EIND 371 Learning Objectives, Part 1

By the end of CHAPTER 1, students should be able to:

- Define three categories of manufacturing systems according to the role of human participation.
- Define three types of automation, and when they are most suitable.
- Explain at least six reasons why automation is used in production, as well as discuss reasons why a company would choose not to automate.
- Explain the USA principle.

By the end of CHAPTER 4, students should be able to:

- Define automation and the basic elements of an automated system.
- Explain the difference between open-loop and closed-loop control systems, and describe examples of each.
- Describe the five levels of factory automation.
- Explain some of advanced automation functions related to error detection and recovery, maintenance, and safety.

By the end of CHAPTER 5, students should be able to:

- Define continuous variable, discrete variable, and binary variable.
- Explain the difference between continuous and discrete control, and continuous (or analog) versus discrete sensors and actuators, with examples.
- Describe how feedforward control differs from regulatory (or feedback) control.
- Explain what polling is in computer control of processes, with examples.
- Explain what an interrupt is in computer control, with examples.
- Explain what an interlock is in computer control, with examples.
- Discuss at least four levels of computer process control: process monitoring, machine control, supervisory control and distributed control.

By the end of CHAPTER 6, students should be able to:

- Describe the roles of sensors, actuators, digital-to-analog converters (DAC) and analog-to-digital converters (ADC) in a closed-loop, computer controlled system.
- Determine the digital output of an analog-to-digital converter (ADC) given an analog input signal using the successive approximation method.

- Determine the analog output of a digital-to-analog converter (DAC) given a digital input signal, assuming a reference voltage and zero-order hold.
- Calculate the accuracy and resolution of an ADC and a DAC, and explain what these measures mean.

By the end of CHAPTER 7, students should be able to:

- Define the two most common coordinate systems used in numerical control (NC).
- Define the two most common motion control strategies used in NC systems.
- Describe what interpolation is in NC systems, and several types of interpolation.
- Describe how absolute positioning is different than relative positioning.
- Describe six situations in which the use of NC technology is more suitable than conventional machines.
- Discuss the advantages and disadvantages of NC over manual machining operations.
- Outline the basic workflow required to fabricate a part on a CNC machine, from 3D solid model of the product model to finished part, using computer-aided manufacturing software such as GibbsCAM.
- Use the mathematical relationships between step angle, pulse frequency, motor speed, leadscrew pitch, and gear ratios to evaluate the performance parameters of open-loop and closed-loop numerically controlled positioning systems (e.g., table feed rate, control resolution, accuracy).
- Calculate the machining parameters of spindle speed, feed rate, depth of engagement and material removal rate of NC milling and turning operations given cutting speed and cutter geometry.
- Identify the various elements comprising the production cycle time of a simple NC operation, and calculate an estimated cycle time to produce a given quantity of parts.

EIND 371 Learning Objectives, Part 2

From the lectures and lab on ADDITIVE MANUFACTURING, students should be able to:

- Outline the general approach used in additive manufacturing, and describe at least five additive manufacturing technologies in use today.
- Describe the basic workflow of the programmer to create a 3D printed part from a solid model.
- Explain when additive manufacturing is advantageous for part fabrication relative to CNC machining, and when it is not; including calculating the breakeven point.

By the end of CHAPTER 8, students should be able to:

- Discuss where robots are most usefully deployed in industry.
- Describe the typical architecture of an industrial robot, along with common configurations and joint types.
- Describe the three robot programming modes, and the relative advantages of each.
- Differentiate between at least four different coordinate systems used in robot programming.
- Define the two interpolation strategies used for moving between taught points.
- Parse a robot motion instruction in FANUC programming language.
- Write robot programs to accomplish simple robot tasks that include robot motions, interference avoidance, programming loops and digital inputs.
- Estimate work cycle times for robot tasks.
- Define and calculate control resolution, accuracy and repeatability as these terms apply to robots, and discuss how they relate.
- Describe common hazards associated with robots, and common safety precautions used to protect operators, programmers, and bystanders.

By the end of CHAPTER 9, students should be able to:

- Define the functions of the six basic Boolean operators: AND, OR, NOT, NAND, NOR and XOR.
- Create a logic statement from both a simple combinatorial circuit diagram and a truth table; and similarly create a truth table from a circuit diagram and a logic statement.
- Simplify Boolean expressions involving 2-5 binary variables by applying Boolean identities.
- Describe the typical PLC architecture, and explain why a PLC is especially suited for industrial automation.
- Describe appropriate applications for a PLC.
- Implement the basic Boolean operations in ladder logic.
- Use a systematic method to develop and evaluate ladder logic programs for simple production control problems using NO and NC contacts.

EIND 371 Learning Objectives, Part 3

By the end of CHAPTER 9, students should be able to:

- Describe how the DN, EN and TT bits behave for TON, TOF and RTO operations of the Allen-Bradley SLC 500 PLC using a timing diagram.
- Describe how the DN and OV bits behave for CTU and CTD operations of the Allen-Bradley SLC 500 PLC using a timing diagram.
- Predict the output states of a ladder logic program given a set of input states, both logically and in the form of a timing diagram. The ladder program could include: normally open (NO) and normally closed (NC) contacts, parallel paths, latched outputs, counters, and timers.
- Find errors in logic or syntax in a given a ladder logic program.
- Use a systematic method to develop ladder logic programs for simple production control problems using NO and NC contacts, counters and timers. Similarly, use a systematic method to evaluate ladder programs, including the creation of system state tables.

By the end of CHAPTER 19, students should be able to:

- Define what a flexible manufacturing system (FMS) is, and describe when it is most useful relative to hard automation and manual operations.
- List and explain criteria for how “flexible” an FMS is.
- Explain three common levels of FMS.
- Identify and describe the core components of any FMS, and several common configurations.
- Define the difference between a primary handling system and secondary handling system, and explain the benefits of having a secondary handling system.

By the end of CHAPTER 22, students should be able to:

- Identify the difference between two basic categories of inspection: contact versus non-contact.
- Define what a coordinate measuring machine is and does.
- Define and use the basic machine vision terminology, e.g., image acquisition, digitization, image processing, frame, illumination, segmentation, thresholding, edge detection, feature extraction, template matching, etc.
- Describe appropriate applications of machine vision.

Additionally, by the final exam, students should be able to:

- Apply systematic problem-solving approaches to the challenges of computer integrated manufacturing technologies.
- Write adequately detailed verification procedures to test engineering solutions and document the results.