

CHINO VALLEY UNIFIED SCHOOL DISTRICT
INSTRUCTIONAL GUIDELINES
DIGITAL ELECTRONICS

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| Course Number | 5954 |
| Department | Project Lead the Way |
| Prerequisite | None |
| Length of Course | Two (2) semesters/One (1) year |
| Grade Level | 9-12 |
| Credit | 5 units per semester/10 total credits - elective |
| Repeatable | Not repeatable for credit |
| UC/CSU | Meets the "g" elective requirement |
| Board Approved | July 14, 2011 |

Description of Course – 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 world electronics. Digital electronics is the foundation of all modern electronic devices such as cellular phones, MP3 players, laptop computers, digital cameras, high definition televisions, etc. This course is aligned to the Project Lead the Way Program.

Rationale for Course – The major focus of the Digital Electronics 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 (APPB) 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.

Standard 1 – (Fundamentals of Analog and Digital Electronics) Students understand the different facets of analog/digital signals, engineering notation, and electronic components.

- 1.1 Objective: Learn classroom/laboratory safety guidelines, scientific and engineering notations, component identification, and proper soldering techniques.
 - 1.1.1 Performance Indicator: Students will know and practice proper safety procedures while working with electronics.
 - 1.1.2 Performance Indicator: Students will be able to express numbers in scientific notation, engineering notation, and System International (SI) notation.

- 1.1.3 Performance Indicator: Students will identify many of the common components used in electronics.
- 1.1.4 Performance Indicator: Students will be able to determine a resistor's nominal value by reading its color code.
- 1.1.5 Performance Indicator: Students will be able to determine a resistor's actual value by reading its resistance with a Digital Multimeter (DMM).
- 1.1.6 Performance Indicator: Students will be able to determine a capacitor's nominal value by reading its labeled nomenclature.
- 1.1.7 Performance Indicator: Students will be able to properly tin the tip of a soldering iron.
- 1.1.8 Performance Indicator: Students will use proper soldering/de-soldering techniques to solder and de-solder components on printed circuit boards.
- 1.2 Objective: Learn the basics of circuit theory, circuit simulation and bread boarding, and understanding analog and digital signal characteristics.
 - 1.2.1 Performance Indicator: Students will be able to identify the parts of an atom and determine if an element would make a good conductor, insulator, or semiconductor.
 - 1.2.2 Performance Indicator: Students will use Ohm's Law, Kirchhoff's Voltage Law, and Kirchhoff's' Current Law to solve simple series and parallel circuits.
 - 1.2.3 Performance Indicator: Students will be able to use a Circuit Design Software (CDS) to analyze simple analog circuits.
 - 1.2.4 Performance Indicator: Students will be able to use a bread board and digital multimeter to analyze simple analog circuits.
 - 1.2.5 Performance Indicator: Students will be able to determine the amplitude, period, frequency, and duty cycle of analog and digital signals.
 - 1.2.6 Performance Indicator: Students will be able to analyze and design simple digital oscillators using the 555 timer chip.
 - 1.2.7 Performance Indicator: Students will utilize the CDS to simulate and test a complete analog design.

- 1.3 Objective: Learn the basics of combinational and sequential logic.
- 1.3.1 Performance Indicator: Students will be able to obtain and extract information from the manufacturer datasheets for components commonly used in digital electronics.
 - 1.3.2 Performance Indicator: Students will know how to identify commonly used electronic components given their part number or schematic symbol.
 - 1.3.3 Performance Indicator: Students will be able to identify various Integrated Circuit (IC) package styles.
 - 1.3.4 Performance Indicator: Students will know the fundamental differences between combinational and sequential logic.
 - 1.3.5 Performance Indicator: Students will identify and describe the function of AND, OR, and Inverter Gates.
 - 1.3.6 Performance Indicator: Students will be able to use CDS to simulate and test a simple combinational logic circuit designed with AND, OR, and Inverter Gates.
 - 1.3.7 Performance Indicator: Students will identify and describe the function of a D flip-flop.
 - 1.3.8 Performance Indicator: Students will be able to use CDS to simulate and test a simple sequential logic circuit design with D flip-flops.
 - 1.3.9 Performance Indicator: Students will utilize the CDS to simulate and test a complete design containing both combinational and sequential logic.

Standard 2 – (Combinational Logic) Students design circuits using combinational logic gates, as well as, apply techniques to simplify complex logic designs. They understand the advantages and disadvantages of programmable logic and discrete logic gates.

- 2.1 Objective: Transform a set of written design specifications into an AND/OR/Invert logic circuit.
- 2.1.1 Performance Indicator: Students will convert numbers between the binary and decimal number systems.
 - 2.1.2 Performance Indicator: Students will translate design specifications into truth tables.
 - 2.1.3 Performance Indicator: Students will extract un-simplified logic expressions from truth tables.

- 2.1.4 Performance Indicator: Students will construct truth tables from logic expressions.
- 2.1.5 Performance Indicator: Students will use the rules and laws of Boolean algebra, including DeMorgan's to simplify logic expressions.
- 2.1.6 Performance Indicator: Students will analyze AOI (AND/OR/Invert) combinational logic circuits to determine their equivalent logic expressions and truth tables.
- 2.1.7 Performance Indicator: Students will design combinational logic circuits using AOI logic gates.
- 2.1.8 Performance Indicator: Students will translate a set of design specifications into a functional AOI combinational logic circuit following a formal design process.
- 2.1.9 Performance Indicator: Students will use CDS and a Digital Logic Board (DLB) to simulate and prototype AOI logic circuits.
- 2.2 Objective: Apply the combinational logic design process.
 - 2.2.1 Performance Indicator: Students will use the K-mapping technique to simplify combinational logic problems containing two, three, and four variables.
 - 2.2.2 Performance Indicator: Students will be able to solve K-maps that contain one or more "don't care" conditions.
 - 2.2.3 Performance Indicator: Students will design combinational logic circuit using NAND and NOR logic gates.
 - 2.2.4 Performance Indicator: Students will translate a set of design specifications into a functional NAND or NOR combinational logic circuit following a formal design process.
 - 2.2.5 Performance Indicator: Students will be able to compare and contrast the quality of combinational logic designs implemented with AOI, NAND, and NOR logic gates.
 - 2.2.6 Performance Indicator: Students will use CDS and a DLB to simulate and prototype NAND and NOR logic circuits.

- 2.3 Objective: Design a combination logic circuit, with multiple outputs, and a seven segment display.
- 2.3.1 Performance Indicator: Students will use a seven segment display in a combinational logic design to display alpha/numeric values.
 - 2.3.2 Performance Indicator: Students will select the correct current limiting resistor and properly wire both common cathode and common anode seven segment displays.
 - 2.3.3 Performance Indicator: Students will follow a formal design process to translate a set of design specifications for a design containing multiple outputs into a functional combinational logic circuit.
 - 2.3.4 Performance Indicator: Students will design AOI, NAND, and NOR solutions for a logic expression and select the solution that uses the least number of ICs to implement.
 - 2.3.5 Performance Indicator: Students will use CDS and DLB to simulate and prototype AOI, NAND, and NOR logic circuits.
- 2.4 Objective: Create complex combinational logic designs.
- 2.4.1 Performance Indicator: Students will convert numbers between the hexadecimal or octal number systems and the decimal number system.
 - 2.4.2 Performance Indicator: Students will use XOR and XNOR gates to design binary half-adders and full-adders.
 - 2.4.3 Performance Indicator: Students will use Small Scale Integration (SSI) and Medium Scale Integration (MSI) gates to design and implement binary adders.
 - 2.4.4 Performance Indicator: Students will design electronic displays using seven segment displays that utilize de-multiplexers.
 - 2.4.5 Performance Indicator: Students will use the two's complement process to add and subtract binary numbers.
 - 2.4.6 Performance Indicator: Students will use CDS and a DLB to simulate and prototype specific combinational logic circuits.

2.5 Objective: Utilize a Field Programmable Gate Array (FPGA) to implement a sophisticated programmable logic device.

2.5.1 Performance Indicator: Students will design combinational logic circuits using a programmable logic device.

2.5.2 Performance Indicator: Students will be able to cite the advantages and disadvantages of programmable logic devices over discrete logic gates.

2.5.3 Performance Indicator: Students will use CDS and a DLB to simulate and prototype combinational logic designs implemented with programmable logic.

Standard 3 – (Sequential Logic) Students design synchronous and asynchronous circuits using flip-flops.

3.1 Objective: Implement sequential logic designs using flip-flops.

3.1.1 Performance Indicator: Students will know the schematic symbols and excitation tables for the D and J/K flip-flops.

3.1.2 Performance Indicator: Students will describe the function of the D and J/K flip-flops.

3.1.3 Performance Indicator: Students will describe the function of, and the differences between, level sensitive and edge sensitive triggers.

3.1.4 Performance Indicator: Students will describe the function of, and differences between, active high and active low signals.

3.1.5 Performance Indicator: Students will describe the function of, and differences between, a flip-flop's synchronous and asynchronous input.

3.1.6 Performance Indicator: Students will draw detailed timing diagrams for the D or J/K flip-flop's Q output in response to a variety of synchronous and asynchronous input conditions.

3.1.7 Performance Indicator: Students will analyze and design introductory flip-flop applications such as event detection circuits, data synchronizers, shift registers, and frequency dividers.

3.1.8 Performance Indicator: Students will use CDS and DLB to simulate and prototype introductory flip-flop applications.

- 3.2 Objective: Design and build SSI and MSI asynchronous counters.
 - 3.2.1 Performance Indicator: Students will know the advantages and disadvantages of counters designed using the asynchronous counter method.
 - 3.2.2 Performance Indicator: Students will be able to describe the ripple effect of an asynchronous counter.
 - 3.2.3 Performance Indicator: Students will be able to analyze and design up, down and modulus asynchronous counters using discrete D and J/K flip-flops.
 - 3.2.4 Performance Indicator: Students will be able to analyze and design up, down and modulus asynchronous counters using MSI circuit counters.
 - 3.2.5 Performance Indicator: Students will use CDS and DLB to simulate and prototype SSI and MSI asynchronous counters.
- 3.3 Objective: Design and build SSI and MSI synchronous counters.
 - 3.3.1 Performance Indicator: Students will know the advantages and disadvantages of counters designed using synchronous counter method.
 - 3.3.2 Performance Indicator: Students will be able to analyze and design up, down and modulus synchronous counters using discrete D and J/K flip-flops.
 - 3.3.3 Performance Indicator: Students will be able to analyze and design up, down and modulus synchronous counters using MSI circuit counters.
 - 3.3.4 Performance Indicator: Students will use CDS and DLB to simulate and prototype SSI and MSI synchronous counters.
- 3.4 Objective: Apply the state machine design process.
 - 3.4.1 Performance Indicator: Students will be able to describe the components of a state machine.
 - 3.4.2 Performance Indicator: Students will be able to draw a state graph and construct a state transition table for a state machine.
 - 3.4.3 Performance Indicator: Students will be able to derive a state machine's Boolean equations from its state transition table.

- 3.4.4 Performance Indicator: Students will be able to implement Boolean equations into a functional state machine.
- 3.4.5 Performance Indicator: Students will describe the two variations of state machines and list the advantages of each.
- 3.4.6 Performance Indicator: Students will use CDS and a DLB to simulate and prototype state machines designs implemented with discrete and programmable logic.

Standard 4 – (Microcontrollers) Students program microcontrollers to create fully autonomous robots.

4.1 Objective: Program a microcontroller for a variety of tasks.

- 4.1.1 Performance Indicator: Students will use the Board of Education (BOE – also called a microcontroller) to write programs.
- 4.1.2 Performance Indicator: Students will create a program that utilizes the debug screen.
- 4.1.3 Performance Indicator: Students will create programs that use variables.
- 4.1.4 Performance Indicator: Students will create programs that use various loops.
- 4.1.5 Performance Indicator: Students will create programs that use inputs and outputs.

4.2 Objective: Design and build a fully autonomous robot.

- 4.2.1 Performance Indicator: Students will program a servo motor.
- 4.2.2 Performance Indicator: Students will program and test an autonomous robot.
- 4.2.3 Performance Indicator: Students will use mathematics to calculate programming values.

4.3 Objective: Design and build a fully autonomous robot to maneuver through an obstacle course.

- 4.3.1 Performance Indicator: Students will draw a flowchart for a microcontroller program that will be used to maneuver a robot.

4.3.2 Performance Indicator: Students will program a microcontroller to maneuver a robot through a design course.