



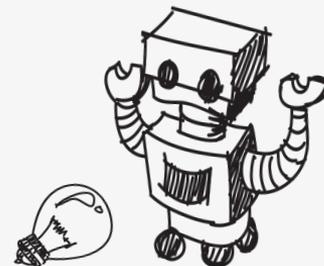
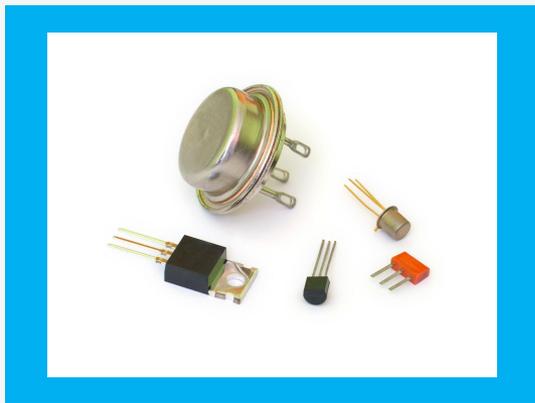
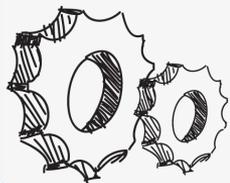
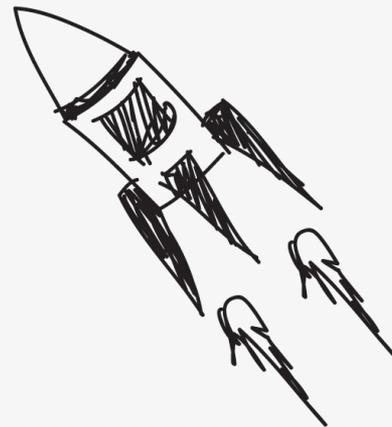
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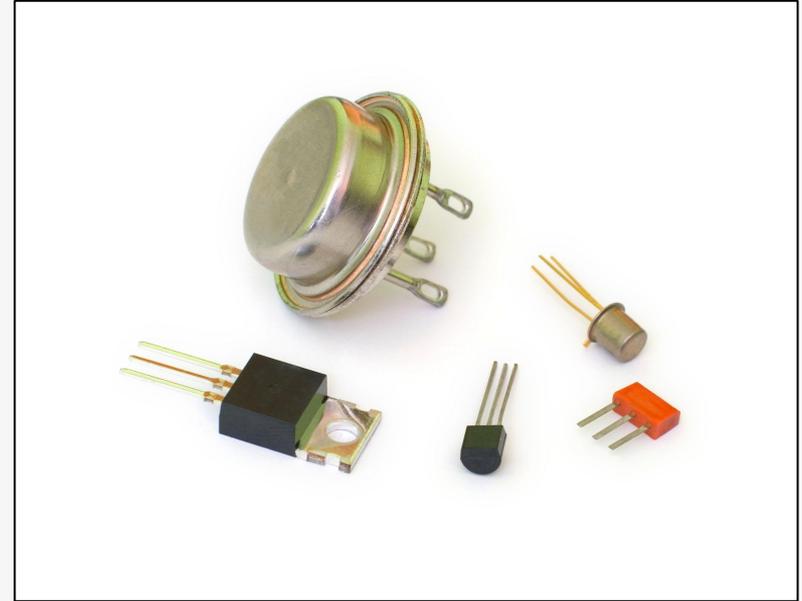
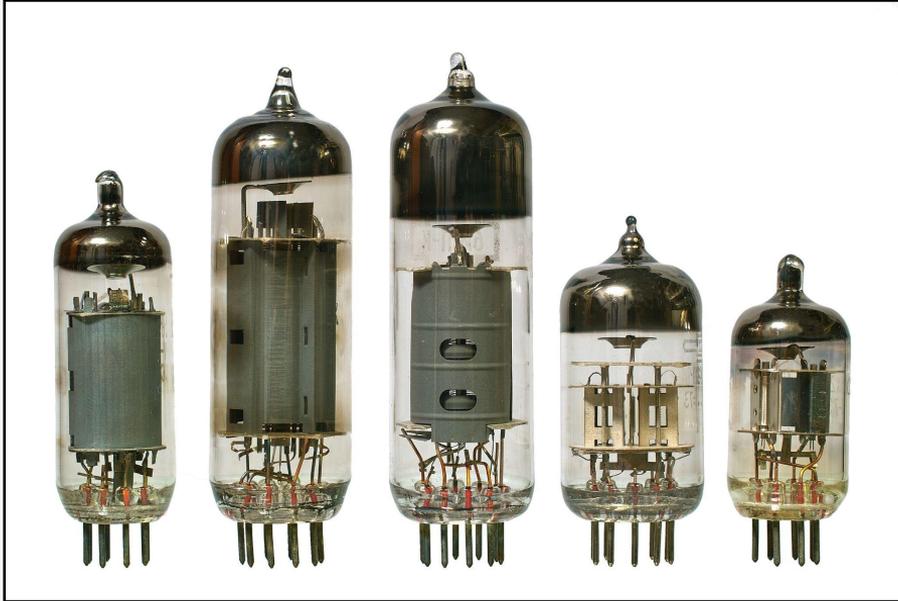


Keysight Lesson

Transistor Power: Night Light Challenge



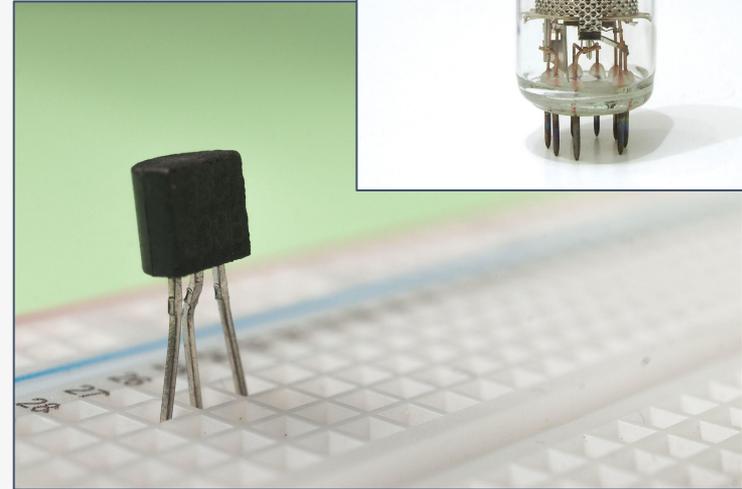
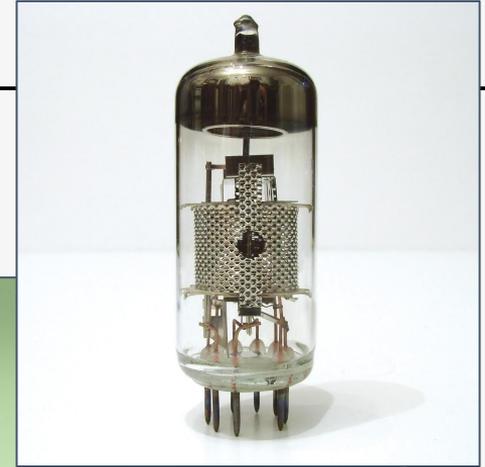
What are these and how are they connected?



Vacuum Tube to Transistor

In 1947, scientists at Bell Labs invented the transistor, a tiny electronic component made from semiconductors.

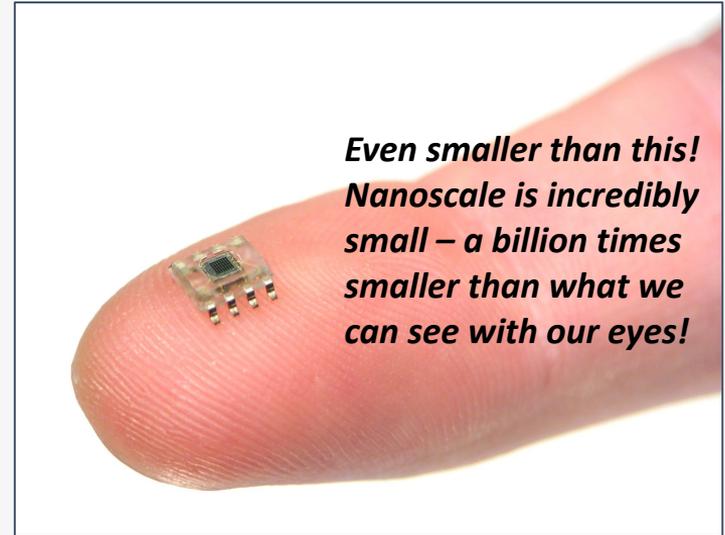
Transistors replaced bulky vacuum tubes (used in radios and telephones) and revolutionized electronics. They're the building blocks of modern devices like computers, phones, and televisions.



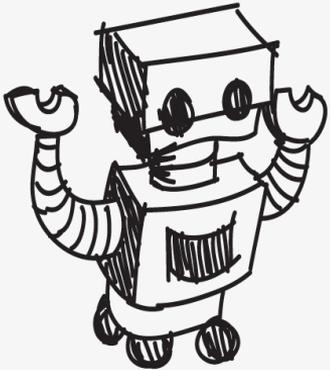
Transistor to Microchip

In the early 1960s, the invention of the integrated circuit (commonly known as a **microchip**) extended the capabilities of the single transistor. To compile an integrated circuit, many transistors are manufactured at once and permanently connected within a single silicon chip.

In the past 50 years, the number of transistors on a chip has grown to more than **one-million on a single chip**. These chips are on a **nanoscale**.



Essential Question:
Why the Transistor?

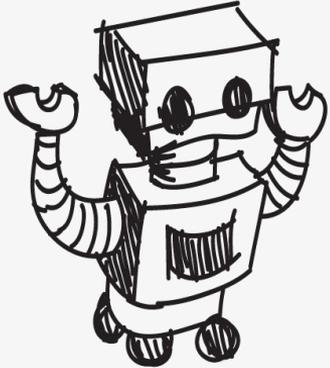


Why the Transistor?

- How has the transistor changed our world?
- Has it changed our world for good?
- Where do we use transistors today?
- What is the future of the transistors?



The Design Challenge



The Design Challenge

Design and construct a functioning night light. When the light goes out in your room your night light goes on. Students design both the circuit and the housing.

Criteria & Constraints

- Use simulation tool (Tinkercad Circuit) to iterate on circuit design
- Transistor & photoresistor must be included in the circuit
- Housing for the night light must include only the material provided



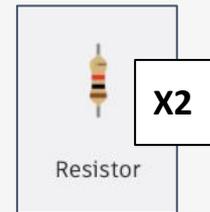
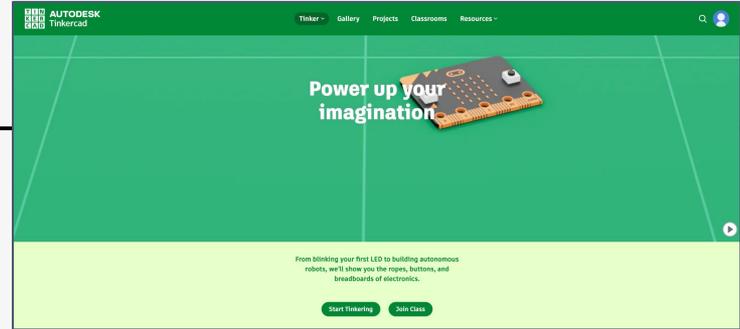
Materials

- Tinkercad Circuits & Computers
- LEDs (10 mm or 5 mm) - any colors
- Photoresistor
- Transistor (NPN)- We used PN2222
- Resistors: 2K Ohm resistor and 100 Ohm resistor (you can play with others as well)
- AA Batteries (4 per team) & Holder
- PlayDough (conductive material) & Clay (non-conductive)- optional
- Table of Possibilities: Creative items are for creating the night light. (pipe cleaners, cups, cardboard, cardstock colored paper, googly eyes, feathers, binder clips, paper clips, tape/glue, scissors, markers, etc). Also play with:
 - Paper circuit material (copper tape, 3V coin cell batteries & holders)



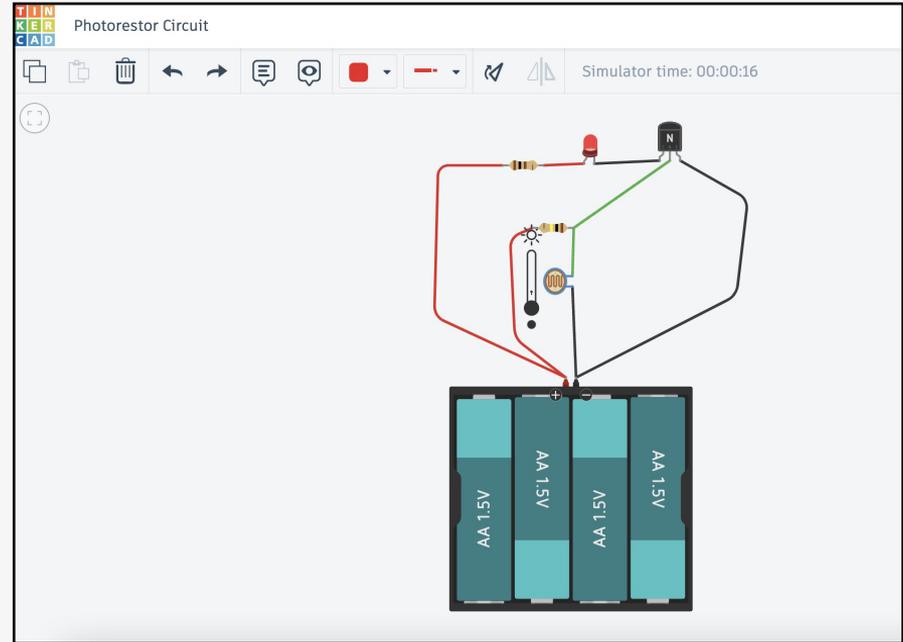
Tinkercad Circuit

- Pull up all the needed parts for the night light & discuss each(see vocabulary list).
- In teams of two (1) Play (2) Test out how to assemble the parts to create a circuit that has the LED light up when it is dark (a night light).
- Come back to the larger group ready to share what you did and if you were successful.



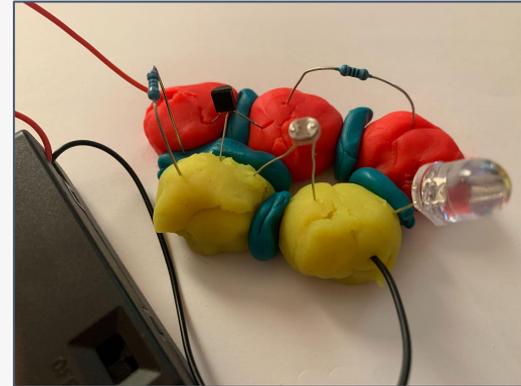
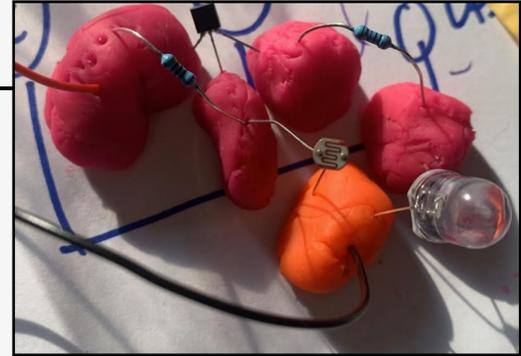
Demo the Creation of the Night Light

- Do you need two resistors?
- What would more power or less power do?
- What would happen if you did not have the transistor?



Night Light with Playdough

- Replicate the Tinkercad circuit using the required material for the playdough circuit. Iterate to get the night light to work
- Test: cover the photoresistor with your hand or place it in a dark area. The LED should light up when it's dark.



Helpful Hints

- Consider Polarity of the LED (long leg is positive)
- Consider using clay to avoid shorts in your playdough circuit
- Typically the flat face of the transistor is the front with the Emitter (left) and Collector (right). It will depend on the transistor you have so check the datasheet to make sure or just flip it if it isn't working.



Night Light Housing Design

Design a housing (cover) for the night light circuit.
See sample (actually a house design out of index cards and marker)

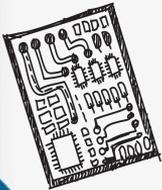
- Consider turning the playdough circuit into a paper circuit with copper tape.



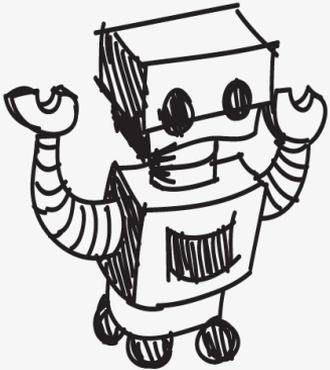
Failure is part of the process

If your circuit does not work, don't worry, we expect that. Engineers fail and they try again and again. So troubleshoot and then redesign until you get your best solution. Failure is part of the process! Have fun!

Ready, Set, Let's Engineer!



Reflect & Debrief

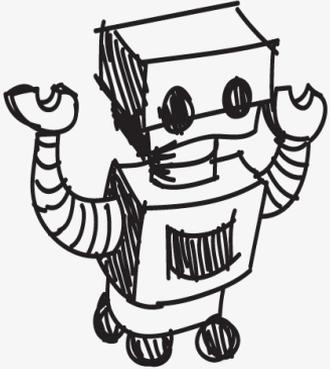


Reflection

- How does the Tinkercad model you made compare to the playdough night light created?
- What challenges did you run into in creating night light? What other tools or materials might have helped you?
- What did you like best and least about your housing?



Engineering Design Process



The Engineering Design Process



Learn about the engineering design process (EDP). The process engineers use to solve problems.
(Video 1:47)



Source: TeachEngineering YouTube Channel <http://www.youtube.com/watch?v=b0ISWaNoz-c>

Engineering Design Process

- Divide into teams of two (or up to 4 max)
- Review the challenge and criteria & constraints
- Brainstorm possible solutions (sketch while you brainstorm!)
- Choose best solution and build a prototype
- Test then redesign until solution is optimized
- Reflect as a team and debrief as a class

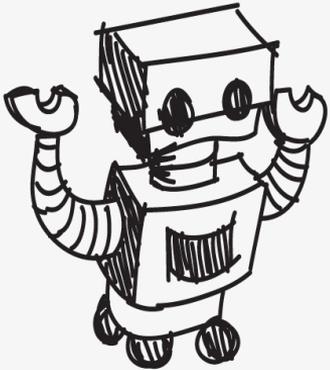


Productive Failure

- The engineering design process involves productive failure: test, fail, redesign. Iterate again and again until you have the best possible solution.
- It is important to document iterations to keep track of each redesign. Use the engineering notebook to sketch ideas, document iterations and any measurement and/or calculations.
- It's also important to showcase the fact that there can be multiple solutions to the same problem. There's no one "right" solution.



Vocabulary



Vocabulary

- **Transistor:** is a switch that can turn things on and off, but with a twist. It can control and amplify electricity. It is made of 3 parts: Base (door that controls the electricity flow), Collector (door electricity comes in through) and Emitter (door electricity goes out)
- **Photoresistor:** is a special kind of electronic part that can “see” light, like a magic eye. It can tell when it’s light or dark. When it’s bright, the magic eye opens wide and lets a lot of electricity flow through. When it’s dark, the magic eye closes and only lets a little bit of electricity flow.
- **P-type Transistor:** (PNP) have positive energy (holes where electrons can move around).
- **N-type Transistor:** (NPN) have negative energy (extra electrons)
- **Amplify:** make a small sound (small signal) into a big sound (big signal). So, if you whisper into it an amplifier, it can make your whisper loud enough for everyone to hear.
- **Automate:** machines/computers do a task instead of people.



Vocabulary

- **Conditional Switches:** are like a special box that does different things based on the switch you flip. If you flip the red switch, it plays music. If you flip the blue switch, it shows a movie. If you flip the green switch, it tells a joke. The box uses a “conditional switch” to decide what to do based on the button you press.
- **Resistance:** is like a roadblock for electricity. In an electrical circuit, resistance makes it harder for the electric current to flow smoothly. This can happen in things like wires or special parts called resistors.
- **Semiconductor:** is a special material that a transistor is made of that is both conductor and insulator of electricity. Sometimes it conducts, sometimes doesn't.
- **Silicon:** is an example of semiconductor material.

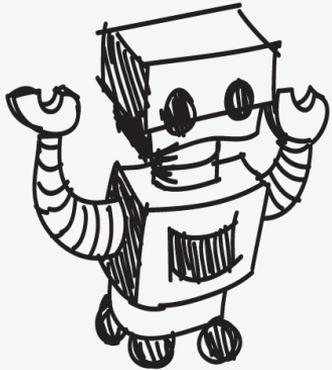


Vocabulary

- **Microchip:** (also known as: semiconductor chip, semi, and chip) – is an integrated circuit (IC) that is etched on the wafers.
- **Nanoscale:** is incredibly small – a billion times smaller than what we can see with our eyes. (For example, chips are made on a nanoscale). There are billions of transistors on a microchip.
- **Moore's Law:** is like a growth spurt for computers! Gordon Moore, the co-founder of Fairchild Semiconductor and Intel, predicted, in 1975, that the number of transistors (tiny switches) on a microchip would double about every two years.



Background Knowledge



So What is a Transistor?

Transistors are the **superhero of electronic parts!** They are made of **semiconductor material** that can either act as a conductor or an insulator giving it its superpower.

Imagine a transistor as a **magic switch** that can turn things on and off, but with a twist. A transistor **helps control and amplify electricity**, making it super important in all the gadgets we use, like phones, computers, and even toys.



Transistors: Teeny Tech that Changes the World

Learn more by watching this video on Vimeo:

[Transistors: Teeny Tech that Changed the World](#)

by Abby Kent (Project for Science and Natural History Filmmaking from Montana State University)



Why Use a Transistor?

(1) **Automate Things:** Imagine you want to turn something on and off really fast, like blinking lights on a toy. A transistor can do this quickly and many times without getting tired.

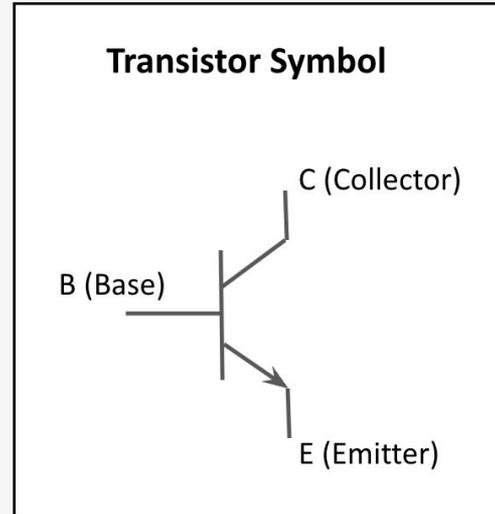
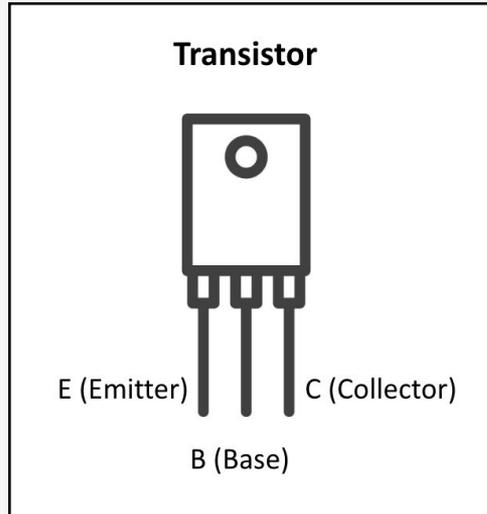
(2) **Conditional Switches:** Think of a transistor like a smart switch. It can turn things on or off based on certain conditions, like turning on a night light when it gets dark.

So, transistors help make things work automatically and smartly!



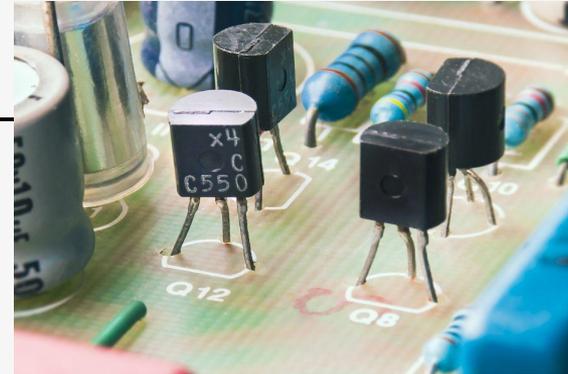
Parts of a Transistor

A transistor has three parts: the Base (B), Collector (C), and Emitter (E). Think of them as different doors:



Parts of a Transistor

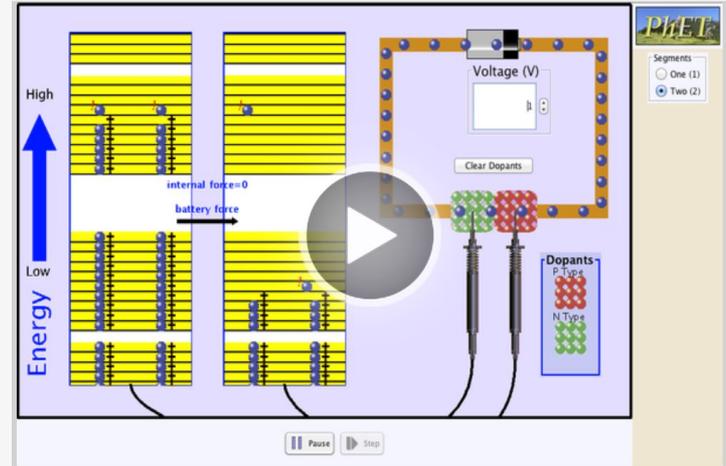
- **Collector (C):** The Collector is the door where electricity comes in. It's not the amplifier itself, but it's part of the path that helps amplify the signal.
- **Emitter (E):** The Emitter is the door where the electricity goes out. It's not the switch, but it works with the Base to control the flow of electricity.
- **Base (B):** The Base is the magic door" that controls everything. When you give it a small push (a tiny electric signal), it can open the other two doors (Collector and Emitter) allowing a bigger flow of electricity to pass from the Collector to the Emitter. Together, they make the transistor turn things on and off and make small signals bigger or amplify them.



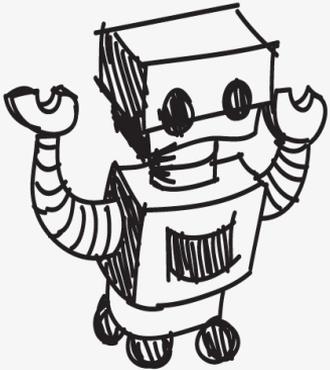
P-Type and N-Type Transistors

There are many different types of transistors. For example, there are N-type (NPN) and P-type transistors (PNP). The main difference is that N-type transistors have negative energy (extra electrons) and P-type transistors have positive energy (holes where electrons can move around).

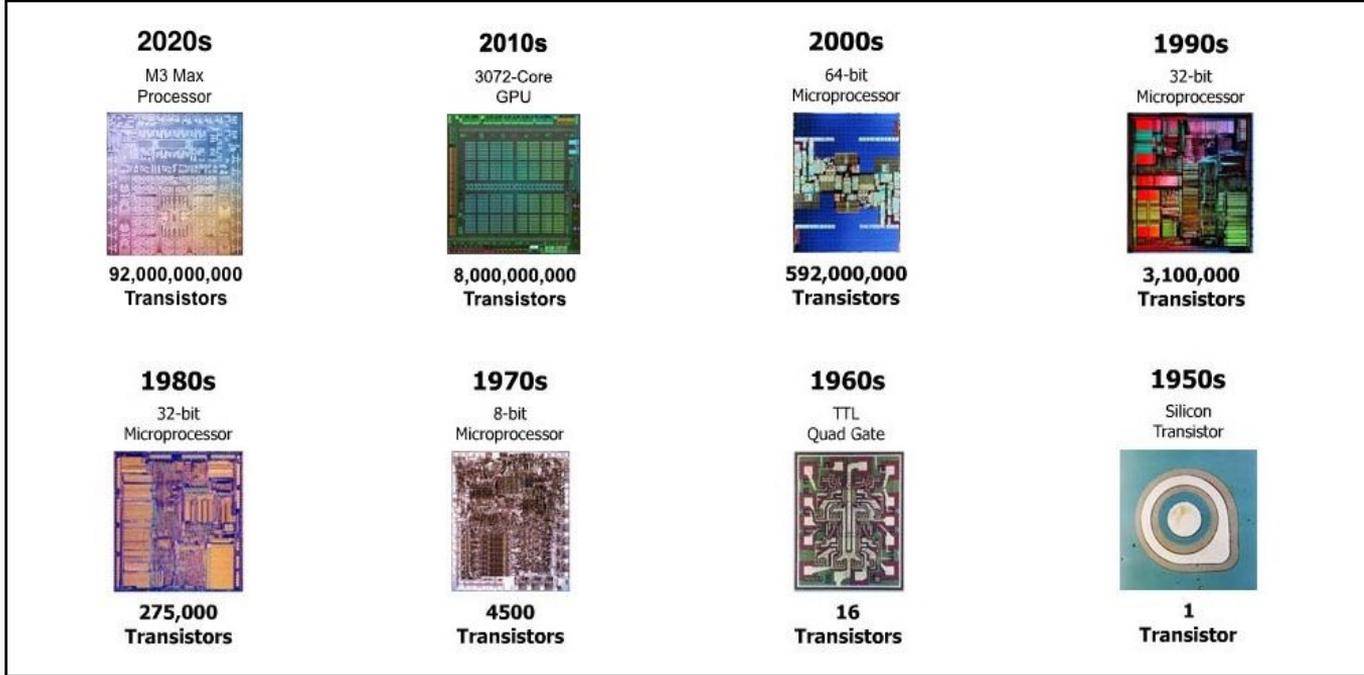
To dive deeper into how the electrons can move in a semiconductor (like our transistor), play the [PhET Semiconductor Simulation](#). Silicon is the most common semiconductor. By adding different atoms to silicon, we can change its behavior.



Dig Deeper



Moore's Law



Moore's Law

Gordon Moore, the co-founder of Fairchild Semiconductor and Intel, predicted, in 1975, that the number of transistors on a microchip would double about every two years (Moore's Law).. That means the chips get smaller and smaller. Imagine it's like your room getting twice as big every two years. This growth helps make computers faster and more powerful. Amazingly, Moore's Law has shown to be true for the last 50 years. (Image Source: <https://www.computerhistory.org/siliconengine/>)

How much smaller can a transistor be? How many might fit on the tip of an eraser in 10 years? Is there a limit to how small a transistor can be? Will Moore's Law last forever?



Dig Deeper (Extension Activities)

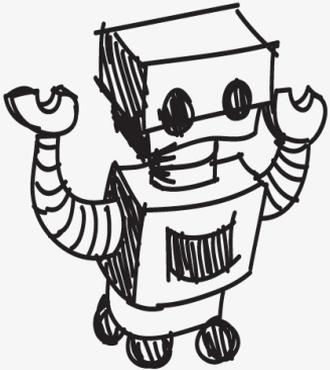
Dive deeper Into Semiconductors. Visit the [TryEngineering Semiconductor](#) page (with three videos and [ebook](#)) and also he [Making of a Microchip](#) lesson.

More Resources

- [How a Transistor Works EASY! - Electronics Basics 22 \(Updated\)](#) by Simple Electronics (Video)
- [How To Use Transistors In YOUR Projects! | Transistors Explained | Transistors As A Switch](#) by Simple Electronics (Video)
- [NPN vs PNP Transistors: Symbol & Working Principle](#) by JAKElectronics (Webpage)



Engineering Fields



What is Engineering?



Learn about engineering and how engineers are creative problem solvers and innovators who work to make the world a better place.

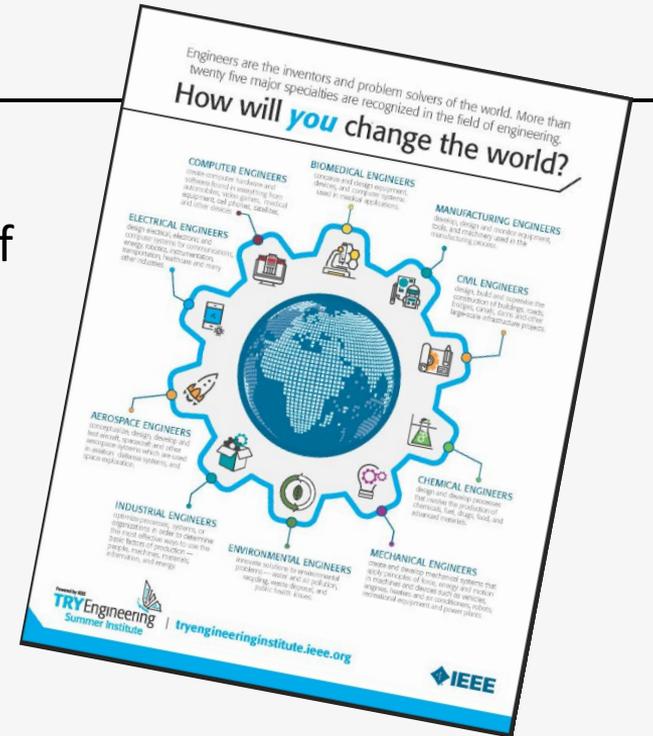
(Video 3:43)



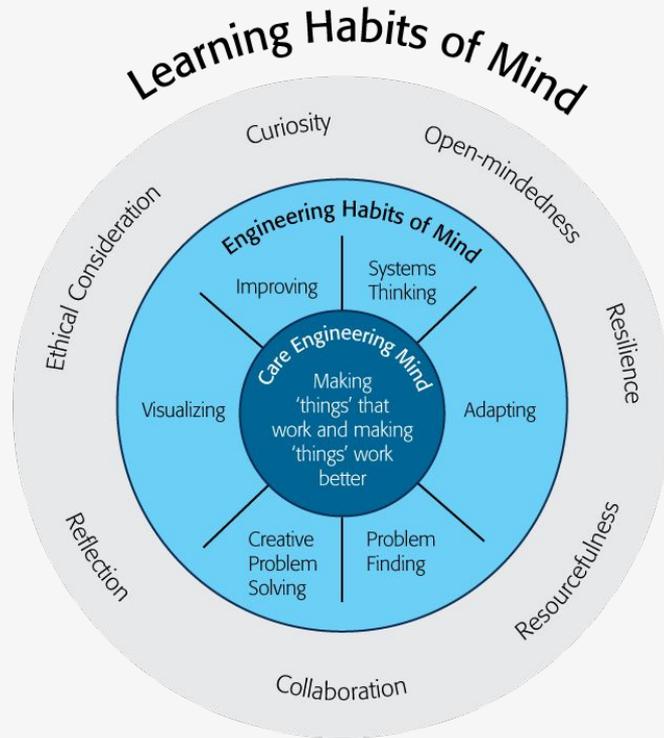
Source: TeachEngineering YouTube Channel - <http://www.youtube.com/watch?v=H9VDkvaGmVo>

Related Engineering Fields

- There are several types of engineering fields that are involved circuits. Here are just some of the related engineering fields.
 - Computer Engineering
 - Software Engineering
 - Power and Nuclear Engineering
- Download the Engineering Fields Infographic
How will **YOU** change the world?
Engineers are the inventors and problem solvers of the world! More than twenty five major specialties are recognized in the field of engineering. **Engineers make the world a better place!**



Engineering Habits of Mind



Engineering Habits of Mind (EHM) is about how engineers think everyday. The Core Engineering Mind is about making things that work and making them work better.

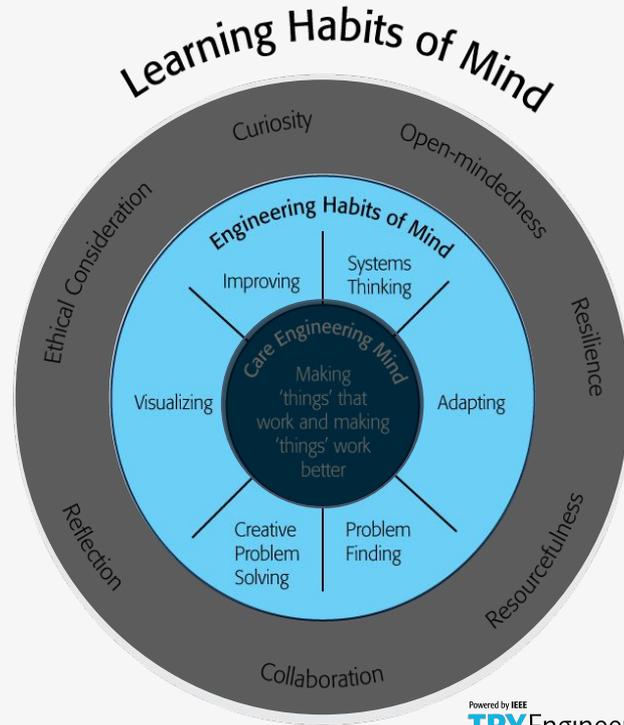
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<https://online-journals.org/index.php/i-jep/article/view/5366>



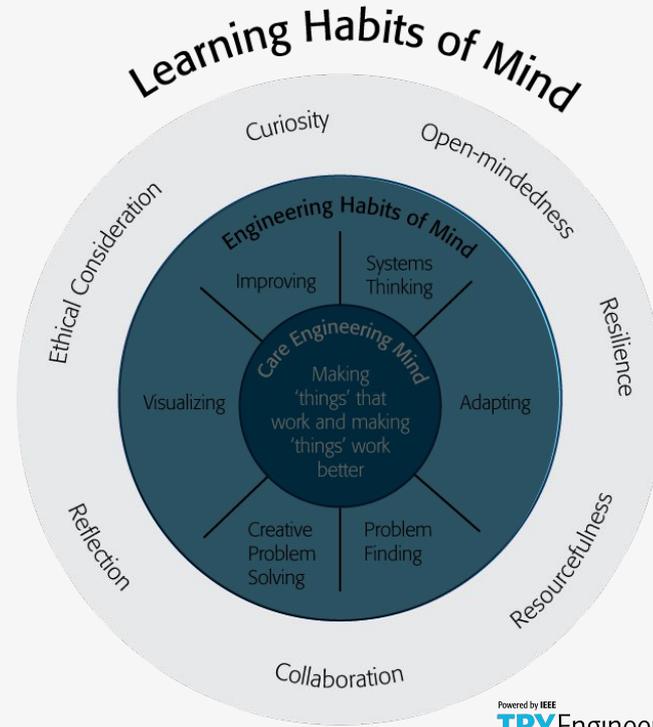
Engineering Habits of Mind Checklist

- ❑ Systems thinking
- ❑ Problem-finding
- ❑ Visualising
- ❑ Improving
- ❑ Creative problem-solving
- ❑ Adapting



Learning Habits of Mind Checklist

- ❑ Open-mindedness
- ❑ Resilience
- ❑ Resourcefulness
- ❑ Collaboration
- ❑ Reflection
- ❑ Ethical Consideration
- ❑ Curiosity



Greatest Engineering Achievements of the 20th Century



Greatest Engineering Achievements OF THE 20TH CENTURY

Welcome!

How many of the 20th century's greatest engineering achievements will you use today? A car? Computer? Telephone? Explore our list of the top 20 achievements and learn how engineering shaped a century and changed the world.

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration

11. Highways
12. Spacecraft
13. Internet
14. Imaging
15. Household Appliances
16. Health Technologies
17. Petroleum and Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials

LinkEngineering



Source: <http://www.greatachievements.org/>

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Learn more about how engineers make the world a better place



The banner features the NAE logo (three interlocking puzzle pieces) and the text "NAE GRAND CHALLENGES FOR ENGINEERING" and "NATIONAL ACADEMY OF ENGINEERING". Navigation buttons for "Challenges", "News", and "Community" are in green rounded rectangles. The main visual is a green puzzle piece with a gear icon on the left and a network of glowing green lines radiating from a central point on the right. Below the puzzle piece, the text "Provide energy from fusion" is displayed, followed by a paragraph: "Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way." A row of ten diamond-shaped icons represents various engineering fields: a smartphone, VR, a gear, a classical building, a water drop, a nuclear symbol, a CO2 molecule, a brain, a laptop, a padlock, and a microscope.

NAE GRAND CHALLENGES FOR ENGINEERING
NATIONAL ACADEMY OF ENGINEERING

Challenges News Community

Provide energy from fusion

Human-engineered fusion has been demonstrated on a small scale. The challenge is to scale up the process to commercial proportions, in an efficient, economical, and environmentally benign way.



For more engineering lesson plans and resources like games, engineering careers, and STEM opportunities visit IEEE's [TryEngineering.org](https://www.tryengineering.org)

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