FACULTY OF ENGINEERING AND APPLIED SCIENCE

Electrical Engineering

Major Program Modifications: Specialization in Smart Grid

Department of Electrical, Computer and Software Engineering

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Executive Summary

Many of the Electrical Engineering (EE) students spend their internships at Power companies, and several of the EE graduates work at power companies. When students come back from internships they always ask for the Engineering elective courses to be in the Power Systems area. To this end, the Electrical Engineering (EE) program is proposing to introduce a new specialization in "Smart Grid", which will be available to EE students starting Fall 2017. The specialization consists of 18 credit hours with specialized courses on the smart grid. The proposed specialization fits within the Strategic Mandate Agreement regarding the Energy area of strength and growth.

1. INTRODUCTION

This proposal presumes that the accompanying proposal regarding the Electrical Engineering Program is accepted. That proposal changes the EE program to include a wider breadth of courses. The specialization in Smart Grid consists of 18 credit hours with specialized courses on smart grid technologies and related areas. It is important to note that the EE program includes two themes: power systems, and communications & signal processing. For this reason, there are several related courses at the third year level. The specialization is proposed to focus on the 4th year, and to be offered starting Fall 2017 to coincide with the CEAB accreditation visit for the program.

Two of the courses in the new specialization have already been approved last year:

ELEE 4115U Fundamentals of Smart Grid
ELEE 4125U Smart Grid Networking and Security

To this end, no new courses are needed and only existing power courses are proposed to be in the Smart Grid specialization. The following is a list of the power courses:

1- Electric Machines (ELEE 3250U)
2- Power Systems (ELEE 3620U)
3- Introduction to Power Electronics (ENGR 4120U)
4- Power System Protection Relaying (ELEE 4140U)
5- Fundamentals of Smart Grid (ELEE 4115U)
6- Smart Grid Networking and Security (ELEE 4125U)
7- Capstone I (ENGR 4940U)
8- Capstone II (ENGR 4941U)

Two of the courses are part of the EE program. The 4 additional courses plus the two capstone courses make up the specialization.

The proposed changes to the EE program to include Smart Grid specialization are:

- Replace “ELEE 4750U” in 4-1 with “ELEE 4115U Fundamentals of Smart Grid”.
- Move the Liberal Studies Elective from 4-2 to 4-1 to allow for the following changes.
- Replace “ELEE 4500U Wireless Communications” in 4-2 with “ELEE 4125U Smart Grid Networking and Security”.
- Replace the two Engineering Electives with: “ELEE 4140U Power System Protection Relaying”, and “ELEE 4120U Introduction to Power Electronics”.

2. DEGREE REQUIREMENTS

a. Program learning outcomes

Graduates of the Smart Grid/Power Option are expected to meet the abilities of the current electrical engineering program, while in addition gaining new knowledge and skills in the field of electric power engineering:

1. Depth and breadth of knowledge

- Describe and explain the basic principles of the smart electric grid, including smart grid definition, role of renewable energy, electric vehicles, storage technologies, networking security and communication systems.
- Demonstrate knowledge of electrical power engineering, control system, design, optimization, and analysis tools by solving problems in the field of smart electric power grid.

2. Knowledge of methodologies
    - To learn about different smart grid architectural design
    - To utilize knowledge and software tools to analyze smart grid operation
    - To evaluate smart meters performance parameters.
    - To learn about the management of electric vehicles, renewable energy sources and storage systems.
    - To learn about possible security threats, interoperability, communication and networking.
3. Application of knowledge
    - Apply knowledge of smart electric power engineering top conduct appropriate research in the field at the level of undergraduate honors thesis.
4. Communication Skills
    - To discuss topics of smart electric power grid accurately and effectively, in both written and oral form, with members of academia as well as industry.
5. Awareness of limits of knowledge
    - Students will recognize the limitations of the current state of knowledge in smart electric grid and appreciate the need to adapt new and emerging technologies in the field.
6. Autonomy and professional capacity
    - Student is expected to become an active member of multidisciplinary and multicultural teams and appreciate the importance of academic integrity, professional ethical conduct, and social responsibility.
    - Student will pursue further scholarly pursuits, employment, and community involvement to advance the knowledge base in smart electric power grid and contribute towards the economic and societal growth of the community.

b. Admission requirements

All first year Engineering programs, including Electrical Engineering, share the same entrance requirements. The specific average or standing required for admission varies from year to year. Students are selected by taking into consideration a wide range of criteria including school marks, distribution of subjects taken, and performance in subjects relevant to the academic program. Possession of the minimum requirements does not guarantee acceptance. Preference will be given to applicants with the best qualifications. The minimum 1st year admission requirements include: current Ontario secondary school students must complete the Ontario Secondary School Diploma (OSSD) with six 4U or 4M credits including English (ENG4U) with a minimum average of 60 per cent, Advanced Functions (MHF4U), Calculus and Vectors (MCV4U), Chemistry (SCH4U), and Physics (SPH4U). In addition, a combined minimum 70 per cent average in math and science courses is required, with no grade below 60 per cent. These are the minimum requirements, and admission is competitive.

No changes to the admission requirements will be made to accommodate the new proposed Smart Grid specialization.

c. Program structure

The current program map (2014/15) for the Electrical Engineering program is in Appendix I. The new proposed program map for the EE program is in Appendix II, and the program map for the specialization in Smart Grid is in Appendix III.

d. Program content

No new courses are being added. However, as part of the comprehensive review exercise several courses have been slightly changed. The program calendar copy is in Appendix IV, and all the course templates for changed courses are listed in Appendix V.

3. RESOURCE REQUIREMENTS

a. Faculty members

The following faculty members in the Department of Electrical, Computer and Software Engineering / FEAS are full-time and do research in the smart grid or related areas. All of them are supervising graduate students in related areas.

Dr. Walid Morsi Ibrahim, Assistant Professor

Dr. Tarlochan Sidhu, Dean of FEAS and Professor

Dr. Vijay Sood, Associate Professor & Design Co-Chair

Dr. Sheldon Williamson, Associate Professor (recently hired for the CRC-Tier II in Electric Energy Storage Systems)

Dr. Mohamed Yousef, Assistant Professor

All related courses of the Smart Specialization will be taught by the above faculty members.

b. Additional academic and non-academic human resources

In the past 2 years, we have hired a sessional instructor to teach one elective course at the 4th year level in the Smart Grid area, but with the two new hires in 2013/2014, there will be no need for sessional or adjuncts to teach any of the core courses in this specialization, and there are no elective courses.

The lab coordinators have recently received training in the operation of the LabVolt equipment, and hence there will be no need for new technical support.

Graduate students working with the above professors have the expertise to operate equipment in this area and some of them will be serving as Teaching Assistants for some of the core and elective courses in this specialization.

c. Physical resource requirements

Most of the resources required for the new specialization already exist. Last year we invested $300,000 in LabVolt equipment that can be used for some of the existing power systems related courses. The LabVolt equipment features a plug-in-play architecture that would allow us to purchase additional equipment that can be utilized on top of the existing equipment.

The lab will be used to provide students with experiential learning.

All of the resources required for the new specialization already exist.

The labs will be used to provide the experiential learning, and the labs go through regular updates.

4. BUSINESS PLAN

a. Statement of funding requirements

There are four faculty members (plus the Dean of FEAS) in the Department of Electrical, Computer and Software Engineering, who are currently working in the area of Smart Grid and they will be supporting the new specialization and teaching all the core courses. No additional faculty members are required to support this specialization at this point in time.

The specialization will be offered to students who will be in their 4^{th} year in Fall 2017, to coincide with the CEAB accreditation visit for the Electrical Engineering program. However, some of courses in this specialization will be offered as elective courses starting Fall 2015 or 2016.

b. Statements of resource availability

The physical resources required for this new specialization already exist within the Department of Electrical, Computer and Software Engineering. Existing labs and lab equipment (LabVolt) will be supporting this new specialization.

Appendix I: Current Program Map for the Electrical Engineering Program

Current Map – Electrical Engineering 2013						
Year	**Course**	**Course**	**Course**	**Course**	**Course**	**Course**
1-1	COMM 1050U Technical Communications	ENGR 1015U Introduction to Engineering	MATH 1010U Calculus I	MATH 1850U Linear Algebra for Engineers (Coreq:MATH 1010U)	PHY 1010U Physics I	
1-2	CHEM 1800U Chemistry for Engineers	SSCI 1470U Impact of Science and Technology on Society	ENGR 1200U Introduction to Programming for Engineers	MATH 1020U Calculus II (MATH 1010U)	PHY 1020U Physics II (PHY 1010U)	ENGR 1025U Engineering Design (ENGR 1015)
2-1	ELEE 2110U Discrete Mathematics for Engineers (MATH 1020U, MATH 1850U)	ELEE 2200U Electrical Engineering Fundamentals (MATH 1020U, PHY 1020U, ENGR 1025U)	SOFE 2710U Object Oriented Programming and Design (ENGR 1200U)	MATH 2860U Differential Equations for Engineers (MATH 1020U)	Liberal Studies Elective	
2-2	ELEE 2250U Introductory Electronics (ENGR/ELEE 2200U)	ELEE 2450U Digital Systems (ENGR/ELEE 2110U)	ELEE 2520U Fundamentals of Electromagnetics (ENGR/ELEE 2200U, MATH 2860U)	ELEE 2530U Complex Analysis for Engineers (MATH 2860U)	ELEE 2210U Circuit Analysis (ENGR/ELEE 2200U, MATH 2860U)	
3-1	ELEE 3230U Electronic Circuit Design (ENGR/ELEE 2250U)	ELEE 3110U Signals and Systems (ENGR/ELEE 2530U, ENGR/ELEE 2210U)	ELEE 3140U Computer Architecture (ENGR/ELEE 2450U)	ELEE 3240U Applications for Electromagnetics (ENGR/ELEE 2520U, ENGR/ELEE 2530U)	ELEE 3180U Design Principles & Project Mgmt in Electrical Engineering (ELEE 2250U, ELEE 2450U, ELEE 2520U, SOFE 2710U)	Liberal Studies Elective
3-2	ENGR 3360U Engineering Economics	ELEE 3070U Probability and Random Signals (ENGR/ELEE 3110U)	ELEE 3130U Communication Systems (ENGR/ELEE 3110U)	ELEE 3250U Electric Machines (ENGR/ELEE 3240U)	ELEE 3490U Microprocessor Systems Design (ENGR/ELEE 3140U)	ELEE 3100U Modern Control Systems (ENGR/ELEE 3110U)
4-1	ELEE 4420U DSP Theory and Design (ENGR/ELEE 3110U)	SOFE 4650U Computer Networks (ENGR/ELEE 3140U)	ELEE 4750U Microwave and RF Circuits (ENGR/ELEE 3230U, ENGR/ELEE 3240U)	ENGR 4940U Capstone Systems Design for ECSE I (Successful completion of all non-elective courses in year three)	ELEE 4110U Power Systems (ENGR/ELEE 3250U)	
4-2	Engineering Elective	ENGR 4760U Ethics, Law and Professionalism for Engineers	ELEE 4500U Wireless Communications (ENGR/ELEE 3130U, ENGR/ELEE 3070U)	ENGR 4941U Capstone Systems Design for ECSE II (ENGR 4940U)	Engineering Elective	

Appendix II: Proposed New Map for the EE Program – Changes highlighted

Proposed Changes – Electrical Engineering 2015-2016						
Year	**Course**	**Course**	**Course**	**Course**	**Course**	**Course**
1-1	COMM 1050U Technical Communications	ENGR 1015U Introduction to Engineering	MATH 1010U Calculus I	MATH 1850U Linear Algebra for Engineers (Coreq:MATH 1010U)	PHY 1010U Physics I	
1-2	CHEM 1800U Chemistry for Engineers	SSCI 1470U Impact of Science and Technology on Society	ENGR 1200U Introduction to Programming	MATH 1020U Calculus II (MATH 1010U)	PHY 1020U Physics II (PHY 1010U)	ENGR 1025U Engineering Design (ENGR 1015U)
2-1	ELEE 2110U Discrete Mathematics (MATH 1020U, MATH 1850U)	ELEE 2200U Electrical Engineering Fundamentals (MATH 1020U, MATH 1850U, PHY 1020U)	SOFE 2710U Object Oriented Programming and Design (ENGR 1200U)	MATH 2860U Differential Equations for Engineers (MATH 1020U)	MECE 2640U Thermodynamics and Heat Transfer (MATH 1020U, PHY 1010U)	
2-2	ELEE 2250U Introductory Electronics (ELEE 2200U)	ELEE 2450U Digital Systems (ELEE 2110U)	ELEE 2520U Fundamentals of Electromagnetics (ELEE 2200, MATH 2860)	ELEE 2530U Complex Analysis (MATH 2860U)	ENGR 2210U Circuit Analysis (ENGR 2200U, MATH 2860U)	
3-1	ELEE 3230U Electronic Circuit Design (ELEE 2250U, ELEE 2215U)	ELEE 3110U Signals and Systems (ELEE 2530U, ELEE 2215U)	ELEE 3250U Electric Machines (Coreq: ELEE 3240U)	ELEE 3240U Applications for Electromagnetics (ELEE 2520U, ELEE 2530U)	ELEE 3450U Microprocessors and Computer Architecture (ELEE 2450U)	Liberal Studies Elective
3-2	ELEE 3260U Power Systems (ELEE 3250U)	ELEE 3100U Introduction to Control Systems (ELEE 3110U)	~~ENGR~~ ELEE 3180U Design Principles & ~~7~~ Proj Mgmt in EE (ELEE 2250U, ELEE 2450U, ELEE 2520U, SOFE 2710U)	ELEE 3130U Communication Systems (ELEE 3110U)	ELEE 3070U Probability and Random Signals (ELEE 2110U)	ENGR 3360U Engineering Economics
4-1	ELEE 4940U Capstone Systems Design for Electrical, Computer and Software Engineering I (Successful completion of all non-elective courses in year three)	ELEE 4750U Microwave & RF Circuits (ELEE 3220U, ELEE 3240U)	ELEE 4420U DSP Theory and Design (ELEE 3110U)	ELEE 4150U Advanced Control Systems (ELEE 3100U)	Engineering Elective	
4-2	ELEE 4941U Capstone Systems Design for Electrical, Computer and Software Engineering II (ELEE 4940U)	ENGR 4760U Ethics, Law and Professionalism for Engineers	ELEE 4500U Wireless Communications (ELEE 3130U)	Liberal Studies Elective	Engineering Elective	

Appendix III: Proposed New Map for the EE Specialization in Smart Grid, Year 4 changes

Smart Grid (Proposed Changes) – Electrical Engineering 2015-2016						
Year	**Course**	**Course**	**Course**	**Course**	**Course**	**Course**
1-1	COMM 1050U Technical Communications	ENGR 1015U Introduction to Engineering	MATH 1010U Calculus I	MATH 1850U Linear Algebra for Engineers (Coreq:MATH 1010U)	PHY 1010U Physics I	
1-2	CHEM 1800U Chemistry for Engineers	SSCI 1470U Impact of Science and Technology on Society	ENGR 1200U Introduction to Programming	MATH 1020U Calculus II (MATH 1010U)	PHY 1020U Physics II (PHY 1010U)	ENGR 1025U Engineering Design (ENGR 1015U)
2-1	ELEE 2110U Discrete Mathematics (MATH 1020U, MATH 1850U)	ELEE 2200U Electrical Engineering Fundamentals (MATH 1020U, MATH 1850U, PHY 1020U)	SOFE 2710U Object Oriented Programming and Design (ENGR 1200U)	MATH 2860U Differential Equations for Engineers (MATH 1020U)	MECE 2640U Thermodynamics and Heat Transfer (MATH 1020U, PHY 1010U)	
2-2	ELEE 2250U Introductory Electronics (ELEE 2200U)	ELEE 2450U Digital Systems (ELEE 2110U)	ELEE 2520U Fundamentals of Electromagnetics (ELEE 2200, MATH 2860)	ELEE 2530U Complex Analysis (MATH 2860U)	ENGR 2210U Circuit Analysis (ENGR 2200U, MATH 2860U)	
3-1	ELEE 3230U Electronic Circuit Design (ELEE 2250U, ELEE 2215U)	ELEE 3110U Signals and Systems (ELEE 2530U, ELEE 2215U)	ELEE 3250U Electric Machines (Coreq: ELEE 3240U)	ELEE 3240U Applications for Electromagnetics (ELEE 2520U, ELEE 2530U)	ELEE 3450U Microprocessors and Computer Architecture (ELEE 2450U)	Liberal Studies Elective
3-2	ELEE 3260U Power Systems (ELEE 3250U)	ELEE 3100U Introduction to Control Systems (ELEE 3110U)	~~ENGR~~ ELEE 3180U Design Principles and Proj Mgmt in Electrical Engineering ~~Design~~ (ELEE 2250U, ELEE 2450U, ELEE 2520U, SOFE 2710U)	ELEE 3130U Communication Systems (ELEE 3110U)	ELEE 3070U Probability and Random Signals (ELEE 2110U)	ENGR 3360U Engineering Economics
4-1	ELEE 4940U Capstone Systems Design for Electrical, Computer and Software Engineering I (Successful completion of all non-elective courses in year three)	ELEE 4115U Fundamentals of Smart Grid (ELEE 3260U)	ELEE 4420U DSP Theory and Design (ELEE 3110U)	ELEE 4150U Advanced Control Systems (ELEE 3100U)	Liberal Studies Elective	
4-2	ELEE 4941U Capstone Systems Design for Electrical, Computer and Software Engineering II (ELEE 4940U)	ENGR 4760U Ethics, Law and Professionalism for Engineers	ELEE 4125U Smart Grid Networking and Security (ELEE 4115U)	ELEE 4140U Power System Protection Relaying (ELEE 3100U, ELEE 3230U, ELEE 3250U, ELEE 3260U)	ELEE 4120U Introduction to Power Electronics (ELEE 3100U, ELEE 3230U, ELEE 3250U)	

Appendix IV: Calendar Copy

Changes for Smart Grid specialization are in Year 4 only, assuming all changes to the EE program are approved.

YEAR 4
Semester 1 (15 credit hours)
ELEE 4150U Advanced Control Systems
ELEE 4420U DSP Theory and Design
~~ELEE 4750U Microwave and RF Circuits~~ (ELEE 4115U Fundamentals of Smart Grid)
ENGR 4940U Capstone Systems Design for Electrical, Computer and Software Engineering I
~~Engineering elective~~ (move to Semester 2)
Liberal studies elective (moved from Semester 2)

Semester 2 (15 credit hours)
~~ELEE 4500U Wireless Communications~~ (ELEE 4125U Smart Grid Networking and Security)
ENGR 4760U Ethics, Law and Professionalism for Engineers
ENGR 4941U Capstone Systems Design for Electrical, Computer and Software Engineering II
~~Engineering elective~~ (ELEE 4140U Power System Protection Relaying)
~~Liberal studies elective~~ (move to Semester 1) (ELEE 4120U Introduction to Power Electronics)

Appendix V: Course Templates

COURSE CHANGE TEMPLATE

Faculty: FEAS	
Course number: ENGR4115U	**Current course title:** Fundamentals of Smart Grid
__X__ Core ___ Elective	

COURSE CHANGES (check all that apply)

	Course title		Credit weighting
	Course description		Contact hours
X	Course number		Prerequisites
	Course design		Co-requisites
	Learning outcomes		Cross-listings
	Mode of delivery		Credit restrictions
	Teaching and assessment methods		Credit exclusions

REASON FOR CHANGE AND WAYS IN WHICH IT MAINTAINS/ENHANCES COURSE OBJECTIVES

In accordance with the course numbering changes for the faculty, ENGR is replaced by ELEE

CHANGE TO CALENDAR ENTRY

Current	Proposed
ENGR4115U Elective	ELEE4115U Core

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

Date of submission to CPRC	October 14, 2014
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COURSE CHANGE TEMPLATE

Faculty: FEAS	
Course number: ELEE4120U	**Current course title:** Introduction to Power Electronics
__X__ Core ___ Elective	

COURSE CHANGES (check all that apply)

	Course title		Credit weighting
X	Course description	x	Contact hours
	Course number		Prerequisites
	Course design		Co-requisites
	Learning outcomes		Cross-listings
	Mode of delivery		Credit restrictions
	Teaching and assessment methods		Credit exclusions

REASON FOR CHANGE AND WAYS IN WHICH IT MAINTAINS/ENHANCES COURSE OBJECTIVES

Removes restriction on software type and gives more freedom to faculty member to choose simulation package.
Tutorial: To synchronize with scheduling to allow for better student scheduling of courses, labs, and tutorials and hence enhancing the students' learning experience.

CHANGE TO CALENDAR ENTRY

Current	**Proposed**
This course covers fundamentals of power conversion techniques: Review of semi-conductor switches, review of basic electrical and magnetic circuits, single-phase and three phase rectifier and inverter circuits, switch mode converters and power supplies, control of switch-mode dc power supplies, snubber circuit design, computer simulation of power electronic converters and systems using EMTP RV. No lab 2 tut	This course covers fundamentals of power conversion techniques: Review of semi-conductor switches, review of basic electrical and magnetic circuits, single-phase and three- phase rectifier and inverter circuits, switch-mode converters and power supplies, control of switch-mode dc power supplies, snubber circuit design, computer simulation of power electronic converters and systems. 2 lab (biweekly). 1.5 tut

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COURSE CHANGE TEMPLATE

Faculty: FEAS	
Course number: ENGR4125U	**Current course title:** Smart Grid Networking and Security
__X__ Core ___ Elective	

COURSE CHANGES (check all that apply)

	Course title		Credit weighting
	Course description		Contact hours
X	Course number	X	Prerequisites
	Course design		Co-requisites
	Learning outcomes		Cross-listings
	Mode of delivery		Credit restrictions
	Teaching and assessment methods		Credit exclusions

REASON FOR CHANGE AND WAYS IN WHICH IT MAINTAINS/ENHANCES COURSE OBJECTIVES

In accordance with the course numbering changes for the faculty, ENGR is replaced by ELEE.

CHANGE TO CALENDAR ENTRY

Current	Proposed
ENGR 4125U Elective Prerequisite: SOFE 4650U	ELEE 4125U Core Prerequisite: ELEE 4115U

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

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COURSE CHANGE TEMPLATE

Faculty: FEAS	
Course number: ELEE4140U	**Current course title:** Power System Protection Relaying
__X__ Core _____ Elective	

COURSE CHANGES (check all that apply)

	Course title		Credit weighting
X	Course description	X	Contact hours
	Course number	X	Prerequisites
	Course design		Co-requisites
	Learning outcomes		Cross-listings
	Mode of delivery		Credit restrictions
	Teaching and assessment methods		Credit exclusions

REASON FOR CHANGE AND WAYS IN WHICH IT MAINTAINS/ENHANCES COURSE OBJECTIVES

Microprocessor is taught in a different course (ELEE 3490).
Power Systems (ELEE 3260U) should be a prerequisite for this course.
Tutorial: To synchronize with scheduling to allow for better student scheduling of courses, labs, and tutorials and hence enhancing the students' learning experience.

CHANGE TO CALENDAR ENTRY

Current	Proposed
Need for protection systems, types of relays, operating principles and relay construction, overcurrent protection, distance protection, pilot relaying schemes, ac machines and Bus protection, microprocessor and interfacing, micro-processor based relays, Overvoltage protection. Prerequisites: ELEE 3100U, ELEE 3230U, ELEE 3250U 2 tut	Need for protection systems, types of relays, operating principles and relay construction, overcurrent protection, distance protection, pilot relaying schemes, ac machines and Bus protection, micro-processor based relays, Overvoltage protection. Prerequisites: ELEE 3100U, ELEE 3230U, ELEE 3250U, ELEE 3260U 1.5 tut

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

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COURSE CHANGE TEMPLATE

Faculty: FEAS	
Course number: ELEE 4150U	**Current course title:** Advanced Control Systems
__X__ Core ____ Elective	

COURSE CHANGES (check all that apply)

X	Course title		Credit weighting
X	Course description	X	Contact hours
	Course number		Prerequisites
	Course design		Co-requisites
	Learning outcomes		Cross-listings
	Mode of delivery		Credit restrictions
	Teaching and assessment methods		Credit exclusions

REASON FOR CHANGE AND WAYS IN WHICH IT MAINTAINS/ENHANCES COURSE OBJECTIVES

Title change reflects more timely description.
Discrete Events were not explicitly mentioned in the description.
The concept of Lyapunov's theorem is just an introduction.
Tutorial: To synchronize with scheduling to allow for better student scheduling of courses, labs, and tutorials and hence enhancing the students' learning experience.

CHANGE TO CALENDAR ENTRY

Current	**Proposed**
2-Modeling of systems: from State Space (SS) to Discrete Event (DE) to Transfer Function (TF). Introduction to SISO and MIMO systems. Coordinate transformation of SS models. Linearization of nonlinear systems. Lyapunov stability theorems. Explicit solutions to the DE for linear time-invariant (LTI) systems (and properties of these solutions) Notions of controllability and observability. Kalman decomposition. Controller Synthesis: feedforward control, pole assignment, optimal control (LQR). Observer design. 2 tut	2-Modeling of systems: from State Space (SS) to Transfer Function (TF). Introduction to SISO and MIMO systems. Coordinate transformation of SS models. Linearization of nonlinear systems. Introduction to Lyapunov stability theorems. Explicit solutions to the DE for linear time-invariant (LTI) systems (and properties of these solutions) Notions of controllability and observability. Kalman decomposition. Controller Synthesis: feedforward control, pole assignment, optimal control (LQR). 1.5 tut

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

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Appendix VI: CEAB AUs for Accreditation Purposes

AUs have been re-calculated to reflect the changes, and the results are shown in the table below Note: This calculation is based on a 12-week semester.

		M Au	NS Au	CS Au	ES Au	ED Au	ES+ED	Math+NS
Total	**2018.4**	308.3	240.0	264.0	800.4	365.9	1166.3	548.3
CEAB Minimums	**1950.0**	195.0	195.0	225.0	225.0	225.0	900.0	420.0