# Engineered Memory

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## Lesson Focus

Lesson focuses on the engineering behind storage devices, and engineering improvements over time. Though exploring the operation of the "floppy" disk, students explore the mechanics underlying operation, and then test the disk under a variety of conditions. Working as a computer engineering group, students then work in teams to evaluate pros and cons of eliminating the floppy disk drive from a new computer under development for use in schools worldwide. They also explore developing punch codes and create punch cards for data storage. They explore the concept of re-engineering and also consider the ethical issues of re-engineering a product.

## Lesson Synopsis

The Engineered Memory lesson not only explores how engineers designed the floppy disk and how it has changed over time, but also explores the challenges of computer engineers who must decide what components to include in new systems. Students explore how floppy disks work, test them under a variety of circumstances, then work in teams to determine if they recommend including or excluding the floppy from a new notebook computer designed for schools worldwide. They also explore developing punch codes and create punch cards for data storage. They explore the concept of re-engineering and also consider the ethical issues of re-engineering a product.

## Age Levels

8-18.


## Objectives

- Learn about computer engineering.
- Learn about product testing.
- Learn about computing history.
- Learn about meeting the needs of society.
- Learn about teamwork and working in groups.

## Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

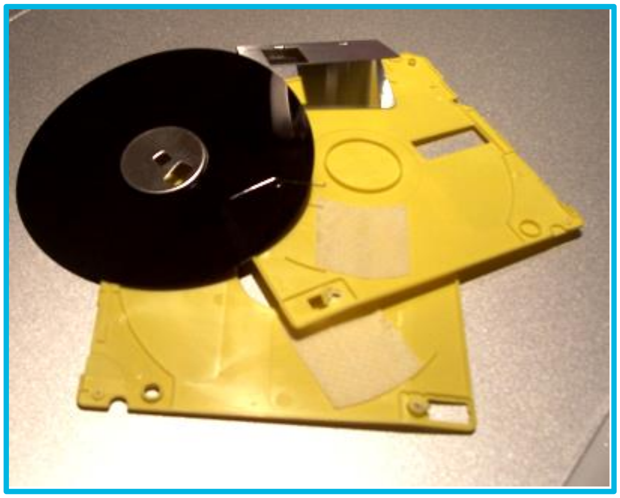
- computer engineering and planning
- computing history
- problem solving
- teamwork

## Lesson Activities

Students learn how floppy disks work and explore how they hold up in a variety of situations. Student teams are then challenged with evaluating and deciding whether to include or exclude a floppy disk drive in a new computer designed to be used by schools all over the world. They also develop their own punch card system and make their own punch cards. Student teams present their recommendations to other teams.

## Resources/Materials

- Teacher Resource Document (attached)
- Student Worksheets (attached)
- Student Resource Sheet (attached)



## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

## Internet Connections

- TryEngineering (www.tryengineering.org)
- Fifty Years of Storage Innovations (www-03.ibm.com/ibm/history/exhibits/storage/storage_fifty.html)
- Wikipedia - Data Storage (https://en.wikipedia.org/wiki/Data_storage)
- Columbia University Computing History (www.columbia.edu/cu/computinghistory/)

## Recommended Reading

- Essentials of Mechatronics (ISBN: 047172341X)
- A History of the Personal Computer: The People and the Technology (ISBN: 0968910807)

## Optional Writing Activity

- Write an essay or a paragraph about how storage devices have impacted present day life.

## For Teachers:
## Teacher Resource

### Lesson Goal

Lesson focuses on the engineering behind floppy disks and how information storage has changed over time. Students weigh the pros and cons of the floppy disk, and test disks in a variety of situations. Then, working as a computer engineering group, students then work in teams to evaluate pros and cons of eliminating the floppy disk drive from a new, low cost, computer under development for use in schools worldwide. They explore the concept of re-engineering and also consider the ethical issues of re-engineering a product. As an optional activity, student also explore developing punch codes and create punch cards for data storage.

### Lesson Objectives

- Learn about computer engineering.
- Learn about product testing.
- Learn about computing history.
- Learn about meeting the needs of society.
- Learn about teamwork and working in groups.

### Materials

- Student Resource Sheet
- Student Worksheets
- One set of materials for each group of students:
  - Six floppy disks (assume all will be destroyed), two plastic bags
  - Access to freezer, refrigerator, several strengths of magnets
  - 20 index cards for optional punch card activity

### Caution

This lesson shows how standard floppy disks may be vulnerable to cold temperatures and magnets. Placing floppy disks in a computer that are damaged due to magnets and temperature will not harm your computer….but teachers are encouraged to limit testing to these methods. If students add dirt, water, salt, sugar, or other materials into the plastic casing of this disk and then put into a computer it will likely cause damage to your computer. Supervision is required; heating should not be to an extent that it causes a change in the shape of the floppy disk case.  Do not put misshapen disks in a computer.

### Procedure

1. Show students the various Student Reference Sheets.  These may be read in class, or provided as reading material for the prior night's homework.
2. Divide students into groups of 2-3 student "computer engineers," providing a set of materials per group.

## *For Teachers:*
## *Teacher Resource (continued)*

3. Explain that students must test the limitations of the floppy disk and then work as a team of computer engineers to determine whether or not a floppy disk drive should be included in a new computer system that is under development.

4. Students disassemble one disk to explore the inner workings. Most disks can be taken apart without any tools, though assistance may be needed with younger students.

5. Students then create or copy both a word processing document and a graphic file or photo onto each of the remaining five disks.

6. Student teams then predict on attached student worksheet what will happen to the data on each disk when exposed to extreme cold (freezer), moderate cold (refrigerator), and three strengths of magnets. Disks going into freezer or refrigerator should be put in plastic bags so moisture does not accumulate. Note: you may encourage students to come up with their own tests. If so, you'll need to approve their proposals and consider safety, both to students and to computer hardware.

7. Teams then execute the tests on the disks, and record their results.

8. Teams then evaluate the floppy disk in order to come to a recommendation as to whether or not a floppy disk drive should be included as a component in a new, low cost, computer system under development for schools worldwide. (student worksheet)

9. Teams present their recommendations to the class.

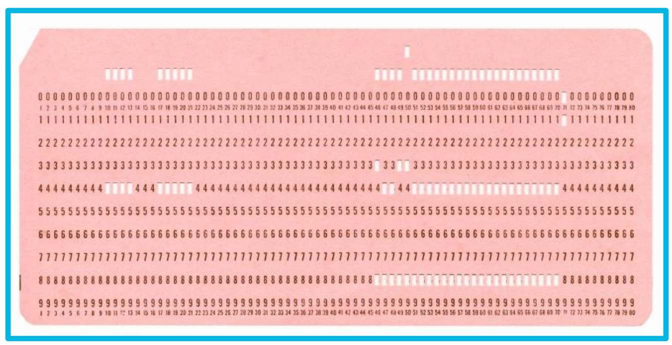
### ◆ Safety Note
When using floppy discs, be sure to check to make sure the sliding metal panel is not bent or damaged before inserting into computer. A bent panel can cause the disc to be stuck in the computer and can cause damage.

### ◆ Time Needed
One to two 45 minute sessions (allowing time for freezing and cooling disks). Be sure to leave plenty of time for the engineers to consider the needs of the worldwide users of the product in development.

## Student Resource:
## Data Storage - How it All Started

### ◆ Punch Cards

A punch card or punched card is a piece of stiff paper that contains digital information represented by the presence or absence of holes in predefined positions. Almost an obsolete recording medium, punched cards were widely used throughout the nineteenth century for controlling textile looms and through the twentieth century in unit record machines for input, processing, and data storage. Digital computers used punched cards, later scanned by card readers, as the primary medium for input of both computer programs and data, with offline data entry on key punch machines. Some voting machines have used punch cards. Punched cards were first used around 1725 by Basile Bouchon and Jean-Baptiste Falcon as a more robust form of the perforated paper rolls then in use for controlling textile looms in France.



The early applications of punched cards all used specifically designed card layouts. It wasn't until around 1928 that punched cards and machines were made "general purpose". The rectangular, round, or oval bits of paper punched out are called chad (recently, chads) or chips (in IBM usage). Multi-character data, such as words or large numbers, were stored in adjacent card columns known as fields. A group of cards is called a deck. One upper corner of a card was usually cut so that cards not orientated correctly, or cards with different corner cuts, could be easily identified. This IBM card format, designed in 1928, had rectangular holes, 80 columns with 12 punch locations each, one character to each column.

Originally only numeric information was coded, with 1 or 2 punches per column. Later, codes were introduced for upper-case letters and special characters. For some computer applications, binary formats were used, where each hole represented a single binary digit (or "bit"), every column (or row) was treated as a simple bitfield, and every combination of holes was permitted.

With widespread adoption of data storage on disk or magnetic tape, punch cards have largely become a thing of the past.  However, they are still used in voting systems in some countries.

## Student Resource:
## "Floppy Disk" History and Engineering

A "floppy" disk is a data storage device that is composed of a disk of thin, flexible ("floppy") magnetic storage medium encased in a square or rectangular plastic shell. Floppy disks were originally also known as floppies or diskettes -- a name chosen in order to be similar to the word "cassette."

### The Beginning

In 1967 IBM gave their San Jose, CA, USA storage development center a new task: develop a simple and inexpensive system for loading microcode into their System/370 mainframes. The 370s were the first IBM machines to use semiconductor memory, and whenever the power was turned off the microcode had to be reloaded ('magnetic core' memory, used in the 370s' predecessors, the System/360 line, did not lose its contents when powered down). Normally this task would be left to various tape drives which almost all 370 systems included, but tapes were large and slow. IBM wanted something faster and more purpose-built that could also be used to send out updates to customers for $5.

Alan Shugart the overall IBM Product Manager assigned this to David Noble who tried a number of solutions to see if he could develop a new-style tape or other media for the purpose, but eventually gave up. Noble's team then invented a read-only, 8-inch (20 cm) floppy they called the "memory disk", holding 80 kilobytes. The original versions were simply the disk itself, but dirt became a serious problem and they enclosed it in a plastic envelope lined with fabric that would pick up the dirt. The new device, developed under the code name Minnow and announced as the 23FD, became a standard part of 370 systems starting in 1969.

Alan Shugart left IBM, moved to Memorex where his team in 1972 shipped the Memorex 650, the first read-write floppy disk drive.

## Student Resource:
## "Floppy Disk" Operations and Advances

### ◆ How Do Floppy Disks Work?

The image to the right shows the basic internal components of a 3½-inch floppy disk:

1. Write-protect tab
2. Hub
3. Shutter
4. Plastic housing
5. Paper ring
6. Magnetic disk
7. Disk sector

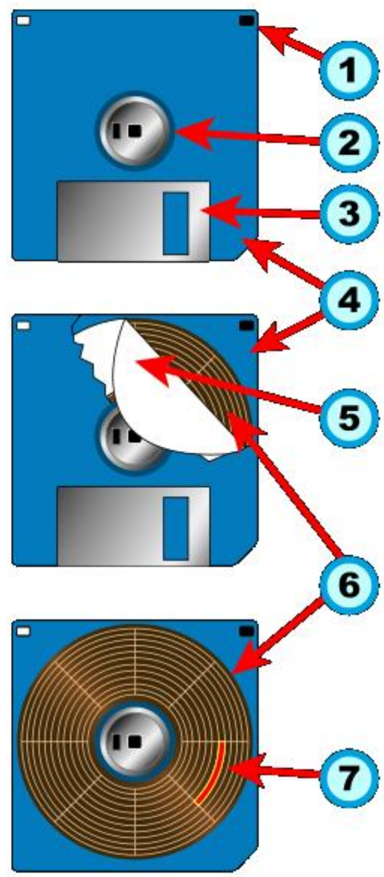



Image Source: Public Domain from Wikimedia (https://commons.wikimedia.org/wiki/File:Floppy_disk_internal_diagram.svg)

Floppy disk drives read or write data to the circular piece of metal-coated plastic that is imbedded in the hard plastic case of the "floppy disk." The plastic is coated with a magnetic material with tracks organized in rings. When being read, the circular plastic spins and the reading heads move to the spot where information is stored almost instantly. When recording, the disk drive will identify blank spots on the disk and record new information where there is space. Electricity and magnetism are the secrets to the process of reading and writing to a floppy disk. In order to record, the electromagnetic head of a disk drive creates a pattern of magnetized and non-magnetized areas on the disk's surface.

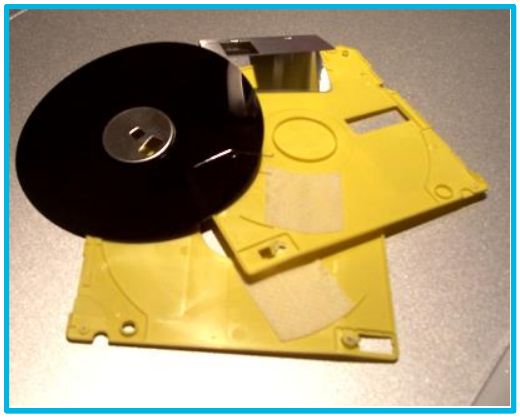
By the early 1990s, the increasing size of software meant that many programs were distributed on sets of floppies. Toward the end of the 1990s, software distribution gradually switched to CD-ROM, and higher-density backup formats were introduced. With the arrival of mass Internet access, cheap Ethernet and USB flash drives, the floppy was no longer necessary for data transfer either. For some time, manufacturers were reluctant to remove the floppy drive from their PCs, for backward compatibility. However, manufacturers and retailers have progressively reduced the availability of computers fitted with floppy drives and of the disks themselves. External USB-based floppy disk drives are now available for computers without floppy drives, and they work on any machine that supports USB.

### ◆ Engineering Improvements to Storage Problems

USB flash drives offer lots of advantages over other portable storage devices, particularly the floppy disk. They are more compact, generally faster, hold more data, and are more reliable (due to their lack of moving parts) than floppy disks. A flash drive consists of a small printed circuit board encased in a plastic or metal casing, making the drive sturdy enough to be carried about in a pocket.

## *Student Worksheet:*

You are a team of computer engineers meeting to determine whether or not to include a floppy disk drive in a new, low cost computer under development to be distributed to schools all over the world.



### ◆ Research/Preparation Phase

1. Review the various Student Reference Sheets.

### ◆ Testing Phase

You have been provided with six floppy disks.

1. Disassemble one disk to explore the inner workings, and compare to the student resource sheet. Most disks can be taken apart without any tools, but ask your teacher for help if you need it!

2. On the remaining five disks, create or copy both a word processing document and a graphic file or photo onto each. Label each, and double check to confirm the files were saved properly on each.

3. As a team, make predictions in the table below about what you think will happen to the data on each disk when exposed to different situations. Note: You may want to come up with your own tests, but be sure to have your teacher approve first.

| | Disk 1 | Disk 2 | Disk 3 | Disk 4 | Disk 5 |
|---|---|---|---|---|---|
| **Environment Change** | **Place disk in freezer overnight** | **Place disk in refrigerator overnight** | **Rub low strength magnet on disk** | **Rub medium strength magnet on disk** | **Rub high strength magnet on disk** |
| **Prediction 1: Will the data be lost? Why?** | | | | | |
| **Prediction 2: Will the data be changed in any way? How?** | | | | | |
| **Prediction 3: Will you be able to reformat the disk or use it again?** | | | | | |

## *Student Worksheet: (continued)*

4. Now, execute the tests on the disks, and record your results below. Note: Put the disks for the freezer or refrigerator in plastic bags to keep out moisture.  Be sure to let the disk return to room temperature before inserting into your computer.

| | Disk 1 | Disk 2 | Disk 3 | Disk 4 | Disk 5 |
|---|---|---|---|---|---|
| **Environment Change** | **Place disk in freezer overnight** | **Place disk in refrigerator overnight** | **Rub low strength magnet on disk** | **Rub medium strength magnet on disk** | **Rub high strength magnet on disk** |
| **Result 1: Was the data lost?** | | | | | |
| **Result 2: Was the data changed in any way? How?** | | | | | |
| **Result 3: Were you able to reformat the disk or use it again?** | | | | | |

### ◆ Team Reflection:

Why do you think you found these results?  Why would certain conditions affect storage devices while others do not?

### ◆ Team Analysis and Recommendations

Next, your "computer engineering" team must consider what you learned through your testing, and also consider your company's "research, and then come to a recommendation as to whether or not a floppy disk drive should be included as a component in a new, low cost, computer system your company is about to manufacture for schools worldwide. The facts on the next sheet have been provided by your company's marketing research department, some of the mechanical engineers working on the project, and the accounting group which will determine the cost of the new product. Remember that your new computer is to be a low cost solution for schools all over the world, and potential users are children and students in both remote areas and cities, in both affluent and poorer communities.

## *Student Worksheet: (continued)*

### ◆ Research Report

1. The computer must be useful for students and teachers all over the world.
2. Floppy Disks can cost less than 40 cents each, and hold about 1.44 MB of data.
3. USB Drives cost more than floppy disks; for example a 1GB drive might cost $10.
4. It might cost about $7 to include a floppy disk drive in each computer.
5. The new computer will have 3 USB ports.
6. Two recent research reports are summarized below:

> **Magnetic Media Information Services:** "In many parts of the world such as Latin America, China, and India, the floppy disk remains a widely-used recording medium, according to Magnetic Media Information Services. For some companies, the production of floppy disks is still a sizable and profitable business. Imation, the world's largest producer, accounts for one-third of the world's total floppy production and claims to produce about two million floppy disks a day, both for itself and for other companies still active in selling diskettes."  According to Yaser Shan, marketing manager, Imation Middle East and Africa, "Floppies are a very easy backup. You can easily store data, you can give it anybody and it doesn't need any security. There are many advantages like they are easy to use, cheap, affordable, and the installed base is very huge. Probably if you give data on floppy to somebody, they will definitely have a floppy drive but if you give it on a CD they may or may not have a CDROM. And in the Middle East market, they are still moving to CDs but also use loads and loads of diskettes."
>
> **Japan Recording Media Industries Association:** "These days, most PC users seldom if ever use a floppy disk for storage or other purposes. It may surprise the reader that the JRIA believes that demand for diskettes in 2006 will still reach 776 million units. Except for the Japanese market, where the diskette is almost completely forgotten, demand in Europe, North America, and the rest of the world, is expected to be almost equal in 2006, nominally 235 million units for each region. However, by 2009, demand will have declined 56 percent to 336 million diskettes, still distributed almost equally in North America, Europe, and countries in the rest of the world."

### ◆ Planning as a Team

Make a decision about your computer, and list the three main factors that led to your team decision in the box below.  Present your decision to other student teams.

| |
|---|
| 1. |
| 2. |
| 3. |

## *Student Worksheet: Reflection*

1. What percentage of the teams in your class decided to incorporate the floppy disk drive in the new computer? Did this surprise you?

2. What did you learn about the re-engineering process through this lesson?

3. What product do you think you'd like to re-engineer? Why? What would you do to change or improve it?

4. What ethical considerations do you think should be discussed when re-engineering a product? What rights or compensation do you think the designer of an original product should retain when a new engineering team re-engineers the original product?

5. Were you surprised that engineers might be working in a team with other engineers (such as mechanical engineers and computer engineers working together)?

## Student Activity: Punch Card Coding

### ◆ Planning

Working as a team of 2-3 students develop a coding system using punches on index cards that can communicate a sentence to another team of students. You'll need to develop a code of punching that represents the numbers and letters and punctuation you choose for your sentence. Write out your plans for your punch code in the box below.

| |
|---|
| |

### ◆ Punch!

Next punch your coded sentence onto index cards and provide both your code and your cards to another team to read.

(Hint, make sure to number your cards so that if they get mixed up you can reassemble your deck in the correct order.)

### ◆ Reflection:

1. Did you find it was easy to come up with a coding system that would efficiently send your message?

2. Was the other team able to read your code?

3. List three drawbacks you can think of to using the punch card system in data processing today:

## *For Teachers:*
## *Alignment to Curriculum Frameworks*

**Note:** Lesson plans in this series are aligned to one or more of the following sets of standards:
- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

### ◆National Science Education Standards Grades K-4 (ages 4 - 9)

**CONTENT STANDARD A: Science as Inquiry**
As a result of activities, all students should develop
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

**CONTENT STANDARD B: Physical Science**
As a result of the activities, all students should develop an understanding of
- Properties of objects and materials
- Light, heat, electricity, and magnetism

**CONTENT STANDARD E: Science and Technology**
As a result of activities, all students should develop
- Abilities of technological design

**CONTENT STANDARD F: Science in Personal and Social Perspectives**
As a result of activities, all students should develop understanding of
- Science and technology in local challenges

### ◆National Science Education Standards Grades 5-8 (ages 10 - 14)

**CONTENT STANDARD A: Science as Inquiry**
As a result of activities, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

**CONTENT STANDARD B: Physical Science**
As a result of their activities, all students should develop an understanding of
- Properties and changes of properties in matter

**CONTENT STANDARD E: Science and Technology**
As a result of activities in grades 5-8, all students should develop
- Abilities of technological design

**CONTENT STANDARD F: Science in Personal and Social Perspectives**
As a result of activities, all students should develop understanding of
- Risks and benefits
- Science and technology in society

**CONTENT STANDARD G: History and Nature of Science**
As a result of activities, all students should develop understanding of
- History of science

## *For Teachers:*
## *Alignment to Curriculum Frameworks*

### ◆National Science Education Standards Grades 9-12 (ages 14-18)

**CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

**CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop understanding of

- Structure and properties of matter
- Motions and forces

**CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

**CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

**CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- Historical perspectives

### ◆Next Generation Science Standards – Grades 2-5 (Ages 7-11)

**Matter and its Interactions**

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- 4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.

**Engineering Design**

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

### ◆Next Generation Science Standards - Grades 6-8 (Ages 11-14)

**Engineering Design**

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

## *For Teachers:*
## *Alignment to Curriculum Frameworks*

### ◆Standards for Technological Literacy - All Ages

**The Nature of Technology**

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

**Technology and Society**

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

**Design**

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

**Abilities for a Technological World**

- Standard 11: Students will develop abilities to apply the design process.
- Standard 13: Students will develop abilities to assess the impact of products and systems.

**The Designed World**

- Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.