PASSAIC COUNTY TECHNICAL INSTITUTE

WAYNE, NJ

PLTW | Engineering

PROJECT LEAD THE WAY 2 CURRICULUM

Revised 2015

Project Lead the Way 2 Curriculum – Overview

I. COURSE DESCRIPTION

Digital Electronics ™ is the study of electronic circuits that are used to process and control digital signals. In contrast to analog electronics, where information is represented by a continuously varying voltage, digital signals are represented by two discreet voltages or logic levels. This distinction allows for greater signal speed and storage capabilities and has revolutionized the world electronics. Digital electronics is the foundation of all modern electronic devices such as smart phones, appliances, laptop computers, digital cameras, high definition televisions, etc.

The major focus of the DE course is to expose students to the design process of combinational and sequential logic design, teamwork, communication methods, engineering standards, and technical documentation.

Utilizing the activity-project-problem-based (APB) teaching and learning pedagogy, students will analyze, design and build digital electronic circuits. While implementing these designs students will continually hone their interpersonal skills, creative abilities and understanding of the design process.

Digital Electronics ™ (DE) is a high school level course that is appropriate for 10th or 11th grade students interested in electrical engineering, electronics, or circuit design. Other than their concurrent enrollment in college preparatory mathematics and science courses, this course assumes no previous knowledge.

Digital Electronics ™ is a specialization course in the Project Lead The Way® high school pre-engineering program. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology.

The goal of this course is to introduce high school students to solving engineering design problems through digital circuit design and creation. Students will build fundamental skill sets and understandings that will transfer to the students designing circuits. The presentation of topics and concepts is meant to align with two historical threads.

- Advancements and improvements made to the circuit design process.
- Advancements and improvements in technology from the invention of the transistor, gates, integrated chips, programmable logic devices, and microcontrollers.

The curriculum is standards-based, aligned with both Common Core and Next Generation Science Standards, and yet is flexible and customizable so that schools and school districts can meet their curricular needs.

Curriculum Design

The PLTW Learning Management System (LMS)

This Learning Management System course instance is intended to be a complete teaching curriculum, not just a guide or an outline. The curriculum is composed of units and lessons. Each lesson contains Activities, Projects, and Problems (APBs). The teacher resource materials for lesson planning and documentation are located in each lesson module on locked pages.

II. COURSE OBJECTIVE/OUTLINE

PCTI CTE Curriculum Unit Planner

Content Area:	Project Lead the Way 2	Grade(s)	10
Unit Plan Title:	Unit 1: Foundations in Electronics	Suggested Time Frame:	9 weeks

Standard(s) Addressed

- **Common Core Writing Standards:**

WHST.9-10.2, WHST.9-10.3, WHST.9-10.4, WHST.9-10.5, WHST.9-10.10

- **Common Core Reading Standards:**

RST.9-10.1, RST.9-10.2, RST.9-10.3, RST.9-10.4, RST.9-10.7, RST.9-10.8, RST.9-10.9

- **Common Core Math Standards:**

N.RN.1, N.RN.2, N.Q .1, N.Q .2, N.Q .3, A.SSE.1, A.SSE.1.a, A.SSE.2, A.SSE.3, A.APR.1, A.APR.6, A.APR.7, A.CED.1, A.CED.3, A.CED.4, A.REI.1, A.REI.2, A.REI.3, A.REI.5, F.IF.4, F.IF.5, F.IF.6, F.BF.4, F.LE.1, F.LE.1.b, F.LE.2.

- **NJCCS -CTE:**

9.3.ST.1-3, 5-6, 9.3.ST-ET.1-6, 9.3.ST-SM.1-4.

- **NJCCS-Technology:**

8.2.12.A.1-2, 8.2.12.B.4, 8.2.12.C.1-5.

Essential Questions (3-5)

1. Why are the safety considerations and best practices associated with working in electronics important?
2. What are the functions of the most common analog and digital components used in electronics? How are the characteristics of digital circuits different than analog circuits?
3. What are the technical skills and processes that are utilized throughout electronics?
4. Why is the understanding of binary and decimal number systems essential to your ability to design combinational logic circuits?
5. What might a design process look like for creating an analog or digital circuit?
6. How are calculations, computer software design (CDS) tools, and measurement tools used in electronics to design, verify and troubleshoot a circuit?
7. Why is the 555 timer design such an important and commonly used design in electronics?

Anchor Text(s)

Project Lead The Way® Curriculum: Digital Electronics ™ © 2014 Charitable Venture Foundation, Indianapolis

Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

Expected Proficiencies

Suggest Time Frame: Level of mastery: I - Introduced, D- Developing, R-Reinforced, M -Mastery

SKILLS TO BE LEARNED	9	10	11	12
Gain knowledge and understanding of electrical lab safety		IDR	R	R
Gain knowledge and understanding of scientific, engineering and SI prefixes	I	IDR	R	R
Gain knowledge and understanding of electrical components		ID	R	R
Gain knowledge and understanding of making presentations	IDR	IDR	IDR	IDR
Gain knowledge and understanding of laws of electricity		ID	R	
Differentiate between digital and analog		ID		
Increase knowledge and understanding of obtaining data through internet research	ID	DR	DR	DR
Gain knowledge and understanding of integrated circuit specification data sheets		ID		
Gain an understanding of various number systems		ID		

Writing Assessments (1-3)

Engineering Notebook, Activity Conclusion Questions.

Resources *(software, videos, career exploration-related activities)*

Multisim Education Version 12.0, NI Elvismx, PLTW Learning Management System (LMS), Microsoft Office Professional Plus 2010.

PCTI CTE Curriculum Unit Planner

Content Area:	Project Lead the Way 2	Grade(s)	10
Unit Plan Title:	Unit 2: Combinational Logic	Suggested Time Frame:	9 weeks

Standard(s) Addressed

- **Common Core Writing Standards:**

WHST.9-10.2, WHST.9-10.3, WHST.9-10.4, WHST.9-10.5, WHST.9-10.10

- **Common Core Reading Standards:**

RST.9-10.1, RST.9-10.2, RST.9-10.3, RST.9-10.4, RST.9-10.7, RST.9-10.8, RST.9-10.9

- **Common Core Math Standards:**

N.RN.1, N.RN.2, N.Q .1, N.Q .2, N.Q .3, A.SSE.1, A.SSE.1.a, A.SSE.2, A.SSE.3, A.APR.1, A.APR.6, A.APR.7, A.CED.1, A.CED.3, A.CED.4, A.REI.1, A.REI.2, A.REI.3, A.REI.5, F.IF.4, F.IF.5, F.IF.6, F.BF.4, F.LE.1, F.LE.1.b, F.LE.2.

- **NJCCS -CTE:**

9.3.ST.1-3, 5-6, 9.3.ST-ET.1-6, 9.3.ST-SM.1-4.

- **NJCCS-Technology:**

8.2.12.A.1-2, 8.2.12.B.4, 8.2.12.C.1-5.

Essential Questions (3-5)

1. How would you use a design process to convert a set of design specifications into a functional combinational logic circuit?
2. What is the relationship between a combinational logic circuit’s truth table, logic expression, and circuit implementation? Can I describe the process of obtaining either of the first two design items given the third?
3. When you simplify logic expressions using Boolean algebra, how do you know that you have the simplest solution and that the solution is correct?
4. In terms of circuit implementation, what is the advantage of representing all logic expressions in either the SOP or POS form?
5. Why are NAND gates and NOR gates considered universal gates, and what are the advantages of implementing a design with them?
6. What are the advantages of using K-mapping over Boolean algebra to simplify logic expressions?
7. Why is the understanding of number systems and conversion between number systems such as binary, octal, decimal, hexadecimal, and Binary Coded Decimal (BCD) essential to your ability to design combinational logic circuits?
8. Why are binary adders such an important design in digital electronics and how do they work?
9. How can different types of seven-segment displays be integrated into your designs?

10. What is the basic operation of digital multiplexers and de-multiplexers and how can they improve a circuit's design?
11. How is the design process impacted by use of Circuit Design Software (CDS) and Programmable Logic Devices (PLDs)?
12. How are programmable logic devices used to implement combinational logic circuits? What are the advantages and disadvantages?

Anchor Text(s)

Project Lead The Way® Curriculum: Digital Electronics™ © 2014 Charitable Venture Foundation, Indianapolis

Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

Expected Proficiencies

Suggest Time Frame: Level of mastery: I - Introduced, D- Developing, R-Reinforced, M -Mastery

SKILLS TO BE LEARNED	9	10	11	12
Gain knowledge and understanding of circuit design		IDR		
Gain knowledge and understanding of integrated circuits		IDR		
Gain knowledge and understanding of programmable logic devices		ID		
Gain knowledge and understanding of designing binary adders		ID		

Writing Assessments (1-3)

Activity Conclusion Questions, Majority Vote Technical Report, Fireplace Control Circuit Technical Report, Birthday Circuit Technical Report,

Resources *(software, videos, career exploration-related activities)*

Multisim Education Version 12.0, NI Elvismx, Xilinx 14.0, PLTW Learning Management System (LMS), Microsoft Office Professional Plus 2010.

PCTI CTE Curriculum Unit Planner

Content Area:	Project Lead the Way 2	Grade(s)	10
Unit Plan Title:	Unit 3: Sequential Logic		Suggested Time Frame: 12 Weeks

Standard(s) Addressed

- **Common Core Writing Standards:**

WHST.9-10.2, WHST.9-10.3, WHST.9-10.4, WHST.9-10.5, WHST.9-10.10

- **Common Core Reading Standards:**

RST.9-10.1, RST.9-10.2, RST.9-10.3, RST.9-10.4, RST.9-10.7, RST.9-10.8, RST.9-10.9

- **Common Core Math Standards:**

N.RN.1, N.RN.2, N.Q .1, N.Q .2, N.Q .3, A.SSE.1, A.SSE.1.a, A.SSE.2, A.SSE.3, A.APR.1, A.APR.6, A.APR.7, A.CED.1, A.CED.3, A.CED.4, A.REI.1, A.REI.2, A.REI.3, A.REI.5, F.IF.4, F.IF.5, F.IF.6, F.BF.4, F.LE.1, F.LE.1.b, F.LE.2.

- **NJCCS -CTE:**

9.3.ST.1-3, 5-6, 9.3.ST-ET.1-6, 9.3.ST-SM.1-4.

- **NJCCS-Technology:**

8.2.12.A.1-2, 8.2.12.B.4, 8.2.12.C.1-5.

Essential Questions (3-5)

1. What are flip-flops and transparent latches and how do they function to store data?
2. What are some of the differences between synchronous and asynchronous inputs on flip-flops?
3. What are some of the ways a flip-flop can be triggered?
4. What are some of the common applications of flip-flops?
5. How can D flip-flops or J/K flip-flops be arranged in order to create a desired asynchronous clock signal? A desired synchronous clock signal?
6. How would you use a design process to create asynchronous or synchronous counters using small scale integration (SSI) and medium scale integration (MSI)?
7. Why is it important to have a counter/start at specific values?
8. How can an asynchronous counter or a synchronous counter be designed to start and stop/repeat a count at the desired values? Why is it important to have a counter/start at specific values?

Anchor Text(s)

Project Lead The Way® Curriculum: Digital Electronics ™ © 2014 Charitable Venture Foundation, Indianapolis

Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

Expected Proficiencies

Suggest Time Frame: Level of mastery: I - Introduced, D- Developing, R-Reinforced, M -Mastery

SKILLS TO BE LEARNED	9	10	11	12
Gain knowledge and understanding of sequential logic		ID		
Differentiate between types of Flip-Flops		ID		
Gain knowledge and understanding of applications of Flip-Flops		I		
Gain knowledge and understanding of clocking devices		ID		
Gain knowledge and understanding of analyzing timing diagrams		ID		
Gain knowledge and understanding of shift registers		ID		
Gain knowledge and understanding of asynchronous counters		ID		
Gain knowledge and understanding of synchronous counters		ID		

Writing Assessments (1-3)

Activity Conclusion Questions, Now Serving Technical Report, Sixty Second Timer Technical Report.

Resources *(software, videos, career exploration-related activities)*

Multisim Education Version 12.0, NI Elvismx, Xilinx 14.0, PLTW Learning Management System (LMS), Microsoft Office Professional Plus 2010.

PCTI CTE Curriculum Unit Planner

Content Area:	Project Lead the Way 2	Grade(s)	10
Unit Plan Title:	Unit 4: Controlling Real World Systems	Suggested Time Frame:	6 weeks

Standard(s) Addressed

- **Common Core Writing Standards:**

WHST.9-10.2, WHST.9-10.3, WHST.9-10.4, WHST.9-10.5, WHST.9-10.10

- **Common Core Reading Standards:**

RST.9-10.1, RST.9-10.2, RST.9-10.3, RST.9-10.4, RST.9-10.7, RST.9-10.8, RST.9-10.9

- **Common Core Math Standards:**

N.RN.1, N.RN.2, N.Q .1, N.Q .2, N.Q .3, A.SSE.1, A.SSE.1.a, A.SSE.2, A.SSE.3, A.APR.1, A.APR.6, A.APR.7, A.CED.1, A.CED.3, A.CED.4, A.REI.1, A.REI.2, A.REI.3, A.REI.5, F.IF.4, F.IF.5, F.IF.6, F.BF.4, F.LE.1, F.LE.1.b, F.LE.2.

- **NJCCS -CTE:**

9.3.ST.1-3, 5-6, 9.3.ST-ET.1-6, 9.3.ST-SM.1-4.

- **NJCCS-Technology:**

8.2.12.A.1-2, 8.2.12.B.4, 8.2.12.C.1-5.

Essential Questions (3-5)

1. Why are state machine designs used in electronics?
2. What are the common components of a state machine and how are they arranged to make state transitions based on inputs?
3. What are some common everyday devices that are controlled by state machines?
4. Why are microcontrollers such a valuable tool today in electronics?
5. What are the components and processes associated with programming microcontrollers to control real world systems?

Anchor Text(s)

Project Lead The Way® Curriculum: Digital Electronics ™ © 2014 Charitable Venture Foundation, Indianapolis

Informational Texts (3-5) *[career-related readings; journal articles, books, etc]*

The PLTW Learning Management System (LMS)

Expected Proficiencies

Suggest Time Frame: Level of mastery: I - Introduced, D- Developing, R-Reinforced, M -Mastery

SKILLS TO BE LEARNED	9	10	11	12
Gain knowledge and understanding of function of a state machine		ID		
Differentiate between a state graph and a state transition table		ID		
Gain knowledge and understanding of interfacing with input and output sensors in real world systems		I	DR	DR
Gain knowledge and understanding of microcontrollers		ID		
Gain knowledge and understanding of programming microcontrollers		ID		
Gain knowledge and understanding of servo motors		ID	DR	DR
Gain knowledge and understanding of programming to sense and respond to outside stimuli		ID	DR	DR

Writing Assessments (1-3)

Activity Conclusion Questions, Copier Jam Detector Technical Report, Toll Booth Technical Report.

Resources *(software, videos, career exploration-related activities)*

Multisim Education Version 12.0, NI Elvismx, Xilinx 14.0, PLTW Learning Management System (LMS), Microsoft Office Professional Plus 2010.

III. METHODS OF STUDENT EVALUATIONS

Students are evaluated using the following criteria:

1. Projects
2. Class Assignments
3. Technical Reports
4. Presentations
5. Quizzes and Tests
6. Homework
7. Portfolios
8. Attendance

Mastering of the core proficiencies of Project Lead the Way 2 shall be evaluated in accordance with the general grading policies as listed in the student handbook:
Tests/Projects/Portfolio – 40%
PLTW/Shop Activities – 20%
Quizzes – 20%
Homework – 10%
Class Participation – 10%

IV. TEXTBOOKS, INSTRUCTIONAL MATERIALS AND SOFTWARE

Project Lead The Way® Curriculum: Digital Electronics™ © 2014 Charitable Venture Foundation, Indianapolis

Digital Electronics Principles and Applications 6th edition, Tokheim; NY, NY: Glencoe/McGraw-Hill, 2003 (Includes workbook and solutions manual)

Multisim 12.0, © 2001-2012 National Instruments.

Xilinx Tools 14.4 © 2014 National Instruments

Arduino 1.0.5r2 – Open Source

Microsoft® Office Professional Plus 2010, © 2010 Microsoft Corporation

Adobe® Reader® XI, © 1984-2012 Adobe Systems Inc.

V. INSTRUCTIONAL STRATEGIES

Project based learning is used in this course. Projects allow the students to demonstrate understanding of the subject content, engage in meaningful activities, become independent learners, make connections from prior knowledge, use real life technologies and resources, obtain ownership of their learning, and exhibit growth in social skills, self-management skills, and ability to learn on one's own.

Instruction will be given using class notes, prepared worksheets, and activities from Digital Electronics Curriculum 2014. Hands on experience in problem solving (in teams and individually) is used along with circuit design software, technical writing, creating spreadsheets and PowerPoint presentations. Research requiring the internet is included.

VI. SOPE AND SEQUENCE CHART

KEY I = Introduced, D = Developed, R = Reinforced

SKILLS TO BE LEARNED	9	10	11	12
Gain knowledge and understanding of electrical lab safety		IDR	R	R
Gain knowledge and understanding of scientific, engineering and SI prefixes	I	IDR	R	R
Gain knowledge and understanding of electrical components		ID	R	R
Gain knowledge and understanding of making presentations	IDR	IDR	IDR	IDR
Gain knowledge and understanding of laws of electricity		ID	R	
Differentiate between digital and analog		ID		
Increase knowledge and understanding of obtaining data through internet research	ID	DR	DR	DR
Gain knowledge and understanding of integrated circuit specification data sheets		ID		
Gain an understanding of various number systems		ID		
Gain knowledge and understanding of circuit design		IDR		
Gain knowledge and understanding of integrated circuits		IDR		
Gain knowledge and understanding of programmable logic devices		ID		
Gain knowledge and understanding of designing binary adders		ID		
Gain knowledge and understanding of sequential logic		ID		
Differentiate between types of Flip-Flops		ID		
Gain knowledge and understanding of applications of Flip-Flops		I		
Gain knowledge and understanding of clocking devices		ID		
Gain knowledge and understanding of analyzing timing diagrams		ID		
Gain knowledge and understanding of shift registers		ID		
Gain knowledge and understanding of asynchronous counters		ID		
Gain knowledge and understanding of synchronous counters		ID		
Gain knowledge and understanding of function of a state machine		ID		
Differentiate between a state graph and a state transition table		ID		
Gain knowledge and understanding of interfacing with input and output sensors in real world systems		I	DR	DR
Gain knowledge and understanding of microprocessors		I		
Gain knowledge and understanding of programming microcontrollers		ID		
Gain knowledge and understanding of servo motors		ID	DR	DR
Gain knowledge and understanding of programming to sense and respond to outside stimuli		ID	DR	DR

i. PASSAIC COUNTY TECHNICAL INSTITUTE

VIII. STUDENT HANDOUT

PROJECT LEAD THE WAY 2

COURSE OVERVIEW

Project Lead the Way 2 (Digital Electronics) is a full year course developed by Project Lead the Way Inc., the nation's leading pre-engineering middle and high school program. The purpose of Project Lead the Way is to increase the quality and quantity of engineers and engineering technologists graduating from a college program. Digital Electronics is a preparation course for entrance into a college engineering/engineering technology program.

Digital Electronics is a second year course designed to teach students problem-solving skills using a design and development process. Models of product solutions are created, analyzed and communicated using electronic modeling computer design software and a digital trainer.

The skills acquired by the students included problem solving, critical thinking, communication, hands-on experience and teamwork which can be applied to many other fields of study. Through activity, project and problem based activities students demonstrate mastery of skills and knowledge

PROFICIENCIES

1. Students will know and practice proper safety while working with electronics.
2. Students will be able to express numbers in scientific notation, engineering notation, and System International (SI) notation.
3. Students will identify common electronics from part numbers and symbols and identify values using codes and a meter.
4. Students will be able to properly soldering and de-soldering.
5. Students will be able to identify the parts of an atom and determine if an element would make a good conductor, insulator, or semiconductor.
6. Students will use Ohm's Law, Kirchhoff's Voltage Law, and Kirchhoff's Current Law to solve circuits.
7. Students will be able to use a breadboard and digital multimeter to build and analyze circuits

8. Students will be able to determine the amplitude, period, frequency, and duty cycle analog and digital signals.
9. Students will be able to analyze and design circuits and utilize the Circuit Design Software (CDS) to simulate, test, and analyze a complete design.
10. Students will be able to obtain and extract information from the manufacturer datasheets.
11. Students will know the fundamental differences between combinational and sequential logic.
12. Students will identify and describe the function of AND, OR, & Inverter gates and flip-flops.
13. Students will be able to convert numbers between the binary, decimal number, hexadecimal and octal systems.
14. Students will be able to utilize truth tables.
15. Students will be able to use the rules and laws of Boolean algebra.
16. Students will design combinational logic circuits following a formal design process
17. Students will be able to use the K-Mapping techniques to simplify combinational logic problems containing two, three, and four variables and with *don't care* conditions.
18. Students will be able to compare and contrast the quality of combinational logic designs implemented with AOI, NAND, and NOR logic gates and prototype NAND and NOR logic circuits.
19. Students will use a seven-segment display in designs to display alpha/numeric values.
20. Students will use XOR and XNOR gates, and SSI and MSI gates to design and implement binary adders.
21. Students will design circuits using a programmable logic device.
22. Students will describe the function of, and differences between, active high and active low signals, edge triggers and synchronous and asynchronous inputs.
23. Students will be able to draw detailed timing diagrams.
24. Students will be able to analyze and design counters including asynchronous and synchronous.
25. Students will be able to design and build a state machine circuit.
26. Students will create flowcharts for programming and write and debug programs.
27. Students will be able to program and test an autonomous robot.
28. The students will design and build a control system using microcontrollers and sensors.