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Lesson #4 Student Handout

Directions: Students read the prompts and answer in complete sentences in the box to the right.

Section A: Diode Simulation	
Follow the instructions for the PhET diode simulation	
Predict - What do you think will happen if you connect a P-type semiconductor to the negative battery terminal and an N-type semiconductor to a positive battery terminal?	The current will die down because by pushing the charges in the wrong direction the flow would be going in reverse rather than promoting the flow with proper orientation.
What do you think will happen if you connect a P-type semiconductor to the positive battery terminal and an N-type semiconductor to a negative battery terminal?	This would encourage flow in the correct direction, lessen the junction that restricts flow, and have the opposite result of the first simulation proposed.
Observe - Record the results of connecting the N-type dopant to the negative battery terminal and the P-type dopant to the positive battery terminal.	The current begins to flow and moves from a positive to negative with little internal force.
Record the results of connecting the N-type dopant to the positive battery terminal and the P-type dopant to the negative battery terminal.	This creates an increase in internal force and leads to the flow slowing to a stop as the energy is traveling from negative to positive.
Explain - What did you notice about the systems when the dopants were switched? Why do you believe the circuits behaved differently?	I noticed that the systems behaved opposite of each other based on the dopant orientation with the p to positive and n to negative flowing easily and p to negative and n to positive halting. This could be because the p type and n type both push the current in one direction based on where they are plugged in but the diode only functions well one way so if the orientation is pushing against the way the diode wants to slow then the whole system will halt.

Explore:

Section B: Transistors Explained

Watch the video about transistors, and answer the following questions.

Name two primary functions of a transistor.

Acts as an amplifier and a switch

What does doping do to a semiconductor?

Modifies the electrical conductivity by having impurities that alter the charge carried

What is the major difference between a diode and a transistor?

A diode has only one depletion layer between P and N types however a transistor has two layers.

Section C: Why Transistors are Used in Computing

Watch the video, and answer the following questions.

What is the type of logic that most binary computers utilize?

Boolean logic/binary logic

How does a computer make interpretations of "true" or "false?"

true=1 false=0

What did the first computers use to make calculations before transistors?

Vacuum tubes

What are the three components of a Transistor?

Base, collector, and emitter

What are some reasons that transistors replaced vacuum tubes?

Smaller size, faster processing and generates less heat

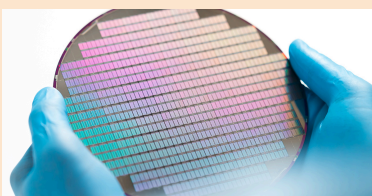
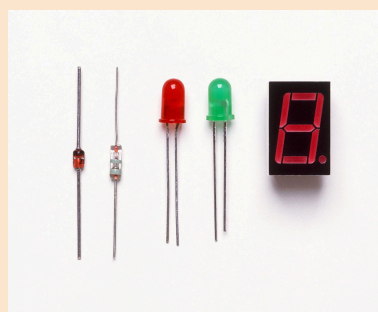
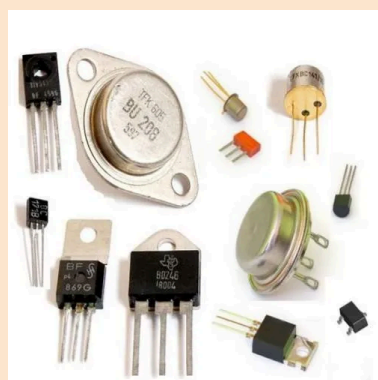
Section D: Logic Gates

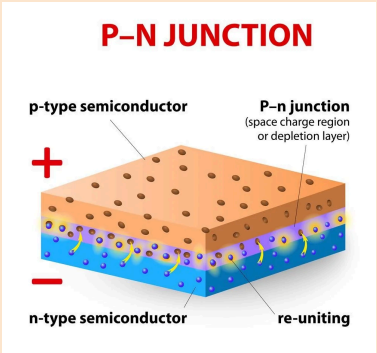
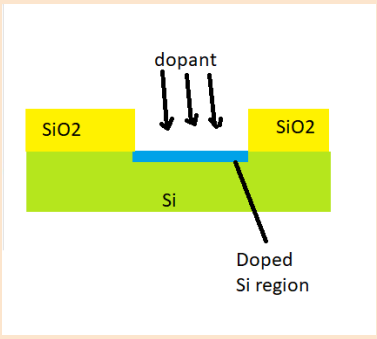
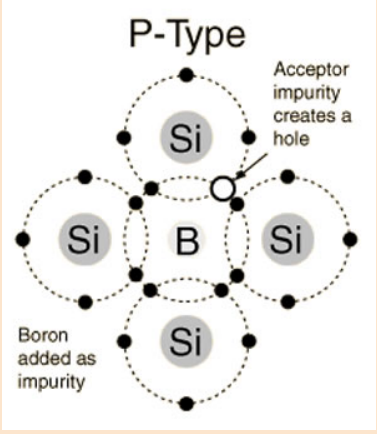
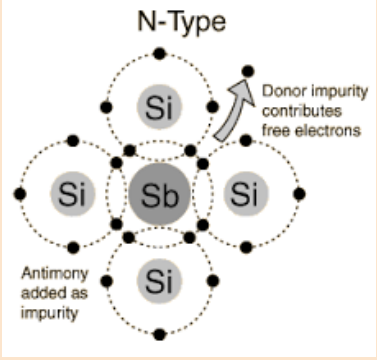
Read the article about Logic Gates and answer the questions below.

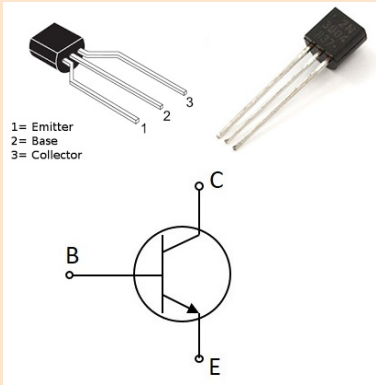
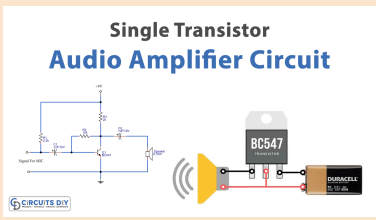
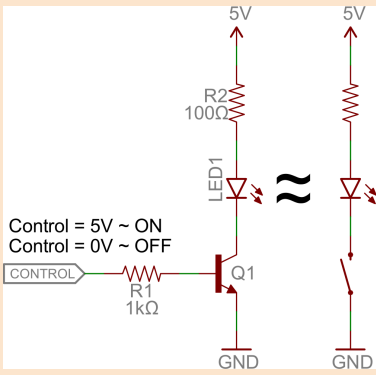
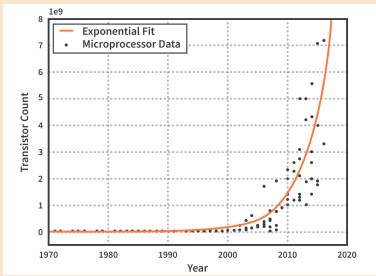
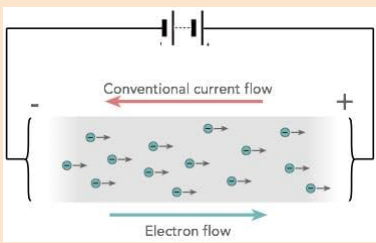
What is a Logic Gate?	Logic gates are constructed by combining transistors in complementary arrangements. They are digital circuits that either allow signals to pass through it or not.
How many types of Logic Gates are there, and what are they?	There are seven types of logic gates. They are AND, OR, NAND, NOR, XOR, XNOR and NOT.
Where does the term “Boolean Logic,” used to describe binary logic systems, come from?	“Boolean Logic” comes from a system of logic gates used to express a relationship. One example of these relationships are true/false, high/low, and on/off.
Section E: Transistors as Building Blocks	
Answer the following questions.	
Amino Acids are the building blocks of:	Proteins
Atoms are the building blocks of:	Matter/molecules
Transistors are the building blocks of:	Semiconductors

Explain:

Section F: Transistor Size	
Watch the video about transistor size and answer the following questions.	
What is surprising to you about the layout of the transistors at the microscopic level?	Precise arrangement of many millions of transistors in a structured pattern
At the time this video was created, how small were we able to create transistors?	At the time the video was created, transistors were three nanometers.
Why are shrinking transistor sizes so important in advancing technology?	More transistors are able to fit and it requires less power to operate

Section G: Moore's Law			
Watch the video about Moore's Law, and answer the questions below.			
In your own words, what is Moore's Law?		Moore's law is the idea that the number of transistors on a chip doubles every year. Not an actual law, just a trend in technological innovation.	
Why do you think that reduction in transistor size is slowing down in recent years?		I think the reason that transistor size is slowing down is the fact that we are approaching the physical constraints of matter and being physically incapable of shrinking the transistors even more	
Do you think that integrated circuits will continue to double in size and complexity indefinitely?		No, I think we will eventually reach a limit or at least a place of diminishing returns where it's no longer reasonable to continue this trend.	
Section H: Academic Vocabulary			
Word	Definition	Image	Description in Own Words
Semicon- ductor	A material that can conduct electricity under certain conditions but not others.		A technology that can be made to conduct electricity when you want it to and is used regularly in modern devices.
Diode	A two-terminal electronic device that allows electric current to flow in only one direction.		A piece of electrical circuits which regulates the way in which current can successfully flow.
Transistor	A semiconductor device used to amplify or switch electronic signals.		A transistor is a small electronic part that can make signals stronger or turn them on or off.

Junction	The boundary between two different types of semiconductors in a transistor.	 P-N JUNCTION p-type semiconductor P-n junction (space charge region or depletion layer) n-type semiconductor re-uniting	The space which exists between different semiconductors and can grow or shrink to impact the level of current.
Doping	The process of intentionally adding impurities to a semiconductor material to alter its electrical properties.	 dopant SiO₂ Si Doped Si region	Doping is when tiny amounts of other materials are added to a semiconductor to change how it conducts electricity.
P-Type	A type of material doped with impurities that accept electrons, resulting in excess positive charge carriers.	 P-Type Acceptor impurity creates a hole Si B Si Si Boron added as impurity	A dopant that accepts electrons and promotes positive charges to be carried and is best connected to positive ends..
N-Type	A type of material doped with impurities that donate electrons, resulting in excess negative charge carriers.	 N-Type Donor impurity contributes free electrons Si Sb Si Si Antimony added as impurity	An n-type semiconductor is a material that has extra electrons added to it, which make it easier to carry more negative charge.

Base	The region of a transistor that controls the flow of current between the emitter and collector.		Part that controls how much current can flow through between the other two parts of the transistor.
Collector	The region of a transistor that collects electrons or holes from the base.		Part that collects electrons that come from the base.
Emitter	The region of a transistor that emits electrons or holes into the base.		Part that sends electrons out into the base.
Amplifier	A device that increases the amplitude of an electrical signal.		A device that makes electrical signals stronger.
Switch	A device that can open or close a circuit to allow or prevent the flow of electrical current.		A device that allows the opening and closing of a circuit that allows electricity to flow through or not.
Moore's Law	The observation that the number of transistors on a microchip doubles approximately every two years, resulting in exponential growth in computing power.		The idea that the number of transistors on microchips doubles every 2 years, leading to faster chips.
Current	The flow of electric charge through a conductor.		The speed of electron flow through a conductor.

Elaborate:

Section J: WebQuest

Read Lesson 1 and answer the following questions.

What are some examples of devices that have become smaller and more compact over the years?

Computer Systems and circuitry. Computers have only gotten smaller and more powerful, and that is a trend that we have seen over the past few decades and will continue to see in the future.

What are some technological breakthroughs that you think might have led to improvements in these smaller devices?

Computer Aided Design, Photolithography and 3D Chip Architecture

Read the Background section of Lesson 2 and answer the following questions.

What do you think Sir Isaac Newton meant by the quote "If I have seen farther than others, it is because I have stood on the shoulders of giants?"

Newton meant that his scientific achievements were built upon the work of previous great scientists and mathematicians.

What examples can you give where others "stood on the shoulders of giants?"

Steve Jobs built on existing technology. So did Henry Ford. He never actually built a car from the ground up, he strung together pre built components to create the car.

What types of electronics interest you?

AI Powered Devices, and how they can be implemented into the everyday lives of normal people.

What do you know about these inventions and their creators?

These inventions are very reminiscent of the needs of the inventors, and are developed in a way that reflects the knowledge and expertise of the inventor.

What skills did these inventors need to have?

One skill that these inventors need to have is the ability to think creatively and outside the box. Especially when trying to create something new, it's a necessity to be able to think in ways nobody else can. The other thing they need is perseverance. Things aren't going to work most of the time, and you need grit to keep going and strive to a working design.

Read Lesson 3 and answer the following questions.

Approximately how large were the original transistors?

When they were first invented transistors were about 40 micrometers.

Why would ENIAC, the vacuum tube equivalent to a computer, require a vast amount of air conditioning to cool it?	So much air conditioning was needed because there were thousands of tubes to cool and these tubes each generated large amounts of heat through use of power.
Read Lesson 4 and answer the following questions.	
When was the first transistor created, and who built it?	The first transistor was created by Bell on December 16th, 1947 by John Bardeen, Walter Brattain, and William Shockley
What function does a P-N Junction provide?	A P-N junction has many capabilities, including the ability to regulate voltage, act as switches, and separate charges.

Evaluate:

Section K: Darlington Pairs	
Follow the instructions for the Darlington Pair lab. Once that is completed, answer the following questions.	
How does a Darlington Pair work?	A Darlington pair combines two transistors where the first transistor's emitter connects to the second transistor's base. This creates a super amplifier.
What do you think one potential use for a darlington transistor is?	You could use a darlington transistor for audio amplifiers and voltage regulators. It has the capability to control large flows of current with very little input current.
How do you think arrangements of different transistors might pertain to logic gates?	The arrangements of different transistors, which are just switches, pertain to logic gates by determining how electrical signals are blocked or passed through a circuit.

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