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| **TEXAS CTE LESSON PLAN**[www.txcte.org](http://www.txcte.org) |
| **Lesson Identification and TEKS Addressed** |
| **Career Cluster** | Science. Technology, Engineering, and Mathematics |
| **Course Name** | Principles of Applied Engineering |
| **Lesson/Unit Title** | Basic Electricity and Electronics: Module Two - Basic Electronics |
| **TEKS Student Expectations** | **130.402 (c). Knowledge and Skills**(2) The student investigates the components of engineering and technology systems(B) The student is expected to identify the inputs, processes, and outputs associated with technological systems(C) The student is expected to describe the difference between open and closed systems(D) The student is expected to describe how technological systems interact to achieve common goals(6) The student thinks critically and applies fundamental principles of system modeling and design to multiple design projects(A) The student is expected to identify and describe the fundamental processes needed for a project, including the design process and prototype development and initiating, planning, executing, monitoring and controlling, and closing a project(B) The student is expected to identify the chemical, mechanical, and physical properties of engineering materials(C) The student is expected to use problem-solving techniques to develop technological solutions(D) The student is expected to use consistent units for all measurements and computations |
| **Basic Direct Teach Lesson**(Includes Special Education Modifications/Accommodations and one English Language Proficiency Standards (ELPS) Strategy) |
| **Instructional Objectives** | The student will be able to:* Recall the basic theory behind transistor operation
* Recall how basic atomic structure allows us to create controllable electronic devices
* Demonstrate a basic understanding of the binary number system
* Restate how we use transistors to create logic devices
* Apply the fundamentals of binary logic
* Use tools like the truth table to define logical operations
* Convert back and forth from decimal, binary, and hexadecimal
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| **Rationale** | It is important for students to understand basic electricity and electronic fundamentals and expand their knowledge of DC circuits as an application to transistor circuits to obtain a career in the engineering field. |
| **Duration of Lesson** | Teacher’s Discretion |
| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* | * **Electrons** are particles that orbit the nucleus of an atom.
* Orbits are grouped into energy bands known as **shells**.
* **Valence electrons** contribute to chemical reactions and bonding.
* **Doping** is the process of adding impurities to pure semiconductor material. Thebase region in a transistor is thin and heavily doped.
* **Recombination** is when an electron falls into a hole.
* We create an N-type semiconductor by adding **pentavalent atoms**.
* The term **bias** means a DC voltage applied to control the operation of a device.
* **Holes** are the space in a covalent bond where a shared electron should be. Themajority carriers in P-type semiconductor material are **holes**.
* **Cathode** is the N region of a diode.
* The atom becomes an **ion** when it gains or loses a valence electron.
* **Covalent bonds** are where electrons are shared between two atoms.
* Atoms within a crystal are held together by covalent bonds.
* There are two PN junctions in a **Bipolar Junction Transistor**.
* The **base-emitter junction** is the PN junction that is forward biased in an operating transistor circuit.
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| **Materials/Specialized Equipment Needed** | **Materials Needed:**Recommended but not required: examples of transistors and diodes.**Equipment Needed:*** Computer with access to internet
* Projector
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | This lesson builds on Basic Electricity and Electronics Module 1 - Electricity.Transistor circuits require a basic understanding of DC electricity, so you may have to review some of that material. Make sure students understand Ohm’s Law, and that voltage drops across resistors allow you to calculate current. |
| **Direct Instruction \*** | **SAY:** Different materials have different physical and chemical properties. We all know aboutthe properties of materials like metals or wood, today we are going to learn about the properties of a material we do not see naturally, a silicon crystal.**ASK:** Does anyone know what we use silicon crystals for? (Transistors and other semiconductor materials)**SHOW:** The type of silicon crystal we use in transistor is not found naturally, but many otherforms of silicon are very common. Look at a window. The glass uses a common form of silicon called silicon dioxide. This rock is also made of silicon in the form of silicate minerals.**SAY:** Silicon is the eighth most common element found on earth, but it is rarely found in a pureform. It is most often found in rocks like granite or sandstone, and makes up a lot of the sand found on beaches.**ASK:** Does anyone know what another element silicon is like? (carbon, they both have 4valence electrons).**SHOW:** The periodic table of the elements.**ASK:** See how carbon and silicon fall in the same column? What is carbon used for?**SAY:** Carbon is called an organic material, because it is found in all living organisms. Basiccellular structure is made from carbon, and so is found in trees, plants, and the human body. The same way that carbon makes a structure that living organisms are made of, silicon can make a physical structure that has many useful properties. Our primary interest is how we use it to make something called a semiconductor, which are used to make the transistor that is found in every electronic device. Instructors can use the handouts, and notes to facilitate the lesson. If necessary, it is recommended Instructors make a PowerPoint presentation in conjunction with the following outline.

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| Outline | Notes to Instructor |
| I. Doping is the addition of a different type of atom into the structure created by silicon atoms, the crystal lattice structure.A. Arsenic and antimony are the N type dopantsB. Gallium and indium are used as P type dopantsC. Arsenic and gallium are far more commonD. Doping creates the conductivity in a semiconductorE. More doping means more impurity atoms, and gives more conductivity | Take your time andcover the materialslowly. Try to allowtime for students todigest the information. |
| II. The P and N material are created side by side (not put together) in a photo lithographic process.http://www.appliedmaterials.com/htmat/animated.html |  |
| III. A PN junction is a Diode, which conducts with only one polarity of voltage appliedA. Positive to the PB. Negative to the NC. Used in a rectifier to convert AC voltage to DC Voltage D. A transistor has 2 junctions and 3 layers, but still only conducts in one directionE. A transistor can give what looks like AC out by varying conduction, with the DC bias voltage filtered out using a capacitor |  |
| IV. You can replace a transistor with a switch and the circuit works the same way.A. An “on” transistor has low resistance and a small voltage drop across it (collector to emitter), about 1 voltB. An “off” transistor has high resistance (infinite), and all the voltage is dropped across it with no currentC. The base to emitter junction always has about a .7 (seven tenths) volt drop across it when forward biased | AND gates and ORgates are generally thefirst logic devicesintroduced using atraditional text, weintroduce the inverterfirst because it is oneof the simplesttransistor circuits. |
| V. The definition of logic is that the same thing happens with a specified set of inputs.A. Logic follows specific rulesB. The rules are defined by a truth tableC. Some of the common rules are the AND, OR, and invert functionsD. These simple functions (gates) are placed together in circuits that can perform much more complex functionsE. Important additional logic functions not discussed include DeMorgans Theorem and the Karnaugh Map. | Distribute and go overthe Terms andDefinition handout.Some of thedescriptions needmore detail and the handout triesto describe things insimple terms thatstudents canunderstand. |
| VI. The adder and the memory decoder are two of the most important circuit functions in a computer. They are also simple and easy to understand.A. Most things in a computer perform very simple operations.B. Millions of simple operations performed very quickly provide the power and the versatility of a computer. |  |
| VII. The binary number system and the decimal number system are very similar.1. Each digit has a value that is a multiple of the previous digit (2 in binary, 10 in decimal)
2. A carry works the same way in both number systems
3. Hexadecimal is also the same, but with 16 values can be confusing
4. The letters a, b, c, d, e, f are used exactly like single digit numbers with values 10, 11, 12, 13,14, 15
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*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Guided Practice \*** | Most of the guided practice will come from having you and the students work problems together. The first problems will involve simple transistor circuits. You can calculate voltage drops across resistors until you get to transistor saturation, where all the power supply voltage is dropped across the collector resistor. You will have many more problems involving decimal to binary, binary to decimal, and hexadecimal conversions.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Independent Practice/Laboratory Experience/Differentiated Activities \*** | Students will work on the Problems worksheet. The teacher should go over problems with the students first, but then have the students work problems independently. You should be able to find or make up any number of additional problems for them to work.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Lesson Closure** |  |
| **Summative/End of Lesson Assessment \***  | **Question:** What are the two types of doping?**Answer:** N and P**Question:** How do we created N and P type materials?**Answer:** For N, dope with a tetravalent atom (an atom with 5 electrons in the outer shell).For P, dope with a trivalent atom (an atom with only 3 electrons in the outer shell).**Question:** What are the two characteristics of the depletion region?**Answer:** A charged region with no current carrying particles.**Question:** What are the two characteristics that describe the base region of a transistor?Answer: Thin and lightly doped.**Question:** Which junction is forward biased in a working transistor? Which junction is normallyreverse biased?**Answer:** The base emitter junction is forward biased; the base collector junction is reversebiased.**Question:** What is the truth table for an inverter? An AND gate? An OR gate?**Informal Assessment:**Students should write out definitions, and complete Basic Electricity and Electronics - Module Two: Basic Electronics Problem Worksheet.**Formal Assessment:**Basic Electricity and Electronics Module Two: Basic Electronics Quiz.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **References/Resources/****Teacher Preparation** | **Teacher Preparation:**Read through all the supporting documents.Transistor circuits require a basic understanding of DC electricity, so you may have to review some of that material. Make sure students understand Ohm’s Law, and that voltage drops across resistors allow you to calculate current.**References:*** Goodheart-Willcox, *Electricity and Electronics* by Howard H. Gerrish, William E. Dugger, Jr., Richard M. Roberts
* Cengage Learning Inc./Delmar (2008) *Engineering Design and Introduction*, by John R. Karsnitz, John P. Hutchinson, Stephen O’Brien
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| **Additional Required Components** |
| **English Language Proficiency Standards (ELPS) Strategies** |  |
| **College and Career Readiness Connection[[1]](#footnote-1)** |  |
| **Recommended Strategies** |
| **Reading Strategies** |  |
| **Quotes** |  |
| **Multimedia/Visual Strategy****Presentation Slides + One Additional Technology Connection** |  |
| **Graphic Organizers/Handout** |  |
| **Writing Strategies****Journal Entries + 1 Additional Writing Strategy** |  |
| **Communication****90 Second Speech Topics** |  |
| **Other Essential Lesson Components** |
| **Enrichment Activity**(e.g., homework assignment) | * Have students figure out the truth table for a binary subtractor. Zero minus one involves the concept of a borrow, which must come from the next higher bit value. Working from the truth table for a subtractor, students can make up a circuit which performs the subtraction function
* The two-bit adder can only be used for the least significant bit in an addition. A three-bit adder is far more useful, but more complicated. Have students figure out the truth table for a 3-bit adder (3 inputs, 2 outputs), then see if they can figure out how to build a circuit that performs the function. This will show students that many logic gates are needed to perform even a simple function, and will also show that we need more than the three simple gates introduced so far.
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| **Family/Community Connection** |  |
| **CTSO connection(s)** | Skills USATechnology Student Association (TSA) |
| **Service Learning Projects** |  |
| **Lesson Notes** |  |

1. Visit the Texas College and Career Readiness Standards at <http://www.thecb.state.tx.us/collegereadiness/CRS.pdf>, Texas Higher Education Coordinating Board (THECB), 2009. [↑](#footnote-ref-1)