



TryEngineering

# Adaptive Device Design



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## Lesson Focus

Lesson focuses on the engineering of adaptive or assistive devices, such as prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, or braces.

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## Lesson Synopsis

The Adaptive Device Design activity explores the concept of how engineering has made possible the development of -- and ongoing improvements to -- adaptive devices that serve to help individuals with a wide range of physical challenges adapt to the world and participate fully in society. Students learn about the engineering process to solve problems, and work in teams to improve the design of a current or proposed adaptive device. Students start with eyeglasses, disassembling, examining component design and shape, and reassembling...then re-engineer the product seeking improvements to the current product.

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## Age Levels

8-18.

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## Objectives

- ✦ Learn about adaptive devices.
  - ✦ Learn about how ongoing changes to adaptive devices have impacted everyday life.
  - ✦ Learn about teamwork and the engineering problem solving/design process.
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## Anticipated Learner Outcomes

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

- ✦ adaptive devices
  - ✦ impact of engineering and technology on society
  - ✦ engineering problem solving
  - ✦ teamwork
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## Lesson Activities

Students learn about how the engineering behind adaptive devices has impacted everyday life. Topics examined include problem solving, teamwork, and the engineering design process. Students work in teams to disassemble a product, evaluate the component parts, and recommend changes to improve functionality through redesign and material selection.

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## Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Resource Sheet (attached)
- ✦ Student Worksheets (attached)

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## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

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## Internet Connections

- ✦ TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))
- ✦ Wheelchair Net ([www.wheelchairnet.org](http://www.wheelchairnet.org))
- ✦ McREL Compendium of Standards and Benchmarks ([www.mcrel.org/standards-benchmarks](http://www.mcrel.org/standards-benchmarks)) A compilation of content standards for K-12 curriculum in both searchable and browsable formats.
- ✦ National Science Education Standards ([www.nsta.org/publications/nses.aspx](http://www.nsta.org/publications/nses.aspx))
- ✦ ITEA Standards for Technological Literacy ([www.iteaconnect.org/TAA](http://www.iteaconnect.org/TAA))

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## Recommended Reading

- ✦ The Design of Everyday Things by Donald A. Norman (ISBN: 0465067107)
- ✦ Emotional Design: Why We Love (or Hate) Everyday Things by Donald A. Norman (ISBN: 0465051367)

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## Optional Writing Activities

- ✦ Write an essay or a paragraph describing which adaptive device you think has most dramatically impacted the world. Give supporting details, and offer suggestions for further improvements to this device.

# Adaptive Device Design



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## For Teachers: Teacher Resources

### ◆ Lesson Goal

Explore how engineers have developed products that help those with physical challenges lead more comfortable and independent lives. Students learn about assistive and adaptive devices, evaluate the design and materials used in sunglasses, and develop or improve an adaptive device working as a team of "engineers."

### ◆ Lesson Objectives

- ✦ Students learn about adaptive devices.
- ✦ Students learn about how ongoing changes to adaptive devices have impacted everyday life.
- ✦ Students learn about teamwork and the engineering problem solving/design process.

### ◆ Materials

- Student Resource Sheets
- Student Worksheets
- One set of materials for each group of students:
  - One pair of sunglasses (either old or inexpensive new)
  - Eyeglass Repair Kit (including mini screwdriver, replacement screws, and if possible a magnifying glass)



### ◆ 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. They may also be directed to bring in a pair of old sunglasses from home.
2. Divide students into groups of 3-4 students; provide one set of materials per group.
3. Ask students to complete the three student worksheets: the first prompts a discussion of what an adaptive device would be; the second requires students to disassemble and reassemble an old pair of sunglasses to evaluate materials and design; the third has students work in teams as "engineers" to design a new or improve an existing adaptive device.
4. Each student group presents the vision for their new or improved adaptive design and their views on societal impact of engineering to the class.

### ◆ Time Needed

One to two 45 minute sessions.

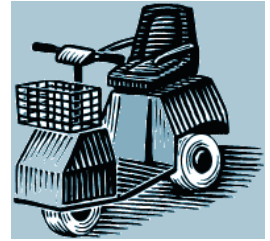
# Adaptive Device Design



## Student Resource: Who Needs Adaptive Devices?

Adaptive or assistive devices are developed to assist individuals with a wide range of disabilities to improve their ability to live healthy and independent. It is estimated that 54 million Americans have some degree of disability. As defined by the U.S. Survey of Income and Program Participation, individuals 15 years old and over were identified as having a disability if they met any one of the following criteria:

1. Used a wheelchair, a cane, crutches, or a walker
2. Had difficulty performing one or more functional activities (seeing, hearing, speaking, lifting/carrying, using stairs, walking, or grasping small objects)
3. Had difficulty with one or more *activities of daily living*. (ADLs include getting around inside the home, getting in or out of bed or a chair, bathing, dressing, eating, and toileting.)
4. Had difficulty with one or more *instrumental activities of daily living*. (The IADLs included going outside the home, keeping track of money and bills, preparing meals, doing light housework, taking prescription medicines in the right amount at the right time, and using the telephone.)
5. Had one or more specified conditions (a learning disability, mental retardation or another developmental disability, Alzheimer's disease, or some other type of mental or emotional condition)
6. Had any other mental or emotional condition that seriously interfered with everyday activities
7. Had a condition that limited the ability to work around the house
8. If age 16 to 67, had a condition that made it difficult to work at a job or business
9. Received U.S. federal benefits based on an inability to work



According to the most recent statistics for the United States:

1. 25 million had difficulty walking a quarter mile or climbing a flight of 10 stairs, or used an ambulatory aid, such as a wheelchair (2.2 million) or a cane, crutches or a walker (6.4 million).
2. About 18 million had difficulty lifting and carrying a 10-pound bag of groceries or grasping small objects.
3. About 14.3 million had a mental disability, including 1.9 million with Alzheimer's disease, senility or dementia; and 3.5 million with learning disabilities.
4. About 8.0 million had difficulty hearing what was said in a normal conversation with another person (even when wearing a hearing aid).
5. About 7.7 million had difficulty seeing the words and letters in ordinary newspaper print (even with glasses); of these, 1.8 million were unable to see words and letters in ordinary newspaper print.



# Adaptive Device Design



## Student Resource: Wheelchair Design Considerations

### ◆ Wheelchair History

Greek vases from 530 BC show wheels incorporated into furniture. And, in 535 AD an engraving shows a wheel chair, and King Phillip II of Spain had a wheelchair in 1595 -- so the need to use wheels to ease motion goes back a long way.



### ◆ What's New?

More recently, materials such as titanium have been used to improve the weight and maneuverability of wheelchairs. And, as wheelchair sports have become popular, engineers had to design additional features and capabilities into sport wheelchairs to meet the need of users who rely on the chair for speed and accurate movements.

### ◆ Material/Design Tradeoffs

Engineers have to weigh different considerations when designing a wheelchair. For example, they know that titanium is the best material in terms of strength to weight ratios -- but it is an extremely expensive material. On the other hand, carbon fiber is less expensive and durable. Different customers may prefer different materials. Engineers might seek to develop the most lightweight wheelchair -- a lighter chair would potentially reduce the amount of wrist injuries because the customer would have a lighter chair to maneuver. And, engineers might have to consider the type of tires that made the most sense for a wheelchair. Also, the braking system is important -- how easy is it for someone with decreased mobility to use the brakes? What type of motor would work best for a motorized chair -- how fast is too fast? Will a new wheelchair design fit on standard wheelchair ramps? Engineers would have to completely redesign a wheelchair for use by children who may have different needs and braking abilities than adults. And, cost is always a big consideration -- if engineers design the best wheelchair, but it costs more than most people could afford, the product will fail.



### ◆ Research

In developing new designs, engineers might also conduct user surveys to find out what type of chair is most comfortable, most easy to move, most easy to brake. In addition, studies are done to determine the amount of oxygen a customer uses to move a chair, as an indication of how much energy is expended in making the chair move forward. Some motorized wheelchairs move so fast that crash testing is done to determine how the chair would protect a customer in the event of a crash.










# Adaptive Device Design



## Student Worksheet: Which Are Adaptive Devices?

As a team, complete the following worksheet, indicating which of the products below would be considered "adaptive devices."

Product	Adaptive? Yes or No	Why or Why Not	What Was the Engineers Goal?
<b>Eyeglasses</b> 			
<b>Platforms</b> 			
<b>Baby Stroller</b> 			
<b>Watch that Speaks the Time</b> 			
<b>Walker</b> 			
<b>Headphones</b> 			
<b>Cast</b> 			

# Adaptive Device Design



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## Student Worksheet: Component Parts

**Step One:** As a team, disassemble a pair of old, unusable sunglasses or glasses, using an eyeglass repair kit provided to you.

### Questions:

1. How many component parts did you find?
2. What different types of materials (plastics, metals, glass) were part of the final pair of glasses?
3. If you were reengineering these glasses to make them safer, would you change the shape of any of the component parts? Why? Why not?
4. If you were reengineering these glasses to make them safer, would you change the materials used to manufacture any of the component parts? Why? Why not?

**Step Two:** Reassemble the glasses.

### Questions:

5. What was the hardest part of the reassembly process? Why?
6. Do you think that assembly would be easier managed by a machine? Why? Why not?
7. How hard do you think it would be for a person with arthritis in their hands to reassemble their glasses?

# Adaptive Device Design



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## Student Worksheet: Your Adaptive Device Design

Throughout history, engineers have solved problems by developing products and systems to help people. In the area of adaptive engineering design, the goal is to create products that make life easier, healthier, and more independent for those who face challenges. The following is just a short list of the many devices that have been designed to help people and animals:

- wheelchairs
- walkers
- eyeglasses
- adaptive gardening tools
- hearing aids
- adaptive canoe seats
- replacement joints
- artificial limbs
- adaptive water-skis
- dressing aids
- safety bars for tubs
- adaptive fitness equipment
- shower chairs
- jar opening tools
- specialty computer mouse
- sleep apnea mask
- adaptive golf clubs
- steering wheels
- adaptive tricycles
- lifts for horses
- crutches
- playing card holders
- bedrails
- illuminated magnifiers
- oversized lamp switches
- adaptive video game joysticks

### You are the Engineering Team!

Your challenge is to work as a team to either improve an existing adaptive product or come up with a new one that solves a specific problem faced by individuals (or animals) that face physical challenges.

#### State the Problems:

1. Identify a physical challenge which your product will help to alleviate (for example, a dog that has undergone back surgery still needs to be able to go for a walk).
2. As a team, develop on paper a new product or develop an improvement to an existing product that meet the need of the person/animal.
3. Present your ideas to the class in three forms:
  - describe how your product works, technically, in words...include the materials you think it would be made from, and what you think the product might cost.
  - draw an illustration of either your final product, or a situation where it is being used.
  - describe how your team believes that engineers have impacted the world.



# Adaptive Device Design



## 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](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 E: Science and Technology**

As a result of activities in grades 5-8, 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

- ✦ 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

- ✦ Science as a human endeavor

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

##### **CONTENT STANDARD E: Science and Technology**

As a result of activities in grades 5-8, 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

- ✦ Personal health
- ✦ 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

- ✦ Nature of science
- ✦ History of science

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

##### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

# Adaptive Device Design



For Teachers:

## Alignment to Curriculum Frameworks (continued)

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

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

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

- ✦ Personal and community health
- ✦ 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

- ✦ Nature of scientific knowledge
- ✦ Historical perspectives

### ◆ Next Generation Science Standards – Grades 3-5 (Ages 8-11)

#### **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-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

### ◆ Next Generation Science Standards – Grades 9-12 (Ages 14-18)

#### **Engineering Design**

Students who demonstrate understanding can:

- ✦ HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### ◆ 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.

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For Teachers:

Alignment to Curriculum Frameworks (continued)

## ◆Standards for Technological Literacy - All Ages

### **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 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.