Tinkering Outside of the Box

Grade Level: 4-8

Lesson Overview

This set of “tinkering” lessons crosses all four academic disciplines as students use everyday items to construct a machine that moves. As you use each of the four lessons, your students will move a project from design development, to machine construction, prototype testing, creating scale drawings, and applying for a patent. Students will use their “thinkers” as they “tinker!”

Student Objectives

1. Identify simple machines and their characteristics. (ELA)
2. Design a product that possesses upward or horizontal mobility, using common items. (ELA)
3. Write step-by-step instructions on how to build a machine. (ELA)
4. Complete an experiment following the Scientific Method. (Science)
5. Use measuring devices, i.e. rulers, to determine sizes for a scale drawing. (Math)
6. Create a scale drawing. (Math)
7. Graph results of class activity. (Math)
8. Define patent, trademark, and copyright and be able to explain why they are an important part of the U.S. government. (Social Studies)
9. Describe individuals who have received agricultural patents and explain how the patent helped them become successful in their business. Explain how these inventions are beneficial to agriculture. (Social Studies)

Materials

- ✓ Simple Machines Information Sheet
- ✓ Miscellaneous items either teacher supplied or brought from students’ homes to construct machine (see ELA Procedure #3 and Tinkering Bag Inventory sheet for ideas)
- ✓ 6 ears of corn
- ✓ Tinkering Outside of the Box ELA Worksheet
- ✓ Tinkering Out of the Box Science Worksheet
- ✓ measuring devices (such as tape measures, rulers or yard stick)
- ✓ materials to propel machines or materials to build a ramp (optional)
- ✓ masking tape or other marking material
- ✓ results from ELA & Science parts of Tinkering Outside of the Box
- ✓ graph paper for graphing and drawing to scale
- ✓ Tinkering Outside of the Box Patent Exploration Worksheet

- ✓ internet access

Vocabulary

- **axle** - the bar or cylinder on which a wheel turns.
- **complex machine** - a machine made up of more than one simple machine.
- **fulcrum** - a pivot point (which can be moved) on which a lever turns.
- **inclined plane** - a sloping surface.
- **lever** - a device such as a bar or board that pivots on a fulcrum.
- **machine** - a device used to do work.
- **pulley** - a wheel with a grooved rim over which a rope, cable, or chain passes.
- **screw** - an inclined plane wrapped around a shaft or cylinder.
- **simple machine** - a machine with few or no moving parts.
- **wedge** - two inclined planes attached back to back.
- **wheel** - a circular object or disk which revolves on a central point such as an axle.
- **ratio** - the comparison of the size of an object in the drawing to the actual size of the object.
- **scale drawing** - a drawing that represents a real object. The scale of the drawing is the ratio of the size of the drawing to the actual size of the object.

Background Information

Humans solve problems by thinking, tinkering, and innovating. Eli Whitney solved the problem of cleaning cotton by hand when he invented the cotton gin. John Deere solved the problem of plowing sticky prairie soil by developing a self-cleaning, polished steel plow. Joseph Glidden and others solved the problem of containing livestock by developing barbed wire.

As evidenced by these examples, many of our most renowned inventions were responses to agricultural problems. These challenges touch all of us because we all need to eat and wear clothes, and agriculture provides these necessities of life.

The cotton gin, steel plow, and barbed wire were all invented around 150 to over 200 years ago. But agricultural inventions aren't all distant history. In the past 20-25 years, robotic milking systems have improved the quality of dairy farm life while collecting more information on each cow, improving herd health, and increasing milk production. GPS (global positioning systems) guidance saves seed, fertilizer, crop protectants, and emissions by allowing precision in growing

crops. Combine yield monitors, agricultural drones, advanced seed technology, automated feed and watering systems, and many, many more innovations continue to improve agriculture.

There are many more agricultural problems to solve. How do we feed a growing population while protecting soil, water, air, and wildlife? How do we produce food on less land? How can farmers cope with the droughts, floods, heat waves, and cold spells that are amplified by climate change?

Facing these and other challenges requires a society that understands how to solve problems. In order to be effective problem-solvers, we need to remember that the answers aren't always provided for us. We need to practice thinking, tinkering, and innovating.

Procedure

To aid in "Tinker" implementation, it is suggested that English Language Arts be the first lesson taught, as this is where the actual machine is developed and constructed. The machine is tested in the Science lesson, scale drawings of the machines are made in the Math lesson and a patent is applied for in the Social Studies lesson.

The following situation, Move It!, could be used as an interest approach:

> "Your parents have decided to improve the look of your front yard. In order to do so, they would like to remove an old cement sidewalk and replace it with paving bricks. The sidewalk is a series of 5-inch thick concrete slabs, each weighing over 200 lbs. Your parents have asked for your help to remove the sidewalk and load the pieces onto a trailer to be hauled away. How would you do it? What simple machines would you use to make the task easier?"
>
> Have students discuss possible answers with a partner. Allow pairs to share their ideas with the class.

English Language Arts

1. Students will construct a machine that possess either upward or horizontal mobility. The only required material that must be used in this machine is an ear of corn. The materials used and methods for propelling each machine is going to be up to the creativity of each student group.
2. In order to get students thinking about how simple machines will be put together to make their machine, review simple machines and their characteristics with the students. Refer to Simple Machines Information Sheet.
3. Brainstorm with the students and develop a list on the board of household items that could be used as simple machines or their parts. In this list, try to include items that will eventually be used to construct their machine that possesses mobility. However, try to be as general as possible, in order to not give the students' a preconceived idea of what each item would be used for. Some examples of items are cereal boxes, caps, screw lids, used paper, paper towel tubes, rubber bands, straws, wooden dowels, Lego wheels and

other household or recyclable materials. Refer to the Tinkering Bag Inventory sheet later in the lesson.

4. Divide students into no more than 6 groups (number of students in each group will vary according to class size). Less groups may be desirable depending on class size.
5. Direct students to design a machine, using the ear of corn and the items the class has listed on the board. (Besides the ear of corn, the teacher may feel the need to make 2 - 4 items required for each group and have 2 - 4 other items chosen by each individual group. This will provide some consistency among the groups, yet still allow for student creativity.) The machine to be constructed should be some type of machine that possesses mobility, that is, it needs to move at least 3 feet in an upward or horizontal direction. The method of making the machine mobile is going to be up to the creativity of the teacher and class. The goal is to build the machine that moves the farthest. The teacher may decide on a reward for the group that builds the winning machine.
6. After each group has designed their machine, have them gather the materials to build it. The items can be supplied by the teacher, gathered from home, or found throughout the school. Again, creativity will lead this process. As they build the machine, it is important to remember that the machine must be able to be disassembled and reassembled by another group.
7. Hand out the Tinkering Outside of the Box ELA Worksheet to each group. Instruct the students to complete the worksheet as they build their machine. Step-by-step, detailed instructions on how to build the machine will be written by students within each group. (Practice with step-by-step direction writing may be necessary. Have the students write directions on how to make a peanut butter and jelly sandwich. Next, use the students' directions to make the sandwich in front of the class to demonstrate the importance of clear, concise directions.)
8. After the students construct their machine and complete the Tinkering Outside of the Box ELA Worksheet, they must take the machine apart and give the items and their worksheet to a different group. The new group must assemble the machine according to the instructions. If the instructions need changes or clarifications, those should be noted along with adding any more answers to question #3. The second group should disassemble the machine again and pass it to a third group for final assembly based on the edited instructions. (The teacher may wish to collect the worksheets from the original groups and make copies prior to passing them onto the next group. This will allow the teacher to have an original document from the group if he/she is taking a grade on the worksheet or the worksheet gets misplaced.)
9. Now the machine is ready to be tested on its' mobility. Please refer to Science section.

Science

1. Review and discuss the Scientific Method with your students, making special note that in a proper experiment, there should only be one variable. In these particular experiments,

the variables may change from one experiment/machine to another. Be sure each experiment is limited to one variable.

2. Divide the students into the same number of groups from the Tinkering Outside of the Box ELA Worksheet.
3. Pass out the Tinkering Outside of the Box Science Worksheet for the students to complete.
4. Have each student hypothesis how far each machine will travel and which machine will travel the farthest. Each machine will have its' own experiment to identify how far it travels. The experiment should be replicated a predetermined number of times. (At least three replications are suggested.)
5. Assign a machine to each group to design an experiment for testing the machine. Be sure the groups complete the procedure portion of their worksheet very accurately.
6. Next, have each group take turns conducting the experiments. Under "Data", a data table is suggested to record the results of the experiment. (It may be possible for each group to conduct the experiment for each machine by rotating from one station/experiment to the next. If this method is preferred, make copies of the procedure for each experiment and leave them at each station.)
7. After all experiments have been conducted, summarize the results of the experiments with the students and discuss why the winning machine traveled the farthest. Was it the design of the machine? (weight, aerodynamics, construction) The method of propelling it? Or was it a combination?
8. Please refer to Math section for graphing of the results and scale drawing of the machines.

Math

1. Review scale drawings with students, using examples. (One easy way to remind the students about scale drawings is to talk about maps being drawn to scale. Also, using your overhead projector, you can move the projector back from the screen to show how an object gets larger and then discuss the ratio of the original to the projected image.)
2. After completing both the Tinkering Outside of the Box ELA and Science lessons with the students, have each group generate a scale drawing of the machine they created, using various measuring devices.
3. From the results of the science lesson, have the class design a graph showing the distances traveled by the various machines.

Social Studies

1. To learn more about patents and inventions, students should complete Tinkering Outside of the Box Patent Exploration Worksheet.

Extension Activities

1. Students may create an advertisement, (print: newspaper, magazine; TV; radio; or website), containing text and/or illustrations of the completed machine to market the product.
2. Visit http://www.deere.com/en_US/compinfo/student/logoentrypage.html - One of the country's most recognized corporate symbols, the leaping deer trademark has been synonymous with quality John Deere products for more than 120 years. The chronological story of its evolution can be explored at this site.
3. After students have constructed their machine and written their instructions, have them create an "Owner's Manual" providing direction on how the machine should be used. Aside from diagrams and directions on how to assemble the item (which the students have already created), typical owner's manuals also contain information on machine operation, any necessary caution or warning statements, and a troubleshooting section that provides the user with tips to try before calling the manufacturer or returning the item. It may help to provide students with a few actual manuals as examples.
4. Students can make a list of the variables in the machines that caused differences in the distances traveled.
5. Have your students write up a patent application for the machine they have created. Use historical patents found and copied off of the USPTO website as a basis for the student's patents. A patent application consists of a scale drawing and written description of the invention.
6. Create a flow chart with your students to show the steps it takes for inventors to receive patents.
7. Research inventors and their patents.
8. American Farm Bureau Foundation for Agriculture's "Purple Plow Challenge" found at www.purpleplow.org

Additional Resources

- Read more about patents, inventors, and their inventions at your local library or on the Internet.
- http://www.uspto.gov/web/offices/ac/ahrpa/opa/kids/index.html - United States Patent and Trademark Office Kids' Pages.
- http://www.archives.gov/education/lessons/cotton-gin-patent/ - The National Archives Teaching with Documents: Eli Whitney's Patent for the Cotton Gin.
- http://www.uspto.gov - United States Patent and Trademark Office website.
- http://www.invent.org - National Inventors Hall of Fame Foundation website.

- http://web.mit.edu/invent/index.html - Lemelson – MIT (Massachusetts Institute of Technology) website. Features an Inventor of the Week as well as games and trivia.
- http://www.wipo.int/portal/index.html.en - World Intellectual Property Organization website.
- http://www.freepatentsonline.com/ - website for searching patents; includes a page of “crazy patents.”
- http://www.ideafinder.com/home.htm - The Great Idea Finder website; includes inventions facts and myths, inventor biographies as well as innovation timeline, articles and games.
- http://wipo.int/freepublications/en/patents/925/wipo_pub_925.pdf - Downloadable 69-page information booklet on patent history, information and process from the World Intellectual Property Organization.

Standards

Illinois English Language Arts Standard

W.5.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Illinois Mathematics Standard

CC.5.G.2 Graph points on the coordinate plane to solve real-world and mathematical problems. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane and interpret coordinate values of points in the context of the situation.

Illinois Science Standard

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Illinois Social Science Standard

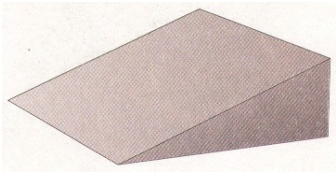
SS.EC.1.6-8.LC: Explain how economic decisions affect the wellbeing of individuals, businesses and society

The **M**ultidisciplinary **AG**ricultural **I**ntegrated **C**urriculum (mAGic) was created in 2004 under the leadership of the Illinois State Board of Education (ISBE) and the Facilitating Coordination in Agricultural Education Project (FCAE). Funding was made available through the FCAE grant budget from the agricultural education line item of the ISBE budget. This revision, as printed, was developed in September 2021.

These mAGic lessons are designed to bring agriculture to life in your classroom. They address the Illinois Learning Standards in math, science, English language arts and social studies.

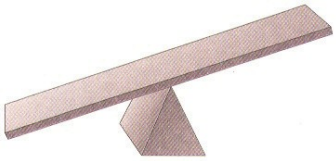
Machines mAGic project update writers/reviewers: Rhodora Collins – Dekalb County; Suzi Myers – Kane County; Connie Niemann – Montgomery County; Debbie Ruff – Livingston County; Jennifer Waters – Sangamon County; and Dawn Weinberg – Hancock County.

Simple Machines Information Sheet



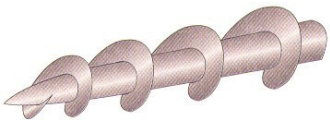
An **inclined plane** is a sloping surface that can be used to helpmove items over a certain distance. By spreading the amount ofwork needed over a larger distance, less force is needed at any particular moment. It can help move things up and down.

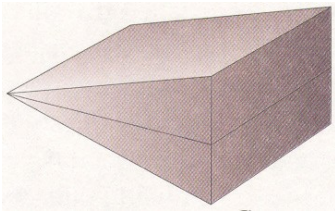
A **lever** is a device such as a bar or board that pivots on a fulcrum. It allows weight to be moved a short distance with a concentrated amount of force. The fulcrum can be moved depending on the weight of the object being lifted. For instance, when you push down on one end the other end lifts up.



A **pulley** is a wheel with a grooved rim over which a rope, cable or chain passes. It changes the direction of the force applied which makes the work easier. For instance, when you pull down on the rope, you can lift an object attached to the other end of the rope.

A **screw** is an inclined plane wrapped around a shaft or cylinder. It allows a force to be concentrated. It may be used to fasten or move things. It maymove itself, an object, or material surrounding the object.





A **wedge** is two inclined planes attached back to back. When youuse the pointed and often sharp edge of an inclined plane, you canseparate or split things when force is applied.

A **wheel** is a circular object or disk which revolves on a central point such as an **axle**,such as a bar or cylinder. These two parts work together. As the wheel turns the axlealso turns. When the axle turns, the wheel turns a greater distance than the axle, but less force is needed to move it. The axle moves a shorter distance, but requires a greater force to move it. They are used to move things and change power, speed or direction. It reduces the amount of friction an object creates during its motion.

“Tinkering” Bag Inventory

**You may wish to assign students to bring some of these items from home in advance.*

1 – Brown Paper Bag
1 – Ear of Squirrel Corn
12 – Small Paper Plates
12 – Drinking Straws
12 – Paper Clips
12 – Rubber Bands
4 - Balloons
6 – Clothespins
6 – Pencils
2 – Water bottles
4 – Toilet Paper Rolls
1 – Paper Towel Roll
2 – CD’s
2 – File Folders
1 – Ball of String
1 – 2 Liter Bottle
1 – Roll of Tape
1 – Glue Stick
1 – Scissors
1 - Ruler
1 – Pad of Paper for “Construction Manual”

Rules for All “Tinkering” Machines

- The purpose of this machine is to move an ear of corn from a selected starting point to another point that is a minimum of 3 feet away.
- Each machine MUST use the ear of corn.
- Any of the items from the bag, including the bag, may be used for machine construction, but a minimum of 6 different items from the inventory must be used.
- The machine must be able to travel 3 or more feet in a horizontal or upward motion.
- The machine must stay together for the entire 3 feet of travel.
- You are allowed ____ minutes to complete machine construction.
- As you are inventing, keep a detailed log of how the machine was made so that another group can recreate your design using the exact same process.
- Be prepared to test your machine for the group so results may be charted.

HAPPY “TINKERING!”

Name _____

Tinkering Outside of the Box ELA Worksheet

1. List the materials needed to construct your mobile machine. (Be as detailed as possible.)

2. Write detailed, step-by-step instructions on how to construct the machine. (Use reverse side if necessary.)

3. List the simple machines used in this machine:

Name _____

Tinkering Outside of the Box Science Worksheet

Hypothesis:

Materials:

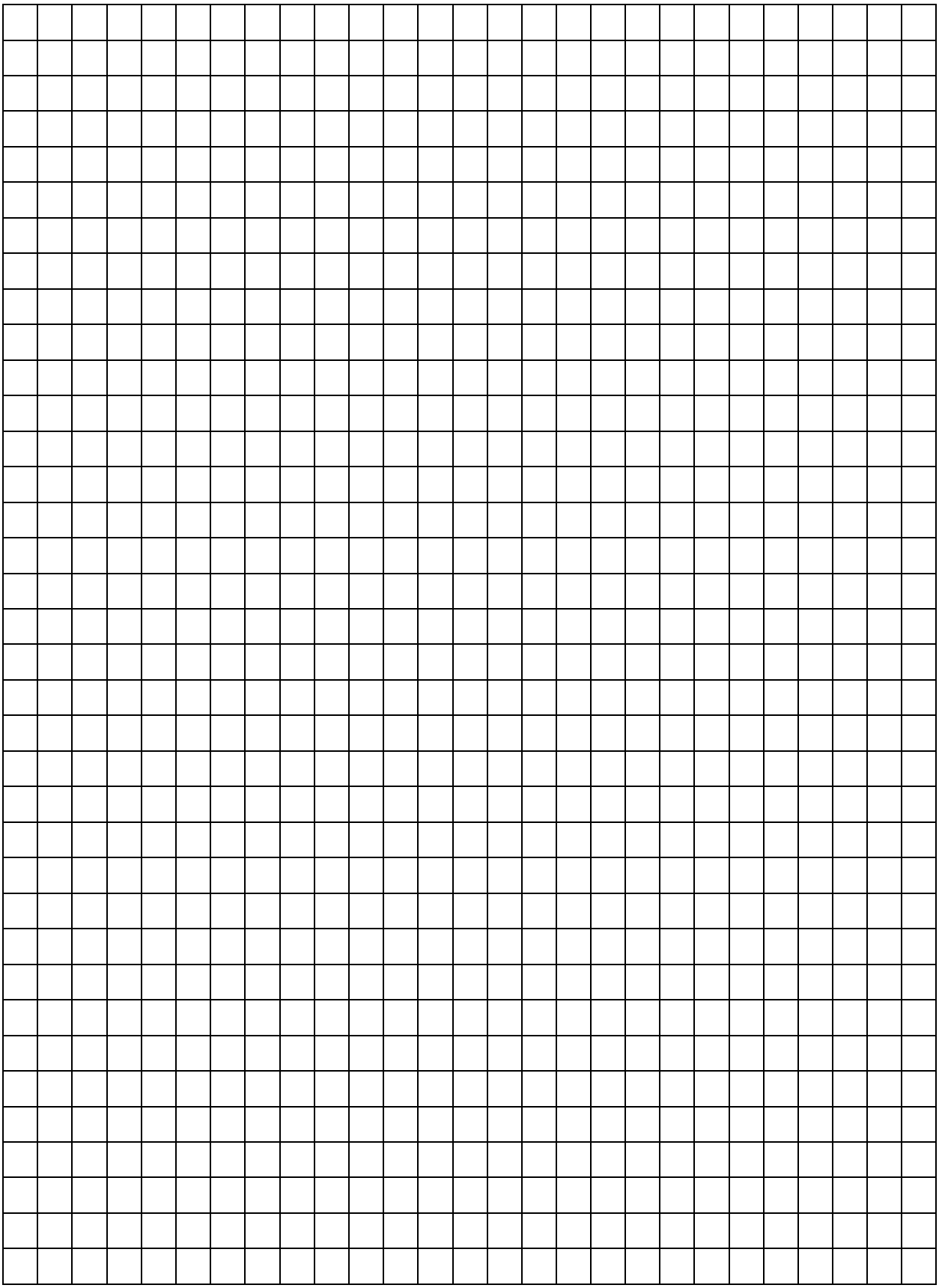
Procedure:

Data:

Results:

Conclusion: (Did the data support the hypothesis?)

Name _____



Name _____

Tinkering Outside of the Box Patent Exploration Worksheet

Find the answers to the following questions at the US Patent and Trade Office Kids Site www.uspto.gov/kids/index.html

1. When did the US issue patent number 10 million?

2. What year did Eli Whitney receive a patent for the cotton gin? What was the patent number?

3. When were miniature models required when applying for a patent?

4. What year was an agricultural division added to the Patent Office? What would it later become?

5. What year did the only president to hold a patent receive patent number 6469 for "A Manner of Buoying Vessels?" Who was it?

6. What year was the Plant Patent Act Passed?

7. Who was the last president to sign a patent?

8. In 1991, patent number 5,000,000 was issued. What was it for?

9. What year did John P. O'Brien receive patent number 7,000,000? What was it for?

10. What is a patent?

11. What is a trademark?

12. What is a copyright?

13. What is intellectual property?

14. Some common terms were once trademarked, but no longer are. What is the once-trademarked term for carbon dioxide in solid form?

15. Where are the US Patent Offices located?

Find the answers to the following questions at US Patent Full-Text Database Number Search https://patft.uspto.gov/netahtml/PTO/srchnum.htm

16. What were the following patents for?

    a. 9,430

    b. 157,124

    c. 271,7437

    d. 46,454

Find the answers to the following questions at National Inventors Hall of Fame www.invent.org

17. In 1987, Andrew J. Moyer was inducted into the National Inventors Hall of Fame. What were his patents for? Where did he retire from?

18. What year was Carleton van Stall Ellis inducted into the National Inventors Hall of Fame? What book did he author?

19. Lorenzo Langstroth was inducted into the National Inventors Hall of Fame in 2007 for his beehive. What was the patent number? Name one reason why this invention is important.

20. What was Benjamin Holt's invention that led to his 2006 induction into the National Inventors Hall of Fame? What did his company eventually become?

21. Perry Lavon Julian was inducted to the National Inventors Hall of Fame in 1990 and is widely regarded as one of the most important American chemists. Which of his discoveries do you feel is most important? Support your answer.

22. Allene Jeanes was inducted to the National Inventors Hall of Fame in 2017. What two patents does she hold? How are each of them used?

23. Mary Engle Pennington was inducted to the National Inventors Hall of Fame in 2018. What are 3 interesting facts about her?

24. Margaret Wu is a recent inductee to the National Inventors Hall of Fame. What does Wu compare chemistry to? How many patents does she hold?

25. Browse the list of National Inventors Hall of Fame inductees. Find a patent that interests you. Why do you feel this inventor was nominated and inducted?

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Find the answers to the following questions at the US Patent and Trade Office Kids Site www.uspto.gov/kids/index.html

1. When did the US issue patent number 10 million?

   June 19, 2018

2. What year did Eli Whitney receive a patent for the cotton gin? What was the patent number?

   1794; X72

3. When were miniature models required when applying for a patent?

   1836

4. What year was an agricultural division added to the Patent Office? What would it later become?

   1839; United States Department of Agriculture

5. What year did the only president to hold a patent receive patent number 6,469 for "A Manner of Buoying Vessels?" Who was it?

   1849; Abraham Lincoln

6. What year was the Plant Patent Act Passed?

   1930

7. Who was the last president to sign a patent? In what year?

   Gerald Ford; 1976

8. In 1991, patent number 5,000,000 was issued. What was it for?
   A means to use E. coli bacteria to produce ethanol.

9. What year did John P. O'Brien receive patent number 7,000,000? What was it for?

   2006; strong, biodegradable, low-cost textile fibers from polysaccharides.

10. What is a patent?

    Patents protect inventions.

11. What is a trademark?

    A trademark is a brand name. They identify the source of products and services.

12. What is a copyright?

    Copyrights protect original artistic and literary works.

13. What is intellectual property?

    Intellectual property is something created and includes trademarks, copyrights, patents, and trade secrets. Intellectual property can be owned by a person or company.

14. Some common terms were once trademarked, but no longer are. What is the once-trademarked term for carbon dioxide in solid form?

    Dry ice

15. Where are the US Patent Offices located?

    Alexandria, Virginia; Dallas, Texas; Denver, Colorado; Detroit, Michigan; San Jose, California

Find the answers to the following questions at US Patent Full-Text Database Number Search https://patft.uspto.gov/netahtml/PTO/srchnum.htm

16. What were the following patents for?

    a. 9,430
       Cotton hoe
    b. 157,124
       Wire fences
    c. 271,7437
       Velcro
    d. 46,454
       Plow

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17. In 1987, Andrew J. Moyer was inducted into the National Inventors Hall of Fame. What were his patents for? Where did he retire from?
    His patents were for the production of penicillin. He retired from the United States Department of Agriculture Northern Research Laboratory in Peoria, Illinois.
18. What year was Carleton van Stall Ellis inducted into the National Inventors Hall of Fame? What book did he author?

    2011; He wrote The Hydrogenation of Oils.

19. Lorenzo Langstroth was inducted into the National Inventors Hall of Fame in 2007 for his beehive. What was the patent number? Name one reason why this invention is important.

Patent number 9,300; Answers will vary, but may include: easier to monitor the health, production and containment of bees; allowed beekeeper to gather honey; boosted honey production.

20. What was Benjamin Holt's invention that led to his 2006 induction into the National Inventors Hall of Fame? What did his company eventually become?

Track-type tractor; Caterpillar

21. Perry Lavon Julian was inducted to the National Inventors Hall of Fame in 1990 and is widely regarded as one of the most important American chemists. Which of his discoveries do you feel is most important? Support your answer.

Answers may vary, but could include glaucoma or rheumatoid arthritis treatment or a fire-extinguishing foam.

22. Allene Jeanes was inducted to the National Inventors Hall of Fame in 2017. What two patents does she hold? How are each of them used?

Dextran – a blood plasma extender and a method of production.

Xantham gum – food thickener, stabilizer, and emulsifier.

23. Mary Engle Pennington was inducted to the National Inventors Hall of Fame in 2018. What are 3 interesting facts about her?

Answers will vary.

24. Margaret Wu is a recent inductee to the National Inventors Hall of Fame. What does Wu compare chemistry to? How many patents does she hold?

Cooking; 2

25. Browse the list of National Inventors Hall of Fame inductees. Find a patent that interests you. Why do you feel this inventor was nominated and inducted?

Answers will vary.