PATHWAY TO LEARNING ENGINEERING

Engineering research and development

A secondary or postsecondary school course featuring NX X Essentials and the TIA Portal

Technical content standards

Developing and documenting ideas

- Apply intellectual property rights concepts to select and document an original idea
- Document original ideas correctly to prove original work in developing the idea
- Design research to inform decisions made for developing intellectual property
- Document original research to analyze, apprise and revise research investigations
- Analyze methods of protecting intellectual property to create a plan for protecting the creation and manufacturing of a product
- Apply divergent and convergent thinking to provide fresh ideas during the creation process
- Create and maintain an engineering notebook for research, prototype creation, documentation and daily reflections
- Apply engineering design and problem solving as an iterative process, incorporating science, mathematics and engineering to optimally convert resources to meet a design solution
- Communicate design solutions using technical writing skills, including correct spelling, proper grammar and accurate technical vocabulary
- Prepare a quantitative plan for completing a project
- Assume leadership responsibility for collaborative team actions and decisions related to completing a project

- Evaluate the needs and costs of resources necessary for completing a project
- Prepare and communicate model documentation to include details like product analysis, size, materials, assembly details, schematics, program design, installation and service requirements

Entrepreneurship and business

- Apply lean startup concepts to create a plan for a new venture or introduce a new product for an existing company
- Research and create a business plan for creating a new product
- Design a feasibility study to gain insights for judging the demand for a new product idea
- Create a marketing plan for introducing and promoting demand for a new product
- Critique issues with a business plan to identify and implement changes to better respond to public demand
- Research and categorize activities that a business conducts to make discoveries that can lead to developing new products or procedures or to improving existing products or procedures
- Research and evaluate new approaches for rapidly developing and deploying products that save time and are more efficient
- Review and evaluate a plan's benefits for an assembly line or workcell
- Create a strategy to increase efficiency and decrease waste by receiving inventory in time for the production process to reduce costs and the use of natural resources
- Create a management plan including quality planning, quality control, quality assurance and quality improvement for an advanced manufacturing environment
- Apply the concepts of lean manufacturing to create a dynamic, growing enterprise producing high-quality products in teams when creating a business plan

Lean design

- Apply the concepts of design for quality to optimize designing a new product or innovation to an existing one
- Analyze the feasibility study results to create a product design to better meet the needs of potential customers
- Apply concurrent engineering to the product design for faster development and production
- Conduct a failure analysis to identify issues and solutions for creating a product
- Create a cradle-to-cradle plan for the eventual disassembly and resource recovery of a product
- After conducting customer surveys, teams revisit the surveyed customers to critique how effective the designs were in meeting their needs
- As a component of their testing protocol, teams incorporate customer input to formulate improvements for better serving their customers in the future
- Teams analyze how well their product design meets customer needs as a component of the marketing plan
- Teams design automated systems to statistically analyze parts of their product design to gauge manufacturing accuracy, how well their selected materials and design perform and how attractive it is to various consumers

Designing for manufacturing

- Apply the principles of design for manufacturing, enabling the efficient and effective production of products
- Develop a logical argument for organizing the tools, machines and labor necessary to produce finished goods from raw materials
- Create a strategy to increase efficiency and decrease waste by receiving goods that are needed in the production process, lowering inventory costs and reducing the impact of consuming water and other natural resources
- Create a plan for protecting the safety, health and welfare of people engaged in the manufacturing environment
- Create technical drawings with proper dimensional tolerances and limits for components
- Teams analyze their designs to identify stresses and forces that apply to the parts and then select the printing process material and how the layers are applied to create the strongest part that is easy to print
- Understand and apply statistical process control (SPC) for quality control
- Research and apply knowledge of material properties to product design and development

Designing for assembly

- Apply the engineering design of components to assure alignment for assembly
- Create a management plan that includes quality planning, quality control, quality assurance and quality improvement for an advanced manufacturing environment
- Research, construct and evaluate a plan for an assembly line or workcell

Lean manufacturing

- Analyze a product design, select the most appropriate type of manufacturing and design a method for producing and assembling parts
- Synthesize information about customer demand and design a manufacturing method to produce components efficiently
- Investigate value, value stream, flow, pull (customer orders), eliminate waste and achieve perfection to design an appropriately sized function to produce parts and maximize profits
- Teams critique using additive manufacturing (AM) design components with the goal of supplying components when they are needed against other methods of manufacturing those components to realize savings and provide an uninterrupted flow of parts to the manufacturing process
- Teams create a plan for manufacturing their product using lean principles, allowing people working on the product to give input on all aspects of the process to improve efficiency
- Apply just-in-time (JIT) principles to streamline a production process and eliminate waste
- Create a process map for the product to streamline processes and effectively improve the flow
- Teams analyze their manufacturing process to create a plan to use artificial intelligence (AI) to improve the accuracy of the manufacturing process
- Apply various techniques to lower work-in-process (WIP), needed floor space, travel distances and inventory buildup, reducing the space necessary to produce products
- Design a data collection system to collect and analyze information about production processes
- Use instruments accurately to make precise measurements to meet plan specifications, achieving the required dimensions, shapes, location of centers, parallel surfaces and other component attributes
- Understand and apply SPC to better inform the Six Sigma analysis of a product
- Create a plan for protecting the safety, health and welfare of people engaged in the manufacturing environment

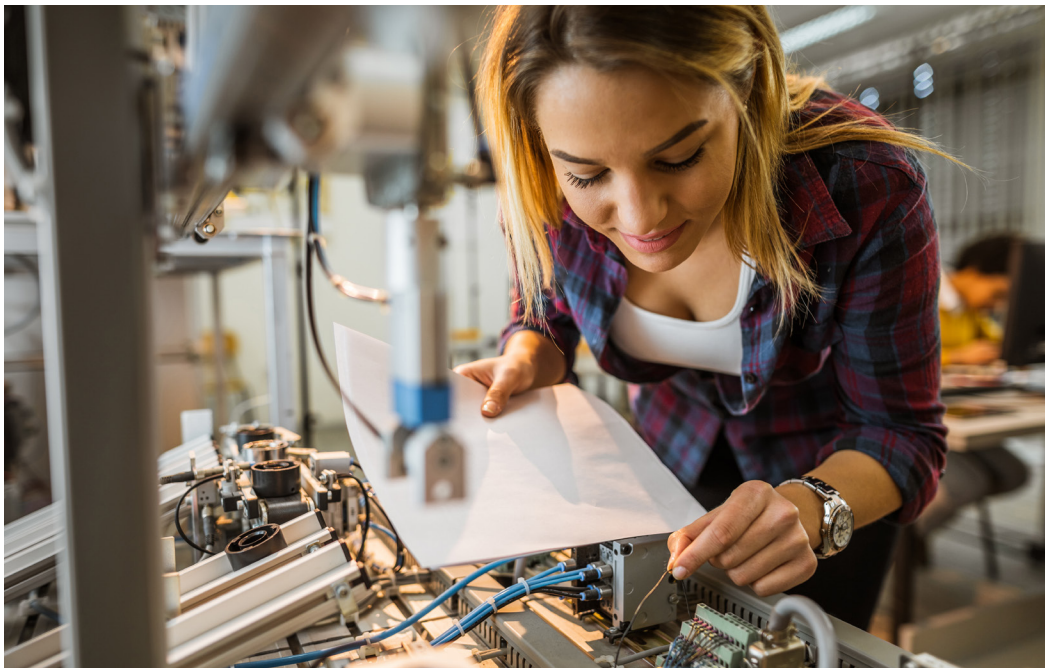
Reverse engineering

- Apply design principles, which include accommodating disassembly and resource recovery
- Research and apply current business practices that lead to new product development or improve products or procedures, including the use of rapid development and deployment to be faster to market
- Analyze an existing product's design attributes by disassembling it into its parts, using precision measuring tools to create sketches and drawings of the parts, identifying the materials and processes used during manufacturing and creating a new and improved design
- Use convergent modeling to capture data and rapidly create new parts to fit existing scans
- Collaborate with teams to combine models and parametrically create solutions
- Use rapid prototyping/additive manufacturing to create highly complex parts designed in a computer-aided design (CAD) system

Electrical and control systems

- Design and analyze an electrical system to efficiently convert, transform and transmit electricity to where it is needed
- Create, read and analyze schematics and provide a concise summary for documentation purposes
- Research and specify the electrical devices necessary to provide power
- Apply machine control systems, sensory feedback and information processing to increase efficiency and productivity in manufacturing
- Teams discuss the sensors they need for gathering data to guide the automation programming to be self-correcting, improving quality and limiting downtime
- Use flow charts and state diagrams to apply logic in the design of control programs

- Teams design programming to allow automation to be creative in applying algorithms for effectively controlling the manufacturing process with negligible human intervention
- Design and analyze applying machine control systems, sensory feedback and information processing to increase productivity in manufacturing
- Teams create proportional-integral-derivative (PID) controls for their automation, allowing the program to continually update the algorithms to produce consistent results
- Apply the principles of programming in designing a control system to solve control issues
- Apply flow charts and state diagrams to design problem solutions
- Create programming to control systems with minimal human interaction
- Create user interfaces (UIs) that display appropriate information to track the functioning of systems
- Select and apply appropriate execution structures for designing control systems
- Design programming to acquire and process data for controlling systems
- Design a system using sensors to monitor changes and use that data to notify the system of changes
- Apply Boolean logic to design a system that monitors input
- Create programs to initialize, calibrate and monitor system parameters
- Select and apply appropriate sensors to obtain data about system performance



- Design a system of elements that manages power to accomplish a task involving defined movement
- Design a control system to vary a motor's speed and performance by using feedback from the system to be as efficient as possible
- Formulate a system that collects and analyzes data to maintain and improve product quality and provide adequate confidence that the product satisfies design requirements
- Create a system to measure and record data about a process
- Design electrical components and other circuits to condition signals from sensors used in the monitoring system
- Specify what hardware is needed to create a system for acquiring the necessary data
- Apply various types of data using the correct format to inform control systems

Manufacturing and automation technology

- Apply Cartesian coordinates to create toolpaths for machine tools
- Research and apply proper cutting tool speeds, feeds and directions for manufacturing
- Create simple numeric control (NC) part programs using a text editor or a computer-aided manufacturing (CAM) package
- Analyze NC part program files to identify and correct errors
- Analyze part geometry to select appropriate cutting tools and fixturing devices to create a part using a computer numeric control (CNC) machine
- Edit the CNC machine program's tool library to establish tool offset values
- Design and prepare 3D models with appropriate units generating toolpaths

- Set up a CAM package by editing the material and tool libraries
- Generate tool paths from a CAD program and edit NC part program files to identify and correct errors
- Design, construct and operate a multi-axis robot for industrial applications
- Design and create wiring diagrams for controlling a robotic arm's motion
- Apply degrees of freedom to describe arm movement for programming the arm
- Integrate a robotic arm into an automated workcell for moving and manipulating components
- Design and create grippers and other end effectors for custom use in an automated setting
- Create a system using sensors to allow a robotic arm to make decisions based on sensor inputs
- Design a system integrating machines, machine tools, specialized dies, jigs, fixtures and instruments used in production to create parts to make jigs, fixtures, alignment and drill guides, gauges and other manufacturing and assembly tools with a rapid prototyping/additive manufacturing device
- Develop a logical argument for selecting the right automation to control tools, machines and the labor necessary to produce finished goods from raw materials
- Research and apply knowledge of material properties to product design and development

Human machine interface (HMI)

- Design visual displays to obtain and display data from a process controlled by a programmable logic controller (PLC)
- Create a system to visualize and remotely control a workcell
- Create a communication system to monitor and automatically capture data on demand for storage in a database
- Design a system to remotely monitor and display real-time machine parameters to change and update operating parameters

Pneumatics design and control

- Construct systems that efficiently use a fluid (liquid or gas) under pressure to generate, transmit and control power
- Design an integrated system of machines, machine tools, jigs, fixtures, instruments and control programs to produce the required parts
- Identify the systems, subsystems and typical components of an automated manufacturing operation
- Apply the necessary safety precautions associated with a fully automated system

Internet of things (IoT)

- Analyze different types of network setups to select the most appropriate for specific tasks
- Compare network operating systems to specify the most appropriate system for data networks
- Synthesize applications for use in gathering, analyzing and displaying data in information environments
- Design and implement a program for device security
- Evaluate various connectivity protocol options for communicating in the design stage of an automated workcell
- Secure the elements of an IoT-connected device
- Teams critique their manufacturing system to identify areas that need defense against cyberattacks and design a system to provide the security necessary to protect the operation while allowing data to transfer between elements of the system and specific operators

Career awareness and development

- Analyze the educational requirements, skills and abilities required for professionals in the referenced career fields
- Research the job outlook, demand for new employees and salary ranges for the referenced careers

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