
ENGINEER
BOY SCOUTS OF AMERICA
SINCE 1910

ELECTIVE ADVENTURE

Complete requirements 1 and 2. Requirements 3 and 4 are optional.	Approved by
1. Pick one type of engineer. With the help of the internet, your local library, or an engineer, discover three things that describe what that engineer does. (To use the internet, be sure that you have a current Cyber Chip or that you have permission from your Webelos den leader, parent, or guardian.) Share your findings with your Webelos den.	________________
2. Learn to follow engineering design principles by doing the following:	
A. Examine a set of blueprints or specifications. Using these as a model, prepare your own set of blueprints or specifications to design a project.	________________
B. Using the blueprints or specifications from your own design, complete your project. Your project may be something useful or something fun.	________________
C. Share your project with others at a den or pack meeting.	________________
3. Explore other fields of engineering and how they have helped form our past, present, and future.	________________
4. Pick and do two projects using the engineering skills you have learned. Share your projects with your den, and also exhibit them at a pack meeting.	________________

SNAPSHOT OF ADVENTURE

Lots of people have great ideas: flying to the moon, tunneling under rivers, building robots that walk and talk, making triple-loop rollercoasters. Engineers turn those ideas into reality. They use science, math, and creative thinking to improve people's lives. In this adventure, you will learn what engineers do. Even better, you can do some engineering projects of your own. So put on your thinking cap, and get ready to think like an engineer!

COMPLETE REQUIREMENTS 1 AND 2. REQUIREMENTS 3 AND 4 ARE OPTIONAL.

REQUIREMENT 1 | Pick one type of engineer. With the help of the internet, your local library, or an engineer, discover three things that describe what that engineer does. (To use the internet, be sure that you have a current Cyber Chip or that you have permission from your Webelos den leader, parent, or guardian.) Share your findings with your Webelos den.

Engineers design everything from tiny materials you can see only through a microscope to spacecraft powerful enough to escape the Earth's gravity. Most engineers work in an area (called a discipline) that focuses on a specific type of project.

There are dozens of different disciplines and subdisciplines.

Here are a few types of engineers whose work we can see and use every day:

- **Chemical engineer:** uses principles of chemistry to turn raw materials into products such as medicine, plastic, and fuel

- **Civil engineer:** designs projects such as roads, bridges, tunnels, and buildings
- **Electrical engineer:** uses electrical and electronic principles to create everything from power transmission systems to computers

- **Mechanical engineer:** designs mechanical products such as engines, bicycles, and the parts and materials that go into them
- **Structural engineer:** makes sure structures can support weight and resist forces like earthquakes and wind
- **Aerospace engineer:** designs aircraft, spacecraft, and satellites
- **Computer engineer:** designs computer hardware and software

Engineers from different disciplines work together on many projects. For example, if you were building a spaceship, you would need aerospace engineers, computer engineers, electrical engineers, mechanical engineers, and several other types of engineers that aren't listed here.

Choose one type of engineer, and learn more about what he or she does. Write what you learned on this page.

My Engineer

My engineer is a ________________________________ engineer.

Two places where this engineer may work:

____

____

Three activities this engineer does as part of his or her job:

____

____

____

Two school subjects you need to study to become an engineer:

____

____

Share your findings with your Webelos den. You could tell your story by drawing a picture of this sort of engineer at work, making a video, or doing some other form of presentation.

REQUIREMENT 2 | Learn to follow engineering design principles by doing the following:

REQUIREMENT 2A | Examine a set of blueprints or specifications. Using these as a model, prepare your own set of blueprints or specifications to design a project.

REQUIREMENT 2B | Using the blueprints or specifications from your own design, complete your project. Your project may be something useful or something fun.

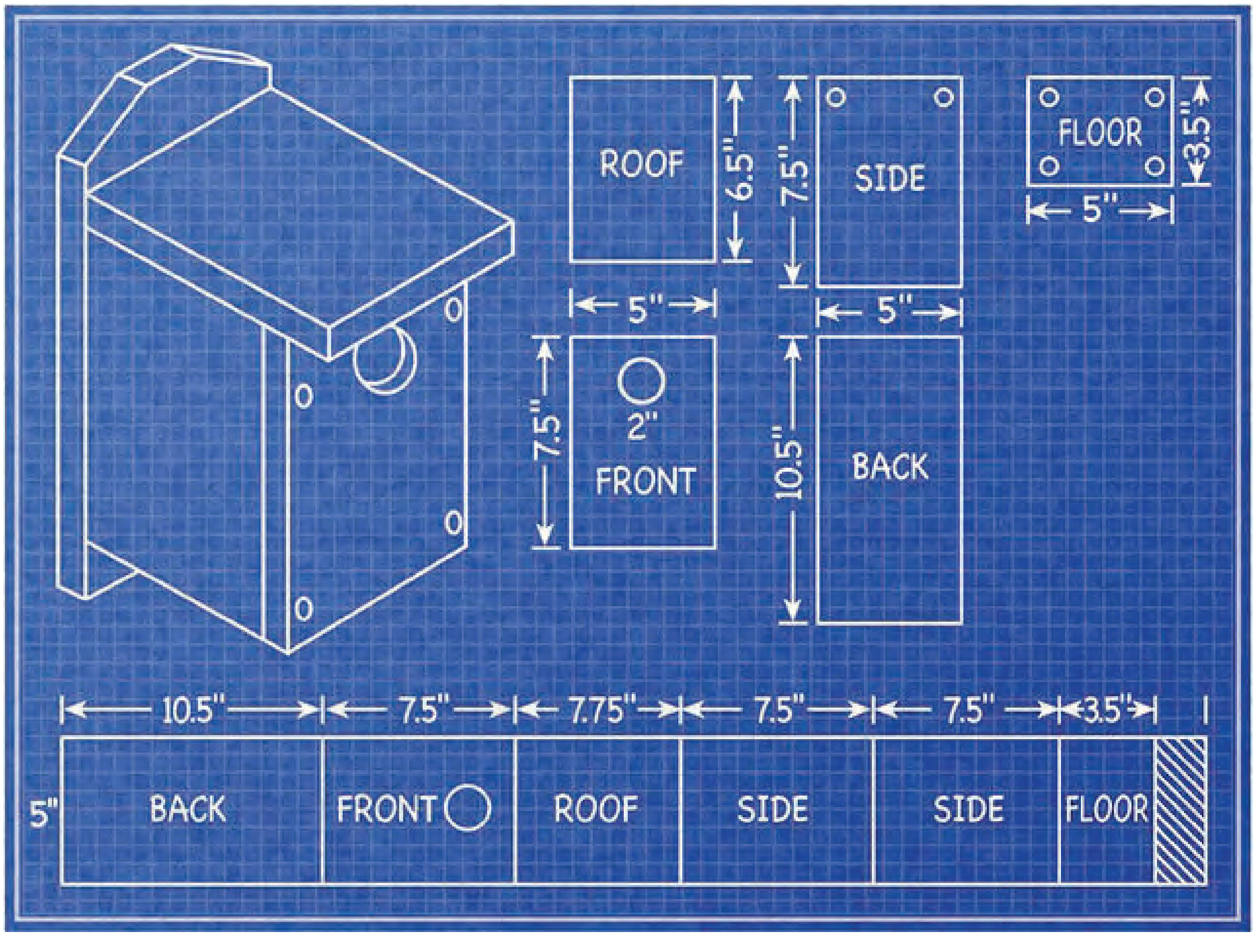
REQUIREMENT 2C | Share your project with others at a den or pack meeting.

Blueprints

A written and/or picture design of a project is called a blueprint. Structural, civil, and electrical engineers are a few of the engineers who use blueprints to assist them with their projects.

Why are blueprints called blueprints? When they were first introduced in the 19th century, they were made with a process that resulted in white lines on a blue background.

Before you design your own project, look at a set of blueprints. You may use your local library, the internet, or an individual you know who is an engineer or works in the construction field to find blueprints. House plans are good examples because many of the pictures they contain will be familiar to you.



Depending on the project, blueprints can be very complicated. Some include hundreds of pages of information. You will find pictures that show the finished project from every side, dimensions of every part of the project, and a list of materials to be used in the project. Blueprints are designed to be so complete that a qualified builder could complete the project without any other information.

Testing and evaluation are also important parts of the engineering process. On major projects, engineers build models and run computer simulations before starting actual construction. These steps can save time and money if the design needs to be changed.

The Engineering Process

To understand how an engineer might approach a project, let's look at the engineering process. After an engineer becomes aware of a need, he or she gathers information and then makes a design. The building phase begins after that.

Here's how you might use that process to construct a small item for your bedroom:

1. **Determine your need.** Let's say you don't have anything next to your bed to set your books and alarm clock on. You need a small table.
2. **Gather information.** Of course, tables come in all sorts of shapes and styles. You could ask questions like these to refine your idea:
   - What will I put on the table? How much do the items weigh? (You need to know how sturdy your table needs to be.)

   - What building materials should I use? (Now that you know your weight requirements, you can pick materials that will be strong enough to handle the weight of the items.)
   - Will the materials be expensive if I have to purchase them? Can I recycle materials I already have? (Engineers have to make sure their designs are cost-effective.)
   - What is the best design I can use? Should it have two, three, or four legs? Should it have a square, round, or rectangular top? How tall should it be? (These questions will guide you to the right design based on your table's location and use.)

- Will it help if I draw pictures of the design before I begin? These drawings can help start your blueprint!

3. **Prepare instructions.** The information you gathered should help you better understand the planning process and your needs. Now you can create a plan for building your table. Because of the process you followed, you will be able to build a better table than if you just started nailing boards together without a plan.

   By drawing your blueprint on graph paper, you can easily keep the drawing to scale. For example, one grid on the paper could equal 1 inch on the finished product.

   Be sure to make notes on your drawing about all dimensions and materials. Remember that another person should be able to create your project from the blueprint you have made.

   You might also want to make a small scale model of your project. Heavy cardboard, toothpicks, craft sticks, and tape are some materials you could use.

4. **Build your project.** Once you have prepared your design and your blueprint, you are ready to build your table. Here you will discover if your design ideas will work and if your blueprints have clear instructions and good information. It's a good idea to take notes and pictures as you go along so you remember what worked and what didn't.
5. **Evaluate your project.** After you build your table, you should test it to make sure it meets your needs. You can also ask yourself questions like these:
   - Did the project turn out as I expected?
   - How much did it cost to build the project?
   - What would I do differently next time?
   - What three things did I learn when I designed and built my project?
   - What am I most proud of about my project?

Share your project with your Webelos den and your pack by displaying the project at a pack meeting.

REQUIREMENT 3 | Explore other fields of engineering and how they have helped form our past, present, and future.

REQUIREMENT 4 | Pick and do two projects using the engineering skills you have learned. Share your projects with your den, and also exhibit them at a pack meeting.

The next few pages introduce you to several engineering disciplines and show you projects you could do in each of those areas. Pick two of the projects, and complete them by using the same design process you used in requirement 2. Be sure to keep notes as you go. That way, if you decide to redo a project to achieve a different outcome, you will have information to refer to.

DEFENSE ENGINEERING

Defense engineers develop items that assist in protecting our country. Around 400 BC, defense engineers in Greece developed catapults to shoot projectiles long distances.

Craft Stick Launcher

You can build a simple machine with craft sticks to launch marshmallows and other soft projectiles.

Materials:

- 9 craft sticks
- Rubber bands
- Plastic spoon
- Marshmallows

Instructions:

1. Stack seven craft sticks together. Secure them at each end with a rubber band.
2. Stack two craft sticks together. Secure one end with a rubber band and leave the other end open.
3. Wedge the large stack of craft sticks in between the other two craft sticks as shown in the picture.
4. Attach the plastic spoon to the top craft stick with a rubber band.
5. To use the launcher, put a marshmallow on the spoon, pull the spoon down as far as you can, and then release it.

Evaluation questions:

- How far can you make the marshmallows go?
- Can you aim them to hit targets?
- What would happen if you launched something heavier?
- Is your machine accurate? Can you send the marshmallow into a

container?

- How could you change the project to make it work better?

AEROSPACE ENGINEERING

Aerospace engineers design aircraft and spacecraft. Among the challenges they face is making vehicles that are light enough to take off but also safe enough to carry humans.

Paper Airplanes

To explore how wings create lift and keep airplanes flying, construct three different paper airplanes. Find multiple designs at the library or on the internet (with your parent's permission), or you can design your own. Fly all three planes, and evaluate how well they performed.

Evaluation questions:

- Which design flew the farthest?
- Which design flew the straightest?
- Which design flew the highest?
- What would happen if you used heavier or lighter paper?
- Which style performed the best?

Stomp Rocket

A stomp rocket is a fun way to test aerodynamics, which is the study of the effects of air on items in motion.

Rocket materials:

- A 12-inch length piece of half-inch PVC pipe
- A center-stapled magazine or catalog with the staples removed
- The fin and nose cone templates
- Transparent tape
- Scissors
- Cardstock

Instructions:

1. Lay three sheets of paper from the magazine or catalog on a table. Carefully roll the paper into a long tube around the pipe. Tape your roll in a few places to hold it.
2. Remove the pipe, being careful not to smash the roll.
3. Use another sheet of paper to cut a circle the same diameter as the tube. Tape this circle over one end of the tube. Be sure to completely seal that end so that no air can leak out.
4. Enlarge the fin and nose cone templates. Copy them onto cardstock and cut them out. You'll need one nose cone and three fins.
5. Fold the fins along the lines shown, and tape them to the tube near the open end.
6. Roll the nose cone so the paper overlaps to the dotted line shown on the template. Tape the nose cone onto the closed end of the tube.

Materials for rocket launcher:

- 1 10-foot length of half-inch PVC pipe
- 1 90-degree elbow of half-inch PVC pipe

- 1 socket cross of half-inch PVC pipe
- 2 socket caps of half-inch PVC pipe
- Empty 2-liter soft drink bottle
- PVC cement
- Hack saw
- Duct tape
- Sandpaper

Instructions (you'll need an adult to help):

1. From the 10-foot length of PVC pipe, cut three 1-foot pieces and one 4-inch piece. With the sandpaper, smooth all rough edges from the cut ends.
2. Insert the remaining long piece of pipe into one opening in the cross fitting and the 4-inch piece in the opposite opening. Insert a 1-foot piece of pipe in each of the other holes. Put socket caps over the open ends of the 1-foot pipes. (These 1-foot pieces will stabilize the launcher assembly.)
3. Attach the elbow to the end of the 4-inch pipe so the other hole in the elbow points straight up. Insert the final 1-foot piece of pipe into the elbow.
4. Once you are sure that the launcher is assembled correctly, disassemble each joint, spread PVC cement around the end of the pipe, and reinsert it in the fitting. PVC cement sets quickly, so just work on one joint at a time.

5. Securely tape the 2-liter bottle to the end of the long piece of pipe with duct tape.
6. To use the launcher, place your rocket over the vertical pipe and stomp on the 2-liter bottle. The air displaced from the bottle will pass through the tubing and send the rocket into the air.

Stomp rockets are fun, but be careful! Never point the rocket at a person or anywhere but straight up. Keep spectators away from the launcher, and only launch under adult supervision.

Evaluation questions:

- Can you determine how high your rocket went? Did it go higher than nearby trees or houses?
- Was the flight path straight up, in an arc, or sideways?
- What was the outside environment like (windy, calm, hot, cold)? Did the environment affect the flight of your rocket?
- Did your rocket survive its first flight? Can it be used again?
- Could you have used different materials in the construction and achieved a different outcome?

- How would a different launcher design affect the rocket's flight?

ARCHITECTURAL ENGINEERING

Architectural engineers design amazing buildings and other structures—some reach a half-mile high!

Ancient engineers built amazing structures, too, without using modern machines. The Great Pyramid of Giza in Egypt contains 2.3 million stones weighing 2 to 30 tons each! The builders used a block and tackle to lift very heavy objects that would otherwise not be movable.

Block and Tackle

One type of block and tackle works by using two pulleys to lift a weight. You thread a rope through the pulleys, and attach a weight to the bottom. You then pull on the other end of the rope. Because of the pulleys, you can lift a weight of 100 pounds by exerting just 25 pounds of force.

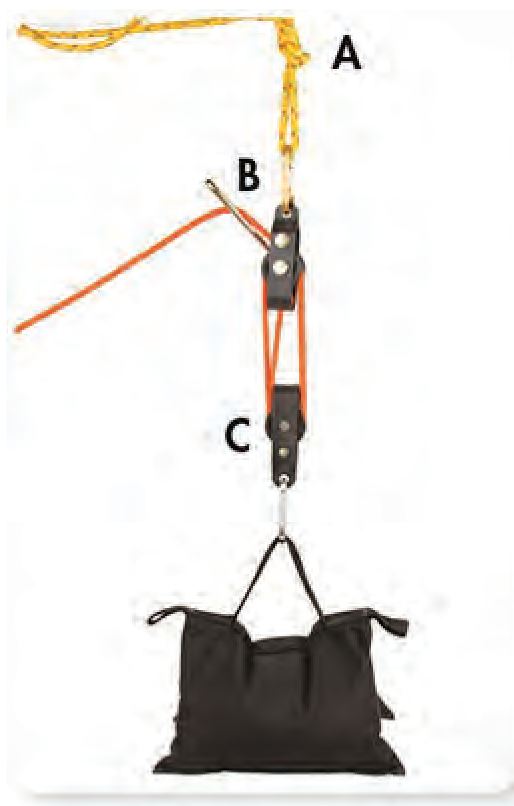
With the help of your parent or adult leader, construct a simple block and tackle with pulleys. After completion, lift several items with the block and tackle.

Materials:

- 2 two-sheave pulleys (pulleys that have two wheels side by side)
- 50 feet of five-eighth-inch rope
- Heavy object

Instructions:

1. Hang one pulley from a bar that is at a comfortable height for you to reach (attachment point A).



2. Pass the rope through the left sheave of the top pulley.

3. Bring the rope down and through the left sheave of the lower pulley, which you can leave on the ground for now.

4. Pass the rope through the right sheave of the top pulley, so that both sheaves are full of rope.

5. Bring the rope down and through the bottom side of the right sheave on the lower pulley. Pull on the rope to draw the two pulleys close together.

6. Tie the end of the rope to the bottom eye of the top pulley (attachment point B).

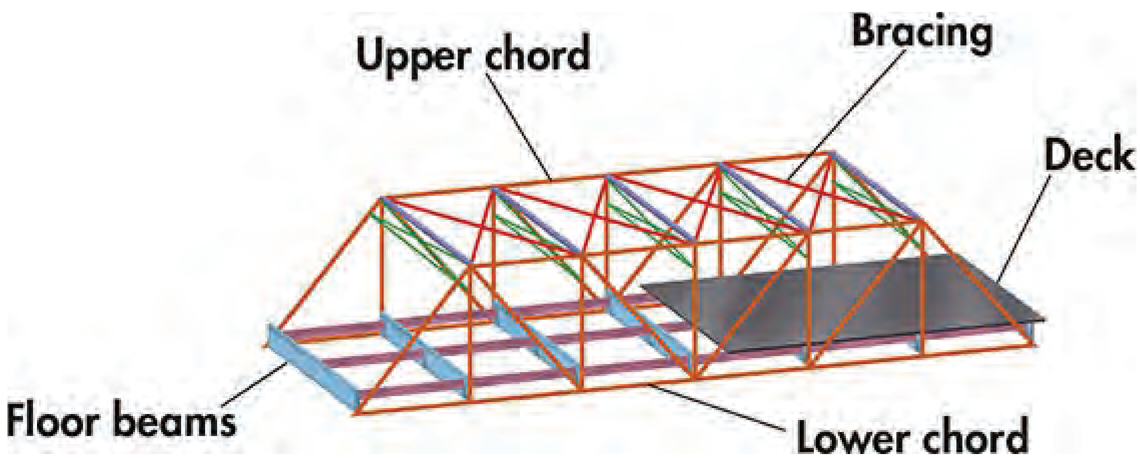
7. Attach the object you want to lift to the bottom eye of the bottom pulley (attachment point C).
8. You've now completed your block and tackle. If you'd like, you can remove it from attachment point A and move it to a different location.
9. Now, use the block and tackle to lift some items. Be sure you ask your parent or den leader to help.

Evaluation questions:

- Were you surprised at how easily you could lift a heavy item?
- What was the weight of the heaviest item? How high did you lift it?
- Can you see how this tool would make building a tall structure faster and easier?
- How could you improve your block and tackle design?

CIVIL ENGINEERING

Civil engineers design bridges, roads, tunnels, and other structures. Part of their job is planning for the different forces that will affect what they build. These forces include torsion (the twisting that happens when wind hits a building) and load (such as the weight of cars and trucks crossing a bridge). Sometimes they account for these forces by making a structure flexible. Sometimes they account for these forces by transferring them to other parts of the structure.



Spaghetti Bridge

A truss bridge is a very common bridge design. It is built with trusses, rigid frameworks made up of a series of triangles. The picture on the previous page shows a truss bridge and some of the bracing that makes it strong.

You can practice civil engineering principles by building a truss bridge out of spaghetti and school glue. Then you can experiment to see how much weight it can support.

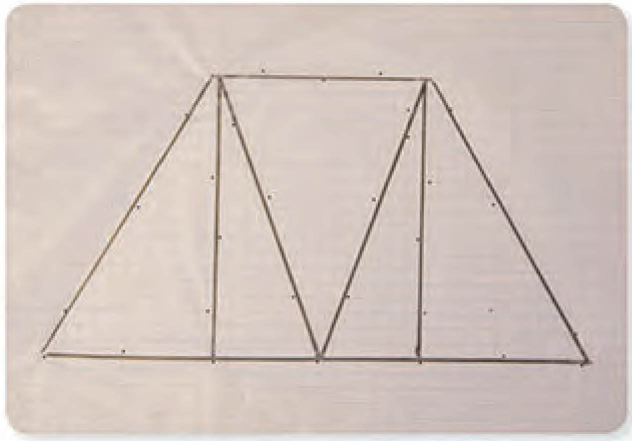
Note: Let each section dry completely before moving it or attaching it.

Materials:

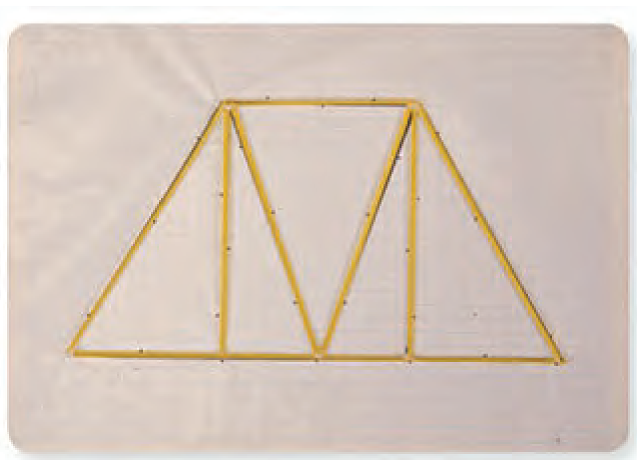
- Spaghetti
- Corrugated cardboard
- School glue
- Graph paper
- Waxed paper
- Straight pins

Instructions:

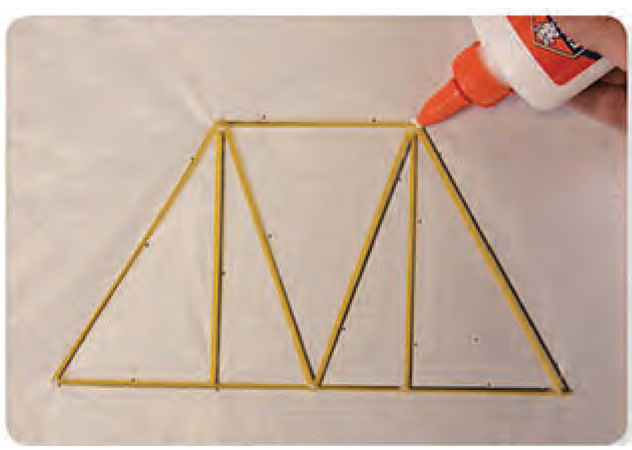
1. Lay a piece of graph paper on top of corrugated cardboard. On the graph paper, sketch your truss. Lay waxed paper on top of the graph paper so the glue you'll use in the next step won't stick to the graph paper.



2. Break pieces of spaghetti to the lengths you need, and lay them on your truss drawing. Hold them in place with pins, and glue them together.

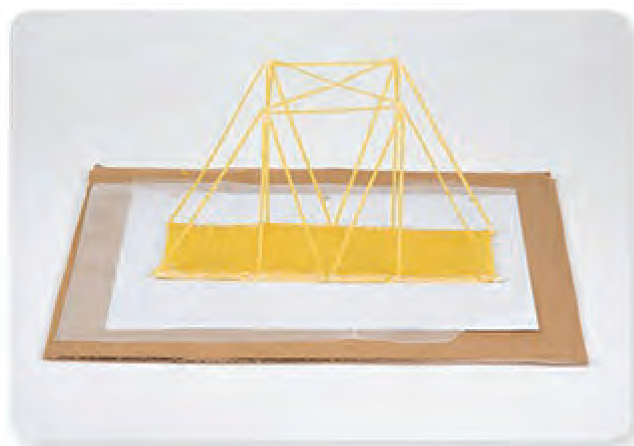


3. Repeat steps 1 and 2 to make a second truss.



4. Build a roadbed out of spaghetti by gluing pieces of spaghetti together to make two long stringers. Then glue pieces across the stringers to create the deck.

5. Stand the trusses up on either side of the roadbed, and glue them into place.



6. Connect the tops of the trusses with pieces of spaghetti. If you have a kitchen scale, weigh the bridge.

7. Set the bridge up between two boxes and hang a lightweight container underneath. Add light objects such as pennies to the container, one at a time, until the bridge collapses.

Evaluation questions:

- How much weight was the bridge able to bear before it collapsed?
- How did that compare with the weight of the bridge?
- What could you have done to make the bridge stronger?

ELECTRICAL ENGINEERING

Electrical engineers design, maintain, and improve products that are powered by or produce electricity. They will often design, assemble, and test new devices. Although some of the devices they work on are very complex, these devices are all based on simple electrical circuits.

Telegraph Machine

Long before telephones and computers, people communicated using telegraph. This machine transmitted a clicking sound each time the operator pressed a switch and closed an electrical circuit. You can make a telegraph out of simple materials (although it won't transmit a signal to someone on the other side of the country!).

Materials:

- 2 pieces of wood
- 1 battery (a lantern battery works well)
- 2 metal strips cut from a can such as a soup can
- 3 screws
- 2 nails
- 2 wires
- Tin snips
- Screwdriver

Instructions:

1. Wearing protective gloves and using tin snips, cut straight strips from a can, and bend in the shapes shown for the "sounder" (the Z shape) and the key. (Make sure you remove sharp edges with a file or emery paper.) Screw them to the blocks of wood, using one screw each.
2. Put one screw underneath the key, with a quarter inch of clearance to the

key.

3. Hammer in the nails for the receiver. (There should be one-sixteenth- to one-eighth-inch clearance between the nail heads and the sounder.)
4. Wire as shown. In wrapping the wire around the nails, start at the top of one nail and work down. Then, go across to the other nail and work up. Have at least eight turns on each nail.
5. When you push down on the key and make contact with the screw underneath it, the electric current is completed and passes through the wire. This magnetizes the wrapped nails, which then pull the sounder down to make a clicking sound.

Evaluation questions:

- How did this project demonstrate how an electrical circuit works?
- How many places in your home demonstrate this principle?
- How does this project compare with “real” telegraph machines? (You might have to do some research to find out.)

CHEMICAL ENGINEERING

Chemical engineers apply their understanding of chemistry and chemical processes to tackle all sorts of problems ranging from fuel production to the treatment of drinking water. Sometimes their work involves creating chemical reactions; sometimes it involves preventing chemical reactions from happening.

Changing a Penny's Color

You can experiment with chemical reactions by using a penny and some vinegar.

Materials:

- 4 shiny pennies
- Vinegar
- A paper towel
- Cooking oil
- Nail polish
- Paint

Instructions:

1. Cover one penny in cooking oil, cover one penny with nail polish, and cover one penny with paint. (Leave the fourth penny alone.) Allow time for the pennies to dry.
2. Soak the paper towel in vinegar and set it on a surface that will not be damaged by the vinegar.
3. Place the four pennies on the paper towel and leave them for several hours.
4. Check the pennies after one, three, and five hours, and note any changes in color.

Evaluation questions:

- What were the results?
- Which coatings (if any) protected the pennies?
- How else could you have protected the pennies?
- What did this experiment teach you about chemical reactions?

MECHANICAL ENGINEERING

Mechanical engineers touch almost every aspect of technology. They create machines, products, and technological systems that benefit society in many ways. Anything that has moving parts was designed with help from a mechanical engineer.

Weather Vane

A weather vane is a simple machine that shows which way the wind is blowing. It's a good example of a machine with moving parts.

Materials:

- Wooden block
- Spool
- Glue
- Coat-hanger wire
- Plastic straw
- Plastic bottle
- Tape

Instructions:

1. On the wooden block, mark compass directions (north, northeast, east, etc.).

2. Glue the spool in the center of the block.
3. Cut a triangle from a flat area of the plastic bottle, and tape it to the middle of the straw.
4. Place the straw in the hole in the spool. Stick a straight piece of coat-hanger wire through the straw and into the spool. The wire should be long enough to stick out the top of the straw.
5. Place the weather vane outdoors with the "north" mark on the base facing

north.

6. Create a chart to show the wind direction at the same time every day. Remember that the wind direction is where the wind is blowing from.

Evaluation questions:

- How accurate is your weather vane? How could you make it more accurate?
- Are the moving parts likely to wear out? If so, how could you protect them?
- What other problems might happen with the weather vane? How could you prevent them?
- How does your weather vane compare with "real" weather vanes and windsocks?

Pinewood Derby Experiments

You've probably built and raced pinewood derby cars as a Cub Scout or Webelos Scout. You can also use pinewood derby cars to learn about principles of mechanical engineering.

Note that some of these modifications will disqualify your car from an actual pinewood derby race!

Build a pinewood derby car (or use one from a previous race).

Make modifications like these, and test the car to see how the modifications change its speed:

- Add weight to the car or reduce the car's weight.
- Move the center of gravity from the back to the front.
- Carve the car's body to make it more aerodynamic.
- Add graphite to the wheels to reduce friction.
- Move the axles farther apart or closer together.
- Sand down the wheels so less of their surface touches the track.

Evaluation questions:

- Which changes made the most difference? Which ones didn't make much difference at all?

- How else could you modify the car to make it go faster?
- How do the principles you learned apply to actual cars and trucks?