisation and search methods for a wide class of engineering problems.
2. Introduce advanced state-space control systems analysis and design methods.
3. Provide tools and methods for the analysis of nonlinear systems.

Objectives
By the end of the Module the student should:
1. list and describe the main methods of operations research;
2. formulate a linear programming (LP) problem and its dual;
3. solve a LP problem by a graphical and the simplex methods;
4. identify and describe different classes of non-linear programming problems;
5. identify, describe and solve different classes of transportation and network, game theory and Markov decision problems;
6. solve one-dimensional and multi-dimensional unconstrained optimisation problems;
7. formulate solution methods for constrained optimisation problems;
8. solve multi-dimensional constrained optimisation problems.
9. be able to describe and analyse multivariable systems in the time domain;
10. be able to relate linear systems behaviour in terms of the modes of the system;
11. be able to determine whether or not a given system can be controlled and observed and if it is stable;
12. be able to design a constant gain feedback controller to achieve desired dynamic response for a given system;
13. be able to design observers to estimate the states of the dynamic system;
14. be able to explain the implications of the separation principle;
15. be able to use MATLAB toolboxes for the state-space-based analysis and design of control systems;
16. be able to solve the linear-quadratic regulator problem;
17. be able to incorporate integral action via the state-augmentation approach;
18. be able to determine equilibrium points of analytic nonlinear systems and linearise around them;
19. be able to apply Lyapunov’s indirect and direct methods to test for the stability of nonlinear systems.

Outline Syllabus
Heuristic Search. Understanding basic features of search methods including evolutionary algorithms.
Analysis and design methods in state-space. Translation from continuous-time to discrete-time system. Analysis of systems; state transition matrix, impulse and pulse response matrix; modal decomposition and structural properties of systems; stability of systems; controllability and observability; minimal realisation; state-feedback control design; pole placement method; reference tracking and integral control design; observer design; reduced order observer; separation principle; linear quadratic control and Kalman filters.

Introduction to nonlinear systems. Nonlinear behaviour; Linearisation; Equilibrium points; Phase plane analysis; Limit Cycles; Linearisation and local stability; Lyapunov’s indirect and direct methods; Invariant sets and domains of attraction.

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<th>Module Format (Hours)</th>
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<tr>
<td>Lectures</td>
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<td>30</td>
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Recommended Books (A - Core text, B - Secondary text, C - Peripheral reading)


Assessment

One 3 hour written examination