Syllabus

Course Title: Basic Mechatronics Workshop

Lecturer: Dr. Mohamed El-Sayed Abdalbar

Course Code:

Course Followers:

Students of Mechatronics Department in 2nd semester of 1st year

Course Meeting Times

Lectures: 1 session / week, 2 hours / session

Labs: 1 session / week, 4 hours / session

Course Credits: 3

Course Introduction

This course give Mechatronics department students necessary knowledge and skills of the mechatronic systems. Another purpose of the course is to equip students with elementary technology and basic control technology for factory automation systems. As a result students can understand complex mechatronics systems easily.

Course Objectives

After successfully studying this course, students will be able to:

1. Understand the basic mechatronics engineering principles and abstractions on which the design of mechatronics systems is based. These include mechatronics system models, basic concepts of unit equipment and characteristics of components.
2. Use these engineering abstractions to analyze and design simple control circuits by the Simulation Software tools such as “ELCO Lab”.
3. Formulate the control behavior of systems containing individual elements. Implement basic control using Individual Elements such as Sensors, PLC, Pneumatics, Motors, HMI.
4. Use intuition to describe the basic elements of each energy such as Electric, Pneumatic, Hydraulic.
5. Build control circuits and control circuits design of controlled systems using simulation software such as “ELCO Lab”.
6. Understand the Sensors principles and abstractions for mechatronics systems. These include Sensors models, basic concepts of Sensor circuit and characteristics of Sensors.
7. Understand the Pneumatics principles and abstractions for mechatronics systems. These include Pneumatics models, basic concepts of Pneumatic circuits and characteristics of Pneumatic elements.
8. Understand the PLC principles and abstractions for mechatronics systems. These include PLC models, basic concepts of PLC circuits and characteristics of PLC elements.
9. Understand the HMI principles and abstractions of mechatronics systems. These include HMI models, basic concepts of HMI network and characteristics of HMI elements.
10. Appreciate the practical significance of the systems developed in the course.
11. Design applied control programs using control algorithms.

Learning Outcomes

1. Build and Understand basic circuits of proximity sensor including Reed sensor, Inductive sensor, Capacitive sensor, Optical sensor and Ultrasonic sensor.
2. Build and design basic circuits of Electric Pneumatic using cylinders and valves.
3. Design Mechatronics control system by selection of PLC elements.
4. Build and design basic circuits of PLC using sensors and valves.
5. Make coding for simple control program for PLC control.
6. Build and Understand basic circuits of Motors including DC motor, AC motor and Servo motor.
7. Understand of HMI's including RS232C, RS422, RS485 and Ethernet.

Prerequisites / Reference Courses

PLC Control (Programable Logic Controller) in Technology

Pneumatic Control in Technology

Motor Control in Technology

Sensors in Technology

HMI (Human Machine Interface) in Technology

System Network in Technology

Textbooks

The course textbooks are:

1. Khaled Kamel and Eman Kamel, PROGRAMMABLE LOGIC CONTROLLERS (Industrial Control), McGraw-Hill, 2007, New York, ISBN: 978-0-07-181047-0

2. Peter Croser and Frank Ebel, Pneumatics (Workbook Basic Level), Festo Didactic, 2002, Denkendorf, D.LB TP101-1-GB
3. D. Waller and H. Werner, Electropneumatics (Workbook Basic Level), Festo Didactic, 2002, Denkendorf, D.S 201-C-SIBU-GB
4. Andrew Parr, Hydraulics and Pneumatics A technician's and engineer's guide (Second edition), BH, 2006, OXFORD, ISBN: 978-0-7506-4419-9
5. Sabri Cetinkunt, MECHATRONICS with Experiments (SECOND EDITION), WILEY, 2015, Chicago, ISBN: 9781118802465
6. Tyson Macaulay and Bryan Singer, Cybersecurity for Industrial Control Systems, (SCADA, DCS, PLC, HMI, and SIS), CRC Press Taylor & Francis Group, 2012, New York, ISBN: 978-1-4665-1611-3.

Homework

· Homework will be issued in lectures and collected a week later in recitation.

· Corrected homework with solutions will be returned in labs the week after it is collected. You are welcome and encouraged to discuss the homework among your colleagues. However, the final formulation and write up of your homework answers must be your own.

· Submitting homework copied from someone else is a breach of ethics, and will be handled by the Committee on Discipline. More importantly, although homework counts for only 5 percent of the grade, they are critical to learning the material and to doing well on the quizzes and final exam. **One homework problem will appear in each of the tests**, and homework performance will be taken into account during grade assignment for cases that are on letter-grade boundaries.

· **Late homework will not be accepted for grading**. However, total homework grades will be based on the best nine out of eleven individual homework grades. Thus, with one exception, two homework assignments may be missed without a grading penalty.

· All homework will be graded on a coarse scale of 0 to 3 points. 3 points if all or nearly all problems are correct, 2 points if homework is approximately half correct, 1 point if mostly incorrect, and 0 points if late or not submitted.

Labs (or Tutorials/Exercise, Workshop)

· Labs will be conducted during the weeks shown in the schedule. Each lab assignment involves one or more accomplishments which must be checked off by an instructor in the lab. The instructor will be available for help and lab check-off during those weeks in which a lab is in progress.

· No written work will be due for the last lab.

· You are welcome and encouraged to discuss the labs among your colleagues. You are also welcome to team up in pairs to execute a lab. However, the write up of your lab must be done on your own. Skipping the lab and submitting work copied from someone else is a serious breach of ethics and will be handled by the Committee on Discipline.

· Lab assignments will be graded on a scale of 0 to 3 (3: lab complete, works, good job on pre- and post-lab; 2: lab mostly complete, reasonable job on pre and post lab; 1: lab partially done, marginal to poor job on pre- and post-lab; 0: lab not done, poor job on pre- and post-lab).

Lab Books

· You must obtain the contents of a few pages for every lab (from Lab #1 to lab #15) for recording measurements, observations and graphs of data taken during the in-lab exercises.

· Written pre-lab and post-lab exercises are also to be completed in your own papers.

Midterm Exam

· One closed-book midterm exam will be given in this term. The exam will take place few days after Lab #7 for a two-hour duration.

· There will be no lecture or lab on the day. **You may bring <u>one two-sided sheet of notes</u> written by your own hands to the exam**. You may also bring a calculator, eraser, pencil or ball pens.

Final Exam

· A three-hour final exam will be given during the end-of-term exam week. Timing and room assignments will be announced later. **You may bring three two-sided sheets of notes written by your own hands to the exam**.

Calendar

The calendar provides information on the course's lecture class (L), lab (Lab #), and exam (E) sessions.

SES #	TOPICS	KEY DATES
L1	Mechatronics Introduction	Homework #1 in
Lab #1	Introduction to Simulation Software ELCO Lab (Practice)	Lab report #1 in
L2	Basic Concepts: Control of Systems, Pilot & Memory, Sequence, Time Schedule	Homework #1 out Homework #2 in
Lab #2	Pilot and Memory control of Pneumatic elements – Use ELCO Lab (Practice)	Lab report #1 out Lab report #2 in
L3	Proximity Sensor Introduction. Principle of operation, Reed and Inductive, Capacitive, Optical, Ultrasonic	Homework #2 out Homework #3 in
Lab #3	Sensor Circuits, Power and Constant voltage, Detector, Amplifier, Display, Output (Conference of Presentation)	Lab report #2 out Lab report #3 in
L4	Sensor Interface, NPN and PNP Type	Homework #3 out Homework #4 in
Lab #4	Sensor Interface, NPN and PNP Type, Lamp control (Practice)	Lab report #3 out Lab report #4 in
L5	PLC Introduction, History and elements	Homework #4 out Homework #5 in

SES #	TOPICS	KEY DATES
Lab #5	PLC Hardware Configure, Power and CPU, Base, Input, Output, Special Module (Conference of Presentation)	Lab report #4 out Lab report #5 in
L6	PLC Input / Output Set up, Parameter and Command, a contact, b contact, coil, M relay	Homework #5 out Homework #6 in
Lab #6	a and b contact, coil, Compare of Pneumatic circuit and PLC circuit (Practice)	Lab report #5 out Lab report #6 in
L7	Logic Introduction, YES and NOT, AND, OR	Homework #6 out Homework #7 in
Lab #7	Use Logic circuit, YES and NOT, AND, OR, use sensor of lamp control (Practice)	Lab report #6 out Lab report #7 in
E1	Midterm Exam	
L8	Pneumatics Introduction, Pneumatic energy and generation, elements (Cylinders, Valves etc.)	Homework #7 out Homework #8 in
Lab #8	Pneumatics Cylinder control, Single acting cylinder and Double acting cylinder, single solenoid valve, double solenoid valve (Conference of Presentation)	Lab report #7 out Lab report #8 in
L9	Pneumatics control circuit, single and double solenoid valve, use sensor	Homework #8 out Homework #9 in

SES #	TOPICS	KEY DATES
Lab #9	Pneumatics control circuit, single and double solenoid valve, use sensor (Practice)	Lab report #8 out Lab report #9 in
L10	PLC use cylinder control, ON first Self holding circuit and OFF first Self holding circuit	Homework #9 out Homework #10 in
Lab #10	PLC use cylinder control, ON first Self holding circuit and OFF first Self holding circuit (Practice)	Lab report #9 out Lab report #10 in
L11	Motor Introduction, DC motor & AC motor	Homework #10 out Homework #11 in
Lab #11	DC motor control, Run / Stop control, CW control, CCW control, use sensor (Practice)	Lab report #10 out Lab report #11 in
L12	Servo motor, Stepping Motor, Encoder	Homework #11 out Homework #12 in
Lab #12	AC motor control, Main circuit design, control circuit (Practice)	Lab report #11 out Lab report #12 in
L13	HMI Introduction, Network component, RS422 and RS485, RS232C, Industrial Ethernet	Homework #12 out Homework #13 in
Lab #13	Network component, RS422 and RS485, RS232C, Industrial Ethernet (Conference of Presentation)	Lab report #12 out Lab report #13 in

SES #	TOPICS	KEY DATES
E2	Final Exam	

Grading (or Assessment) Policy

Initial grading will be based on the following weighting:

ACTIVITIES	PERCENTAGES
Homework	5%
Labs (performance & reports)	35%
Midterm	30%
Final exam	30%

- Lab assignments will be graded on a scale of 0 to 3

  i) 3: lab complete, works, good job on pre- and post-lab;

  ii) 2: lab mostly complete, reasonable job on pre and post lab;

  iii) 1: lab partially done, marginal to poor job on pre- and post-lab;

  iv) 0: lab not done, poor job on pre- and post-lab.

- All homework will be graded on a coarse scale of 0 to 3 points,

  i) 3 points if all or nearly all problems are correct,

  ii) 2 points if homework is approximately half correct,

  iii) 1 point if mostly incorrect, and

iv) 0 points if late or not submitted.

· This will be followed by considerable discussion among the entire teaching staff to factor in your diligence on the homework and labs, and your participation in class and labs. This discussion can affect your letter grade for the course, particularly if your initial grade is on a letter-grade boundary.

· Furthermore, failure to complete the labs in this subject will result in an overall grade that is one letter grade lower (not an Incomplete).

· This subject has been designed so that lectures, homework and labs are integral and essential parts of the learning process. Although there is no specific reward for participation, there is a clearly defined penalty for not participating. Students who consistently miss lectures, homework and labs will not be included in the grading discussions.

Lecture notes

This section contains lecture notes from some chapters of the following books,

I) Sabri Cetinkunt, MECHATRONICS with Experiments (SECOND EDITION), WILEY, 2015, Chicago, ISBN: 9781118802465

II) Andrew Parr, Hydraulics and Pneumatics A technician's and engineer's guide (Second edition), BH, 2006, OXFORD. ISBN: 978-0-7506-4419-9

III) Peter Croser and Frank Ebel, Pneumatics (Workbook Basic Level), Festo Didactic, 2002, Denkendorf, D.LB TP101-1-GB

IV) Khaled Kamel and Eman Kamel, PROGRAMMABLE LOGIC CONTROLLERS (Industrial Control), McGraw-Hill, 2007, New York. ISBN: 978-0-07-181047-0

V) Tyson Macaulay and Bryan Singer, Cybersecurity for Industrial Control Systems, (SCADA, DCS, PLC, HMI, and SIS), CRC Press Taylor & Francis Group, 2012, New York. ISBN: 978-1-4665-1611-3.

LEC #	TOPICS	LECTURE NOTES
L1	Mechatronics Introduction	BOOK III Chapter 1: Characteristics and applications of pneumatics
L2	Basic Concepts: Control of Systems, Pilot & Memory, Sequence, Time Schedule	BOOK III Chapter 1: Characteristics and applications of pneumatics
L3	Proximity Sensor Introduction. Principle of operation, Reed and Inductive, Capacitive, Optical, Ultrasonic	BOOK I Chapter 6: Sensors
L4	Sensor Interface, NPN and PNP Type	BOOK I Chapter 5: Transistors
L5	PLC Introduction, History and elements	BOOK IV Chapter 1: Introduction
L6	PLC Input / Output Set up, Parameter and Command, a contact, b contact, coil, M relay	BOOK IV Chapter 1: Hardwired Systems
L7	Logic Introduction, YES and NOT, AND, OR	BOOK IV

LEC #	TOPICS	LECTURE NOTES
		Chapter 1: PLC Ladder
L8	Pneumatics Introduction, Pneumatic energy and generation, elements (Cylinders, Valves etc.)	BOOK II Chapter 3: Air compressors BOOK III Chapter 2: Components of a pneumatic system
L9	Pneumatics control circuit, single and double solenoid valve, use sensor	BOOK II Chapter 4: Control valves
L10	PLC use cylinder control, ON first Self holding circuit and OFF first Self holding circuit	BOOK IV Chapter 4: Circuit Theorems
L11	Motor Introduction, DC motor AC motor	BOOK I Chapter 8: Electric actuators
L12	Servo motor, Stepping Motor, Encoder	BOOK I Chapter 8: Electric actuators Chapter 5: Encoder
L13	HMI Introduction, Network component, RS422 and RS485, RS232C, Industrial Ethernet	BOOK V Chapter 1: HMI, PLCs

Lab notes (or Practice Manual)

This section contains lab notes from every chapter of the practice manual, Basic Mechatronics Workshop, (Practice Manual), 2020."

LAB #	TOPICS	LAB NOTES (PRACTICE MANUAL CHAPTER)
Lab #1	Introduction to Simulation Software ELCO Lab (Practice)	Module 1 Chapter 1
Lab #2	Pilot and Memory control of Pneumatic elements – Use ELCO Lab (Practice)	Module 1 Chapter 2
Lab #3	Sensor Circuits, Power and Constant voltage, Detector, Amplifier, Display, Output (Conference of Presentation)	Module 2 Chapter 1
Lab #4	Sensor Interface, NPN and PNP Type, Lamp control (Practice)	Module 2 Chapter 2
Lab #5	PLC Hardware Configure, Power and CPU, Base, Input, Output, Special Module (Conference of Presentation)	Module 3 Chapter 1

LAB #	TOPICS	LAB NOTES (PRACTICE MANUAL CHAPTER)
Lab #6	a and b contact, coil, Compare of Pneumatic circuit and PLC circuit (Practice)	Module 3 Chapter 2
Lab #7	Use Logic circuit, YES and NOT, AND, OR, use sensor of lamp control (Practice)	Module 3 Chapter 3
Lab #8	Pneumatics Cylinder control, Single acting cylinder and Double acting cylinder, single solenoid valve, double solenoid valve (Conference of Presentation)	Module 4 Chapter 1
Lab #9	Pneumatics control circuit, single and double solenoid valve, use sensor (Practice)	Module 4 Chapter 2
Lab #10	PLC use cylinder control, ON first Self holding circuit and OFF first Self holding circuit (Practice)	Module 4 Chapter 3

LAB #	TOPICS	LAB NOTES (PRACTICE MANUAL CHAPTER)
Lab #11	DC motor control, Run / Stop control, CW control, CCW control, use sensor (Practice)	Module 4 Chapter 5
Lab #12	AC motor control, Main circuit design, control circuit (Practice)	Module 4 Chapter 6
Lab #13	Network component, RS422 and RS485, RS232C, Industrial Ethernet (Conference of Presentation)	Module 5 Chapter 1