STUDENT GUIDE

Name

School

Grade
# JV InvenTeams™ - Shoe Soles

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Welcome to JV InvenTeams, where students develop skills in science, technology, engineering, and math (STEM) through fun, invention-based design activities and challenges.

About Lemelson-MIT

The Lemelson-MIT Program (https://lemelson.mit.edu) is dedicated to honoring those who have helped improve our lives through invention. The Program was established in 1994 at the Massachusetts Institute of Technology (MIT), by one of the world’s most prolific inventors, Jerome Lemelson (1923 -1997), and his wife, Dorothy. It is funded by The Lemelson Foundation and administered by MIT’s School of Engineering. The Lemelson-MIT Program recognizes outstanding inventors, encourages sustainable new solutions to real-world problems, and enables and inspires young people to pursue creative lives and careers through invention.

The Lemelson-MIT Program encourages great inventors through various outreach programs such as InvenTeams (https://lemelson.mit.edu/inventeams), a national grants initiative for inventive high school students who have a strong foundation in scientific and technical skills. InvenTeams are teams of high school students, teachers, and mentors that receive grants of up to $10,000 to invent technological solutions to real-world problems. The Lemelson-MIT Program developed JV InvenTeams in order to reach slightly younger high school students and provide them an introduction to inventive thinking and doing.

About JV InvenTeams

The goal of JV InvenTeams is to cultivate new ways of thinking and develop technical skills for students with limited access to hands-on STEM enrichment opportunities. Through prescribed activities, students will add to their own “toolkits” of minds-on knowledge and hands-on skills while having fun!

Students will learn how to identify a need in their lives or in the world around them and to develop their own invention after completing the main activity in each unit. They will pull from their expanding toolkit to come up with solutions.
JV InvenTeams Activity Guide Components

Each unit of JV InvenTeams activities is presented in the same format. The Educator Guide includes specific notes and segments, while the student version is more streamlined and includes working space for the students. The educator may decide how much of the information should be shared with the students and in what manner – e.g., read out loud or individually. Each meeting within the unit is estimated to take between 1.5 and 2 hours to complete.

Each group of young people will be different, so the pace of each unit is up to the educator. Know that there are numerous resources to balance the unit to meet your needs. Some may find that breaking units into a couple of sessions will allow the think-time needed for your group. Others may want to streamline items and skip some of the videos.

Each unit has the following in the first pages:

- Title page with summary of the unit and learning objectives
- Summary of each meeting within the unit
- Master consumable materials and tools lists
You may ask, “Why should I invent?” Here are some of the reasons. Invention...

- solves world problems like finding clean sources of energy and treating unsafe water;
- helps people;
- allows people to explore a creative process that often involves teamwork;
- provides fulfilling careers: inventors are often scientists and engineers who improve areas of health, energy, food and transportation;
- can also lead to a high-paying career with many job opportunities as an engineer or scientist; and
- is fun!

Group size

JV InvenTeams is recommended for approximately 20 students in Grades 7, 8, 9 and 10. Most activities require students to work in teams of four.
Partnerships

The Lemelson-MIT Program encourages participating schools to seek community partnerships to sustain JV InvenTeams. Partnership opportunities include:

- Science and technology museums, to provide direct mentoring;
- Local technology and engineering companies, to provide funding for future extension ideas, materials, or mentors;
- Local universities or colleges, to provide collegiate mentors; and
- Hardware stores, to provide tools or materials.

Flexibility

JV InvenTeams has built flexibility into the program to meet the needs of educators, school systems, and grants-based clubs and organizations. Following are some examples:

- Each unit is designed to stand on its own. Educators can lead one unit, a few units or all of the units.
- The program can be held in any educational setting with a science or technology educator facilitating the activities.
- Each unit has approximately 6 meetings of 1.5 - 2 hours' duration.
- Meetings can take place multiple times a week or once a week.

Inventive Thinking

Both educators and students will develop an understanding of the invention process as you navigate through JV InvenTeams. This new way of thinking, part of the minds-on toolkit, may take some time to adopt since learning within the school day increasingly focuses on standardized tests of academic knowledge. Invention is a variable, non-linear process. JV InvenTeams introduces the curiosity and creativity of recognizing problems and addressing them with novel solutions. You will not need to worry about knowing the “right” answer since there are countless possibilities. Experiencing failure is part of the invention process.

Inventing is creating something new that is useful or helpful, by means of one’s own investigation, experimentation, and thinking. An invention is the product of the inventing process. It can be a device, a material, a system, and even a plant. Invention refers to a new physical thing made possible by technology for the purposes of JV InvenTeams. Inventive thinking challenges what people come to expect or anticipate. Revolutionary inventions, known as macro-inventions, make a huge impact on the way we live. Examples include the internal-combustion engine for the automobile and the integrated circuit for consumer electronics. Most inventions are micro-inventions, or adaptations that grow from larger-scale inventions. This means making an existing product faster, stronger, cheaper, easier, safer, more efficient, or more useful.
User-Centric

The key to inventing is to make sure the invention is user-centric. This means that you need to think about and understand problems affecting real people and their specific needs. Researching the unique characteristics and needs of the user is essential to coming up with an effective design – as is working directly with them! You will develop empathy for the beneficiary during the process.

An example of this would be a student noticing that his or her grandmother has difficulty moving around the house in her slippers, due to slippery floors. The student should investigate by first asking his or her grandmother:

- Do you wish your slippers had a better grip?
- What parts of the slipper do you like? What parts would you change? Why?

After learning from the user, the student can further investigate. Questions he or she might ask include the following:

- Does the solution lie in changing the floors or the footwear?
- How can I change her slippers to make the grip better?
- Is there another product on the market that provides the ease and comfort of slippers with the safety features of shoes with more grip?

These questions will inform research and allow the you, the student, to develop meaningful solutions.

Deciding on a Good Problem to Solve

Identifying a good problem to solve can be challenging, but it is just like any other skill: it becomes easier with practice. Therefore, at the beginning of each unit in JV InvenTeams, you will be given a problem or scenario that requires devising an original solution. Coming up with solutions to problems can be difficult at first, but you will gain confidence in generating new ideas over time. One way to accomplish this is through transgressive thinking – applying flexible or “out of the box” thinking in one area to another. The SCAMPER technique is a good technique to start with because it provides a framework to come up with solutions.

SCAMPER

The SCAMPER brainstorming technique was developed by Bob Eberle and published in a book by the same title. SCAMPER is based on the notion that something new can be modified from something that already exists. Each letter in the acronym represents a different way you can mentally view the characteristics of the challenge. It’s a “mash-up” of disparate things to conceive something new.

- S = Substitute (playing basketball with a softball)
- C = Combine (toothbrush combined with a pencil to create a new product)
- A = Adapt (how would you eat your spaghetti without a utensil?)
- M = Magnify (how would your chair function if the legs were wider and longer?)
- P = Put to Other Uses (could your fork be used as a comb?)
• E = Eliminate (could you play tennis without a racket?)
• R = Rearrange (what if the laces of a shoe were placed on the bottom and not the top?)

The SCAMPER technique, you will first state the problem you would like to solve – this defines the challenge. After determining the challenge, it’s then a matter of asking questions about using SCAMPER to guide you. No idea is a “good” or “bad” idea at this point.

Documentation

Students should be encouraged to document their progress along the way. This includes saving sketches, designs, research data, graphs, images, and early prototypes. Most of this work, with the exception of the actual prototypes, can be compiled in the student guides. Students should routinely review their guide, adapting what they have learned and experienced to new challenges.

Patents

Since this program is all about invention, it is important that educators and students familiarize themselves with the United States laws that protect the intellectual property of inventors. A patent is one type of intellectual property that can be legally protected through the U.S. Patent and Trademark Office (USPTO). The other types of intellectual property are trademarks and copyrights. A trademark includes any word, name, or symbol used to distinguish one manufacturer from another (e.g., brand name). Copyrights are recorded with the U.S. Copyright Office in the Library of Congress for original authored works like books and music.

According to the U.S. Patent and Trademark Office, patents provide legal protection to inventors’ intellectual property by excluding others from profiting from their property in the U.S. for a specific amount of time, in exchange for the inventors’ disclosure of their idea according to the criteria for granting a patent. There are three different types of patents. Utility patents are granted to inventors who discover a new and useful process, machine, article of manufacture, or a new and useful improvement. Design patents are granted to those who invent a new, original, and ornamental design for an article of manufacture. Finally, a plant patent is granted to an inventor who invents a new variety of plant. The basic components of a U.S. patent are: patent number, title, inventors, assignee (optional transfer of intellectual property to a company or other individual), abstract (short overview of invention), drawings, description (technical details), and claims (legal information). To learn more about the patent process, visit: http://uspto.gov/. Students will be required to search patents to ensure that their idea is unique. Patent searches can be done through Google Patents and Free Patents Online. Both have easier search functions than the U.S. Patent and Trademark Office.

Jerome Lemelson, founder of The Lemelson Foundation, had a productive life as an inventor, holding more than 600 patents. He was awarded his first patent in 1953 for a toy cap, and spent the next 45 years coming up with inventions that led to products such as bar code readers, automatic teller machines, cordless phones, cassette players, fax machines, machine vision, and personal computers.

It is important to keep in mind that not all inventions are patented. Some inventors purposefully do not seek a patent with the idea that their inventions are immediately and widely available. An example is open source software, which allows anyone to use the software without paying a fee. This openness can spur further invention since anyone can access it and make adaptations. In spite of the changes in patent law through the Innovation Act of 2013, students should adopt the habit of recording and dating their work, including early sketches and research. This practice will be useful for future science exploration and invention. To learn more, visit: https://govtrack.us/congress/bills/113/hr3309.
Unit Summary for Students

This unit will guide you to create shoe soles that meet the needs of a chosen user.

You will learn about the biomechanics of the human foot in action. You will research treads and thicknesses of various athletic shoes to observe differences and similarities, and also look toward nature (biomimicry) for insight. You will pick a specific athletic activity such as basketball in your small teams for the design of a shoe sole. You will design a shoe sole and use clay to create a model of your sole after researching the activity and interviewing prospective users. You will create molds of the clay model and will use polyurethane compounds to create your shoe sole prototypes.

You will gain both minds-on and hands-on skills in this unit to begin expanding your toolkit. Minds-on skills include learning about biomechanics, biomimicry, and the design process – identifying a problem, brainstorming, researching, interviewing prospective users, sketching ideas, building, and testing. Hands-on skills include learning to cut and fold cardboard, sculpting clay models, and practicing the molding process. You will draw from these new skills towards the end of the unit to brainstorm an invention of your own. You might think of additional materials to design a low-cost shoe, or maybe you will use the molding process to create a completely different device. You will learn to be an inventive thinker as you progress through this unit.

Learning Principles

Design Process
Forces
Biomechanics
Biomimicry
Materials
Molding
Meeting Synopses

1  Invention Introduction
Introduction to invention and JV InvenTeams. Do warm-up activities and discuss invention. Play “Four Corners” to determine your strengths for team assignment.

2  Biomechanics & Biomimicry
Learn about biomechanics and how footwear is designed to meet specific needs. Learn about biomimicry as a method for brainstorming designs. You are introduced to the main design challenge of the unit and assigned to a small team. Research shoe soles of your chosen activity.

3  Sketch & Design
Learn to draw to scale and how to make isometric and orthographic drawings of your shoe soles.

4  Sculpt Clay Models
Finalize a shoe sole design and use modeling clay and tools to make 3D models of the soles. Team members share designs and select one model for casting.

5  Cast Clay Models
Prepare a molding box. Cast the selected shoe sole model in rubber solution. In the remaining time, meet Gihan Amarasiriwardena, a footwear inventor and clothing designer.

6  Shoe Sole Prototypes
Remove the clay model; the result is a mold of the shoe sole. Cast your prototype. Learn about real-world shoe design from a designer at Columbia Sportswear Company. Use your toolkit of new skills to brainstorm ideas for a purposeful invention using shoe design, biomimicry, and/or the molding process.

7  Test Prototypes & Invention Ideas
Test out your shoe soles and provide feedback to other teams. Conceptualize a new purposeful invention that uses shoe design, biomimicry, and/or the molding process.
Shoe Soles
Meeting 1: Invention Introduction

Procedure

- Get Your JV InvenTeams Guide
- Introduction to Invention and Problem Solving
- Design a Cell Phone Stand
- Think About Your Invention
- Watch Invention Videos
- Research an Invention
- Discuss Improvements to an Invention
- Investigate Real-World Improvements
- Watch Videos about the Design Process
- Set Rules and Develop Teams
- Self-Assessment

Your Guide

1. You will use your JV InvenTeams guide as an invention guide. This guide will be a portfolio of your work and ideas.

2. The grid paper and blank paper at the end of each meeting can be used to sketch, brainstorm, and document ideas.
Introduction to Invention and Problem Solving

1. We all run into challenges on a daily basis. You will now get a taste of what being an inventor means by coming up with ideas to address some of these problems.

2. Your educator has written down some problems on strips of paper. You will work with a team to build a solution to one of these problems using everyday materials.

3. After you receive your problem, use the recycling bin to find building materials and work with your team to devise a quick invention to meet your need.

4. When you are finished, take turns sharing your simple solutions with the full group. Some questions to ask other groups include:
   • How would you change your invention if you had more time?
   • How would you change your invention if you had a bigger budget?

5. Inventors often use inexpensive, everyday materials to create prototypes of their inventions. That’s because they don’t want to waste expensive materials in the early stages of designing. Failure and mistakes are common and part of the process.
Design a Cell Phone Stand

1. Do you ever get annoyed by your phone not being able to stand up on its own? Inventors think outside of the box and create prototypes of their ideas using everyday materials.

2. Your challenge is to invent a low-cost cell phone stand using recycled materials like cardboard. You can also use duct tape.

3. Before you start, watch Josh Ramos’ Cardboard Videos to learn some cardboard cutting tips and tricks. Josh is a PhD candidate in Mechanical Engineering from MIT.

4. If you are having difficulty coming up with your own design, check out Josh Ramos’ Cardboard Phone Stand.

Think About Your Invention

1. What do you like about the stand you made?

2. How would you change your design if you wanted to watch a video in the landscape format (sideways)?

3. Where are the speakers on your phone? How might you use the placement of the cardboard or other materials to improve the sound?

4. Share your design with another student. Write their feedback below:
5. How would you incorporate your and their comments in your next design? Describe this next design iteration in words or pictures.

During the JV InvenTeams initiative, you will learn about new tools and materials through invention activities like this one. You will think of iterations to improve your design after successfully meeting these challenges.

Watch Some Invention Videos

1. Each year, teams of undergraduate and graduate students apply for the Lemelson-MIT National Collegiate Student Prize Competition. Check out some cool videos from previous winners and finalists:

- Alice Chen’s Inventions Make Our Lives Healthier (2:27)
- Ben Peters’ Inventions Make Our Lives More Engaging (1:57)
- Eduardo Torrealba’s Inventions Make Our Lives Easier (first 9 min)

2. All good inventions, including the ones presented in these videos, stem from a real problem or need. Most inventions do not produce radical change in society, but rather build upon previous inventions to make aspects of life easier, safer, more comfortable, more engaging, and/or healthier.

Invention Research

1. Identify an object in the room.

2. We often take the daily products and tools in our world for granted. Each of these items has a history of evolution. Scientists, engineers, and designers made modifications over time that produced the modern object you see today.

3. You will conduct research on inventions using Google Patent Search. Google Patents lists U.S. patents as well as international patents. Patents are sequentially numbered; for example, search for “student desk” and look at the images for US7571959B2.

VIDEO NOTES

Write down some thoughts you have about the videos here:

1. General thoughts:

2. How can failure turn out to be a good thing?

3. What failure have you learned the most from?

MIT alumna Alison Wong invented Keyprop™, a simple solution to the problem of keeping your smart phone propped up. Check out a video of her invention: Invention Profile: Keyprop.
Shoe Soles
Meeting 1: Invention Introduction (cont.)

   
   • How can this product continue to improve?
   
   • What information can you gather from the technical drawings? Why are detailed images such an important part of a patent?

Discuss Improvements to an Invention

1. Think about a timeline of your daily routine. If you could improve one product or process during your typical day, what would it be?

2. In your group, discuss the following:
   
   • How might you go about making the improvement? Describe your process.
   • What might be some challenges to meeting this need?
   • Thinking further, do you notice anyone in your family or community who struggles to complete a certain task? What invention might improve this aspect of their life?

Investigate Real-World Improvements

• **Sesame Ring**: Several MIT undergraduate students were having difficulty locating their reusable train tickets upon entering the train station. Their solution is a wearable reader in the form of a customizable ring.

• **Tile™**: Do you ever have difficulty finding your keys or wallet in your home? The solution is a small piece of plastic with a chip that
connects to an application on your smart phone.

- **uBeam**: Meredith Perry, a graduate of the University of Pennsylvania, was sick of long electrical wires for laptop computers. She started a company, uBeam, that is working on a wireless charger.

### Watch Videos about the Design Process

1. Watch the [MIT Design Process Videos](#).

2. Draw a visual model or outline below that will help you remember the steps of the design process as you invent something.

### Set Rules and Develop Teams

1. The JV InvenTeams initiative is all about hands-on fun. To make this possible, here are a few important rules to follow:

   - Safety is the number one priority! Watch tutorial videos before using new tools and materials.
   - Ask for help. Don’t guess, especially about how a tool works.
   - Consider all ideas. No idea is “dumb.” As an inventor, focus on the ideas with the most potential when developing a prototype.
   - Embrace failure. Failure is a part of the invention process!
   - Value your team. Everyone brings different skill sets and knowledge to the table.

2. Diverse teams are successful teams

3. Play a game called “Four Corners” to help the educator create balanced teams. Instructions are on the next page.

### EXTEND THE LEARNING

You can continue exploring invention by researching well-known inventors in your community. How? Go to [Free Patents Online](#). The login is free. Click on the Search tab, then use the “Quick Search” feature to enter your location under “Inventor Fields.” You may want to search chronologically by the last 20 years.

**Steps of the design process are:**
- identifying needs,  
- brainstorming ideas,  
- sketching,  
- building a prototype,  
- testing,  
- modifying, and  
- re-testing.
Name: ___________________________

Four Corners Game

Teams of inventors include people with different interests and skills. Ask students to think about their own interests and skills to help you organize the class into diverse teams. Have students draw a line from each type of team member on the left to the best-matching description on the right.

Types of Team Members

**Tinkerer:** I like to take things apart and build things.

**Talker:** I like to talk to people and I enjoy public speaking.

**Doodler:** I like to draw things and express my thoughts through drawing.

**Organizer:** I like to organize people and things.

Your Interests and Skills

Sounds most like me

Sounds almost like me

Sounds a little like me

Sounds least like me

The corners of your classroom will be marked with the four types of team members. Go to your “sounds most like me” description of yourself. Your educator will make balanced teams using this information.

Alison Wong, Illustrator
Draw It!

Student Name

Date
Shoe Soles
Meeting 2: Biomechanics & Biomimicry

Procedure

• Introduction to shop safety
• Introduction to biomechanics
• The science of movement
• Investigate Foot Physiology
• Gihan on Biomechanics
• Examine your shoes
• Introduction to biomimicry
• Begin the shoe sole project (research)
• Self-Assessment

Introduction to Shop Safety

1. In this unit, you may be using hand tools such as saws and screw drivers and basic power tools such as drills and rotary tools. To stay safe, you must use tools in the way they were designed to be used. Watch General Shop Safety.

2. Review the general shop safety rules:
   • Wear safety glasses
   • If you are in doubt about how to use a tool, ask!
   • Have a plan for what you are going to do with the tool
   • Be mindful of others who might enter into your working space accidentally
   • Secure the workpiece

Key Terms

Aesthetic (adj): Relating to the visual or artistic appeal of something.

Biomechanics (n): The study of mechanics relating to the structure and function of living things.

Biomimicry (n): Using nature as inspiration to solve human problems.

Center of gravity (n): The middle of an object’s weight distribution.

Force (n): A push, pull, or twist.

Friction (n): The resistance that one object encounters when in contact with another.

Gait (n): The pattern of movement of the legs during walking or running.

Mass (n): A measurement of the amount of matter something contains.

Physiology (n): The way in which a living thing or body part functions.

Terrain (n): Physical features of specific land.

Traction (n): A type of force describing how well something grips onto something else.

INVENTORS TOOLKIT

Hands-on
• General shop safety

Minds-on
• Biomechanics
• Biomimicry
• Have a balanced stance while using a tool
• Remove all jewelry, watches, and loose clothing before working with machinery
• Pin up long hair and wear closed-toe footwear
• Never work when you are tired or not focused
• Leave the workspace cleaner than you found it

Introduction to Biomechanics

1. Do you like to run or play a sport? Have you ever thought about the complex processes that allow you to move in the right way?

2. You will watch a compelling video that centers on the biomechanics of Olympic sprinter, Usain Bolt. Mechanical engineers Dr. Anette Hosoi (MIT) and Samuel Hamner (Stanford University) examine how Usain Bolt’s physical structure affects his running ability.

3. Watch The Biomechanics of Usain Bolt (5:24) and answer the questions below.

• What did you learn about biomechanics from the clip?

• Why is Usain Bolt not expected to run as fast as he does?

• How does force come into play with movement?

• How does the stance phase of running differ from the flight phase?

• Why is the design of a shoe important in determining the performance capabilities of the athlete?
The Science of Movement

1. Underline the important parts of the following reading.

2. After reading, talk with a partner about what you learned.

Have you ever wondered why athletic shoe stores have so many options? It is because the requirements for various sports are different. Engineers and designers need to identify the needs of the user and understand their body and movements in order to know how to make a functional shoe sole for each activity. Will the user be walking, running, cutting from left to right with a soccer ball, or needing traction for climbing rocky, snowy mountains? What unique physical attributes does the user have? How will these attributes impact their performance?

In the case of Usain Bolt, engineer Samuel Hamner analyzed the physical characteristics of Bolt’s body. He also examined how various parts of Bolt’s body work together when he is running.

Running is an impact sport. It is an act that exerts a force against the ground. The force against the ground provides traction and allows a body to “bounce” forward. The relationship between force and running speed is dependent on body weight, gait, stride mechanics and functionality of biological tissues such as bone, ligament, tendon, skin, and muscle. Humans have a center of gravity, which changes as humans walk, move, sit, and stand. Sprinters, while running, have a low center of gravity and the upper body is slightly leaning forward. Joggers or long distance runners tend to carry a high center of gravity and the upper body is vertical. As the center of gravity moves from low to high, the vertical force applied to the ground increases. As the vertical force increases, running speeds decrease.

The diagram shows the interplay of body weight (mass), friction, and force. You can begin to see the importance of designing a shoe that will provide the correct amount of friction (to help push off the ground), and support (to help land on the correct part of your foot and avoid injury).
Investigate Foot Physiology

1. Use the prompts below to investigate your own foot physiology with a partner.

   • What parts of your foot hit the ground when you move? Go outside and observe a partner running if you have time.

   • Remove your shoe/sock and examine your foot. Do you think you have a flatfoot, normal arch, or high arch? How would this impact what type of shoe sole you need for walking?

Gihan on Biomechanics

1. Watch Gihan Amarasiriwardena Discusses Shoe Design (3:58) in which Gihan discusses the biomechanics of running at Fenway High School in Boston, MA. Gihan is a footwear and clothing designer who graduated from MIT.

2. Now that you know more about the anatomy and biomechanics of the foot, you will find out what shoe companies do to design shoes that fit the needs of their users.

3. Investigate running shoe design by visiting web sites like Nike, New Balance, and Reebok. Do you see running shoe designs that help people run more naturally?

Elijah McCoy was an African-American inventor from Massachusetts (1844-1929) who made improvements to the rubber shoe heel. Check out his fascinating story by clicking on History: Elijah McCoy. Explore his rubber heel design patent from 1925 here: History: Design for a Rubber Heel.
Examine Your Shoes

1. You must make many observations to determine the ideal shoe sole for a given sport. These include:
   - Movements required by the sport
   - Physical body attributes of user
   - Characteristics of user’s foot
   - **Terrain** of the intended activity

2. Inventors and designers often examine products already on the market before creating a new product.

3. Why do you think the shoes you are wearing were designed?
   - Intended use:
   - Intended terrain and weather conditions:
   - Comfort features:
   - Traction features:
   - **Aesthetic** design (the look of the shoes):
   - Materials selection:

4. Now observe another classmate’s shoes. Discuss the following:
   - What activity do you think the shoes were intended for?
   - What do you notice about the out sole (bottom) of the shoes?
   - Are there ridges, grooves, or treads in the outsole? Why?
   - Are there patterns or shapes in the outsole? Why?
   - Do you use this shoe as it was intended to be used? Why or why not?
   - What do you notice about the shoe that makes you curious?

5. Working in pairs, use the following chart to list problems with the designs of the shoes you just examined, and then list possible...
solutions. Inspiration for the possible solutions may come from combining positive attributes of multiple shoes or substituting materials that are used in making the shoes.

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<th>Problem</th>
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**Introduction to Biomimicry**

1. Inventors always look for problems to solve. Inspiration can come from many places. Sometimes, inventors look to nature for inspiration and mimic nature's solutions through engineering. This is called biomimicry. Biomimicry is an example of transgressive thinking, applying knowledge from one area flexibly to another.

2. Watch **Biomimicry in Action** (17:39), a TED talk featuring Dr. Janine M. Benyus, a leader in the emerging field of biomimicry.

3. Reflect on the video using the following prompts:
   - What does this talk have to do with your focus on shoe soles?
   - How can nature influence design? What can we learn from animals, plants and insects?
   - Could any of the examples from nature that Dr. Benyus mentioned inspire your shoe sole designs?
   - What animal, plant or insect inspires and informs the design of athletic shoes?

Visit [AskNature](http://asknature.org), a project of the Biomimicry 3.8 Institute.

In the “how would nature” search box in the top right of the homepage, put in words associated with athletic shoes.

Source: fbei.wordpress.com
NIKE created a running shoe inspired by mountain goat hoof traction. Check out their patent by clicking on Invention Spotlight: NIKE, Goat Hooves, and Shoes.

Shoe Soles
Meeting 2: Biomechanics & Biomimicry (cont.)

Begin the Shoe Sole Project (Research)

1. You have completed the first few steps of the design process, a process that inventors follow in their pursuit of new products. This process starts with identifying a problem or need (i.e., shoe sole that functions for a specific purpose), researching, brainstorming, and formulating ideas.

2. You will move from thinking about the problem to doing something that solves the problem. You will work in teams to design and build a prototype for a shoe sole. You will start with researching and interviewing prospective users. Then, you will sketch your design, make 3D clay models, and present your ideas to the team. Your team will make a mold of the clay model and create a prototype using rubber compounds.

3. Your educator will assign you to a team based on your choices in the Four Corners game from the last meeting.

4. Your team will design a shoe sole for a specific athletic activity. Possible activities include: basketball, soccer, dancing, football, and skateboarding. Choose an athletic activity as a team and record it below (if your team is having trouble coming to an agreement, try voting).

My team’s athletic activity is:

________________________________

What are features of existing shoe soles that you like?

________________________________

________________________________
What are some problems you foresee with these shoe soles?

_________________________
_________________________

What would you do to modify these shoe soles?

_______________________________
___________________________________

How could you include some inspiration from nature?

___________________________________________
___________________________________________

What are some questions you might ask a person who participates in your activity to find out what problems they have with their current shoes?

__________________________________________________________
__________________________________________________________
__________________________________________________________

5. Divide the following research and interview tasks among your team. Teams were created based upon varied interests and skills, so think about your strengths as you view the list.

- Search for images and videos that focus on the foot impact involved during your athletic activity.
- Research the terrain and weather specific to your athletic activity (loose rocks, grass, snow, cement, etc.)
- Interview people who participate in your athletic activity about the problems they have with their shoes. Propose some of your solutions and get their feedback.
- Take pictures, make sketches, or create short videos of an athlete doing your activity.

6. Take notes using the blank pages on the back of your guide. You will be asked to share your findings during the next meeting!
MEETING 3

Shoe Soles
Meeting 3: Sketch & Design

KEY TERM(S)

Insole (n): The fixed inner layer of a shoe.

Isometric drawing (n): Visually representing a 3D object in two dimensions on paper.

Lug (n): A ridge that helps to provide traction as on a tire or the sole of a shoe.

Negative space (n): The space around and between an object.

Orthographic drawing (n): A drawing showing all views of an object - top, side, and front.

Outsole (n): The outermost layer of a shoe.

Scale (n): The ratio of an object in a drawing to the size of the true object.

Procedure

- Triathlete Shoe Video and Discussion
- Share Research
- Investigate Existing Shoe Soles
- Practice Drawing to Scale
- Draw Your Shoe Sole
- Introduction to Isometric Drawing
- Introduction to Orthographic Drawing
- Continue the Shoe Sole Project (Design)
- Self-Assessment

Triathlete Shoe Video and Discussion

1. Watch Triathlete Shoe Video (5:49), which showcases Chi-An Wang, a former undergraduate at MIT. As part of her undergraduate degree in Mechanical Engineering, Wang worked closely with shoe manufacturer, New Balance, to design and test a new shoe for triathletes.

2. Reflect on the video using the following prompts:

   - Identify Problem: What is the real-world problem that Wang identified?
• Research: What type of research did Wang use to get answers? Why was it important to find out what the user wants?

• Design Prototype: How did Wang’s prototype address the needs of the potential users? What role did making and testing a prototype play in determining the final version of the shoe?

• How did failure play a key role in making her shoe better?

• What did Wang’s advisor mean when he said, “consumers don’t want to buy a product; they want to solve a problem”?

Share Research

1. Share research on your athletic shoe soles with your team. Compile everyone’s research and record major findings. Include what you learned last meeting about force, friction, tread, foot structure, biomechanics, and biomimicry.

2. Your team can organize its thoughts using this list:
   • What activity is the shoe designed for?
   • What type of terrain? (e.g., dirt, grass, rocks, wet)
   • What type of movement is involved? (running, climbing, etc.)
   • How will the sole be shaped? (placement of lugs and negative space)
   • What materials will I need for the sole?
   • What part is inspired by nature?

3. Use the information on the next two pages to investigate existing shoe soles and to sketch your first design for your athletic shoe sole.
Investigate Existing Shoe Soles

**Intended Use:** Walking in the rain  
**Terrain:** Wet ground  
**Movements:** Forward motion through puddles  
**Sole design and materials:** Triangular lugs to allow for water to drain; more detailed pattern on toes and heels to provide additional friction at point of contact

Columbia Drainslip™ II

**Intended Use:** Hiking  
**Terrain:** Rugged trails  
**Movements:** Up and down, side-to-side, over hills with loose gravel  
**Sole design and materials:** Multidirectional traction lugs and heel crash zone

Columbia Peakfreak Enduro™ Outdry

**Intended Use:** Winter boot  
**Terrain:** Snow and ice  
**Movements:** Forward through uneven ground, up and down snowy mounds  
**Sole design and materials:** Rubber compound with winter-specific lug tread pattern for traction in snow

Columbia Bugaboot™ Slip

**Intended Use:** Basketball  
**Terrain:** Hard wooden court  
**Movements:** Jumping, pivoting, sprinting  
**Sole design and materials:** Cushions at the point of impact; stability throughout the midfoot, and responsiveness in the front of the foot; high-abrasion rubber outsole for durability

Reebok Zigkick Hoops
Fill in the blanks next to the shoe sole images below.

**New Balance MSD400**

**Intended Use:** Track spike  
**Terrain:**  
**Movements:**  
**Sole design and materials:**

**Adidas Seeley**

**Intended Use:** Skateboarding  
**Terrain:**  
**Movements:**  
**Sole design and materials:**

**Capezio Kids Daisy**

**Intended Use:**  
**Terrain:**  
**Movements:**  
**Sole design and materials:**

**Simple First Sketch of Shoe Sole for Team’s Activity**

**Intended Use:**  
**Terrain:**  
**Movements:**  
**Sole design and materials:**
Practice Drawing to Scale

1. A **scale** drawing is a drawing that shows an object with accurate sizes except they have all been reduced or enlarged by a certain amount.

2. Engineers and architects make drawings to scale. They can then build models to scale from their drawings. Drawings of larger objects such as machines and buildings are scaled down to fit on paper. However, drawings of tiny objects like electronic parts are scaled up so that they can be easily seen.

3. If a drawing has a scale of “1:10”, anything drawn with the size of “1” would have an actual size of “10” in the real world. A measurement of 1 inch on the drawing would be 10 inches on the real object. As you can see, drawing to scale involves some mathematics.

4. Practice making an object larger using the outline below:

---

**HISTORY**

Did you know that running shoes and breakfast have a connection? Read about Bill Bowerman’s invention of “waffle-soles” by clicking on [History: Waffle Shoes](#).
Draw Your Shoe Sole

1. Draw an outline of your shoe sole on your graph paper. Your drawing should be scaled down by half, which is a 1:2 scale.

2. How can you calculate a 1:2 scale?

   • Use a Shoe Size Conversion Chart (on the next page) to determine shoe size in inches or centimeters.
   • Divide the measurement in half to figure out how large the scaled drawing should be.

3. Use rulers to mark your graph paper with your measurements. Remember to mark length and width. Label your drawing with your name, date, and scale.

Introduction to Isometric Drawing

1. Do you like to draw?

2. Most sketches of 3D objects show just one view of the object, like the front view.

3. Engineers and architects use many different techniques to represent their 3D designs on paper. These drawings need to be incredibly accurate so the project can be built with correct measurements.

4. “Isometric” comes from the Greek for “equal measure.” An isometric drawing is a drawing of an object, incorporating all three views (front, side, top) in one drawing.

5. Review the isometric drawing of the cube to the right.

6. Draw an isometric outline of your shoe sole.

Erez Lieberman, winner of the 2010 Lemelson-MIT Student Prize, invented the iShoe, an intelligent shoe insole that provides valuable information regarding a person's sense of balance. Lieberman was even featured on CNN. Click on College Connection: iShoe.

Source: www.web.mit.edu
Introduction to Orthographic Drawing

1. Orthographic drawings take each of the views - top, front, side - and put them into separate two-dimensional drawings next to each another. This makes it easier to see the complete view of each component.

2. Review the example of isometric drawing on the left with its orthographic representation on the right.

3. Add orthographic views of your shoe sole on your graph paper. Focus on the top and side views.

4. The top view is where you will draw the design of the treads, and the side view is where you will show the thickness of various sections.

---

Shoe Soles

Meeting 3: Sketch & Design (cont.)

shoe sole. You can add to the scaled shoe sole you already drew. It’s a little trickier than a cube, and it might look something like this:

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<th>Cm</th>
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<td>31</td>
</tr>
<tr>
<td>16</td>
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<td>31.8</td>
</tr>
</tbody>
</table>
Continue Shoe Sole Project (Design)

1. Practice drawing to scale and making isometric and orthographic drawings.

2. Check out Technical Drawing, an interactive site from the Museum of Science in Boston, where you can practice this type of drawing. Need some guidance to improve your sketches? Check-out the Howtoons Visual Communication Guide.

3. Use the rest of the meeting to begin designing the shoe sole for your team’s athletic activity. You should fill in your final outlines - top and side views - with your choice of design features. You may need to do more than one drawing to convey the design elements the way you envision them.
### Key Term(s)

**Cast (v):** To pour a liquid material into a mold, and then let it harden.

**Model (n):** A 3D version of a proposed structure or thing.

**Mold (n):** A hollow container used to give shape to liquid material when it hardens.

**Pattern (n):** A form or model to be used for imitation.

**Pitch (v):** To make a bid to get a contract or other business.

### Invention Spotlight

Take a look at the awesome Adidas® Springblade running shoe, which has a very unique pattern and use of materials on the outsole! Click on **Invention Spotlight: Springblade** to see more.

### Inventor’s Toolkit

**Hands-on**
- Finalize designs
- Sculpt clay models

**Minds-on**
- Translate drawing to 3D representation

### Procedure

- Finalize shoe sole designs
- Sculpt clay models
- Select model for prototype
- Self-Assessment

### Finalize Shoe Sole Designs

1. Continue drawing designs from the previous meeting.
2. Use your graph paper for your final drawing. Your final drawing must include:
   - Name and scale on top
   - Two views: top and side
   - Important dimensions
   - Labels for parts: lugs, negative space, etc.
   - At least one part inspired by nature

### Sculpt Clay Models

1. Once you have finished your final design, you will carve your design out of clay. You will use this clay model to make your **mold**, or **pattern**.
2. Your final design should be full-scale, so about the size of your foot.
3. Follow these instructions to make your clay model:
   • Cover your work space with paper.
   • Lay out 1/2 inch of clay to cover the outline of your shoe sole.
   • Look at your side view drawing. Add clay to your sole to match the heights on your drawing.
   • Use your design sketch for inspiration.
   • Remove clay using carving tools from all areas that will not be part of your shoe sole.
   • Make sure the clay comes out exactly as you want it to look, as you will use it to make your **mold**.
   • Finish by smoothing out the clay with your fingers.
   • Wash your hands and clean your work space.

**Select Model for Prototype**

1. Share your model with your team. **Only one design per team will be molded.** Each person can "pitch" their design for selection to **cast** into the final prototype.

2. Your choice should be based on the design that most effectively and uniquely addresses the needs of your user. Everyone will get to participate in the molding process regardless of the selection.

**TEAMWORK NOTE**

**Selecting a Model**
If your team is having trouble selecting a model, try letting everyone vote. Remember to be a positive contributor to your team.
**Meeting 5: Cast Clay Models**

**Shoe Soles**

**Procedure**

- Introduction to the molding process
- Prepare molding box
- Prepare VytaFlex® 30
- Cast clay model
- Meet Gihan Amarasiriwardena
- Self-Assessment

**Introduction to the Molding Process**

1. Have you experienced the molding process? Not the kind that grows on rotting food, but the kind that gives a shape to liquid when it hardens.

2. Read below to learn about some real-world uses of the molding process.

   - Getting an impression of your teeth made at the dentist for a mouth guard is a real-world example of a mold.

   - If you have ever made JELL-O®, then you have experienced a molding material. Making JELL-O involves mixing parts - powdered gelatin and water - to create a liquid. The liquid is then poured into molds of various shapes. When the liquid *cures*, it becomes a jiggly, fun food.
Chocolate is also often molded. Stores carry themed chocolates wrapped in foil during the holidays. Have you ever thought about how these are made? It is likely that they are produced through the molding process. The Culinary Institute of America® created a video, **Molded Chocolate Bunnies**. Watch the video and stop at 4:18.

3. You will use a strong elastomer for your shoe sole. **VytaFlex 30**, a urethane compound, is both elastomeric and durable. It cures to mimic a rubber shoe sole.

4. Today, you will prepare a molding box in which you will cast your clay model in VytaFlex 30 to create a mold. You will use the mold as a **casting** to create your prototype in the next meeting.

**INVENTOR SPOTLIGHT**

Do you like playing or watching basketball? Inventor Tinker Hatfield from Oregon is responsible for many of the designs of Air Jordan sneakers, one of the most widely recognized shoe products from the 1990s. Continue reading by clicking on **Inventor Spotlight: Building a Shoe**.
Prepare Molding Box

1. You will make a molding box out of cardboard lined with aluminum foil.
2. Keep a few things in mind when sizing your box:
   • The box must have a smooth bottom to work well.
   • The box must be lined with smooth, heavy-duty aluminum foil.
   • Use scrap cardboard and shipping tape to segment the box so there is just enough room for the clay model to fit inside.
   • Add ½ inch to the length and width of the clay model. This is all the space you need around the clay model.
   • Make sure the box is 1 inch higher than the clay model.
   • Label the outside of the box with a fun and descriptive name for the shoe sole.

Prepare VytaFlex 30®

Make sure the work area is well ventilated. The VytaFlex can be mixed ahead of time for each team by The educator may mix each team’s VytaFlex ahead of time, but if not, you’ll do your own mixing. Below are the instructions for mixing the correct amount:

1. Each team will have one trial-size box of VytaFlex (parts A and B) to work with in this meeting and the next meeting. Approximately 2/3
will be used in this meeting and the remaining 1/3 in the next meeting. Use the 16-ounce measuring container to mark 7-ounces on one deli container as a guide. Pour 7 ounces of VytaFlex 30, part A, into a deli container.

2. Pour 7 ounces of VytaFlex 30, part B, into another 16-ounce container.

Cast Clay Model

1. Follow the instructions below:
2. Prepare the area:
   • Put on protective gloves, eyewear, and dust masks.
   • Line tabletops with newspaper or plastic trash bags.
3. Place the clay model, tread side up, in the molding box. Make sure it is firmly touching the bottom of the box so there is no room for the VytaFlex to seep underneath.
4. Hand off the box with the clay model in it to your educator, who will spray the inside with a mold release agent.
5. Prepare the VytaFlex:
   • Combine part A into part B in a deli container. Mix well with a craft stick.
   • Pour the mixture into the box to cover the model without letting it overflow.
   • Let your educator know if you need more VytaFlex to cover the clay model. Remember to only ask for what you need as supplies are limited.
6. Curing: Let the mold cure (harden) for 24 hours.
7. Clean up:
   • Clean up your space and make sure the VytaFlex containers are sealed.
   • Throw unused VytaFlex from deli containers into the trash. DO NOT pour it down a sink.
8. If your team finishes early, skip ahead and read the next section on Gihan Amarasiriwardena.
Shoe Soles
Meeting 5: Cast Clay Models (cont.)

Meet Gihan Amarasinghe

Gihan Amarasinghe began thinking like an inventor from a very young age. Gihan had a business taking care of lawns in his neighborhood from fifth grade through high school. He learned that he could save time and earn more money by doing two lawn chores simultaneously – mowing and trimming. Using parts from a local repair shop, Gihan added a trimmer assembly to a push mower.

Gihan was always interested in building tree forts or simply creating things with construction sets. He learned to work with his hands so he could turn his ideas into reality. After Boy Scout camping trips, Gihan began to see a need for low-cost, high-performance outdoor gear and started designing on his own.

Gihan’s early prototype was a waterproof fleece vest that he tested, redesigned, and re-tested until the vest design met his needs. The selection of the materials for the vest’s inner layer took him from plastic trash bags to DuPont™ Tyvek®, a lightweight waterproof and breathable barrier, popular in the construction industry.

Gihan graduated in 2011 from MIT with a degree in Chemical-Biological Engineering. While at MIT, he focused on engineering innovative footwear. Examples include customized racing shoes for a Paralympian at the Sports Technology Institute and customized racing shoes with added spikes for his own use. You can explore Gihan’s products and design process on Gihan’s Website.

EXTEND THE LEARNING

Gihan “hacked” products by taking pieces apart and adding better features. NIKE’s CEO and head designer did the same thing with shoes as kids. Click on Extend the Learning: NIKE’s Top Brass Hacked Their Own Shoes.

READING NOTES

Write down three new things you learned while reading about Gihan and exploring his website:

1. ____________________________
   ____________________________
2. ____________________________
   ____________________________
3. ____________________________
   ____________________________

Source: www.gihan.amarasiriwardena.com
1. You are going to watch two video clips of Gihan discussing invention and biomechanics.

2. Before beginning the videos, find and discuss definitions for the following words. Write down any new definitions in your guide.
   • Traction
   • Pattern
   • Prototype
   • Orthotic
   • Strain Analysis
   • 3D Printing
   • Invention Process
   • Podiatrist
   • Innovative

3. Watch **Gihan Talks About Shoe Invention** (5:09), in which Gihan discusses his experience designing customized racing shoes, including a pair for a British Paralympian.

4. Today, Gihan has integrated his interest in performance wear with men’s dress clothes. He co-founded a successful line of menswear called **Ministry of Supply**. Watch **Gihan as Entrepreneur** (6:42), in which Gihan explains the launch of his business and how he became interested in being an inventor.

5. Reflect on the videos using the prompts below:

   How did Gihan inspire you?

   ________________________________________________________________

   How do you work in teams in your life to accomplish things?

   ________________________________________________________________

   What are two lessons you learned from Gihan in starting a successful business?

   ________________________________________________________________

**EXTEND THE LEARNING**

Read about Gihan’s Ministry of Supply company in the New York Times by clicking on **Extend the Learning: Rolling Up Their Sleeves**. Source: www.bizjournals.com
Shoe Soles
Meeting 6: Shoe Sole Prototype

**Procedure**

- Remove clay models
- Cast shoe sole prototype
- Scott Portzline on inventing
- Introduction to purposeful and unique inventions
- Brainstorm invention ideas
- Self-Assessment

**Remove Clay Models**

1. Carefully remove your clay model from the box. Patience is important. There may be sticky spots or places where the VytaFlex 30 seeped too much. If there are sticky spots, use a clay tool to gently separate the clay from the mold. Use scissors to cut off extra pieces of VytaFlex, if it seeped.

2. The resulting VytaFlex shape is a mold that you will now use to create your prototype.

**KEY TERM(S)**

**Adaptive (adj):** Having the capacity for change.

**Empathy (n):** The ability to understand and share the feelings of another.

**Prosthetics (n):** Artificial body parts.

**SAFETY**

Wear protective gloves and safety glasses for this activity. Avoid breathing in the release agent spray. Use it in a well-ventilated room or outdoors.
Cast Shoe Sole Prototype

1. Review the casting process below.
2. Prepare the area:
   • Put on protective gloves, eyewear and dust masks.
   • Line tabletops with paper or plastic trash bags.
3. Hand off your box to the educator to spray release agent in your mold.
4. Prepare the VytaFlex:
   • Color your prototype by adding a few drops of color tint to the part B container and mix it with a craft stick. (optional)
   • Combine part A into part B in a deli container. Mix well with a craft stick.
   • Pour the mixture into the mold without letting it overflow.
5. Curing:
   • Let it cure (harden) for 24 hours.
6. Clean up:
   • Clean up your space.
   • Throw unused VytaFlex from deli containers into the trash. DO NOT pour it down a sink.
7. If you finish early, jump ahead to the reading on the next page.

Margaret Knight (b.1838) was one of the most prolific female inventors in United States history. She had over 26 patents, which includes her famous machine for making paper bags. One of her notable inventions was a machine that could cut shoe soles. Click on History: Margaret Knight to learn more.
Scott Portzline on Inventing

Scott Portzline is currently the Footwear Design Director on the SOREL, Montrail, and Columbia brands, based in Portland, Oregon. When he was a kid, Scott was heavily influenced by his dad, who constantly built and fixed things, and his brother, who was an excellent drawer. These two family members taught him the basics of visualizing and making things. Scott always enjoyed drawing and later became obsessed with comics and anime. These interests took him on the pathway to becoming a product designer.

Scott Portzline’s first footwear design experience was with ski boots and skates. He did projects for companies like RollerBlade and Ultrawheels while working as an industrial designer in Minneapolis. What struck Scott about his first footwear projects was the level of “intimacy” between the product and the user. The footwear needs to move with the foot and leg, can affect one’s performance ability, and can become an extension of the user’s personality.

In 1995, Scott began an in-line skate project with NIKE, which eventually resulted in a design position within NIKE’s newly-formed equipment division, focusing on NIKE Hockey. Scott spent nine years on the footwear side of the business during his eleven years at NIKE. He now works for Columbia Sportswear Company.

Scott’s advice for future designers and inventors:

- **Be creative:** Draw everyday and carry a sketchbook around with you. Get comfortable building things in 3D.
- **Be passionate:** The best design ideas get people EXCITED. Connect on an emotional level with your work, as well as functional.
- **Be curious:** Pay attention to how people interact with the things they use. Ask “Why?” Take stuff apart and figure out how it goes back together.
- **Be flexible:** Things never go completely as planned. Be okay with failure and learn from mistakes. Accept critique and criticism about your work in order to make it better.

If you could ask Scott one question pertaining to his work or the footwear industry, what would it be?
What classes in high school or college might help prepare you to be a designer?

Would you be interested in becoming a footwear designer? Why?

Is there a company or brand that you would like to work for? Why?

Introduction to Purposeful and Unique Inventions

1. Sit back and reflect on the new toolkit of skills you have acquired in this unit. You have new minds-on skills such as working in teams, understanding the design process, biomechanics, and biomimicry. You have gained hands-on skills such as drawing to scale, building models, molding, and creating footwear. Invention is centered on **empathy** and fulfilling people’s needs.

2. How could you use your new skills to solve a real problem? Your challenge is to select a person or group of people with a need and apply your skills to invent a solution.

3. Before you decide *WHAT* to invent, you must research a real need and determine *WHO* you will be helping. You can think locally, regionally, nationally, or even internationally. If you look internationally, you can research the needs of a particular country or region to develop a product that may be useful. Perhaps your school already has a partnership with a “sister city” in another country.

4. For additional information on problems/needs in other countries, explore the [World Bank](http://www.worldbank.org) website.

INDUSTRY SPOTLIGHT

A large percentage of shoe manufacturing is accomplished less expensively overseas. New Balance prides itself on manufacturing their shoes in the United States, which also provides jobs for people living in the United States. Check out [Industry Spotlight: New Balance](http://www.newbalance.com) to see their vibrant production floor.
Purposeful and Unique Inventions

Review the examples of purposeful inventions on these pages as a class.

Example 1

Hugh Herr directs the Biomechatronics Group at the MIT Media Lab. This group seeks to restore mobility to those who have experienced trauma or disease and develops technologies for human performance that go beyond what nature intended. Learn more by clicking on MIT Biomechatronics Group.

Watch PBS’ Titanium Chairs and Cheetah Legs to learn about adaptive technologies, prosthetics and advanced wheelchairs used for athletes with amputations or physical disabilities.

Discuss as a Class

- How are the technologies shown in the video similar? How are they different?

- How do the materials and design features of wheelchairs used in Paralympic tennis reflect the needs of the athletes who use them?

- Adaptive technologies are constantly changing. What do you think are the advantages and disadvantages for the Paralympic athletes who use them?

INVENTOR SPOTLIGHT

Still trying to find really comfy shoes? Ronald Demon was an MIT student who invented an athletic shoe with cushioning that automatically adjusts to provide the maximum support and comfort to the user. Click on Inventor Spotlight: Ronald Demon to get the details.
Example 2

Ecosandals is a company that serves as an excellent example of invention with service and purpose in mind. Click on Ecosandals to learn more about how Kenyan workers use tires from the streets of East Africa to create durable sandals.

Can you think of any other durable materials besides car tires that could work for a low-cost shoe? What other populations might benefit from low-cost or specialized footwear? Record your thoughts in the margin.

Click on Printable, Foldable Shoes Could Solve World’s Footwear Shortage to see an example of a low-cost, easy-to-make shoe.

Example 3

David Wallace, a professor in Mechanical Engineering at MIT, teaches a class on toy design. Students work in teams throughout one semester to develop a toy with a specific theme. They often use molding materials in the construction of their toys. Click on Toy Projects to get some inspiration from their toys and to see how molding can be used for a beneficial purpose. The specific theme in 2007 was inexpensive manufacturing in Brazil.

Can you think of a meaningful way to use molding other than footwear? Write down your thoughts in the margin.

Brainstorm Invention Ideas

1. Share your ideas with your team and work together to brainstorm new ones. Try to apply your hands-on and minds-on toolkit as you brainstorm. For example, how can the molding process be used to make something new? How can you create low-cost or adaptive footwear?

2. Use the Invention Challenge Brainstorm on the back of your guide to develop and track ideas.
Shoe Soles
Meeting 7: Test Prototypes & Invention Extension

**INVENTOR’S TOOLKIT**

- Hands-on
  - Remove prototype
  - Test prototype

- Minds-on
  - Develop a plan for an invention to solve a real problem

**Procedure**

- Test your prototype
- Get feedback
- Brainstorm ideas for unique and purposeful inventions
- Make a plan
- Self-Assessment

Shoe soles made by students
Test Your Prototype

1. Carefully remove your prototype from its mold. Congratulations on your first prototype!

2. These shoe soles are in the prototype phase. Prototypes are often made out of different materials or made using a smaller scale than the final version.

3. It’s time to test your prototype. Shoe designers typically test with users once the product is made to scale with the final materials. However, there is a lot of intermediate testing, often in a laboratory setting, to help guide designers.

4. Review the testing procedure below.
   - Wash the shoe sole in warm, soapy water to remove any remaining release spray. Dry it.
   - Cut a piece of cardboard slightly larger than the shoe sole.
   - Glue the shoe sole (side without treads) to one side of the cardboard.
   - Let the shoe sole dry for five minutes.
   - Lay the paper on a tabletop or on the floor.
   - Apply roll-on stamp ink evenly over the shoe sole thread.
   - Press the cardboard/shoe sole onto paper to make an imprint.
   - Complete the testing chart on the next page.

The 2013 St. Ursula Academy InvenTeam (Toledo, Ohio) invented a pill dispensing organizational system for individuals having difficulty managing their medications. They used a molding process called vacuum molding to create some of their parts. Click on High School Connection: Vacuum Molding to learn more about this process.
### Shoe Soles

Meeting 7: Test Prototypes & Invention Extension (cont.)

Team’s Activity: _____________________________

<table>
<thead>
<tr>
<th>Questions</th>
<th>Self-critique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look at the imprint on the paper. What parts of the shoe sole are hitting? Is this how it was intended?</td>
<td></td>
</tr>
<tr>
<td>Does the shoe sole allow the user to move in the directions needed for the assigned activity?</td>
<td></td>
</tr>
<tr>
<td>Does the shoe sole have an arch? How well does it support the foot for the intended activity?</td>
<td></td>
</tr>
<tr>
<td>Observe the placement of lugs and negative space. Are the lugs adequate? Is more or less negative space needed?</td>
<td></td>
</tr>
<tr>
<td>Would your shoe sole be appropriate for the terrain of your assigned activity? Explain.</td>
<td></td>
</tr>
<tr>
<td>What are some recommendations for improvement?</td>
<td></td>
</tr>
<tr>
<td>How would you design the rest of the shoe to go with the shoe sole? What materials would you use?</td>
<td></td>
</tr>
</tbody>
</table>
Get Feedback

1. Conference with another team to get feedback on your shoe sole prototypes.

2. Start by selecting a communications leader for your team. This person will present your intended activity for the sole and provide information pertaining to the terrain and motion required by the activity.

3. Ask each other the same questions that you answered about your own design to get started. Remember, keep the feedback constructive and specific!

Sneakers4Success is an organization that uses sneaker design and culture to empower underserved high school students. This nonprofit was started in 2011 by Sam del Pilar, a Mechanical Engineering student at the University of Massachusetts at Amherst who learned about footwear design from his internship at Reebok, Inc. (located in Canton, Massachusetts).

Click on College Connection: Sneakers for Success to learn more.
Invention Challenge

1. You began brainstorming ideas for the Invention Challenge in the last meeting. Today you will determine a need that can be realistically and successfully addressed among your team members.

2. This is not a project that will be completed from start to finish in the JV InvenTeams meetings. It is a project that can be planned and completed outside of meeting time.

3. You can apply for an InvenTeam grant to help fund the development of your idea. Potential materials that will be used do not need to fit into a specific budget.

4. You can research specific communities or regions to gather ideas using the World Bank website.

5. Record all of your research findings and ideas in your guide.

Brainstorm Solutions

1. SCAMPER is a process for coming up with solutions. It is based on the notion that many new things are modifications of something that already exists. Each letter in the acronym represents a different way you can arrange the characteristics of what is challenging you to come up with new ideas:

   S = Substitute
   (playing basketball with a softball)
   C = Combine
   (toothbrush combined with a pencil to create a new product)
   A = Adapt
   (how would you eat your spaghetti without a utensil?)
   M = Magnify
   (how would your chair function if the legs were wider and longer?)
   P = Put to Other Uses
   (could your fork be used as a comb?)
   E = Eliminate
   (could you play tennis without a racket?)
   R = Rearrange (or Reverse)
   (what if shoelaces were placed on the bottom and not the top?)
2. To use the SCAMPER technique, first state the problem you would like to solve. Then, ask questions about it using the SCAMPER checklist.

3. Do some personal brainstorming using SCAMPER on the next page and record your ideas.

4. Discuss your ideas with your team and streamline them. Work with your team to select one idea to take to the next step.

Make a Plan

1. Remember that all ideas are good ideas. You should record all ideas in your guide.

2. Ask yourself the following questions to make sure you are on target:
   
   • Is the product offering something useful and unique?
   • Are you excited and motivated to develop your idea?
   • What new tool and/or material skills would you need to learn?
   • If the product meets a local need, would a community group, municipality, university, or company want to get involved with the project?
   • Who will benefit from the invention? Is there a user clearly identified?

3. Use the invention worksheet in your guide to document and sketch your idea. This worksheet is a version of what high school InvenTeams use in their project proposals. When you are finished, share your work with your class!

4. If you are interested in continuing this work, consider applying for an InvenTeams grant!

COLLEGE CONNECTION

Researchers at MIT discovered that a typical pair of running shoes has a pretty big carbon footprint. Most of the impact comes from carbon emissions generated by the manufacturing process. Read more by clicking on College Connection: Footwear’s Carbon Footprint. How can you create an environmentally friendly shoe?
What problem do you want to solve?

________________________________________________________________________

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(playing basketball with a softball)

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(what if shoelaces were placed on the bottom and not the top?)
Invention Worksheet

Our JV InvenTeam members are:

The product we are inventing is: _________________________ to
________________________________________________________________________
(short description of what it does)
________________________________________________________________________.

It is useful for ____________ because _________________.
(the user) (description of the need or problem)

It is unique because ______________________________________________
(description of how it’s different from other solutions)
________________________________________________________________________.

It functions by _______________________________________________________
(description of how it works)
________________________________________________________________________.

The tools we need are:

__________________________

The materials we need are:

__________________________

__________________________

__________________________

__________________________

The estimated total cost of our invention will be: $ __________________
Invention Challenge Brainstorm

For this brainstorm, it's important that you get ALL of your ideas down, especially the wacky ones! You never know when a wacky idea will turn into a great invention.

WHO will you help?

WHAT will you invent?
My Thoughts

Student Name

Date
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