

Achievement Level Descriptors for Digital Electronics (DE)

	Basic	Proficient	Advanced
Descriptor	The student demonstrates a minimal or limited understanding of course concepts. Major gaps may be present in the student's knowledge and skills.	The student demonstrates a competent understanding of the course concepts. The student can apply knowledge and skills to familiar situations. There may be minor gaps in the student's understandings.	The student demonstrates a comprehensive and complex understanding of the course concepts. The student has the capability to transfer knowledge and skills to novel situations. Gaps in knowledge and skills are minimal.
Theme or Concept	A student who has reached the highest level of the <u>basic</u> category should be able to perform the following:	A student who has just reached the <u>proficient</u> level should be able to perform the following:	A student who has just reached the <u>advanced</u> level should be able to perform the following:
DESIGN PROCESSES IN CIRCUIT CREATION	Able to recall steps of the design process and work through some of the steps.	Able to implement the design process to design a circuit when guided.	Able to implement the design process to design a circuit.
SAFETY IN THE ELECTRONICS CLASSROOM	Able to recall appropriate safety procedures in the electronics classroom.	Able to demonstrate appropriate safety procedures with instructor guidance in the electronics classroom.	Able to consistently demonstrate and apply appropriate safety procedures.
SOLDERING SKILLS IN THE ELECTRONICS CLASSROOM	Able to solder and de-solder components to printed circuit boards, but requires instructor assistance in identifying bad solder joints.	Able to solder and de-solder components to printed circuit boards with minimal need for troubleshooting by student and minimal assistance from instructor.	Able to solder and de-solder components to printed circuit boards with minimal need for troubleshooting and no assistance from instructor.
SCIENTIFIC AND ENGINEERING NOTATION	Able to convert numbers with the proper notation and minimal errors.	Able to convert numbers and solve calculations with the proper notation and minimal errors.	Able to solve complex calculations using appropriate notation.
NUMBER SYSTEMS	Able to convert values between binary number and decimal	Able to describe the mathematical process for number conversions.	Able to systematically use mathematical processes to

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	systems. Able to convert values between binary number and decimal systems and hexadecimal number systems.		convert any value between any number systems.
CIRCUIT THEORY LAWS	Able to calculate the relationship between voltage, current, and resistance using Ohm's Law. Able to distinguish between a series and parallel circuit. Able to calculate the equivalent resistance for a series or parallel circuit.	Able to calculate voltage, current, and/or resistance for components in a series or parallel circuit. Able to calculate the equivalent resistance for a series or parallel circuit.	Able to calculate voltage, current, and/or resistance for components in a complex circuit. Able to design a circuit to meet voltage, current, or resistance design requirements based on available components.
ANALOG AND DIGITAL SIGNALS	Able to distinguish between analog and digital signals. Able to identify the parts of a waveform.	Able to capture analog and digital signals and characterize the frequency and period of a signal. Able to calculate the parts of a waveform.	Able to select components in a design to produce a desired waveform.
COMBINATIONAL LOGIC DESIGNS	Able to identify the steps of the combinational logic design process.	Able to identify where in the combinational logic design process a student is and determine next steps.	Able to implement the best combinational logic circuit design and provide evidence that a design process was used.
LOGIC GATES	Able to identify a logic gate by its symbol and describe the outputs associated with AND, OR, INVERTER logic gates.	Able to identify a logic gate by its symbol and describe the outputs associated with NAND, NOR, XOR, XNOR logic gates.	Able to apply knowledge of logic gates to select the appropriate gate for the circuit design.
TRUTH TABLES	Able to identify a logic gate by the truth table outputs. Able to identify truth table outputs by the logic gates symbol. Able to create a truth table based on design requirements or written expression of a circuit.	Able to design and implement a circuit design from a truth table.	Able to troubleshoot the design of a circuit by analysis of the circuit and comparison to the truth table.

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	Able to derive a logic expression from a truth table. Able to create a truth table based on analysis of an existing circuit.		
LOGIC EXPRESSIONS	Able to derive an un-simplified logic expression from a truth table. Able to derive an un-simplified logic expression from analysis of a circuit's design. Able to identify and contrast a sum of product expression from a product of sum expression.	Able to convert an un-simplified logic expression between sum of product expressions and product of sum expressions.	Able to translate circuit designs, truth tables, and design requirements into logic expressions. Able to implement a circuit design and troubleshoot existing circuits based on logic expressions.
CIRCUIT SIMPLIFICATION: BOOLEAN ALGEBRA AND DEMORGAN'S THEOREMS	Able to apply Boolean algebra theorems and DeMorgan's theorems to simplify mathematical expressions.	Able to recognize and interpret how Boolean algebra theorems and DeMorgan's theorems simplify a circuit to fewer required components.	Able to apply Boolean algebra theorems and DeMorgan's theorems to simplify circuit implementations during the design phase of a circuit. Able to demonstrate that a circuit is in its simplest and most efficient design through application of Boolean algebra theorems and DeMorgan's theorems.
CIRCUIT SIMPLIFICATION: KARNAUGH MAPPING	Able to construct a Karnaugh Map and relate it to a truth table. Able to simplify a logic expression graphically using the Karnaugh Mapping process.	Able to simplify a logic expression graphically using the Karnaugh Mapping process and defend that the expression is in fact in the simplest form.	Able to simplify a logic expression graphically using the Karnaugh Mapping process with the inclusion of "don't care" conditions and defend that the expression is in fact in the simplest form.
UNIVERSAL GATE IMPLEMENTATION: NAND/NOR	Able to describe the benefit of translating AOI logic designs into NAND only or NOR only designs. Able to describe the relationship	Able to translate AOI logic designs into NAND only or NOR only designs and defend that the circuit is in its simplest form.	Able to determine when NAND only or NOR only implementations are the most efficient design and

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	between NAND gates and AND gates. Able to describe the relationship between NOR gates and OR gates. Able to translate AOI logic designs into NAND only or NOR only designs.		implement effectively into a circuit.
7 SEGMENT DISPLAYS	Able to distinguish between a common cathode and common anode seven segment display. Able to describe the design of a seven segment display and identify the seven segments used to create values on the display.	Able to effectively implement a seven segment display into a circuit design.	Able to effectively implement a seven segment display into a circuit design utilizing seven segment display drivers. Able to determine when a common cathode or common anode seven segment display may perform better in a particular circuit design.
BINARY ADDITION AND SUBTRACTION	Able to add numbers in binary. Able to subtract numbers in binary.	Able to describe two's complement arithmetic process. Able to describe the sign convention (sign bit) used to identify negative binary numbers.	Able to describe two's complement arithmetic process and relate the process to decimal number systems without the use of negative numbers.
BINARY ADDERS AND SUBTRACTORS	Able to distinguish between a half adder and full adder. Able to use an adder/subtractor circuit to verify binary addition or subtraction hand calculations.	Able to create an adder/subtractor circuit.	Able to describe the design of an adder/subtractor circuit related to the carry out and use of XOR gates.
EXCLUSIVE LOGIC GATES: XOR AND XNOR	Able to describe the relationship between OR gates and XOR gates. Able to describe the relationship between NOR gates and XNOR gates.	Able to simplify circuits with the use of XOR/XNOR gates.	Able to describe the function of XOR/XNOR gates in a circuit design.
SEQUENTIAL LOGIC DESIGNS	Able to differentiate sequential logic design from combinational logic	Able to manipulate a sequential logic circuit to produce a desired	Able to design a sequential circuit based on specific

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	design. Able to describe the structure and function of a sequential logic design in a digital circuit. Able to differentiate between Small Scale Integration (SSI) and Medium Scale Integration (MSI) designs.	output.	design constraints.
CLOCK SIGNALS AND TIMING DIAGRAMS	Able to describe the function of a clock signal in a digital circuit. Able to describe level triggered or edge triggered event. Able to describe the function of a 555 timer circuit.	Able to interpret when changes in input and output events will occur on a timing diagram. Able to describe the role of resistors and capacitors in controlling the frequency of a clock signal in a 555 timer design.	Able to validate circuit design through measurement using a probe/oscilloscope and analysis of timing diagram. Able to design a desired frequency of a clock signal in a 555 timer design.
FLIP-FLOPS	Able to describe the structure and function of D Flip-Flops and J/K Flip-Flops. Able to describe how flip-flops outputs, when linked together, translate into binary counts. Able to identify when a flip-flop is activated by a leading edge or trailing edge clock signal.	Able to manipulate a sequential logic circuit to produce a desired output.	Able to design a sequential logic circuit to produce a desired output.
FLIP-FLOP APPLICATIONS	Able to describe the use of flip-flops in common sequential logic designs such as counters, event detectors, and shift registers.	Able to manipulate flip-flops in common sequential logic designs such as counters, event detectors, and shift registers.	Able to design common sequential logic circuits such as counters, event detectors, and shift registers using flip-flops based on given design requirements.
ASYNCHRONOUS COUNTERS	Able to describe the relationship of the clock signal in an asynchronous design.	Able to identify specific commonly used Medium Scale Integration (MSI) ICs.	Able to design asynchronous counter circuits based on specific design requirements

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	Able to differentiate between Small Scale Integration (SSI) and Medium Scale Integration (MSI) designs. Able to identify if a circuit is counting up or counting down. Able to identify where a count range starts and stops/resets.	Able to identify if a circuit is counting up or counting down utilizing specific, commonly used, Medium Scale Integration (MSI) ICs. Able to identify where a count range starts and stops/resets utilizing specific, commonly used, Medium Scale Integration (MSI) ICs.	using SSI and/or MSI to count up/down, hold/rest, and start/stop counts according to any desired range.
SYNCHRONOUS COUNTERS	Able to describe the relationship of the clock signal in a synchronous design. Able to differentiate between Small Scale Integration (SSI) and Medium Scale Integration (MSI) designs. Able to identify if a circuit is counting up or counting down. Able to identify where a count range starts and stops/resets/hold.	Able to identify specific commonly used Medium Scale Integration (MSI) ICs. Able to identify if a circuit is counting up or counting down utilizing specific, commonly used, Medium Scale Integration (MSI) ICs. Able to identify where a count range starts and stops/resets utilizing specific, commonly used, Medium Scale Integration (MSI) ICs.	Able to design synchronous counter circuits based on specific design requirements using SSI and/or MSI to count up/down, hold/rest, and start/stop counts according to any desired range.
STATE MACHINES	Able to identify and describe the characteristics of a state machine. Able to interpret a state graph. Able to interpret a transition table. Able to translate a state graph into a state transition table. Able to identify the relationship between a state graph, transition table, and final design of a state machine circuit.	Able to manipulate a state graph, transition table, or final design of a state machine circuit to meet a specific design requirement.	Able to design a state machine based on specific design requirements including a state graph and transition table to communicate the design.
MOTOR CONTROL WITH DIGITAL DESIGN	Able to identify the role of an H-bridge in a circuit design requiring motor voltages other than logic	Able to manipulate a voltage divider to create a desired voltage source from a 5V source.	Able to design a circuit with motors as outputs that operate at different voltage

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	voltages. Able to describe the role of a voltage divider to create a 3.3V source from a 5V source. Able to describe how Pulse Width Modulation PWM is used to control a servo's speed and direction.	Able to manipulate Pulse Width Modulation to control a servo's speed and direction.	levels than the logic voltage levels.
PROGRESSION OF ADVANCES IN DIGITAL TECHNOLOGY	Able to identify advancements in digital electronics technology from the invention of the transistor, to the logic gate, to integrated circuits, to programmable logic devices, to microcontrollers.	Able to describe the relationships between transistors, logic gates, integrated circuits, programmable logic devices, and microcontrollers.	Able to select and apply the most appropriate technology for circuit implementation based on specific design requirements.
PROGRAMMING SYNTAX RELATED MICROCONTROLLERS	Able to define the roles of variable, setup functions, and loop functions.	Able to manipulate variables, setup functions, and loop functions to produce a desired result.	Able to create a program to manage inputs and outputs of a microcontroller.
PROGRESSION OF ADVANCES IN DIGITAL CIRCUIT DESIGN	Able to identify advancements in digital electronics design from Boolean simplification, to K-Mapping, to PLD design, to microcontroller design.	Able to distinguish the most appropriate design method for circuit implementation between two design options or approaches.	Able to select and apply the most appropriate design method for circuit implementation based on specific design requirements.

Note: Assume that the higher levels of achievement include all prior columns.