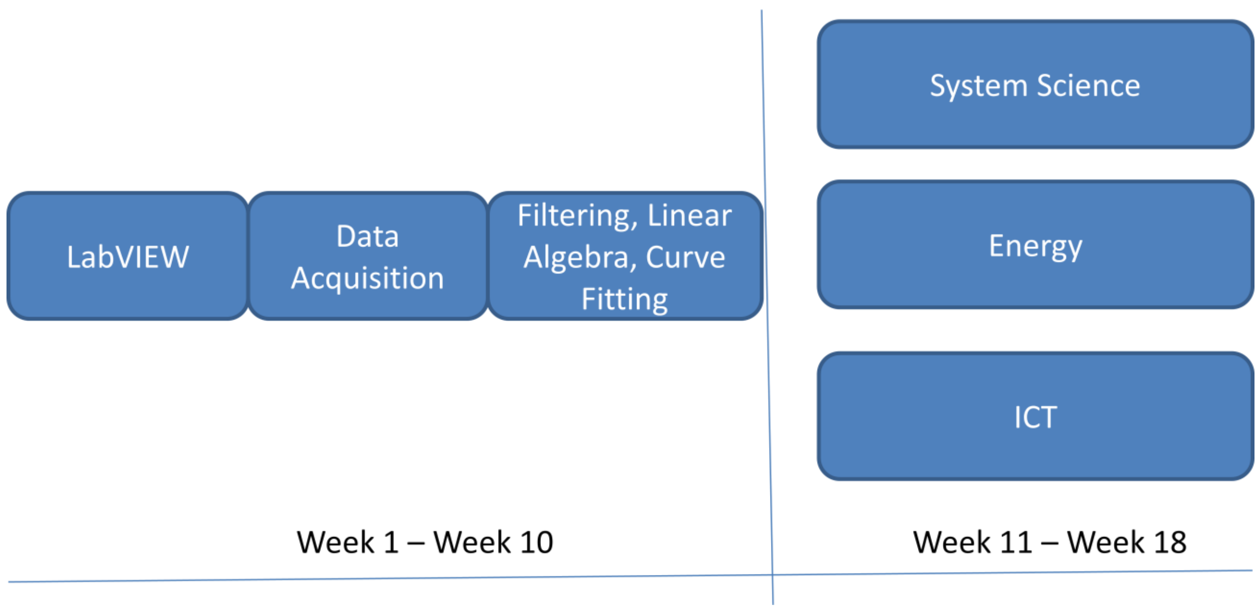
System Analysis Techniques

Course Title: System Analysis Techniques

Instructor: Dr. Sandeep Yadav (for first

Course Objective: Modern-day systems are getting increasingly intelligent, which in turn increases the complexity of the system. This is true for systems in various domains, such as energy, bio-medical, mechanical, electrical and communication. As time to market pressure mounts, designers have to choose the right type of system analysis tools which scales from design to verification and validation and production. As engineers and researchers, we should be aware of efficient data analysis techniques in our respective fields. Such knowledge will help us in carefully analyzing the system, to better understand how it works and responds to various stimulus signals. Data analysis techniques vary across fields. While some techniques such as filtering, curve fitting, Fast Fourier Transform, linear algebra cut across all domains, there are other techniques that are specific to each domain. For example, model analysis techniques are commonly used in analyzing mechanical systems. For the first 10 weeks, course material will be common across all center of excellences. For the last 6 weeks, course will cover signal analysis techniques unique to each stream as shown in the picture below



Course will cover both hardware and software aspects. You will learn about software programming paradigms which allow you to rapidly develop system analysis techniques.

Course Duration: July 27th to November 23rd. One (1) lab section per week, 2 hours, One (1) Theory class, 1 hour

Credits: 2

Week	Starting on	Lecture and Lab Focus	Instructor
W1	July 30	Introduction to Graphical Programming Language, LabVIEW	SY
W2	August 6	Introduction to Graphical Programming Language, LabVIEW	SY
W3	August 13	Introduction to Graphical Programming Language, LabVIEW	SY

W4	August 20	Introduction to transducers, signal conditioning and data acquisition		SY
W5	August 27	Introduction to Data Acquisition devices and driver software		SY
W6	September 3	Revision, Lecture and Lab Make-up sessions, First Mid-semseter exams		
W7	September 10	Signal Generation		SY
W8	September 17	Linear Algebra, Singular Value Decomposition, Cholesky Decomposition		SY
W9	September 24	Fast Fourier Transforms, Filtering		SY
W10	October 1	Differential Equation Solvers, Curve Fitting and Interpolation Techniques		SY
W11	October 8	ICT		TBD
		Energy		TBD
		SS		TBD
W12	October 15 (partial week due to second mid-sem exams)	ICT		TBD
		Energy		TBD
		SS		TBD
W13	October 22	Mid-Semester Break		
W14	October 29	ICT		TBD
		Energy		TBD
		SS		TBD
W15	November 5	ICT		TBD
		Energy		TBD
		SS		TBD
W16	November 12	ICT		TBD
		Energy		TBD
		SS		TBD
W17	November 19	ICT		TBD
		Energy		TBD
		SS		TBD
W18	November 26	End Semester Exams and Make-up exams		

Lectures Details

Legends: W*n*L*n*: Week *n*, Lab *n* in that week. Each lab is of 3 hours duration

Class slides and lab solutions will use the same naming legends. Class slides will have the title System Analysis Techniques WnCn.pdf. Lab Solutions will use the title System Analysis Techniques W1L1 Solution

W1L1: Students will be introduced to LabVIEW. We will cover LabVIEW programming constructs such as controls, indicators, primitives, for-loops, while-loops. Students will learn LabVIEW front panels and block diagrams. Students will learn about LabVIEW programming style and guidelines for block diagrams and front panels. Students will learn about the concepts of LabVIEW libraries and LabVIEW projects. Students will build LabVIEW programs which require the usage of controls, indicators, for-loops, while loops, and LabVIEW primitives.

W2L1: Students will also learn about LabVIEW tools available in the programming environment and online. Students will build LabVIEW programs which require the usage of controls, indicators, for-loops, while loops, and LabVIEW primitives.

W3L1: Students will learn about advanced LabVIEW programming constructs such as templates, polymorphic functions, semaphores, queues, notifiers. Parallel for-loops, parallel programming constructs, producer-consumer loops, event structures, and File I/O. Students will also learn how to integrate other programming languages such as C and Matlab into LabVIEW. Students will build LabVIEW programs which require the use of producer-consumer loops, event structures, File I/O, notifiers and queues.

W4C1: In this class, students will learn about various types of transducers. We will talk about transducers such as photo-sensors, optical encoders, strain gauges, thermocouples. Students will then learn about signal conditioning concepts. Next, students will be introduced to data acquisition techniques and various types of A to D converters, such as delta-sigma converters. Topics covered included sampling devices such as analog to digital converters, digital to analog converters, Nyquist sampling rate, scaling and calibration.

<u>Note</u>: This will be a 3 hour classroom session and will prepare students for the upcoming labs.

W5L1: Students will be introduced to various data acquisition devices and drivers for controlling these devices. Student will build a program which will allow them to acquire audio signals fed into a microphone and analyze these signals using built-in LabVIEW functions. Students will then implement a simple custom measurement and embed in inline with the data acquisition.

W6: If required, make-up sessions for classes and labs. Else, Revision time. First mid-semester exam which will cover topics covered so far.

W7L1: (Hands-on) Now that we have learned about LabVIEW and Data Acquisition, we will move to signal generation and signal analysis techniques, that are common across all domains. In this week's class, we will learn about how we can create different types of signals. Such signals can be used as stimulus to our system analysis programs. Students will create arbitrary waveforms in software and then play those waveforms out using arbitrary waveform generators.

W8L1: In this week's lab, we will learn about Linear Algebra techniques. Starting with simpler techniques such as matrix-matrix operations, we will learn how to calculate eigenvalues and eigenvectors of a matrix. We will also learn about calculating inverse of matrices. Next, we will learn about advanced linear algebra techniques such as Singular Value Decomposition, Cholesky Decomposition..

W9L1: In this week's lab, we will learn about techniques such as Fast Fourier Transform (FFT) for doing time to frequency domain transformation. We will also learn about various filtering techniques such as low-pass, high-pass, band-pass filtering.

W10L1: In this week's lab, we will learn Differential Equation Solvers, Curve Fitting and Interpolation Techniques

After this, we will learn about different signal analysis techniques that are unique to a particular domain. Once we have identified session owners from each center of excellence, they can define the type of signal analysis that they would like to cover in each of the remaining classes.

Week	ICT	Energy	System Science
11			
12			
13	Mid-semester break	Mid-semester break	Mid-semester break
14			

15			
16			
17			
18	Exams	Exams	Exams

Grading Criteria

Successful completion of lab sessions, which includes demonstration of working programs: 15%

First mid-term examination: 10%

Second mid-term examination: 10%

Final examination: 35%.

Project: 30%

Office Hours: To be announced after class timings are announced.