Introduction
The aims are: to introduce state-space methods for the analysis and design of controllers for multivariable systems; to teach the use of analytical tools and methods for state-space control design; to demonstrate similarities between continuous and sampled data systems; and to extend the analysis to non-linear systems. Material to be covered includes: Structural properties (modal decomposition, controllability, observability, stability); design (pole assignment, observer design, separation principle, internal model principle, optimal control, LQG, reference tracking, integral control) of continuous systems and equivalents for sampled-data systems.

Aims
The aims of the module are:
To introduce the state-space approach to control system analysis of multivariable systems.
To provide analytical tools and methods required for state-space control design.
To present state-space control design methods.
To demonstrate design similarities between continuous and sampled-data systems.

Objectives
At the end of the course, the student should be able to:
1. outline the differences between classical and state-space analysis and control design;
2. derive state-space models of multivariable physical systems;
3. characterise the behaviour of continuous-time and sampled-data dynamic systems based on the state-transition matrix and decomposition of modes;
4. perform modal decomposition of linear systems;
5. determine whether a given system can be controlled and observed and whether it is stable;
6. appreciate the importance of minimal realisation of a given system;
7. design a constant gain feedback controller to achieve desired dynamic response for a given system;
8. apply modal control and eigenstructure assignment techniques to the design of multi-input systems;
10. design observers to estimate the states of the dynamic system;
11. appreciate the duality of controller and observer design;
12. explain the implications of the separation principle;
13. understand the principles of optimal controller design;
14. specify the similarities between continuous and sampled-data systems in the design and analysis methods.
16. understand how to derive and implement a state space output feedback controller upon a model simulated in Matlab.

Module Format
Lectures 20
Tutorial 4

Text Books
CORE TEXTS
RECOMMENDED TEXTS

ADDITIONAL TEXTS
2. Dorf and Bishop, Modern Control systems, 11th edition, Addison-Wesley, 2008

Outline Syllabus
Introduction to state-space. State-space description of multivariable physical systems; continuous-time and sampled-data systems; Linear state-space description; Canonical state-space transformations; Linearisation and equilibrium points. 
Analysis. Solution of state-space equations; State-transition matrix; Discretisation of continuous-time systems; Modal decomposition; Transfer functions of state-space systems. 
Structural Properties. Controllability; Observability; Stability; Minimal realisation; Stabilizability; Detectability.
Controller Design. State-feedback pole assignment; Linear Quadratic Regulator (Optimal control); Reference tracking, Integral control (state augmentation and disturbance estimation); Internal model principle.
Observer Design. Pole assignment; Separation principle; Kalman filter (Optimal estimation).

Assessment
Two-hour written examination.