SUGGESTED REFERENCES

- *Merriam-Websters Visual online Dictionary, Search: Printed Circuit Board*
  http://visual.merriam-webster.com/

- *How Circuits Work*
  http://science.howstuffworks.com/environmental/energy/circuit5.htm

NATIONAL SCIENCE EDUCATION STANDARDS

Grades 9 - 12
Science & Technology
Abilities of technological design
Understandings about science & technology

Grades 9 - 12
Science in Personal & Social Perspectives
Science & technology in local national and global challenges

Grades 9 - 12
Physical Science
Chemical Reactions

**Source: National Science Education Standards, 1996, National Academy Press*

CREDITS

EDUCATOR ADVISORY PANEL

Patricia Heydet-Kirsch, Ed.D.
John A. Murnan III, M.S.
Debra A. Murnan, B.A.

PRODUCTION CREDITS

WRITER/PRODUCER:	Jon Glassman
ASSOCIATE PRODUCER:	Judi Sitkin
EDITOR:	Stuart Scoon
NARRATOR:	J.J. Wilson

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1000 Clint Moore Road, Suite 108, Boca Raton, FL 33487
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VOLUME 41 ISSUE 4

ELECTRONICS - *The Science of Circuit Boards*

ABET
Accreditation Board for Engineering and Technology
www.abet.org

NMOE
National Museum of Education
www.nmoe.org

CILC
Center for Interactive Learning and Collaboration
www.cilc.org

JETS
Junior Engineering Technical Society
www.jets.org

SYNOPSIS

Peer inside any electronic device and you will see at the heart of that device, a printed circuit board. These boards which used to connect just enough capacitors and resistors to run a simple transistor radio are now used to run all of our electronic devices. New technology has shrunk the size of all of the components that attach to the board, the width of the wires that connect them and even the size of the circuit board itself. Without the printed circuit board, our world would look a lot different.

This edition details the processes involved in planning, designing, and building printed circuit boards. The process begins when a design is created in computer-aided design software. Students will learn what materials are used to construct the boards as well as how the circuits are planned and built into the boards.

CURRICULUM UNITS

- CHEMISTRY
- COMPUTER ENGINEERING
- COMPUTER SCIENCE
- ENGINEERING
- PHYSICAL SCIENCE
- PHYSICS

RUNNING TIME

16 minutes

BACKGROUND

There are dozens of printed circuit boards in the average home. They can be found in everything from the television to the stereo and the microwave to the mobile phone. With ever increasing demand for printed circuit boards, manufacturing them has become a multi billion dollar industry.

Over the years, the printed circuit boards have evolved. Components are constantly becoming smaller and more efficient. What started off with very few capacitors and resistors has become an integral part of almost every electronic device. As devices have become smaller, engineers have to squeeze more tracks and components onto boards. The distance between gaps in tracks have become smaller, sometimes down to 0.1 millimeters.

Printed circuit boards (PCBs) start off as a design brief. Computer aided design, or CAD software is used to lay out the working components. Each component has a connection point called a footprint which is linked together with virtual wires in the software.

Most PCBs are made of fiberglass and covered with a thin layer of copper, later removed in the manufacturing process. A machine with a tungsten carbide drill bit is then used to drill precise holes in the board, allowing signals to pass from one side of the board to the other and provide locators for later in production.

The boards then go through extensive chemical processes to prepare them for the circuit patterns that will be literally printed on them. Finally, the components are attached.

CRITICAL THINKING EXERCISES

1. Have students research the function of metal components on printed circuit boards such as heat sinks, crystals, switches, batteries and connectors.
2. CAD technicians can work in fields as different as jewelry design and aerospace. Discuss other fields that benefit from CAD technologies.
3. Get PCB's from different devices (cell phone, computer, printer, remote control) or print pictures of PCB's and compare them to see what components are present in each device (and how many).
4. Identify the functions of different kinds of components found on a PCB for a computer.
5. Since many electronic devices quickly become obsolete, there is a problem with disposing of the device. Have students identify how PCB's can be recycled to reduce the impact of these devices on the environment.

CAREER POSSIBILITIES

- CHEMIST
- ENGINEER
- COMPUTER AIDED DESIGN AND DRAFTING (CADD)

ADVANCED ORGANIZERS

Prior to viewing this program, students should have some understanding of the following Benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 3. The Nature of Technology
Section A: Technology & Science, Grades 9-12

- Technological problems and advances often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.
- Mathematics, creativity, logic, and originality are all needed to improve technology.
- Technology usually affects society more directly than science does because technology solves practical problems and serves human needs (and also creates new problems and needs).
- One way science affects society is by stimulating and satisfying people's curiosity and enlarging or challenging their views of what the world is like.

Benchmark 8. The Designed World
Section B: Materials and Manufacturing, Grades 9-12

- Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently.
- Increased knowledge of the properties of particular molecular structures helps in the design and synthesis of new materials for special purposes.

Benchmark 8. The Designed World
Section E: Information Processing, Grades 9-12

- Miniaturization of information processing hardware can increase processing speed and portability, reduce energy use, and lower cost. Miniaturization is made possible through higher-purity materials and more precise fabrication technology.

**Benchmarks can be found at www.project2061.org/tools/benchol/bolintro.htm*

VOCABULARY

Anode . . . . . The positive electrode in an electrolytic cell toward which negatively charged particles are attracted. The anode has a positive charge because it is connected to the positively charged end of an external power supply.

Capacitor . . . . . An electrical device consisting of two conducting plates separated by an electrical insulator designed to hold an electric charge.

Cathode . . . . . The negative electrode in an electrolytic cell toward which positively charged particles are attracted. The cathode has a negative charge because it is connected to the negatively charged end of an external power supply.

Electrolyte . . . . . A conducting medium in which the flow of current is accompanied by the movement of matter in the form of ions.

Graphite . . . . . A naturally occurring, steel-gray to black, crystalline form of carbon. The carbon atoms in graphite are strongly bonded together in sheets. Because the bonds between the sheets are weak, other atoms can easily fit between them, causing graphite to be soft and slippery to the touch. Graphite is used in pencils and paints; also as a lubricant and electrode.

Photopolymer . . . . . A polymer or plastic that undergoes a change in physical or chemical properties when exposed to light.

Resistor . . . . . A device used in electrical circuits to maintain a constant relation between current flow and voltage. Resistors are used to step up or lower the voltage at different points in a circuit and to transform a current signal into a voltage signal or vice versa.

Tungsten Carbide . . . . . An inorganic carbon compound that forms a fine gray powder of extremely hard, dense grains. Tungsten carbide is used in tools, die castings, wear-resistant machine parts, and abrasives.