Fundamentals of Automation Engineering

The course: Fundamentals of Automation Engineering has been introduced in first year of B.Tech. since 2018-22 batch with aim of building key technical competencies for automation engineering. The course is delivered using Project Based Learning Pedagogy for batches 2018-22, 2019-23 and 2020-24. This document shows the updates in the course in there years, where the course was delivered in on-campus mode for the first time and then modified to online mode in next two iterations.

First Iteration BES202 Fundamentals of Automation Engineering (2018-19), 6 Credits.

Faculty: Dr Devika Kataria, Dr. Gustavo Sanchez, Dr Pushpendra Singh, Mr. Yogesh Rohilla.

Course Description: This course is focused on basic knowledge and critical understanding of different technologies in the design and maintenance of automation systems. The design of the course and the project goals and feedback have been published in journal paper Fundamentals of Automation Engineering: A hybrid project-based learning approach, *The International Journal of Electrical Engineering & Education*, 0020720920928460, 2020. The course outcomes, syllabus and evaluation rubric are mentioned below.

Course Outcomes

On successful completion of this course, the students should be able to:
1) propose and implement a complete solution for a simple automation problem, including power supply, actuator, sensor, sensitized with energy usage and effects on environment
2) evaluate the benefits and challenges of automation technologies
3) explain the importance of adopting suitable engineering standards for automation projects
4) use basic management practices for developing automation projects

Unit 1 Introduction to Electrical Engineering – U1

1) Analyze electrical circuits using network theorems
2) Measure electrical parameters of passive as well as active electrical components
3) Design rectifier circuit using semiconductor devices.
4) Design filters for power conditioning.
5) Design and build Printed Circuit Boards.
6) Use electrical safety practices while working on electrical projects.

Unit 2 Introduction to Automation Engineering and Control Systems – U2

1) Design and implement open-loop control system
2) Formulate mathematical models for basic mechanical, electro-mechanical and fluid systems
3) Conduct analysis of dynamic control system.
4) identify the need for feedback in control systems

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Unit 3 Introduction to Digital Circuits and Embedded Systems – U3

1) Evaluate and simplify Boolean functions and design the minimized logic using logic gates.
2) Design basic combinational and sequential circuits with minimum complexity
3) Implement various logic functions using software programming with micro controller, to make optimal utilization of resources.
4) Identify the key features of embedded systems in terms of hardware and software
5) Interface sensors and design low power embedded systems projects using microcontroller

Evaluation Scheme

Sr. No	Specifications	Regular student(s)
01	Attendance	Nil
02	Assignment (04)	20
03	Class Participation & Attendance	5
04	Quizzes	5
05	Theory Exam I	10
06	Theory Exam II	Nil
07	Theory Exam III	20
08	Report -I	Included with Project
09	Report-II	Included with Project
10	Report-III	Included with Project
11	Project -I	Included with Project
12	Project -II	10
13	Project -III	10
14	Lab Evaluation I (End Term)	20
15	Lab Evaluation II	Nil
16	Course portfolio	Nil
	Total (100)	**100**

Syllabus:

- Electric Circuit Analysis: Application of network Theorems, Laplace Transform, Application of network Theorems. Laplace Transform for solving equations for reactive components. Concept of Phasors and Phasor diagrams, power factor calculations. Smart energy meter. Single phase and three phase wiring and balancing of loads.
- Transformers and power supply(rectifiers). Safety in handling Electrical equipment.
- Working principle of DC Motors, PWM for speed control, Principle of working of Servomotors, Introduction to control system: open and closed loops. Block diagrams, PID control of servomotors, Mechanical models. Actuators, DC motor. PWM. DC servomotor, Brushless motors - AC motor, Introduction to Feedback Controllers

- Digital circuits for automation: Boolean Algebra, Karnaugh map, Logic gates, Decoders and Multiplexers, Displays, Counters and Timers (555) and applications. Architecture of ATMega328 (concepts on ALU, memory, ports). Implementing logical functions using microcontroller programs.

- Familiarization with standards on Instrumentation and Measurements. Significance of SCADA and HMI in automation projects. Working principle of Sensors and their interfacing to microcontrollers Movement detection, gyro motors, vision, sonar, laser, tactile, calibration of few analog sensors.

Textbooks:

1. WH Hayt, J E Kemmerly, SM Durbin, Engineering Circuit Analysis, Eight Edition, 2013, Mc. Graw Hill, ISBN 978-0-07-352957-8.
2. M. Morris Mano, Digital Logic and Computer Design, 1st Edition, 2016, Pearson India Publication, ISBN: 9789332542525.
3. S Palani, Control Systems Engineering, 2nd edition,2 August, Mc. Graw Hill Education, ISBN-10: 0070671931.

Snapshots:

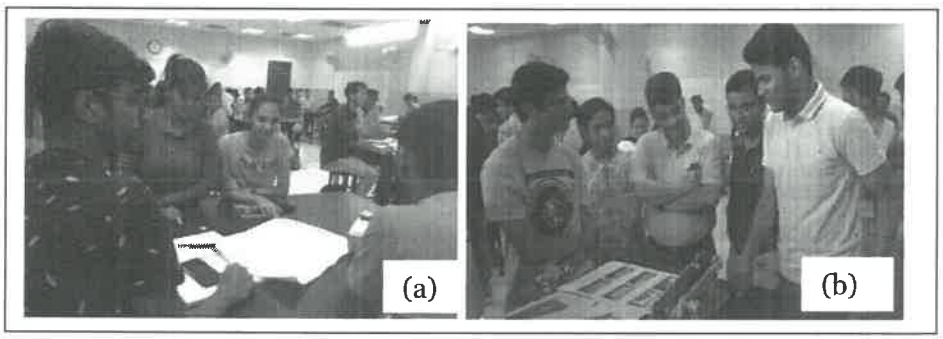

Figure 1 (a) Design studio session for Fundamentals of Automation Engineering
(b) Project on Material Movement System Model displayed at Open Day to parents

Second Iteration:

ES1104 Fundamentals of Automation Engineering, (2019-20),6 credits
Faculty: Dr Devika Kataria, Dr Gustavo Sanchez, Mr H.P. Agarwal, Mr Divanshu Jain

The course was partly delivered in on campus mode and then due to COVID lockdown the online mode of delivery was made. The course outcomes were modified as follows for the online mode (outcomes 9-12)

1) Analyze electrical circuits using network theorems
2) Measure electrical parameters of passive as well as active electrical components
3) Design rectifier circuit using semiconductor devices.
4) Design filters for power conditioning.
5) Design and test a linear power supply for given specifications
6) Design and build Printed Circuit Boards.
7) Use electrical safety practices while working on electrical projects.

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8) Formulate mathematical models for basic mechanical, electro-mechanical and fluid systems.
9) Design and simulate open-loop control system.
10) Evaluate and simplify Boolean functions and design the minimized logic using logic gates.
11) Design basic combinational and sequential circuits with minimum complexity
12) Implement combinational circuit using simulation tools.

Projects: The course involves three modules which ultimately lead to common goal of developing a dynamic model for cycles developed in course Design and Prototype.
Project 1: Power supply (Specifications:)
Domain Knowledge: AC and DC current, circuit theory, semiconductor pn junction, regulators, filters.
Project 2: Dynamic system modelling for cycle
Domain Knowledge: Control Systems, Dynamic models, Simulation.
Project 3: Digital tachometer for cycle
Domain Knowledge: Digital Logic, developing software for logical functions using microcontrollers.

The design and experiences of this iteration have been published at 12th Asian Conference on education, held in Tokyo, Japan, from Friday, October 30 to Monday, November 2, 2020. The presentation may be viewed at link https://vimeo.com/469610392

Few pictures taken during testing of the bicycles for dynamic model are shown in Fig. 2:

Figure 2 Activities done for dynamic model parameters determination of Bicycles fabricated in Design and Prototype, modelled using physical measurements and compared with simulated results.

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Third Iteration : The course has been divided into two parts Fundamentals of Automation Engineering-I (SemesterI) and Fundamentals of Automation Engineering -II (SemesterII).

ES1111 Fundamentals of Automation Engineering-Part 1, 3 credits
Faculty: Dr Devika Kataria, Dr Gustavo Sanchez, Mr Divanshu Jain

Syllabus for first semester:

Digital circuits for automation: Boolean Algebra, Karnaugh map, Logic gates, Decoders and Multiplexers, Sequential Circuits, Finite State machines.
Element of DC /AC circuits, Resonance-Series/Parallel, Semiconductor devices and applications.

Unit-specific Course Outcomes

Unit 1 Introduction to Digital Circuits – U1

1) Evaluate and simplify Boolean functions and implement the minimized logic using logic gates.

2) Simulate basic combinational and sequential circuits with minimum complexity.

3) Model Digital system using Finite State Machine.

4) Propose real world applications using digital systems for healthcare.

Unit 2 Introduction to Analog Circuits– U2

1) Design circuit using semiconductor devices and passive components

2) Identify the components for use in ac/dc circuits

3) Simulate resonance in series and parallel RLC circuits.

4) Implement applications for home automation.

Projects: Students modelled real life digital systems using Finite State Machine models and Python programs. Some of the snapshots from the project reports are shown in Fig

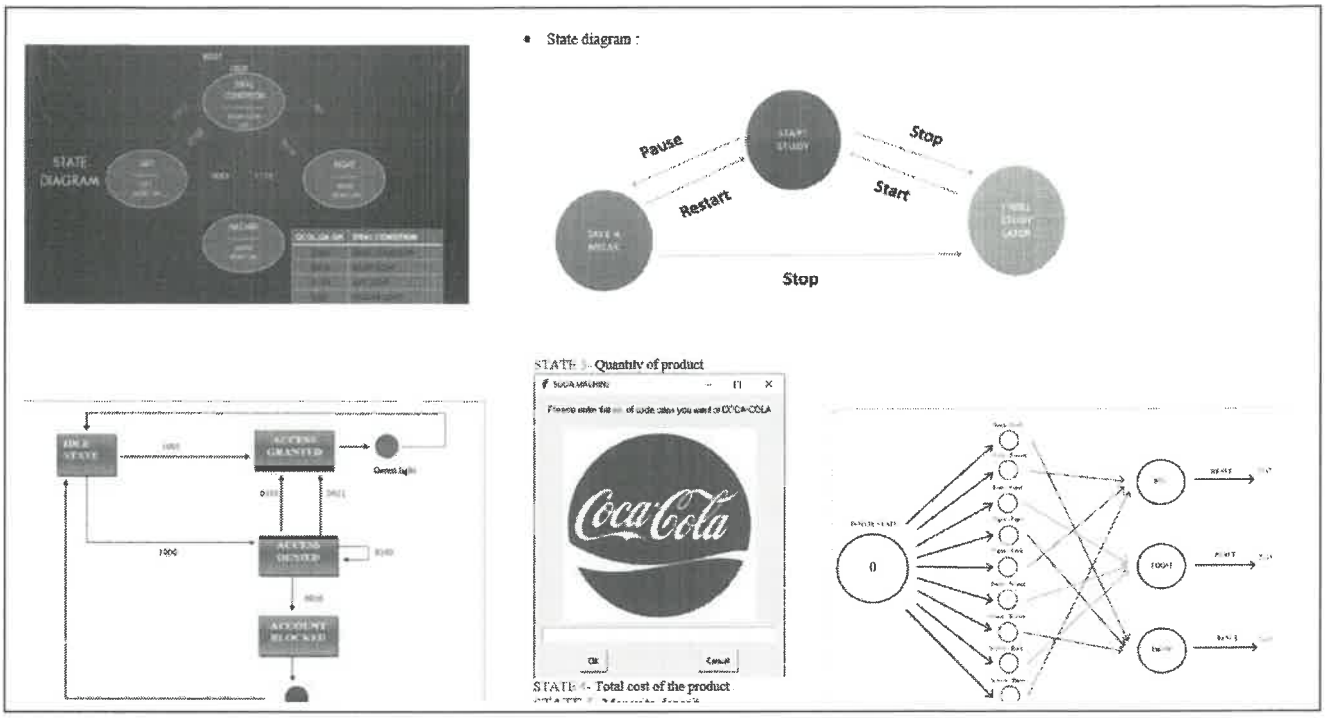

Figure 3 Snapshots from Project Reports for Simulations of Finite State Models for some real life applications

ES1113: Fundamentals of Automation Engineering II, 3 Credits

Syllabus: Syllabus: Element of DC network and circuits, Application of network Theorems, Safety in handling Electrical equipment.

Introduction to control system: open and closed loops. Block diagrams, Electro-Mechanical models.

Sensors, display devices and Microcontrollers for automation: Working principle of sensors and display devices. Architecture of ATMega328/MSP430 Lunchbox (concepts on ALU, memory, ports). Applications of sensors, display devices interfacing with microcontroller.

Unit-specific Course Outcomes

Unit1 Introduction to Electrical Engineering – U1

1) Analyze electrical circuits using network theorems
2) Measure electrical parameters of passive electrical components
3) Use electrical safety practices while working on electrical projects.
4) Use transfer function to model a system
5) Formulate mathematical models for basic mechanical and electro-mechanical systems
6) Simulate dynamic response of a system for bounded inputs.

Unit 2 Introduction to Embedded Systems – U2

1) Learn the concept, classification, characteristics, quality attributes and applications of Embedded Systems.
2) Describe the architecture of MSP430 and use the peripherals for various applications.
3) Interface different sensors and displays for different applications.
4) Develop programs for various application using embedded C.

Apply low power modes for MSP430 to optimize power consumption

Project 1: Dynamic simulation of DC motor in Python

Domain Knowledge: Python, AC and DC current, circuit theory, Electromechanical modeling.

Project 2: Interface sensors and actuators on MSP430 to make useful applications

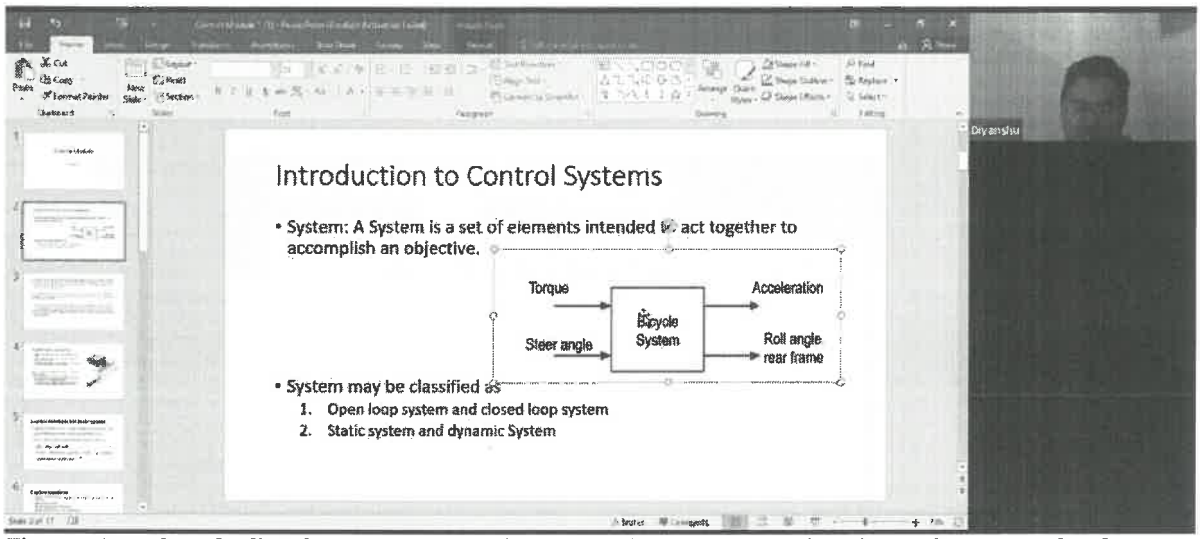

Figure 4 Snapshot of online class on ES1113 Fundamentals of Automation Engineering-II for 2020-24 batch.