LEMELSON-MIT JV InvenTeams™

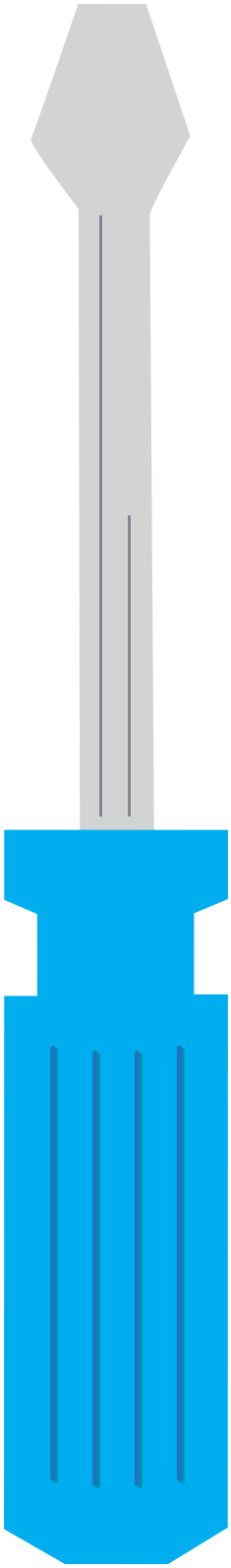
EDUCATOR GUIDE

ACTIVITY OVERVIEW

MEETINGS

APPENDIX

INTRODUCTION TO JV INVENTEAMS



SHOE SOLES

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 students and provide them an introduction to inventive thinking and doing.

About JV InvenTeams

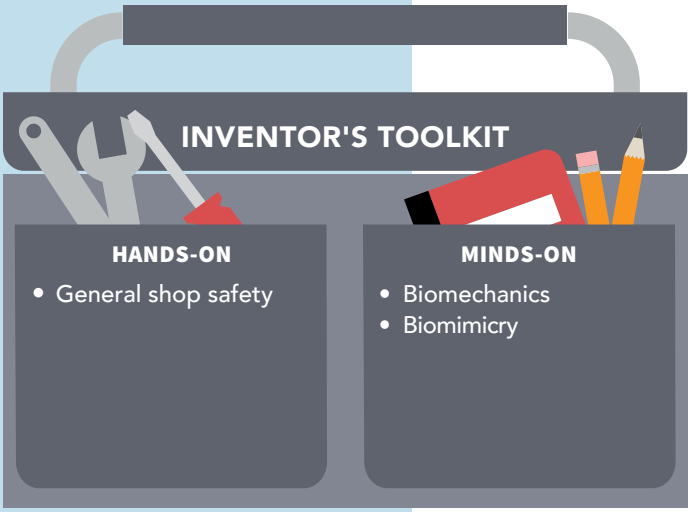
The goal of JV InvenTeams is to cultivate new ways of thinking and develop technical skills for students with limited access to hands-on STEM enrichment opportunities. Through prescribed activities, students will add to their own "toolkits" of minds-on knowledge and hands-on skills while having fun!

Students will learn how to identify a need in their lives or in the world around them and 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 read 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 meetings 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
- Synopsis of each meeting within the unit
- Master consumable materials and tools lists

Each meeting within the unit includes the following:

- "Toolkit" of hands-on and minds-on skills to be learned
- List of tools and materials
- Agenda
- Key terms
- Safety message(s)
- Video clips
- Instructions with step-by-step procedural notes
- Pop-outs that include any of the following: Historical Connections, Inventor and Invention Spotlights, Related Patents, Extend the Learning, High School Connections and College Connections
- Student Self-Assessments that serve as exit slips
- Indicators of a successful meeting

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.

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.

INVENTOR SPOTLIGHT

In 1902, mechanical engineer Willis Carrier patented the air conditioner, a device he originally invented to solve a problem facing a paper printing plant in Brooklyn, New York. Read more about his invention—and how the invention of air conditioning helped expand Southern cities such as Houston and Atlanta.

LEMELSON-MIT InventTeams

Students may ask, "Why should I invent?" Here are some of the reasons you can share during the first meeting. Invention…

- solves world problems;
- 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 7-10. 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

The 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. 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 students 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! Students 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 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, students 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 students 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)*

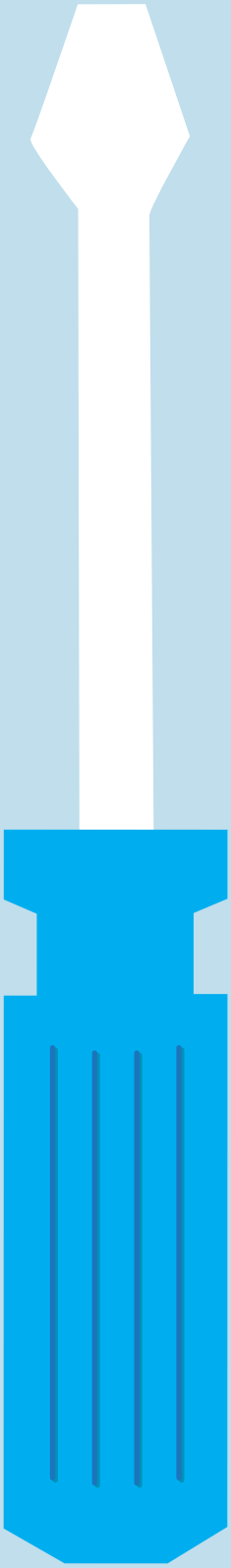
A = **Adapt** *(how would you eat your spaghetti without a utensil?)*

M = **Magnify** *(how would your chair function if its 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 involves the students first stating the problem they would like to solve, which defines the challenge. Then it's a matter of asking questions, using SCAMPER to guide the students. No idea is a "good" or "bad" idea at this point. There can certainly be good ideas!

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://www.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 EDUCATOR

UNIT SUMMARY

This unit will guide students to create shoe soles that meet the needs of an assigned user.

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

Students will gain both minds-on and hands-on skills in this unit to begin expanding their 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. Students will draw from these new skills toward the end of the unit to brainstorm an invention of their own. They might think of additional materials to design a low-cost shoe, or maybe they will use the molding process to create a completely different device. Students will learn to be inventive thinkers as they progress through this unit and others.

Learning Principles

- Design Process
- Forces
- Biomechanics
- Biomimicry
- Materials
- Molding

MEETING SYNOPSES

1 Invention Introduction

Introduction to invention and JV InvenTeams. Students do warm-up activities and discuss invention. Students play “Four Corners” to help the educator assign diverse teams.

2 Biomechanics & Biomimcry

Students learn about biomechanics and how footwear is designed to meet specific needs. Students also learn about biomimicry as a method for brainstorming designs. The educator introduces the main design challenge of the unit and assigns students to small teams. They begin to research the shoe soles of a chosen activity.

3 Sketch & Design

Students learn to draw to scale and how to make **isometric** and orthographic **drawings** of their shoe soles.

4 Sculpt Clay Models

Students 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

Students prepare a molding box. Students cast the selected shoe sole model in VytaFlex® 30. In the remaining time, students meet Gihan Amarasiriwardena, a footwear inventor and clothing designer.

6 Shoe Sole Prototypes

Students remove the clay model and have a mold of the shoe sole. Students cast their prototype in VytaFlex 30. Students learn about real-world shoe design from a designer at Columbia Sportswear Company. Team members use their toolkit of new skills to brainstorm ideas for an invention using shoe design, biomimicry, and/or the molding process.

7 Test Prototypes & Invention Ideas

Students test out their shoe soles and provide feedback to other teams. Students conceptualize a new purposeful invention that uses shoe design, biomimicry, and/or the molding process.

Facilitation Tips

Word Wall
Consider using the Key Terms to construct a Word Wall. Use the Word Wall to help young inventors review what was covered in the previous session, reinforce concepts that may need some review, and reinforce the use of new words to promote vocabulary growth.

Idea Board
Consider creating an Idea Board out of poster board to serve as a repository for new ideas and questions. Students can post new invention ideas here, which can be referenced for the development of their inventions at the end of the unit.

Teamwork
Students will be working in teams throughout this program. Consider inviting a coach from one of your school's sports programs to talk about how important teamwork is on and off the field.

Facilitating Redesign
Teams test their first prototypes and think about ways to improve them. You may find that your students would like to design a second prototype and test again. If you have the time and resources to facilitate a second round of designing and testing, follow these tips to help you engage your students in engineering practices as they work:

Encourage students to improve only what needs to be improved.
It is natural to want to throw away an entire design idea because one element of it needs improvement. Encourage students to think hard about what elements of their design work well and what elements do not. Help them narrow their focus so they are truly improving specific elements of their original design, as opposed to starting from scratch.

Have students link their improvement ideas to particular results from their first test and from peer feedback they received. Make sure students use evidence from their test results and specific ideas from peers to justify each improvement. This helps students stay grounded in their actual design.

Encourage students to learn from the work of others before implementing improvements. Engineers and inventors always learn from the work other people have done! Have students do more research on athletic shoe soles before deciding on their improvements. Encourage students to link their improvement ideas to specific information they learned in their research.

Have students predict how their results might change based on the improvements they made before testing. Students will likely have lots of ideas about how their second prototype will perform, as compared to their first prototype. Allow students to explain what they think will happen and why. Encourage students to apply their understanding of foot physiology to the design process.

Have students reflect on the strengths and weaknesses of their second prototype after testing. Encourage students to identify what worked well and what did not in their second design. Have students brainstorm further improvements and justify their ideas with evidence from their previous tests. Tell students that inventors often repeat this process of prototyping and testing many, many times before releasing a final design!

JV INVENTEAMS SELF-ASSESSMENT: SHOE SOLES

Inventors need to be confident and know their own strengths and weaknesses. Use this table to think about how likely you are to complete these skills with confidence. Check the response that best describes your confidence right now.

I CAN...	PROBABLY	MAYBE WITH HELP	PROBABLY NOT
design something to scale.			
make something useful out of material like cardboard, wood, or fabric.			
work as part of a team.			
make designs inspired by nature (**biomimicry**).			
make a technical drawing.			
identify a real-world problem to solve.			
apply my skills to solve a real-world problem.			

TODAY

Which skill was the most challenging?

_____

Which skill was the most enjoyable?

_____

IN THE FUTURE

What will YOU invent?

_____

How is it unique?

_____

How is it useful?

_____

PROBLEM STRIPS (INVENTION INTRODUCTION)

Copy and cut out these Problem Strips prior to leading the Invention Introduction with students.

You want to eat soup but you don't have a spoon.

You need to walk across a hot concrete parking lot after going to the beach, but you don't have any shoes.

You hit a baseball over a barbed-wire fence and need to get it back.

A fly is buzzing in your room and the noise it makes is bothering you.

You lost an item under your heavy dresser and want to get it back.

JV INVENTEAMS
GENERAL SHOP SAFETY RULES

Discussing shop safety helps set the tone to introduce inventing with electronics in the classroom. It introduces safe practices and helps students understand why these practices are used. Asking your students to help develop the rules may help with the ownership and understanding of the lab safety rules. You may also choose to set the rules. Either way, make sure students understand these rules and why they are necessary. You may ask students to create posters for display in the room throughout the year to emphasize safety and remind students of the specific safety rules. Keep these safety rules posted throughout the unit.

SAFETY

1. **Wear safety glasses.**
2. **If you are in doubt about how to use a tool, ask!**
3. **Have a plan for what you are going to do with the tool.**
4. **Be mindful of others who might enter into your workspace accidentally.**
5. **Secure the workpiece.**
6. **Have a balanced stance while using a tool.**
7. **Remove all jewelry, watches, and loose clothing before working with machinery.**
8. **Pin up long hair and wear closed-toe footwear.**
9. **Never work when you are tired or unfocused.**
10. **Leave the workspace cleaner than you found it.**

SHOE SOLES
MEETING 1: INVENTION INTRODUCTION

KEY TERMS

Engineering (n): Using science and technology to design and improve objects and systems to solve a problem or meet a need.

Invention (n): A unique and useful device or process.

Iteration (n): A version of a design in a series of designs.

Modification (n): The act of making small or partial changes.

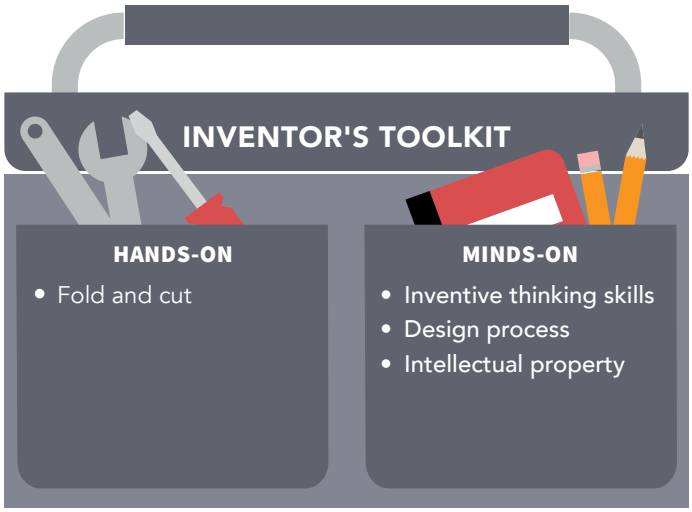
Patent (n): An intellectual property right issued by the U.S. **Patent** and Trademark Office, excluding others from making or selling the **invention** in the U.S. for a specified period of time in exchange for disclosing the **invention**.

PhD (n): A postgraduate academic degree awarded by universities.

Prototype (n): A model of something built to test a concept. Many **iterations** are created before the final design is determined.

MEETING SYNOPSIS

Students do warm-up activities and discuss **invention**. Students play "Four Corners" to help you assign diverse teams.



Tools & Electronics

- Writing utensils
- Utility knives or sharp scissors
- Projector and computer to show video

Materials & Shop Supplies

- Student guide
- Shipping tape
- Cardstock
- Cardboard and scrap materials from the recycling bin
- Problem strips
- Self-Assessment

Procedure

- Distribute Guides and Introduce JV InvenTeams
- Introduction to **Invention** and Problem Solving
- Design a Cell Phone Stand
- Watch Some **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

MEETING 1

DISTRIBUTE GUIDES AND INTRODUCE JV INVENTEAMS

1. Let students know that today they will learn about the basics of **invention**. Get everyone thinking about **invention** by asking:
   - How would you define "**invention**?"
   - Why do you think people invent things?
2. Distribute one JV InvenTeams guide to each student. Tell students that their **invention** guides will be a portfolio of their work. Explain that the grid paper and blank paper at the end of each meeting can be used to sketch, brainstorm, and document ideas.
3. Explain that items written in **bold underline** represent links to be clicked.

INTRODUCTION TO INVENTION AND PROBLEM SOLVING

1. Tell students that we all run into challenges on a daily basis. They will now get a taste of what being an inventor means by coming up with ideas to address some of these problems.
2. Divide the class into teams of 3 or 4 and give each team one of the Problem Strips you prepared.

Early prototypes of the Polaroid camera from the MIT Museum collection

3. Have teams devise a quick **invention** that solves their problem by using materials from the recycle bin.
4. Bring everyone back together and have teams take turns sharing their solutions. To facilitate sharing, students can ask the following:
   - What else would you do if you had more time?
   - What would you add or change if you had more expensive supplies?
5. Explain that 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.

EDUCATOR NOTE

Consider constructing a Word Wall with these Key Terms to help young inventors review what was covered in the previous session, reinforce concepts that may need some review, and reinforce the use of new words to promote vocabulary growth. Add new Key Terms with each Meeting—or have the students add new terms!

EDUCATOR NOTE

The cell phone activity could take even longer if students get invested. Consider breaking this meeting into two sessions if you want to take your time.

Hands-On and Minds-On

MIT's motto is Mens et Manus, which translates to Mind and Hand. Inventors are resourceful and use many tools. Some "tools" are based on learned knowledge stored in our minds from science and math classes. Other "tools" are practiced – hands-on skills like drawing and building things.

EDUCATOR NOTE

After Cell Phone Stand

It is beneficial for students to conduct some peer evaluation if you have extra time. Have students leave their finished cell phone holders on their table tops. Leave a blank piece of paper and pen next to each stand. Students can walk around the room and anonymously leave some constructive feedback. A few students can share their feedback and explain how they would improve their project.

DESIGN A CELL PHONE STAND

1. Ask students if they ever get annoyed by phones not being able to stand up on their own. Explain that inventors think outside of the box and often create **prototypes** of their ideas using everyday materials.

2. Tell students that their challenge is to invent a low- cost cell phone stand using recycled materials like cardboard and tape.

3. Before students start, have them watch **Josh Ramos' Cardboard Videos** to learn some cardboard cutting tips and tricks. Josh earned his **PhD** in Mechanical **Engineering** from MIT in 2018.

4. If students are having difficulty coming up with their own design, they can check out **Josh Ramos' Cardboard Phone Stand.**

5. When finished, have students respond to the follow-up questions (below) in their guides.
   a. What do you like about the stand you made?
   b. How would you change your design if you wanted to watch a video in the landscape format (sideways)?
   c. Where are the speakers on your phone? How might you use the placement of the cardboard or other materials to improve the sound?

6. Have students share their design with another student.

7. Ask students how they would incorporate their peer's comments and their own in their next design? Tell them to describe this next design **iteration** in words or pictures in their Student Guide.

8. Tell students that during the JV InvenTeams initiative, they will learn about new tools and materials through **invention** activities like this one. They will think of **iterations** to improve or change their designs, after successfully meeting challenges these activities present.

Cellphone stand example

Students folding cardboard

WATCH SOME INVENTION VIDEOS

1. Explain that each year, teams of undergraduate and graduate students apply for the Lemelson-MIT Student Prize. Have students check out some cool videos from previous winners and finalists on the **Lemelson-MIT Program's** website.

- **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** (watch first 9 min)

2. Explain that 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.

PATENT PROFILE

MIT alumna Alison Wong invented **Keyprop**, a simple solution to the problem of keeping your smartphone propped up.

EDUCATOR NOTE

After Videos: Debrief

Engage students in a discussion about the videos. Students should be asked to think and converse about the common themes, the inventors' approach, and why failure during the process is okay.

EDUCATOR NOTE

Extend the Learning

An additional resource that may inspire **invention** research is a video called **Extend the Learning: InvenTeens**. Produced by the Museum of Science in Boston.

JV InvenTeams LEMELSON-MIT

EDUCATOR NOTE

Before Product Discussion

Ask students in small teams or as a class to devise a list of problems or things that don't work quite right in their daily lives. Give them a few examples to help them get started, such as a grandparent slips walking in socks, their laptop computer wires get tangled up, and they can't wake up to an alarm.

EDUCATOR NOTE

Before Real-World Examples

Explain to the students that **invention** follows a process of identifying needs, brainstorming ideas, sketching, building a **prototype**, testing, modifying, and re-testing. Potential users are consulted for feedback throughout the process.

RESEARCH AN INVENTION

1. Have students identify an object in the room. Ideas include a specific type of desk, piece of technology, chair, tool, writing utensil, or article of clothing.

2. Explain that 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 product you see today.

3. Tell students that they will conduct research on **inventions** using **Google Patent Search**. Explain that Google **Patents** list 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.

4. Give students a few minutes to conduct research on the product they identified.

    - 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. Have students work in small groups to brainstorm how they could improve one product or process they use during a typical day. Students will respond to the following prompts in their guides:

    - 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?

2. Tell students they will learn to carefully observe the world around them in search of problems that can be addressed with a technological solution.

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 app on your smartphone.

- **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.

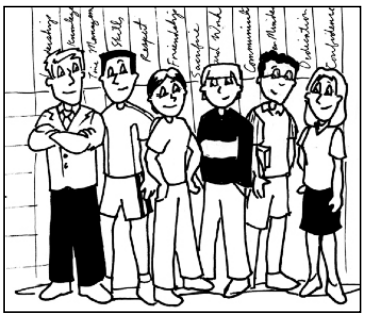
WATCH VIDEOS ABOUT THE DESIGN PROCESS

1. Have students watch the **MIT Design Process Videos**. The videos cover: Design Introduction, Observation, Brainstorming, Idea Selection, and Prototyping.

2. Give students time to outline the design process in their guides.

SET RULES AND DEVELOP TEAMS

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



Allison Wong, Illustrator

- 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. Explain that most of the projects require working in small teams. Diverse teams are successful teams.

3. Use the directions on the next page to play "Four Corners." This game will help you place students into diverse teams.

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.

MEETING 1

EDUCATOR NOTE

After Design Process Videos

Ask a volunteer to recap the steps of the design process. Have them draw a visual outline to include on the Idea Board. Survey the students to see if they have any questions before proceeding.

Steps of the design process are:

- identifying needs,
- brainstorming ideas,
- sketching,
- building a **prototype**,
- testing,
- modifying, and
- re-testing.

EDUCATOR NOTE

Before Setting Rules

You can create a bold list of these rules to place on the Idea Board or somewhere else that is visible in the classroom.

SELF-ASSESSMENT

Collect the completed self-assessments as exit slips when students leave.

INDICATORS OF A SUCCESSFUL MEETING

Students can build a cardboard cell phone stand. They can demonstrate how to think like an inventor, and they understand how the design process works.

FOUR CORNERS GAME

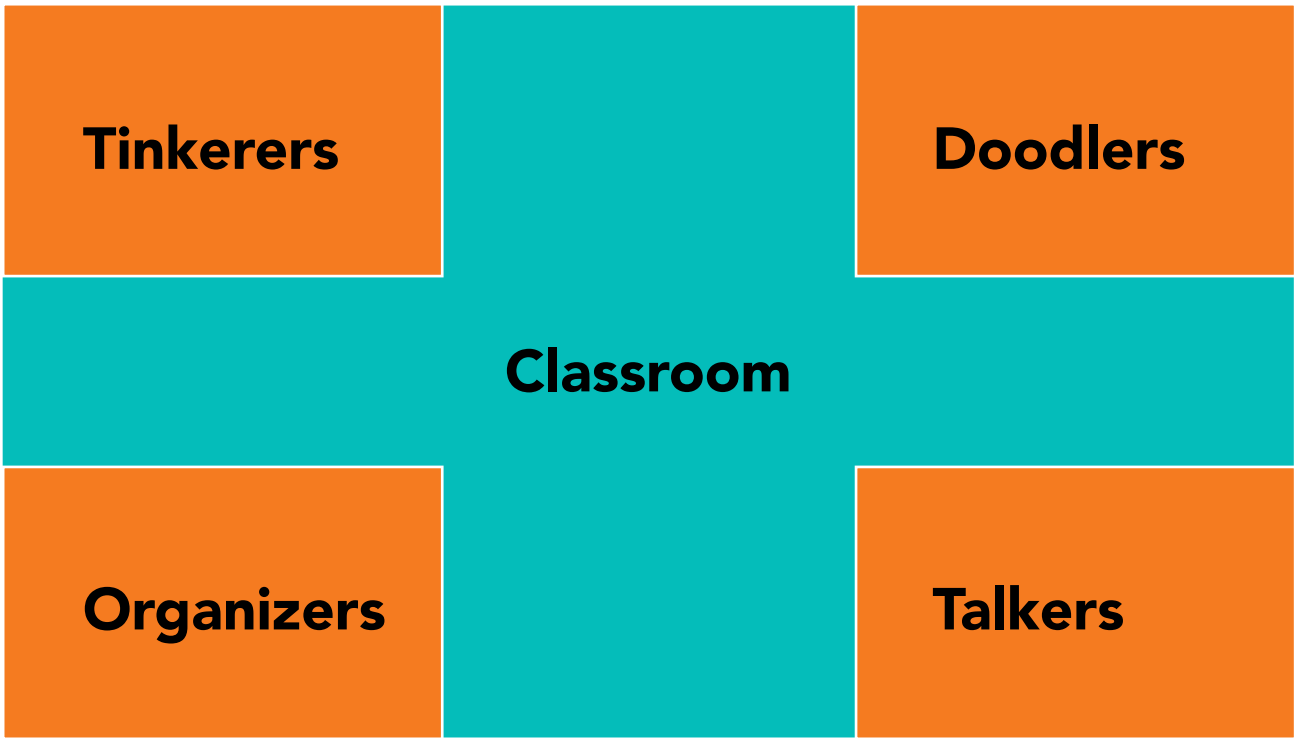
Teams of inventors include people with different interests and skills. Ask students to think about their own interests and skills to help you organize the class into diverse teams. Have students draw a line from each type of team member on the left to the best-matching description on the right.

The corners of your classroom will be marked with the four types of team members. Students will decide which corner best matches their interests and skills.

Ask students to go to their respective corners based on their "sounds most like me" description. The corners will have an equal number of students in an ideal world. If they don't, mention to the students that equal numbers are needed in order to make well-balanced teams. Have students in the larger group(s) look at their "sounds almost like me" description and compare with the corners needing students. Ask students to consider rearranging.

Types of Team Members	**Your Interests and Skills**
Tinkerer: I like to take things apart and build things.	Sounds most like me
Talker: I like to talk to people and I enjoy public speaking.	Sounds almost like me
Doodler: I like to draw things and express my thoughts through drawing.	Sounds a little like me
Organizer: I like to organize people and things.	Sounds least like me

Have students count off within their corners once each has a nearly equal number of students. Finally, have all 1s, 2s, 3s, and 4s come together to form their **invention** teams. Write down the names and teams in your notes. These teams will come into action when students start designing.



MY NOTES

SHOE SOLES
MEETING 2: BIOMECHANICS & BIOMIMICRY

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.

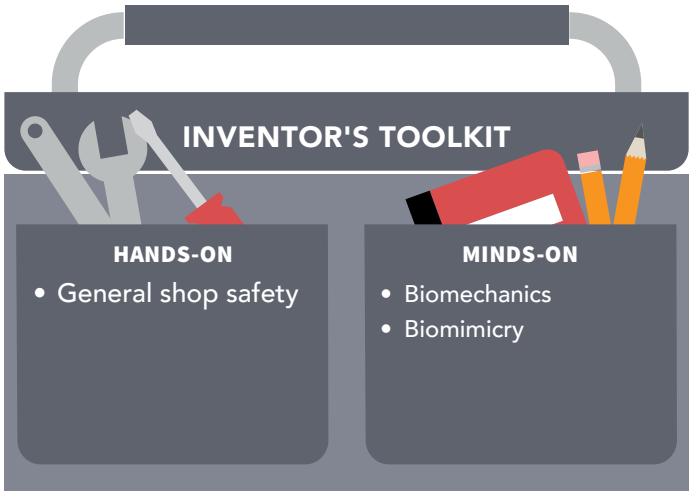
Gait (n): The pattern of movement of the legs during walking or running.

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.



Tools & Electronics

- Writing utensils
- Projector and computer to show video(s)

Materials

- Student guides
- Shop safety rules

If students will not be able to conduct internet or library research during this meeting, you will need to provide:

- Images of a variety of shoe soles
- Images of various animals and plants
- Self-Assessments

Procedure

Note that you may need to extend this meeting over two sessions in order to cover all aspects of **biomechanics** and **biomimicry** that are necessary to begin designing a shoe sole.

- 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

Before the students arrive:

1. Tell students that they may be using hand tools such as saws and screw drivers and basic power tools such as drills and rotary tools. To ensure safety, students must use tools in the way they were designed to be used. Have students watch **General Shop Safety.**

SAFETY

1. **Wear safety glasses.**
2. **If you are in doubt about how to use a tool, ask!**
3. **Have a plan for what you are going to do with the tool.**
4. **Be mindful of others who might enter into your workspace accidentally.**
5. **Secure the workpiece.**
6. **Have a balanced stance while using a tool.**
7. **Remove all jewelry, watches, and loose clothing before working with machinery.**
8. **Pin up long hair and wear closed-toe footwear.**
9. **Never work when you are tired or unfocused.**
10. **Leave the workspace cleaner than you found it.**

MEETING 2

EDUCATOR NOTE

Before Biomechanics Video

Ask students if they play sports. Ask a few volunteers to explain their sport and some of the movements involved. Where do they feel the impact after a hard game or workout? Encourage students to jot down notes about Bolt's motion as they watch the video.

EDUCATOR NOTE

Post Video Debrief

Consider using the Idea Board to post diagrams if additional assistance is needed to enhance students' comprehension of movement.

INTRODUCTION TO BIOMECHANICS

1. Let students know that they are going to focus on designing a shoe sole for a specific athletic activity. Ask students:
    - What is your favorite athletic activity?
    - What movements does your body have to perform in order to succeed in this activity?
    - How might learning about how the body moves help you design a useful shoe sole for that activity?

2. Tell students they 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. Play **The Biomechanics of Usain Bolt** (5:24). Have students respond to these questions in their guides:
    - 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. Either read the following out loud to students or have them read it on their own. Have students underline the important parts as they read.

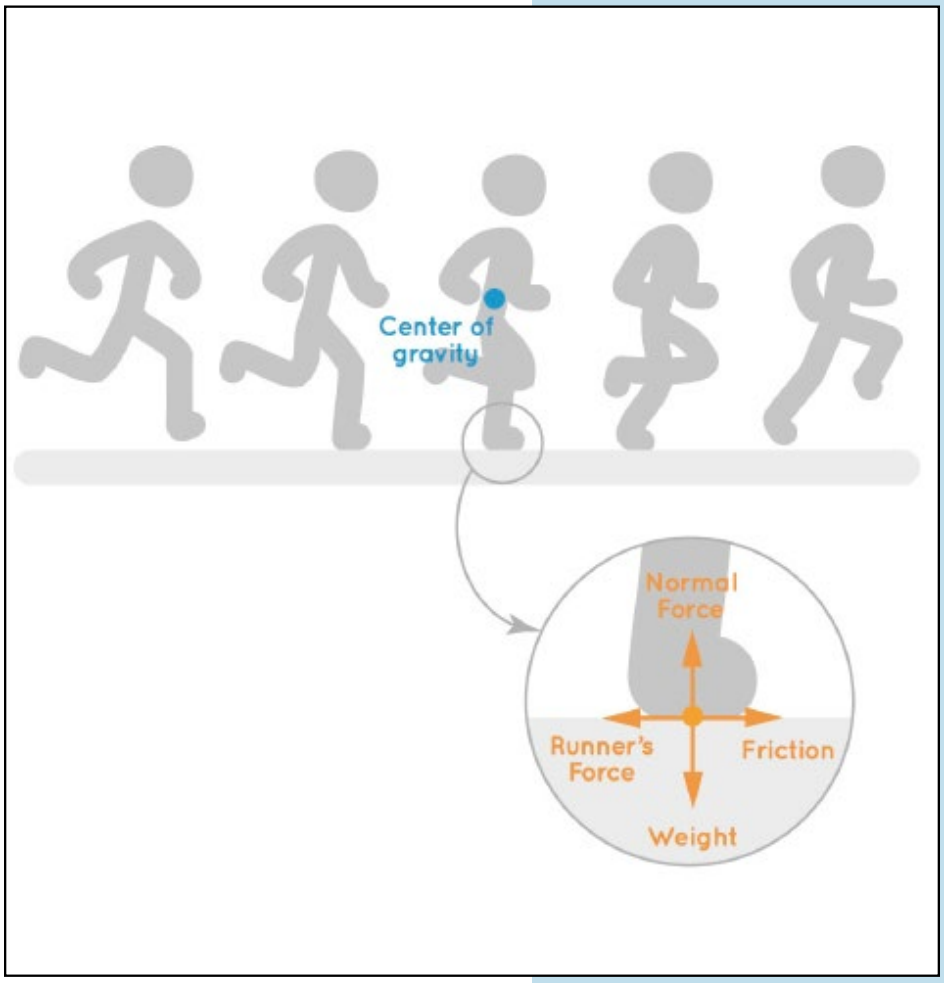
2. After reading, have students share what they learned with a partner.

MEETING 2

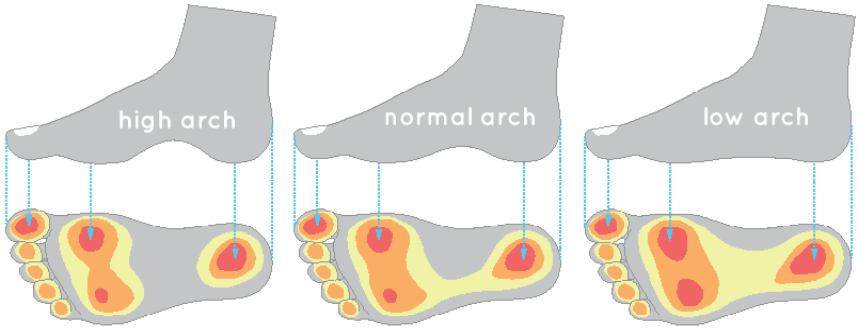
Have you ever wondered why athletic shoe stores have so many options? It is because the requirements for various sports are different. Engineers and designers need to identify the needs of the user and understand their body and movements in order to know how to make a functional shoe sole for each activity. 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 affect 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 leaning forward slightly. Joggers or long distance runners tend to carry a high **center of gravity** and the upper body is vertical. The vertical **force** applied to the ground increases as the **center of gravity** moves from low to high, and 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. Review the diagram above regarding the **physiology** of the human foot.

2. Have students use the prompts to investigate their 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 flat foot, normal arch, or high arch? How would this affect what type of shoe sole you need for walking?

GIHAN ON BIOMECHANICS

1. Have students 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.

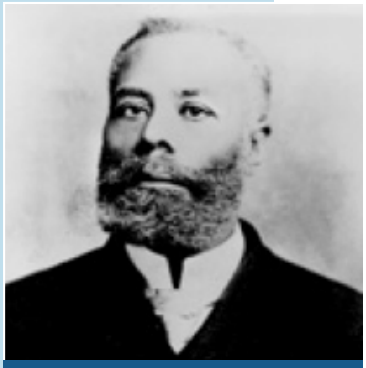
2. Explain: now that students know more about the anatomy and **biomechanics** of the foot, they will find out what shoe companies do to design shoes that fit the needs of their users.

3. Have students investigate running shoe design by visiting websites like **NIKE**, **New Balance** and **Reebok**. Do they see running shoe designs that help people run more naturally?

EDUCATOR NOTE

Extend the Learning

Find out more on runner's **gait** here: **Understanding Running Gait.**



source: www.wikipedia.org

INVENTOR SPOTLIGHT

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.

MEETING 2

EXAMINE YOUR SHOES

1. Explain that many observations must be made in determining 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. Tell students that inventors and designers often examine products already on the market before creating a new product.
3. Have students consider why they think their shoes were designed and record their ideas in their guides.
   - Intended use
   - Intended **terrain** and weather conditions
   - Comfort features
   - **Traction** features
   - **Aesthetic** design
   - Materials selection
4. Have students make similar observations about another classmate's shoes. They will use the prompts in their guides to discuss their findings.
   - What activity do you think the shoes were intended for?
   - What do you notice about the outsole (bottom) of the shoes?
   - Does the outsole have ridges, grooves, or treads? Why?
   - Does the outsole have patterns or shapes? Why?
   - Do you use this shoe as it was intended to be used? Why/why not?
   - What do you notice about the shoe that makes you curious?

INVENTOR SPOTLIGHT

Dutch designer Marieka Ratsma, along with American architect Kostika Spaho, created an innovative shoe using a 3D printer, inspired by a bird's hollow skull. Not only are the shoes unique looking, but they also use far less material than a typical high heel shoe, while still being structurally supportive. Check them out here: Inventor Spotlight: Biomimicry in Fashion.

Source: www.dezeen.com

EDUCATOR NOTE

Pre-chart

Before students complete the chart in their guides, assess a sample shoe as a class to provide an example.

5. Have pairs work together to complete the chart in their guide, listing problems with the designs of the shoes they just examined, and then possible solutions. Explain that inspiration for the possible solutions may come from combining positive attributes of multiple shoes or substituting materials that are used in making the shoes.

Shoe	Problem	Possible Solution	Inspiration

INTRODUCTION TO BIOMIMICRY

1. Remind students that 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. Have students watch **Biomimicry in Action** (17:39), a TED talk featuring Dr. Janine M. Benyus, a leader in the emerging field of **biomimicry**.

3. Facilitate a discussion of 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?

EXTEND THE LEARNING

Visit AskNature, a project of the Biomimicry 3.8 Institute.

In the "how does nature..." search box at the upper center of the homepage, put in words associated with athletic shoes.

source: fbei.wordpress.com

BEGIN THE SHOE SOLE PROJECT (RESEARCH)

1. Explain to students that they 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 (e.g., shoe sole that functions for a specific purpose), researching, brainstorming and formulating ideas.

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

3. Place students in the teams you created at the last meeting.

4. Tell teams they should follow the directions in their guides to select an athletic activity, research shoes designed for that activity, and brainstorm potential improvements.

5. As teams work, walk around the room and record the activity selections from each team.

6. If students do not have internet access, they will need your help conducting some research on their shoe soles. Print a few images of existing shoe soles for each activity to bring to the next meeting. Students will be using the following prompts in their guide to guide their work:
   - 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?

MEETING 2

EDUCATOR NOTE

SCAMPER

Students will be introduced to the SCAMPER brainstorm technique in Meeting 6 (page 43). Feel free to introduce this technique earlier if you think your students would benefit from its structure.

INVENTION SPOTLIGHT

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.

Source: www.nike.com

Each team will divide the following research and interview tasks among its members. Remind team members to think about their strengths as they select tasks.

- 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.

EXTEND THE LEARNING

The biomimetic robotics lab at MIT develops robots inspired by animals. Robots include:

- **Cheetah-inspired quadruped**
- **Cockroach-inspired hexapod**
- **Gecko-inspired climbing robot**

Explore these robots in action at:

College Connection: MIT Biomimetic Robotics Lab Videos.

photo credit: Charl Durand | Unspalsh.com

SELF-ASSESSMENT

Collect the completed self-assessments as exit slips when students leave.

INDICATORS OF A SUCCESSFUL MEETING

Students demonstrate an understanding of **biomechanics** and **biomimicry**. Teams have an assigned activity for their shoe sole project and have begun researching.

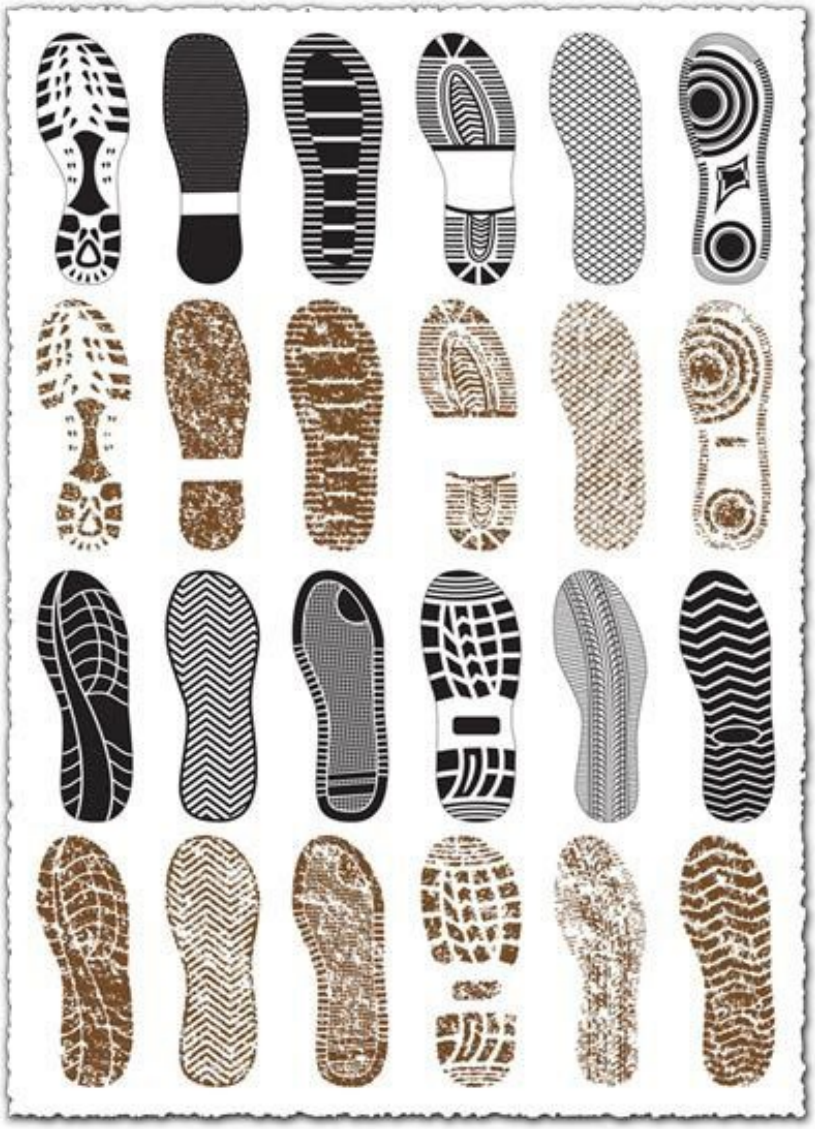


image credit: Free Online Vectors

SHOE SOLES
MEETING 3: SKETCH & DESIGN

KEY TERMS

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

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

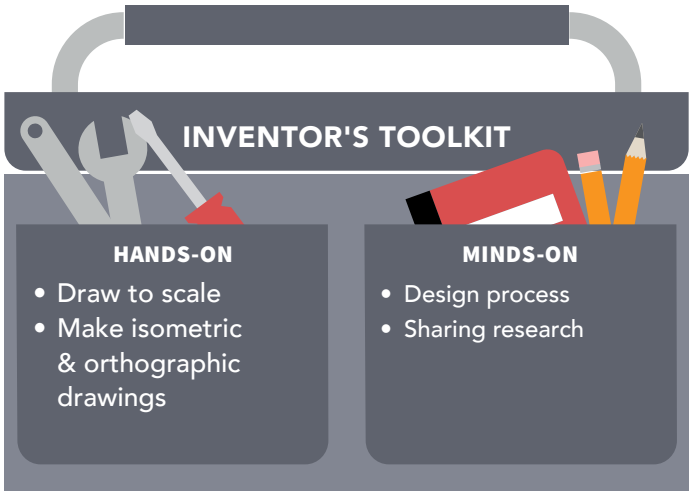
Lug (n): A ridge that helps to provide traction as on a tire or the sole of a shoe.

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.



Tools

- Writing utensils
- Rulers
- Computer and projector to show video

Materials & Shop Supplies

- Student Guides
- Self-Assessments

If students will not be able to conduct internet or library research during this meeting, you will need to provide:

- Images of shoe soles specific to each team's athletic activity

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. Play **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. Tell students they are going to continue researching shoe soles. Ask:

   - Why do you think conducting research is important to inventors?
   - How do you think professional shoe designers conduct their research? Why do you think so?

3. Facilitate a discussion about the video using these prompts:

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

EXTEND THE LEARNING

Traditionally, running shoes are made with a cushioned outsole to help absorb shock and prevent injury.

Manufacturers are beginning to make minimalist or low-cushioned running shoes, which allow runners to strike first with the ball (front) of their foot instead of the heel. This results in less reaction force and may help prevent injury. Visit The Physics of Running Bared to read more about this debate.

photo credit: Sage Friedman | Unspalsh.com

SHARE RESEARCH

1. Tell students they will share research on their athletic shoe soles with their teams. They should compile everyone's research and record major findings in their guides. Teams should include what they learned last meeting about force, friction, tread, foot structure, biomechanics, and biomimicry.

2. Teams can organize their 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. Have teams use the next two pages in their books to design their first shoe sole.

INVESTIGATE EXISTING SHOE SOLES

Columbia Drainslip™ II

INTENDED USE: Walking in the rain

TERRAIN: Wet ground

MOVEMENTS: Forward motion through puddles

SOLE DESIGN AND MATERIALS: Triangular **lugs** to allow for water drainage; more detailed pattern on toes and heels to provide additional friction at point of contact

Columbia Peakfreak™ Enduro OutDry

INTENDED USE: Hiking

TERRAIN: Rugged trails

MOVEMENTS: Up and down, side-to-side, over hills with loose gravel

SOLE DESIGN AND MATERIALS: Multi-directional traction **lugs** and heel crash zone point of contact

Columbia Bugaboot™ Slip

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

Reebok Zigkick Hoops

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

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:

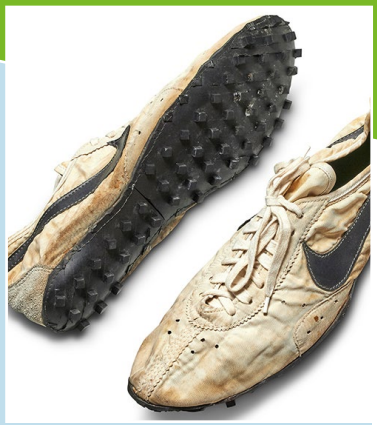
EDUCATOR NOTE

Extend the Learning

Use **Drawing to Scale** as an additional resource for students.

EXTEND THE LEARNING

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



source: robbreport.com

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

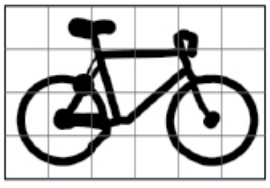
1. Explain that a scale drawing is a drawing that shows an object with accurate sizes except they have all been reduced or enlarged by a certain amount.

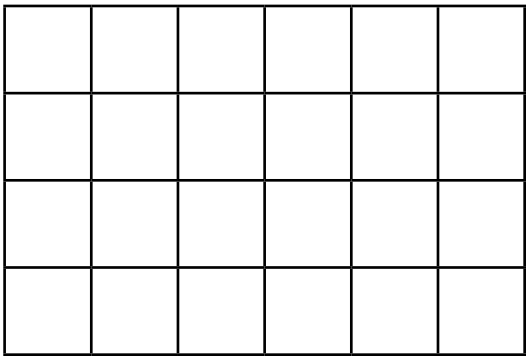
2. Tell students that engineers and architects make drawings to scale. They can then build models to scale from their drawings. Drawings of larger objects, such as machines and buildings, are scaled down to fit on paper. However, drawings of tiny objects like electronic parts are scaled up so that they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

3. Explain that 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. Have students practice making an object larger using the outline below:

Drawing to **Scale**





MEETING 3

DRAW YOUR SHOE SOLE

1. Tell students they are going to draw an outline of their shoe sole in their guide. Their drawing will be **scaled** down by half, which is a 1:2 **scale**.

2. Ask students how they might calculate this?

   - Use a **Shoe Size Conversion Chart** (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. Have students use rulers to mark their graph paper with their measurements. Remind students to mark length and width.

4. Have students label their drawings with their name, date, and **scale**.

INTRODUCTION TO ISOMETRIC DRAWING

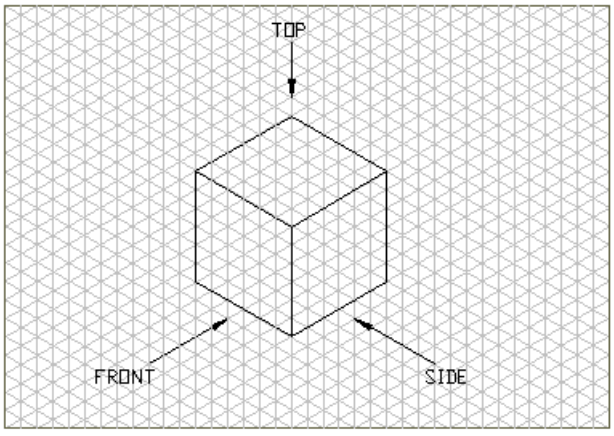
1. Ask students whether they like to draw.

2. Explain that most sketches of 3D objects show just one view of the object, like the front of someone's face.

3. Tell students that engineers and architects use many different techniques to represent their 3D designs on paper. These drawings need to be incredibly accurate so anyone could build their project with the correct measurements.

4. Introduce the term "isometric." Explain that "isometric" comes from the Greek for "equal measure." An **isometric drawing** is a 3D drawing of an object, incorporating all three views (front, side, top) in one drawing.

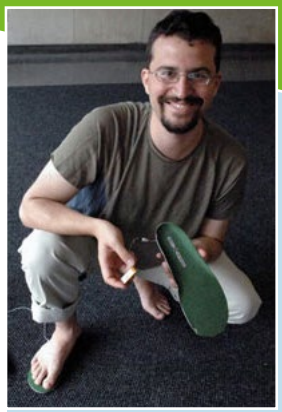
5. Review the **isometric drawing** of a cube that students have in their guides.



STUDENT SPOTLIGHT

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: College Connection: iShoe



source: www.mit.edu

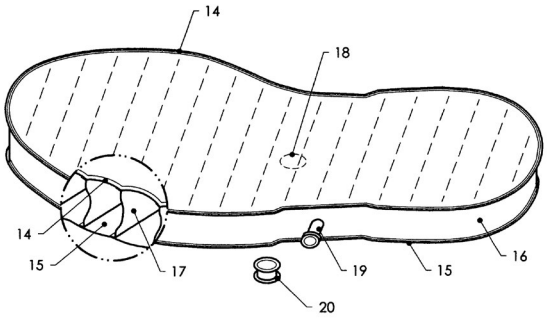
Women's Shoe Size (US)	In	Cm
4	8.1875	20.8
4.5	8.375	21.3
5	8.5	21.6
5.5	8.75	22.2
6	8.875	22.5
6.5	9.0625	23
7	9.25	23.5
7.5	9.375	23.8
8	9.5	24.1
8.5	9.6875	24.6
9	9.875	25.1
9.5	10	25.4
10	10.1875	25.9
10.5	10.3125	26.2
11	10.5	26.7
11.5	10.6875	27.1
12	10.875	27.6

Men's Shoe Size (US)	In	Cm
6	9.25	23.5
6.5	9.5	24.1
7	9.625	24.4
7.5	9.75	24.8
8	9.9375	25.4
8.5	10.125	25.7
9	10.25	26
9.5	10.4375	26.7
10	10.5625	27
10.5	10.75	27.3
11	10.9375	27.9
11.5	11.125	28.3
12	11.25	28.6
13	11.5625	29.4
14	11.875	30.2
15	12.1875	31
16	12.5	31.8

1. Have students draw an isometric outline of their shoe sole. They can add to the scaled shoe sole they already drew. Their isometric outlines might look something like this:

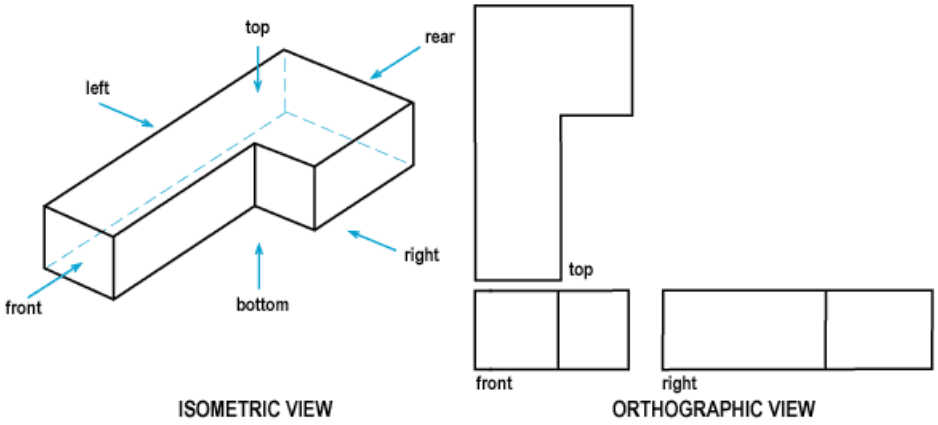
INTRODUCTION TO ORTHOGRAPHIC DRAWING

1. Explain that **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.



Google Patent US 7523565 B1

2. Review the example of **isometric drawing** (below) on the left with its orthographic representation on the right.



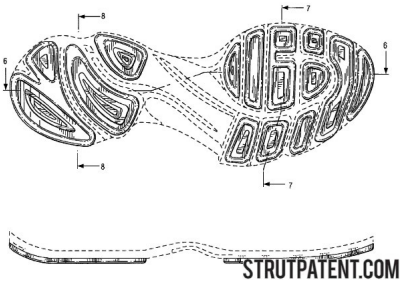
ISOMETRIC VIEW ORTHOGRAPHIC VIEW

3. Have students add orthographic views of their shoe sole in their guide. Have students focus on the top and side views.

4. Explain that the top view is where they will draw the design of the treads, and the side view is where they will show the thickness of various sections.

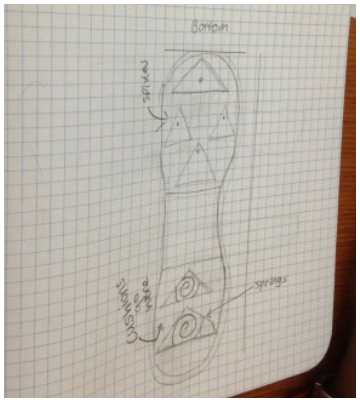
CONTINUE THE SHOE SOLE PROJECT (DESIGN)

1. Give students time to practice drawing to **scale** and making isometric and **orthographic drawings**.



2. Encourage students to check out the **Howtoons Visual Communication Guide** for some guidance on improving their sketches.

3. Have students use the rest of the meeting to begin designing the shoe sole for their team's athletic activity. They should fill in their final outlines - top and side views - with their choice of design features. They may need to do more than one drawing to convey the design elements the way they envision them.



SELF-ASSESSMENT

Collect the completed self-assessments as exit slips when students leave.

INDICATORS OF A SUCCESSFUL MEETING

Students have an improved understanding of the design process. They can successfully draw their shoe soles with a 1:2 **scale** and can represent the drawing both isometrically and orthographically.

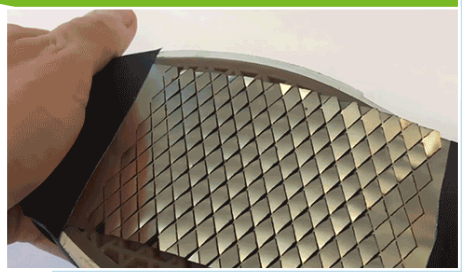
EDUCATOR NOTE

While Students Work

Make sure students label their drawings with their name, date, and correct **scale**.

INVENTION SPOTLIGHT

Researchers from MIT and Harvard University have developed a new way to avoid slipping on dangerous surfaces. They were inspired by kirigami, the Japanese art of intricately cutting and folding paper, to invent shoes soles with more traction. Their research showed that using a pattern of inward curves in metal or plastic had the best results. Their next steps are figuring out how to attach the surfaces on shoes. Learn more about kirigami here: Kirigami Coated Shoes



source: MIT News

SHOE SOLES
MEETING 4: SCULPT CLAY MODELS

KEY TERMS

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.

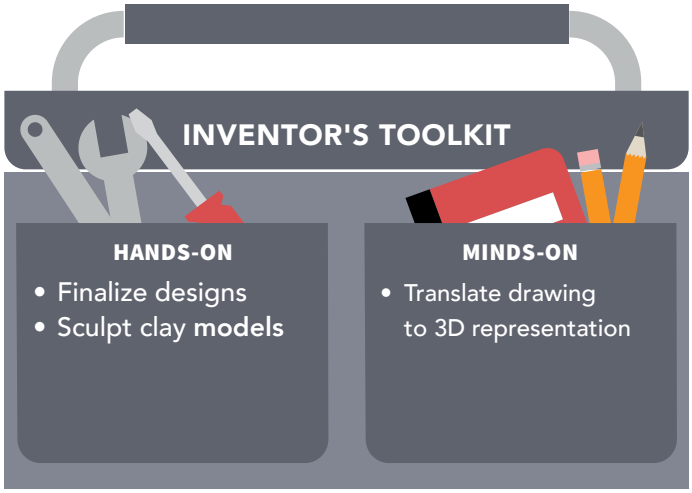
Pattern (n): A form or model to be used for imitation.

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

EDUCATOR NOTE

Teamwork

Encourage students who are not confident in their drawing skills to partner with someone on their team who can help them.



Tools & Electronics

- Writing utensils
- Clay sculpting tools
- Rulers
- Computer and projector to show video

Materials & Shop Supplies

- Student Guides
- One-pound block of **modeling** clay per student
- Wax paper for protecting tables
- Self-Assessments

Procedure

- Finalize Shoe Sole Designs
- Sculpt Clay **Models**
- Select **Model** for Prototype
- Self-Assessment

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!
Springblade


courtesy: www.adidas.com

MEETING 4

FINALIZE SHOE SOLE DESIGNS

1. Ask students: how do you think you will move from your shoe sole design drawing to a 3D shoe sole prototype? Accept all responses. Let students know that they will be sculpting their shoe sole out of clay today, and then selecting certain shoe soles to **cast** into a final prototype during the next meeting.

2. Have students continue drawing designs from the previous meeting.

3. Tell students they should use the graph paper in their guides for their final drawing. Their 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

EDUCATOR NOTE

Before Sculpting

Inform students that it is easier to carve out of their clay than add pieces onto it.

A pencil or other pointed tool will help make fine lines and grooves.

INVENTION SPOTLIGHT

In the early spring of 2020, COVID-19 swiftly became a global pandemic, infecting millions of people worldwide. Researchers discovered that the virus could live for days on many surfaces, including shoe soles. This posed a risk for hospital workers who could potentially carry the virus from hospital room to hospital room or back to their homes. HealthySOLE invented a device that could get rid of the coronavirus by over 99.5%. Learn more about the device here:

UVC-Powered Shoe Sanitizer

source: HealthySOLE PLUS

SCULPT CLAY MODELS

1. Tell students that when they have finished their final design, they will carve their design out of clay. They will use this clay model to make their **mold**, or pattern.

2. Remind students that this design should be full-scale, so about the size of their foot.

3. Review the instructions with students. These instructions are also in their guides.

- Cover your workspace with wax 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 from all areas that will not be part of your shoe sole using carving tools.
- 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 workspace.

EDUCATOR NOTE

After Sculpting

Be sure to find a safe place to store the clay models that will be cast in the subsequent meeting.

SELECT MODEL FOR PROTOTYPE

1. Have students share their models with their team. Tell students that only one design per team will be **molded**. Each person can "**pitch**" their design for selection to **cast** into the final prototype.

2. Remind students that their 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.

SELF-ASSESSMENT

Collect the completed self-assessments as exit slips when students leave.

MEETING 4

EDUCATOR NOTE

Selecting a Model

If a team needs help coming to a decision, have each member vote. Encourage students to be positive contributors to their team.

SHOE SOLES
MEETING 5: CAST CLAY MODELS

KEY TERMS

Casting (n): Object made by pouring liquid into a mold.

Cure (v): To harden or set.

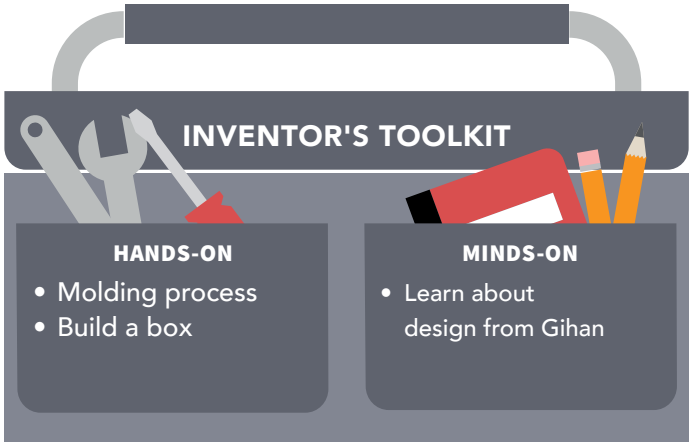
Elastomeric (adj): Having the elastic (stretchy) properties of natural rubber.

Entrepreneur (n): A person who organizes and operates a business, taking on financial risk to do so.

VytaFlex® 30 (n): A urethane rubber used in various processes such as architectural restoration, candlemaking, prototyping, and inventing. It is used to make a 3D physical representation of ideas to help determine commercial potential.

EDUCATOR NOTE

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.



Tools & Electronics

- Writing utensils
- Paint stirrers or wooden craft sticks (1 for each team)
- 16-ounce plastic mixing containers (2 for each team)
- Rulers
- Computer and projector to show video

Materials & Shop Supplies

- Student Guides
- Clay shoe models from the previous meeting
- **VytaFlex 30**, parts A and B
- Can of release agent
- Disposable aluminum pans with smooth bottom, 13” x 9” (1 for each team) OR cardboard boxes with aluminum foil
- Scrap cardboard
- Shipping tape
- Protective gloves (one pair for each student)
- Safety glasses (one pair for each student)
- Self-Assessments

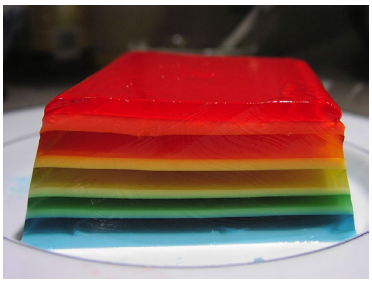
Procedure

- 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. Ask students what comes to mind when they hear the words "molding process." Explain that the type of molding process students will use is the process that gives a shape to liquid when it hardens.

2. Use the suggestions below to facilitate a discussion of real-world uses for 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 students have ever made JELL-O®, then they 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. Check out the following video: **Callebaut Molded Chocolate**.

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

4. Explain that today, students will prepare a container for their mold, and then **cast** their clay model in **VytaFlex 30** to create the mold. They will use the mold as a **casting** to create their 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 Building a Shoe.

EDUCATOR NOTE

Extend the Skills

Students can build a molding box from scratch. Material options include:

- **Foam core**;
- Wood using a saw, hammer, and nails; or
- Corrugated plastic (for tutorial videos, click: **Cardboard**).

The inside of these boxes will need to be lined with a plastic trash bag or Press'n Seal® plastic wrap. An extra meeting or two would be needed for this building process.

PREPARE MOLDING BOX

1. Tell students they can use a disposable aluminum pan or a shallow cardboard box for their molding box.

2. Have students keep a few things in mind while creating their boxes:

- The molding boxes must have a smooth bottom to work well.
- The cardboard box, if used, must be lined with smooth aluminum foil.
- Use scrap cardboard and shipping tape to segment the molding box so there is just enough room for the clay model to fit inside.
- Add 1/2 inch to the length and width of the clay model. Make sure the box is 1 inch higher than the clay model.

PREPARE VYTAFLEX 30

EDUCATOR NOTE

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.

1. Prepare **VytaFlex 30** while students make their molding boxes.
2. Pour 8 ounces of **VytaFlex 30**, part A, into a 16 ounce container. Repeat until there is one for each team.
3. Pour 8 ounces of **VytaFlex 30**, part B, into a 16 ounce container. Repeat until there is one for each team.
4. When teams are ready, distribute a poured set of **VytaFlex 30**, parts A and B, to each team.

SUSTAINABLE SOLUTIONS

NIKE created a sneaker collection made from recycled waste in response to the growing demand for footwear created through sustainable practices. The shoe collection is called "Space Hippie," inspired by life on Mars where materials are hard to come by. The shoes are made from at least 25% recycled materials from the upper section to the outsole. Watch how NIKE is reducing their carbon footprint:

Nike's Space Hippie

source: nike.com

CAST CLAY MODEL

1. Review the **casting** process below with students. This process is also in their guides.

- Put on protective gloves and eyewear.
- Place the clay model, tread side up, in your aluminum pan. Make sure it is firmly touching the pan so there is no room for the **VytaFlex 30** to seep underneath.

- Get a can of release agent.
- Ensure this area is well ventilated, then spray release agent evenly around the inside, bottom, corners and sides of the box. Make sure every space in the box is covered with a thin coating.

- Let it sit for 5 minutes.
- Mix parts A and B (1:1 ratio) of **VytaFlex 30** in a plastic container with a wooden stirrer. Mix well.
- Pour the mixture into the mold without letting it overflow.
- Label the outside of your team's box with a fun and descriptive name for your shoe sole.
- Let the mold **cure** for 24 hours.
- Clean up your space.
- Throw unused **VytaFlex 30** into the trash. **DO NOT** pour it down the sink.

2. Tell teams that finish early to skip ahead and read the next section on Gihan Amarasiriwardena.

3. Store the molding boxes in a safe place until the next meeting.

EDUCATOR NOTE

Before Using VytaFlex

Review the Safety Data Sheet (**SDS**) for **VytaFlex 30** and the release agent. Good ventilation is needed for this activity; if necessary, consider doing this activity in an outdoor space or bring in some fans. Hold a fan by the window as you spray to blow the fumes outside.

EDUCATOR NOTE

After Casting Models

Encourage teams that finish early to read the next section on Gihan and explore his website. Wait to show the video clips until everyone is ready.

MEET GIHAN AMARASIRIWARDENA

1. Either read the following out loud to students or have them read it on their own. Have students underline the important parts as they read.

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. Check it out: NIKE's Top Brass Hacked Their Own Shoes.

Gihan Amarasiriwardena 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.

source: www.gihan.amarasiriwardena.com

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.

2. Explain that students are going to watch two video clips of Gihan discussing invention and biomechanics.

3. Before beginning the videos, have students find and discuss definitions for the following words:

   - Traction
   - Pattern
   - Prototype
   - Orthotic
   - Strain Analysis
   - 3D Printing
   - Invention Process
   - Podiatrist
   - Innovative

EDUCATOR NOTE

Extend the Learning

Read about Gihan's Ministry of Supply company in the New York Times:

EXTEND THE LEARNING

Read about Gihan's Ministry of Supply company in the New York Times:

Rolling Up Their Sleeves

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

5. Tell students that 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**. Play **Gihan as Entrepreneur** (6:42), in which Gihan explains the launch of his business and how he became interested in being an inventor.

6. Facilitate a discussion of 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?

SELF-ASSESSMENT

Collect the completed self-assessments as exit slips when students leave.

INDICATORS OF A SUCCESSFUL MEETING

In their teams, students build an effective molding box. They learn about the molding process and **cast** their shoe soles in **VytaFlex 30**.

SHOE SOLES
MEETING 6: SHOE SOLE PROTOTYPE

KEY TERMS

Adaptive (adj): Having the capacity for change.

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

Prosthetics (n): Artificial body parts.

EDUCATOR NOTE

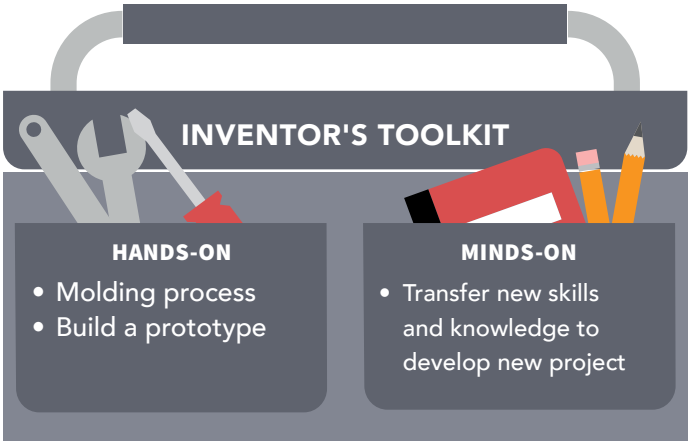
Before the Meeting

Move the boxes with clay models into the JV InvenTeam space. Ask students to find their projects and in their small teams instruct them to carefully remove their clay model. What they now have is a mold.

EDUCATOR NOTE

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.



Tools & Electronics

- Paint stirrers
- 16-ounce plastic mixing containers (2 for each team)
- Writing utensils
- Computer and projector to show video

Materials & Shop Supplies

- Student Guides
- VytaFlex 30, parts A and B
- Can of release agent
- Dye
- Plastic gloves (1 pair for each student)
- Safety glasses (1 for each student)
- Self-Assessment (page P13, copy one per student)

Procedure

- Remove Clay Models
- Cast Shoe Sole Prototype
- Scott Portzline on Inventing
- Purposeful and Unique Inventions
- Brainstorm Invention Ideas
- Self-Assessment

MEETING 6

REMOVE CLAY MODELS

1. Let students know that today they will cast their prototypes and begin their Invention Challenge.

2. Have teams carefully remove their clay models from the box. If there are sticky spots, students can use one of the clay tools to gently separate the clay from the mold. Students can cut off extra pieces of VytaFlex if it seeped.

3. Tell students the resulting VytaFlex shape is a mold that they will now use to create their prototype.

4. As teams take out their clay models, prepare 5 ounces each of VytaFlex parts A and B in separate mixing containers, one for each team.

CAST SHOE SOLE PROTOTYPE

1. Review the casting process below with students. This process is also in their guides.

   - Put on protective gloves and eyeware.
   - Ensure the area is well-ventilated, then spray release agent inside the mold. Be sure to spray evenly around the crevices.
   - Let it sit for 5 minutes.
   - (optional) Color your prototype by adding a few drops of dye to the part B container and mixing with a paint stirrer.
   - Mix parts A and B (1:1 ratio) of VytaFlex 30 in a plastic container with a paint stirrer. Mix well.
   - Pour the mixture into the mold without letting it overflow.
   - Let it cure for 24 hours.
   - Clean up your space.
   - Throw extra VytaFlex 30 in the trash. Do not pour it down a sink.

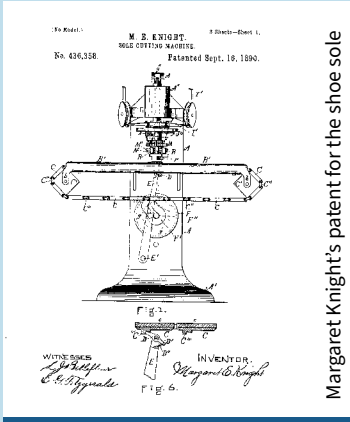
2. Tell teams who finish early to start the reading on the next page.

EDUCATOR NOTE

Suggestions for VytaFlex

Prepare the containers of part A and B in advance at each team's table. Each team will need approximately 5 ounces of each part to create their prototypes.

Consider experimenting with other materials such as hot glue or caulk.



Margaret Knight's patent for the shoe sole cutting machine

INVENTOR SPOTLIGHT

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. Learn more: Margaret Knight

SCOTT PORTZLINE ON INVENTING

1. Either read the following out loud to students or have them read it on their own.

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.

INVENTION SPOTLIGHT

Scott Portzline has many footwear design patents. Find US D655483 S1 using the Google patent search. The patent contains 21 different views of the same shoe! Discuss why you think there are so many visuals.

Scott's advice for future designers and inventors:

- Be creative: Draw every day 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.

2. Have students answer these questions in their guide:

- 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. Read the following out loud to students. This section gives students more information about the Invention Challenge.

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.

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.

Students will conceptualize a project. Their ideas have the possibility of becoming InvenTeams projects in future years!

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 choose to 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.

For additional information on problems/needs in other countries, explore the **World Bank** website.

2. Review the examples of purposeful inventions on the next two pages as a class.

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 their vibrant production floor:

New Balance

PURPOSEFUL AND UNIQUE INVENTIONS

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. Get the details here: Ronald Demon

Example 2

Rothy's is a company that serves as an excellent example of invention with service and purpose in mind. Click on **Rothy's** to learn more about how they transform eco-friendly materials into stylish, wear-everywhere products.

Can you think of any durable materials that could work for a low-cost shoe? What other populations might benefit from low-cost or specialized footwear? Record 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.

MEETING 6

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.

INVENTION CHALLENGE

1. Remind students that as they brainstorm invention ideas, they need to first think about WHO their invention will help.

2. Tell students that the most successful brainstorms are the ones in which all ideas, even wacky ones, are proposed and all ideas are accepted. You never know when a wacky idea will inspire a great invention!

- Give students a few minutes to brainstorm on their own using the next pages in their guides. Then, have students rejoin their teams to share their ideas and brainstorm new ones. Encourage students to apply their hands-on and minds-on toolkit as they brainstorm. For example, how can the molding process be used to make something new? How can you create low-cost or **adaptive** footwear?

SELF-ASSESSMENT

Collect the completed self-assessments as exit slips when students leave.

INDICATORS OF A SUCCESSFUL MEETING

Students mix VytaFlex 30 and create their prototypes by pouring it into their molds. Students begin to apply their new toolkit of skills and knowledge toward solving a real-world problem.

EDUCATOR NOTE

After Examples 2 and 3

Give students a few minutes after reading each example to record their ideas in their guides.

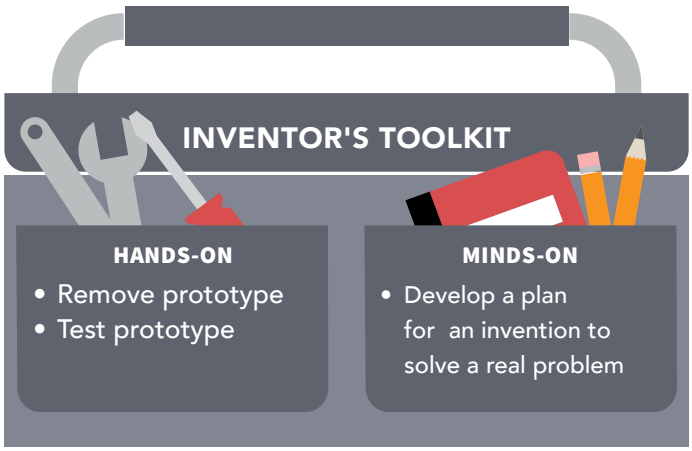
INVENTOR SPOTLIGHT

Jason Mayden grew up in the Southside of Chicago during the Michael Jordan era and dreamed of somehow interacting with his hero. A creative and artistic kid, he decided to use design as his way of inspiring people and engaging with the world. While studying at Detroit's College for Creative Studies, his mind was set on interning for NIKE, specifically on his hero's Air Jordan brand. After three rejections, he finally landed an internship. His determination, creativity and skills led him to eventually become lead designer at NIKE's Air Jordan Brand. In 2018 he became CEO of Super Heroic, a line of affordable footwear for children that encourages them to be creative in their play. Learn more about Jason Mayden and his inspiring career path:

Jason Mayden's Super Heroic Line

How He Got There

2012 TedEx Talk



Tools & Electronics

- Writing utensils
- Computer and projector to show video

Materials & Shop Supplies

- Student Guides
- Prototypes
- Flip-flop (1 for each team)
- Quick-cure epoxy
- Paint stirrers
- Newsprint
- Roll-on stamp pad ink (or finger paint)
- Self-Assessments

Procedure

- Test Your Prototype
- Get Feedback
- Brainstorm Ideas for Unique and Purposeful Inventions
- Make a Plan
- Self-Assessment

TEST YOUR PROTOTYPE

1. Distribute the molding boxes with the shoe sole prototypes to each team. Have teams carefully remove their prototype. Congratulate teams on their first prototype!

2. Explain that 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. Tell students it is time to test their prototypes. 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. Ask students how they think they should test the prototypes? What information do they need from the tests and why?

Shoe soles made by 9th & 10th graders

4. Review the testing procedure with students. This procedure is also in their guides.

   - Choose a flip-flop that best matches the size of your prototype.
   - Use epoxy to adhere the prototype to the bottom of the flip-flop. Mix the epoxy with a paint stirrer.
   - Let the shoe dry for five minutes.
   - Lay out newsprint on a tabletop or on the floor.
   - Apply roll-on stamp ink evenly over the bottom of the shoe sole.
   - Using your hand, or with a team member wearing the flip-flop, step onto the newsprint to make an imprint.

Complete the testing chart on the next page.

HIGH SCHOOL CONNECTION

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:

Vacuum Molding

EDUCATOR NOTE

After Removing Prototype

If one or more teams do not have fully intact prototypes, explain that failure is part of the invention and learning process. Ask them: Why do you think your prototype tore, came apart, etc.? Ask what they would do differently if they did this unit again. You can ask these students to join other teams for testing and feedback.

Why Flip Flops?

Tell students they are using flip flops because they do not have an outsole.

EDUCATOR NOTE

Facilitating Redesign

You may find that your students would like to design a second prototype and test again. If you have the time and resources to facilitate a second round of designing and testing, follow the tips for facilitating redesign on P12 of the Educator Guide.

Team's Activity: _____

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

GET FEEDBACK

1. Have teams conference with another team to discuss their shoe sole prototypes.

2. Start by having each team select a communications leader. This person will present the team's intended activity for the sole and provide information pertaining to the terrain, and motion required by the activity.

3. Encourage teams to ask each other the same questions that they answered about their own designs in their guides.

4. Ensure that students are keeping the feedback constructive and specific.

source: Vivobarefoot

SUSTAINABLE SOLUTIONS

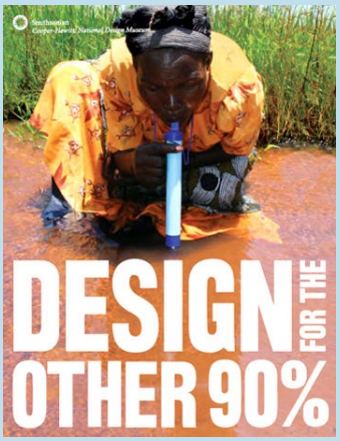
Shoes made out of algae? Yes, that's right! Algae overgrowth in ponds and lakes is an increasingly big problem due to pollution from agricultural runoff water. A major algae explosion in China's Lake Taihu left several million people without safe drinking water. Vivobarefoot recognized a solution to the problem by collecting the algae and turning it into a rubbery material for shoes.

Read more: Shoes that Clean Lakes

EDUCATOR NOTE

Extend the Learning

Explore the book "Design for the Other 90%" by Cynthia E. Smith to read about projects that help the world's close to 5.8 billion people with little or no access to products and services many of us take for granted.



INVENTION CHALLENGE

1. Remind students that in the last meeting, they began brainstorming ideas for the Invention Challenge. Tell students that today they will determine a need that can be realistically and successfully addressed among your team members.

2. Explain that 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. Encourage teams to apply for an InvenTeam grant to help fund the development of their idea.

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

5. Have students record their research and ideas in their guides.

BRAINSTORM SOLUTIONS

1. Tell students that 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 to 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. Explain that to use the SCAMPER technique, they should first state the problem they would like to solve. Then, ask questions about it using the SCAMPER checklist.

3. Have students do some personal brainstorming on page 46 in their guides.

4. Bring teams together to discuss ideas and streamline them. Have teams select one idea to take to the next step.

MAKE A PLAN

1. Remind students that all ideas are good ideas. They should record all ideas in their guides.

2. Encourage students to ask themselves the following questions to make sure they 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. Have teams use the invention worksheet in their guides to document and sketch their idea. This is a version of what high school InvenTeams use in their project proposals.

4. Have teams share their ideas with the class in a culminating celebration of their work. Encourage students to **apply for InvenTeams grants** if they want to continue this work!

MEETING 7

EDUCATOR NOTE

During Invention Planning

Walk around the room and make sure progress is being made. It would be ambitious for all teams to complete the worksheet pages by the end of the meeting. Ask them to continue researching and working on their ideas outside of meeting time. Emphasize that they can consider applying for InvenTeams grants if they want to continue their work!

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 and think about how you can create an environmentally friendly shoe: Footwear's Carbon Footprint

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?

What problem do you want to solve?

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?)

INVENTION WORKSHEET

Our JV InvenTeam members are:

The product we are inventing is: _____

to: _____

_____

It is useful for: _____

_____

because: _____

_____

_____

It is unique because: _____

_____

It functions by: _____

_____

_____

The tools we need are: _____

_____

The materials we need are: _____

_____

_____

The estimated total cost of our invention is: _____

LEMELSON-MIT

JV InvenTeams™

The Lemelson-MIT Program congratulates _____

on completing the Shoe Soles unit of JV InvenTeams on _____

You did a wonderful job as an inventor and made fantastic molded soles!

Thanks for all your contributions to the team.

Award for _____

Signed,

_____

Your JV InvenTeam Educator

engineering

- -

invention

- -

iteration

modification

- -

patent

- -

PhD candidate

prototype

- -

aesthetic

- -

biomechanics

biomimicry

- -

center of gravity

- -

force

biomimicry

- -

center of gravity

- -

force

friction

- -

gait

- -

mass

physiology

- -

terrain

- -

traction

insole

- -

isometric drawing

- -

lug

negative space

- -

orthographic drawing

- -

outsole

mold

pattern

pitch

casting

- -

cure

- -

elastomeric

entrepreneur

- -

VytaFlex® 30

- -

adaptive

empathy

- -

prosthetics

- -

Standards

ITEEA STLs

Standard	Details
Standard 3	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
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.

SHOE SOLES - NGSS - HIGH SCHOOL

Meeting/ Standards	Core Ideas	Engineering Standards	Cross-Cutting Concepts	Practices
Meeting 1: Invention Introduction	ETS1.A ETS1.B	HS.ETS1-3	• Structure & Function	• Asking questions and defining problems. • Constructing explanations and designing solutions. • Obtaining, evaluating, and communicating information.
Meeting 2: Biomechanics	ETS1.A ETS1.B	HS.ETS1-2 HS.ETS1-3	• Influence of Sciences, Engineering, and Technology on Society & the Natural World • Structure & Function	• Planning and conducting investigations. • Obtaining, evaluating, and communicating information.
Meeting 3: Sketch & Design	ETS1.A ETS1.B	HS.ETS1-1 HS.ETS1-2	• Systems & System Models • Structure & Function • Scale, Proportion & Quantity	• Constructing explanations and designing solutions. • Developing and using models.
Meeting 4: Sculpt Clay Models	ETS1.B	HS.ETS1-3	• Structure & Function	• Developing and using models.
Meeting 5: Cast Clay Models	ETS1.B *	MS.ETS1-4 *	• Systems & System Models	• Developing and using models.
Meeting 6: Shoe Soles Prototype	ETS1.A	HS.ETS1-1	• Influence of Sciences, Engineering, and Technology on Society & the Natural World • Structure & Function	• Asking questions and defining problems. • Constructing explanations and designing solutions. • Developing and using models.
Meeting 7: Test Prototypes & Invention Extension	ETS1.B	HS.ETS1-3	• Influence of Sciences, Engineering, and Technology on Society & the Natural World • Systems & System Models	• Constructing explanations and designing solutions. • Analyzing and interpreting data. • Developing and using models. • Planning and carrying out investigations. • Obtaining, evaluating, and communicating information.

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