Industry Certifications – Sample Course Sequence

Overview

The objective of the **Sample Course Sequence** is to assist with a framework with the topics in a suggested sequence to build a curriculum around, or incorporate elements of existing curricula. This is done by utilizing the schools' and teachers' expertise for curricula, facility and materials. For additional detail of specific topics to develop or select curricula around, see the REC Foundation's Pre-Engineering and Robotics Certifications document "**Knowledge and Occupational Skills List**". These documents are designed to work with existing curriculum materials. They may also be utilized in building a curriculum, but they are not a curriculum in and of themselves.

The Sample Course Sequence is broken into two parts:

- **Part One:** The Fundamentals of Engineering Exam: Covers the topics and skills in the Fundamentals of Engineering Module.
- **Part Two:** Pre-Engineering Area Modules: Covers each of the individual eight "Pre-Engineering Area Module" topics and skills for the Pre-Engineering and/or the Robotics Certifications.

Both the **Pre-engineering Certification** and the **Robotics Certification** require passing of the **Fundamentals of Engineering** as a pre-requisite before taking any of the eight modules. Two of the eight modules are required to earn the **Pre-Engineering Certification**. These are selected by the instructor based on community need, available facilities, curricula, equipment and supplies as well as instructor expertise.

Three modules of the eight are required to earn the Robotics Certification: specifically Mechanical, Computer Science/Programming and Electrical. The individual then earns both the Pre-Engineering and the Robotics certification when they pass the third engineering module because at this point they exceed the two areas required for Pre-Engineering.

Pre-Engineering Modules	
Mechanical Engineering	Aerospace Engineering
Electrical Engineering	Chemical Engineering
Computer Science & Engineering (Programming)	Civil Engineering
Engineering Technology	Manufacturing Technology

Part One: The Fundamentals of Engineering

I. Introduction to Engineering

- What is engineering and technology? What is science?
- Types of engineering areas: Electrical, Mechanical, Aerospace, Robotics, Civil, Computer Science, CAD, Manufacturing. Education required for vocational certification to BS, salaries, typical work weeks.
- History of engineering, including timelines from early history until today. Space history, specifically early space programs and the technologies we enjoy today as a result of them. Also includes miniaturization of components and an overview of the history of American and Soviet rockets and astronauts. The Industrial Revolution as the time period of Engineering Societies and development of standards. The development of assembly lines and mass production of products

II. Materials and Processes

- General lab safety
- Basic hand tool and power tool safety and applications
  - Band saw
  - Bench grinder
  - Belt and disc sander
  - Drill Press
  - Portable power tool safety
  - CNC Mill
- Types of metals, properties and common applications
- Types of wood, properties and common application
- Types of plastics, properties and common applications
- Types of epoxies, properties and common applications

III. Engineering Design Process

Document the design process in an Engineering Notebook using the 10-step process:

1) Identify the problem
2) Design brief
3) Research problem
4) Brainstorm solutions
5) Select a solution
6) Design
7) Build
8) Test
9) Redesign
10) Implement solution/product

Industry utilizes many variations or abbreviations of the 10 steps; be able to understand the engineering design sequence in any form.

IV. Engineering Drawings and Computer Aided Drafting (2D and 3D)

- Introduce and practice engineering sketching techniques for orthographic and perspective views.
- Introduce computer aided drafting with available software (Several software options are available for CAD software that are available for free or low cost for education. These include Google Sketch Up, TinkerCad, Autodesk Fusion 360 and Solidworks). Check with product vendors for specific availability and terms of use.
- Introduce parts/materials list with team assignments on how to build a project/robot.
- Introduce equipment that integrates CAD for its operations: computer numerically controlled equipment; milling, laser/plasma cutting, wood working-routing, water jet or 3D printing.

After Introducing the Skills/Knowledge in I-IV

Suggestions and Key Points for Supportive Activities Inclusive of Individual or Several Engineering Areas

After completing activities in areas I-IV, for the remaining areas you can build original or existing curricula into the areas of engineering in any sequence that suites your program to cover all of the topics in the **Fundamentals of Engineering Module** and then your selected **Pre-Engineering Modules** for 150 hours of in-class curricula.

Incorporate hands-on activities utilizing your available curricula, lab, equipment, and materials for each of engineering areas that follow. Activities should be inclusive of the topics covered in that engineering area and be documented in an engineering notebook. Consider assigning each team or individual a PowerPoint presentation documenting the engineering design process. A single activity can easily incorporate multiple engineering concepts and areas while reinforcing topics and skills previously introduced.

For example:

- With available materials, design a robot to pick up a tennis ball and place it in a five gallon bucket autonomously, then remove the tennis ball by driver control. Accomplishing this task will require use of the design process, engineering drawings, and materials and processes; plus knowledge of the fundamentals of mechanical, electrical, and robotics systems and computer science/programming.
- Design a popsicle stick bridge to support 50 pounds using no more than 100 sticks. This involves use of the design process, engineering drawings and materials and processes; and knowledge of the fundamentals of civil engineering and manufacturing.
- Using the available materials of balsa, rubber bands, propellers, and model wheels, design and build a plane (specify max size) to take off and land on its own power and stay aloft for 10 seconds without crashing. This involves use of the design process, engineering drawings and materials and processes; and knowledge of the fundamentals of aerospace engineering.

V. Fundamentals of Mechanical Engineering

- Education required, salaries, work weeks, job duties
- Introduce types of gears, chains, pulleys
- Gear ratio calculations
- Kinetic and potential energy
- Thermal systems applications: Heating and cooling
- Robotics systems

VI. Fundamentals of Electrical Engineering

- Education required, salaries, work weeks, job duties
- Ohms law calculations: amperage, voltage, resistance

VII. Fundamentals of Computer Science / Programming

- Education required, salaries, work weeks, job duties
- Binary and hexadecimal systems understanding
- Basic computer systems: RAM, ROM, FIFO
- Common programming languages: Python, C++, JAVA, HTML
- Evaluating pseudo code, loops and common programming structures

VIII. Fundamentals of Aerospace Engineering

- Education required, salaries, work weeks, job duties
- Bernoulli's principle: lift, thrust, drag, gravity
- Early rocketry history and types of the US and former USSR rocket systems
- Common materials used in the aerospace industry: carbon fibers, aluminum

IX. Fundamentals of Civil Engineering

- Education required, salaries, work weeks, job duties
- Methods of transportation: rail, air, harbor, bridges, rivers/dams
- Efficiency calculations

X. Fundamentals of Manufacturing

- Education required, salaries, work weeks, job duties
- Introduce manufacturing techniques: CNC -- Milling (water jet, plasma, laser), lathe, routing
- Practice Cartesian coordinate calculations

XI. Fundamentals of Robotics

- Education required, salaries, work weeks, job duties
- Applications (in industry, in space, at home)
- Cartesian Coordinates for robotic arm automation (x, y, z)

Part 2: Pre-Engineering Area Modules

The Pre-Engineering Modules are required after passing the **Fundamentals of Engineering Module**. Select any two **Pre-Engineering Modules** required for the Pre-Engineering industry certification with specifically Mechanical, Computer Science, and Electrical for the Robotics industry certification.

I. Mechanical Pre-Engineering Module

- Mechanical advantage
- Rack and pinion
- Simple machines
- Gear ratio calculations
- Newton's laws
- Chain and Sprocket
- Laws of thermodynamics
- Speed and Torque
- Application problems to solve in: Velocity, Acceleration

II. Computer Science (Programming) Pre-Engineering Module

- Common programming languages and related terminologies
- Parts and workings of a computer
- Common programming languages: C++, Python, JAVA, Scratch
  and Common Databases: SQL, Oracle, DB2
- Evaluating pseudo code, loops and common programming structures
- Networking and inter-computer communications
- Binary and Hexadecimal representations of numbers
- Malware and Prevention: Virus, Worm, Denial of Service, Spam, Firewall
- Applications include finding solutions in basic C programming lines and recognizing binary and hexadecimal representations

III. Electrical Pre-Engineering Module

- AM and FM radio frequencies
- Mechanical energy and efficiency
- Motor windings function
- Ohms law calculations
- Basic computer hardware components
- Digital and Analog Sensors and their applications
- Applications include potential and kinetic energy, frequencies, and kilowatt hours calculations

IV. Chemical Pre-Engineering Module

- Chemical reactions and related terminology
- Chemical handling safety
- Familiarize the Periodic Table
- Applications include solutions calculations and gas law calculations

V. Aerospace Pre-Engineering Module

- Basic aerodynamic principles
- Basic rocket design
- Types of clouds
- Applications include Newton's drag calculations, winds aspect ratio, horsepower to wattage calculations, airspeed and velocity calculations

VI. Civil Engineering Pre-Engineering Module

- Common types of bridges
- Common bridge materials
- Various methods of transportation
- Surveying
- Rivers, dams and canals
- Applications include boat hull design calculations, surveying techniques, and bridge efficiency calculations

VII. Engineering Technology Pre-Engineering Module

- Engineering design process/loop
- Practice and know soft skills
- Common manufacturing processes
- Aerospace basics
- Civil engineering basics
- Mechanical systems
- Programming basics
- Common manufacturing materials and their processing
- Engineering drawings
- Applications include engineering design process in multiple configurations, select proper tools for tasks, select proper lab and tool safety situations, and identify missing views of engineering drawings

VIII. Manufacturing Technology Pre-Engineering Module

- Various manufacturing methods
- Engineering drawings with 2D and 3D computer aided drafting systems
- Quality assurance methodsApplications include tensile strength applications, hardness testing techniques, and stress and