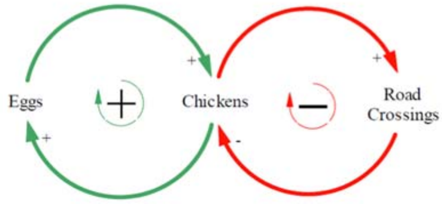
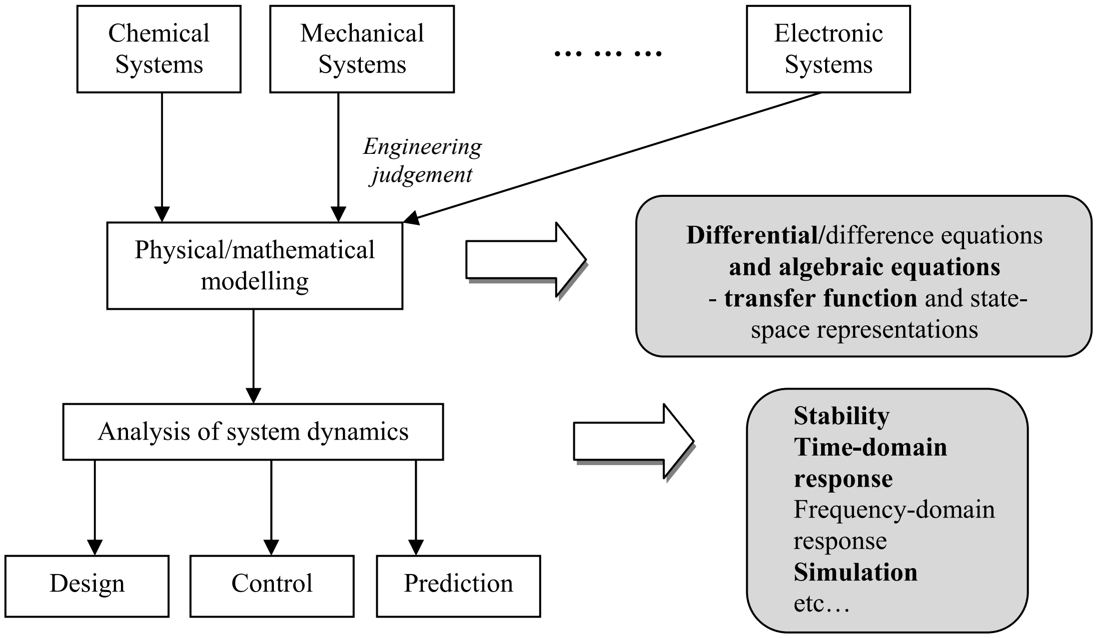
1. Overview of the System Dynamics Module

- System dynamics involves developing a mathematical model of a dynamical system with a view to analyzing the system's performance. This, in turn, can lead to better design, better control and better prediction of the system.



- Ultimately, the success of all these depends on the validity of the underlying mathematical model. In other words, the validity of a prediction depends largely on how accurately the mathematical model captures the behaviour of the actual system.

- This concept of modelling, analysis and design/control/prediction is summarized in the 'big picture' diagram below:



- Previously in EE114 - An Introduction to Systems and Control (as highlighted in bold font in the 'big picture' diagram) …

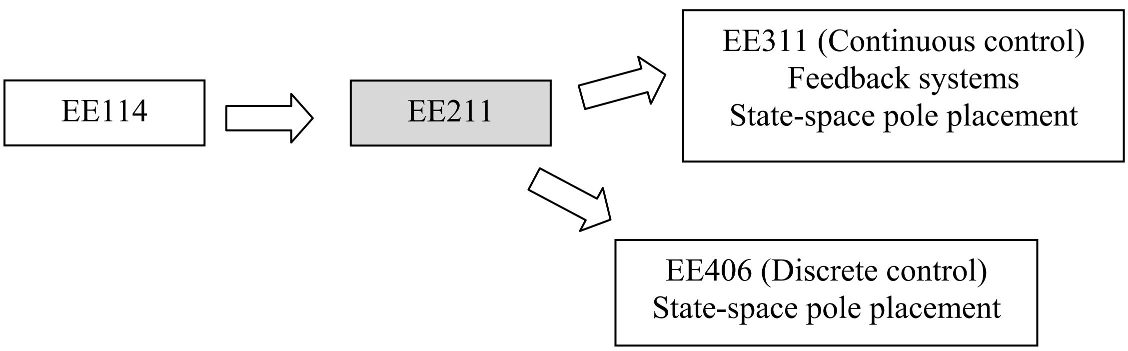
  - we mostly studied **basic first-order** dynamical systems in **continuous-time**
  - we modelled these systems and represented them both as **differential equations and transfer functions**
  - we analyzed such systems in terms of **stability and transient responses (time-domain)**, and
  - finally, we looked at some **basic control**.

- In this module, we will now expand on the work done in EE114 as follows:

  - we will study **higher-order** dynamical systems in both **continuous-time and discrete-time**
  - we will model these systems and represent them in transfer function format and, also, **in a new format known as state-space**
  - we will examine how to linearise nonlinear systems (using state-space representation)
  - we will **analyze state-space models in terms of stability**, and
  - finally, we will **analyze our models from a frequency-domain viewpoint** and, in doing so, **introduce Nyquist diagrams and Bode Plots**.

- These are the non- highlighted parts in the 'big picture' diagram previously!

- Going forward in the BE programme, this module links to two control-based modules as follows:



1.1 Remainder of EE211 module

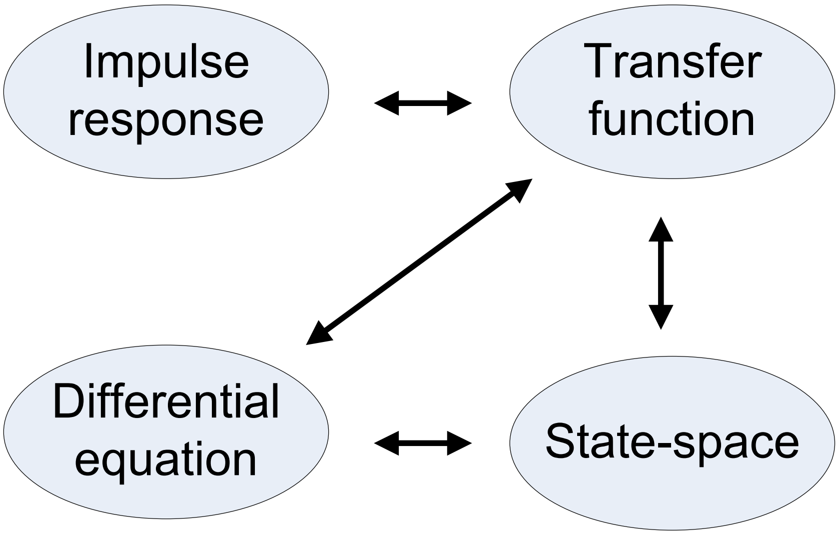
- The next section revises (in a brief manner!) key aspects of the EE114 module. In addition, some of the key concepts that *you should have learned* in previous modules will also be summarized.

- Section 3 of these notes covers mathematical modelling of dynamical systems in continuous- and discrete- time. We will consider systems that are more complicated than those covered in EE114. We will express the final models as either a differential or difference equation and also in transfer function format.

- Section 4 introduces the state-space method of representing differential and difference equations. It also looks at the relationship between the state-space and transfer function representations.

- Section 5 shows how a nonlinear system can be *linearised*, allowing us to apply standard linear analysis techniques.

- Section 6 outlines how to actually solve the state-space equations. In previous modules (including EE114 and EE214), you have solved differential equations directly. You have also used Inverse Laplace Transforms as an alternative means for obtaining the same solution. Here, we will complete the *trilogy* by obtaining the same solution (again!) from a state-space viewpoint.



- Section 7 looks at stability analysis from a state-space viewpoint.

- Finally, in, section 8, we introduce the frequency-domain and use two graphical-based methods to present frequency response - Nyquist Diagrams and Bode Plots.