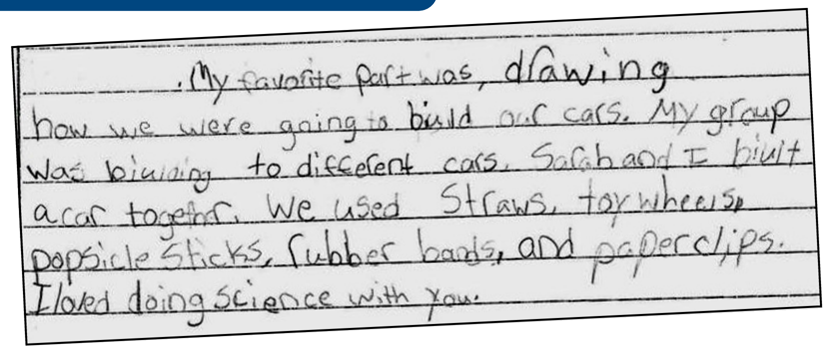
Junk Drawer Robotics

Facilitator's Guide

Overview

I loved doing science with you!


. My favorite part was, drawing how we were going to build our cars. My group was biulding to different cars. Sarah and I biult a car togethr. We used Straws, toy wheels, popsicle Sticks, rubber bands, and paperclips. I loved doing science with you.

Sophia sums up her experience about how she and Sarah designed and built a Clipmobile car as part of the activities in *Junk Drawer Robotics*. Helping young people become excited about doing science, engineering, and technology is what you'll find in the *Junk Drawer Robotics* curriculum. You don't need expensive equipment either as most of the activities can be done with everyday items found at home. This curriculum is not about just telling someone how to do something but helping to facilitate the experience so they can create their own understanding of robotics and then design and build upon that understanding.

So, let's get started so that we can excite other Sarah's and Sophia's to learn to love science.

The ***Junk Drawer Robotics*** curriculum is divided into three levels, each around a central theme related to robotics design, use, construction, and control. Each level starts out with background information on working with youth, curriculum elements, and a focus of the concepts to be addressed.

- **Level 1** is about robotic arms, hands, and grippers.
- **Level 2** is about moving, power transfer, and locomotion.
- **Level 3** is about the connection between mechanical and electronic elements.

Modules within a *level* target major concepts related to the theme. The *modules* contain five or more *activities* that help the members develop an understanding of the concepts, create solutions to challenges, and develop skills in constructing alternatives.

Activities can be grouped into delivery times from 20-minute sessions, to 50-minute classes, to 2 or more hour workshops or camps.

Each *activity* is one of three types:

To Learn - activities help youth explore fundamental science concepts and gain knowledge to apply in other activities.

To Do - activities are thinking, brainstorming, and design activities to highlight engineering processes.

To Make - activities challenge youth to build/construct their designs.

Junk Drawer Robotics
- Level
  - Module
    - Activity
      - To Learn
      - To Do
      - To Make

Junk Drawer Robotics
Facilitator's Guide

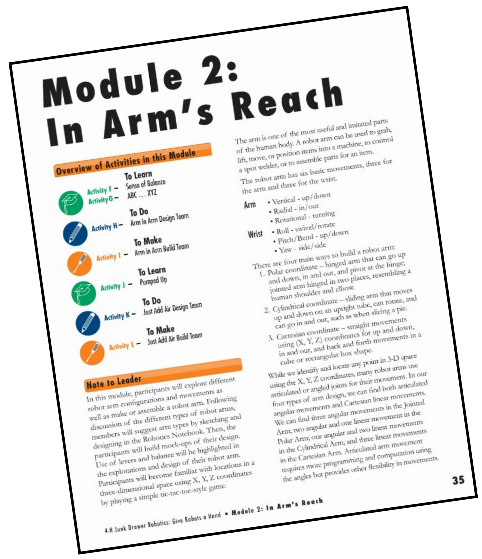
Overview - Modules

What Is in a Module?

At the beginning of each module you will find a few pages to acquaint you with the concepts and activities to be covered in the module. Use this section to help you gather supplies and prepare for facilitating the activities. You should review all of the activities in the module as many offer sequential learning experiences.

Overview of the Activities in the Module

This is a list of the activities and what type it is; to learn, to do, to make.



Note to Leader

Each module contains a note to leader describing the robotics concepts presented through the activities. This background section helps the presenter understand key concepts and terms before presenting the activities.

What You Will Need

A list of the activity supplies, tools, handouts, and other materials required to present all the activities in the module. See the individual activities for specific items used in each activity.

Timeline

The timeline outlines the approximate time required for each activity. It also suggests work area, groupings, and links to other activities. Use this to decide how to best group the activities to fit your schedule.

Focus

In addition, each module contains a page identifying many of the elements addressed through the activities, including: Big Ideas, National Science Education Standards, Standards for Technological Literacy, 4-H SET abilities, and Life Skills . You'll also find performance task indicators and success indicators for the module's activities.

Activities

Following the module's introduction are the individual activities. Because each module focuses on a set of robotic ideas and content knowledge, the learning is scaffolded from activity to activity. Youth will often use the design they built in one activity in a subsequent activity - making additions or redesigning their original product. *Activities within a module should be presented sequentially.*

Junk Drawer Robotics
Facilitator's Guide

Overview - Activities

What Is in an Activity?

Each activity will be highlighted by color and symbol to indicate its type. Each type is laid out in a similar format, but each type of activity has a different outcome:

The **To Learn** activities explore some scientific knowledge area.

The **To Do** activities will focus on designing, drawing, and idea generating.

The **To Make** activities will usually include building, constructing, and use of tools.

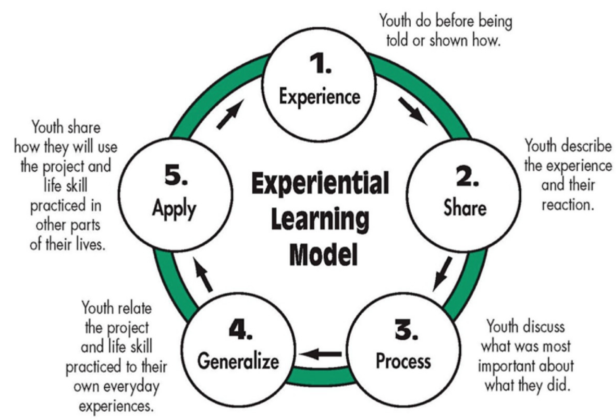
Preparation Information is listed for each activity:

- Performance tasks and success indicators
- Supplies needed
- Activity timeline
- Other preparation needs and safety notes

Each activity is structured around the five-step experiential learning cycle. The role of the facilitator of the activity is to set the stage, then step back to allow the members to do the activity, and finally assist in dialogue and questioning to allow the members to share and apply what they have done. We have grouped some of the steps so that we focus on the following three areas:

Experiencing - provides instructions to guide the facilitator in setting the stage with materials, background sharing, and steps for the members to conduct.

Sharing and Processing - presenters help youth reflect on the experience. The presenter should help guide this reflection by asking questions, encouraging sharing and suggesting comparisons of observations. Each activity contains sample open-ended questions to prompt particular points.



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Generalizing and Applying - to complete the learning cycle, each section contains a section to help youth connect concepts to both broader robotic concepts and to the real world. Again, there are sample open-ended questions to prompt particular points.

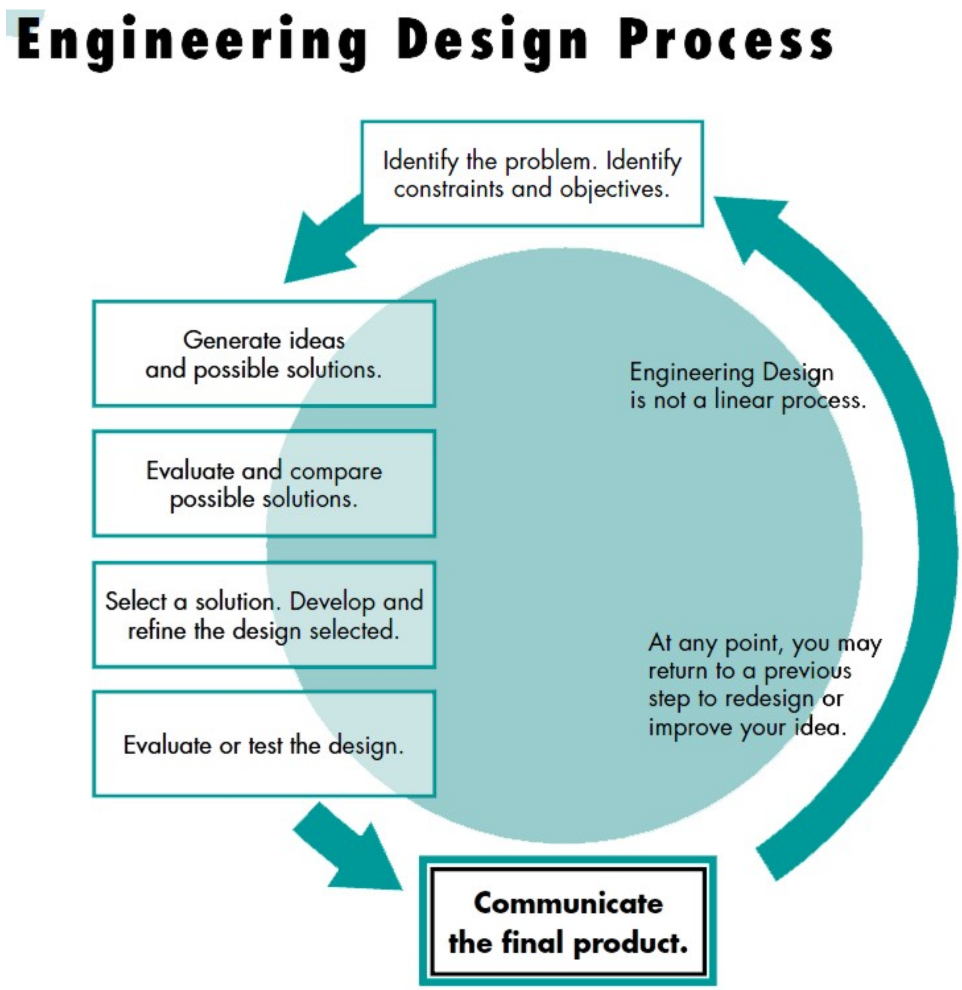
Overview - Resources

The Engineering Design Process

While we highlight science, engineering, and technology in the curriculum, a major focus is around the design process that engineers use in solving challenges or problems. There are different models that engineers use to describe and show the steps in that process. The model that we are following for this curriculum is shown here.

Like most problem solving models it is cyclic and can be entered at different steps along the way. Also in the process, if new information or new problems arise, stepping back to reevaluate or redo a step or two is considered normal.

Note that communicating and sharing is an important step. We encourage this in verbal sharing as well as in writing, sketching, and notes gathered and recorded in the Robotics Notebooks.



The Role of the Facilitator

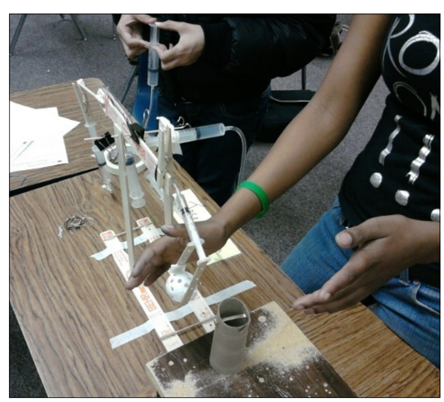
This may be a new role for you. The role of the facilitator in *Junk Drawer Robotics* is different from the normal role we may think of for a classroom teacher. This curriculum is not about mere transfer of knowledge from teacher to student. Learning is about assisting the youth participants to develop their own knowledge and problem-solving skills.

This process is facilitated using the experiential learning cycle in which youth will explore a topic; then given a problem, will design a solution; and, finally, using what they have learned and designed will build or construct a working model.

In your facilitator role, you will be coaching the youth through these processes by how you ask the youth questions and have them share their ideas, designs ,and results. This curriculum is not about building the "correct robot arm" but about the process of thinking, designing, and building. The "processes" are the important parts that you are striving to develop in the youth.

Junk Drawer Robotics is designed around the three domains of science, engineering, and technology. Depending on the length of the meeting, your group may work in all three while at other meetings may only work in one or two and complete the other topics at the next meeting.

To promote this process each of the activity types are highlighted on the pages to follow. Included are some examples of specific activities and how they can be best facilitated to encourage the development and increase the use of these processes.



To Learn

To Do

To Make

The Role of the Facilitator

To Learn: **Science** is finding out how things work.

The science activities are designed to allow the youth to explore concepts related to the session topic. These are very open-ended activities in which the youth can have fun learning by messing around with the activity.

For example, youth might be given a battery, a flashlight bulb, and pieces of aluminum foil and asked to get the light to light up. They can try different ways to connect the battery and bulb to see what works.

The important part is **NOT giving them a correct answer**, but giving the youth an opportunity to explore, discover, and construct their own knowledge; in this case about how electricity works. Yes, some will get the bulb to light up right away while others will struggle to figure out how to get it to light. Your role as the facilitator may be to ask those who got the light to light up to draw on poster paper what worked and what didn't work for them. This will allow others to look at and compare what they were trying.

Asking questions is very important during this time; ask them to compare what worked and didn't work; was there more than one way that worked? Then when they get it to work, challenge them to see if they could get two or more light bulbs to light up and if they could do it in different ways.

Most times the exact question can not be preplanned, but comes out of the participants, the activity, and the discussion during the presentation. For example, while trying to get a bulb to light up, some youth will short circuit the battery and feel it warm up. When they say "it's getting hot," it gives you a chance to pose questions such as, "why do you think it is getting hot?" or "where are other places you've used electricity for heat?"

Looking for cues from the discussion can help you in asking questions that expand on the activity.

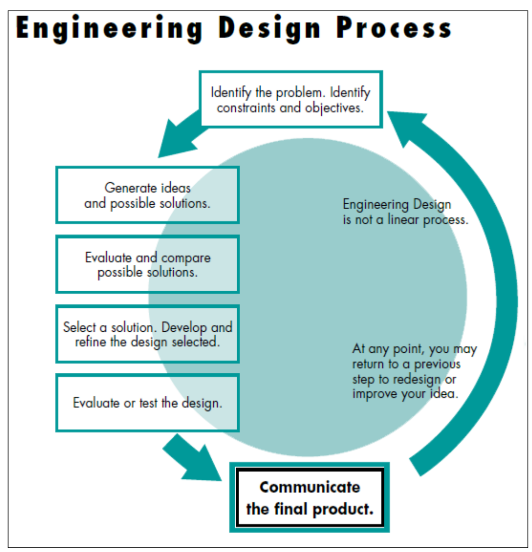
Junk Drawer Robotics
Facilitator's Guide

The Role of the Facilitator

To Do: **Engineering** is using what you found out to design something to work.

In the engineering phase, youth will have a topic to share and discuss. This might be the types of robot arms, power systems, or other subjects. During the sharing, you will want to ensure the youth share and interact about things that they have seen or know about that are similar. For example, when talking about a robot arm, they may relate how the arm is similar to a tractor backhoe or how garbage trucks pick up trash cans. They can then relate common things to the design of their robot arm. Following the brief discussion, you will then give them a challenge to solve.

During the engineering phase, you will ask youth to draw the ideas they have for the challenge. For many putting their ideas into a picture form is hard. Simple graph paper can help and the Robotics Notebook is designed to assist them in how to draw and sketch.



The other hard part is to draw and design without handling real items. To force the youth to focus on the drawing design, do not let them have the items they will be using during this engineering phase. You can let them look at or see the types of parts they can use, but don't let them touch or hold them.

In real life the movement between science, engineering, and technology flows back and forth and there is opportunity for manipulation of items. But for this curriculum, we want to focus on just one phase at a time.

The science learning section and the engineering background sharing should assist them in their designs. In the case of the robot arm session, the science activities cover levers and three-dimensional space. The youth can use this information along with the engineering background to develop their robot arm design.

Once the groups have come up with designs, you can ask them to share with the rest of the group. The sharing gives the youth a change to self-evaluate their own idea and design. It also gives others a chance to compare and/or change their designs. You could even ask the teams if they want to change their designs based on the sharing from the other teams. Sharing is a collaborative function of real engineers as they work on real problems.

The Role of the Facilitator

To Make: **Technology** is using tools and processes to make something work.

In the Technology phase the teams get to construct their design. This is the model making or building phase. In some of the challenges they will have specific items to work with, and in others they will have specific actions to be accomplished.

For example:

- In the "Can-Can" robot activity, they are given just a few specific items and have to design and build using only those items.
- Then in the "Es-Car-Go" activity, they can use any amount of items to build a car that will go slow.

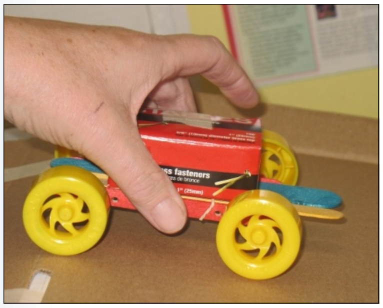
In those activities in which the building items are not limited, teams could be encouraged to find and use additional items they can locate or collect around home or the activity work area. These items can become part of the "Trunk of Junk" for building materials.

One of the biggest concerns in the building phase will be safety and working with tools. The reason for using wood craft sticks and paint stirring sticks includes the fact that they are readily available and reasonable in costs allowing teams to experiment in building.

Starting with predrilled sticks will make them useful for most applications. But they are also easily cut to other lengths or additional holes can be drilled or punched in other locations as needed. With just a few limited hand tools, most of the building activities should be able to be accomplished.

See the safety section of the online facilitator resources for specific information about common tools youth may be working with in these robot activities.

Experiential and Inquiry Learning



Junk Drawer Robotics activities are designed around the five-step experiential learning cycle and promote exploration. There are no prepackaged kits or prepared design plans. Instead, youth are challenged to utilize paint sticks, paper clips, tape, string, and dozens of other everyday objects to design and build robots.

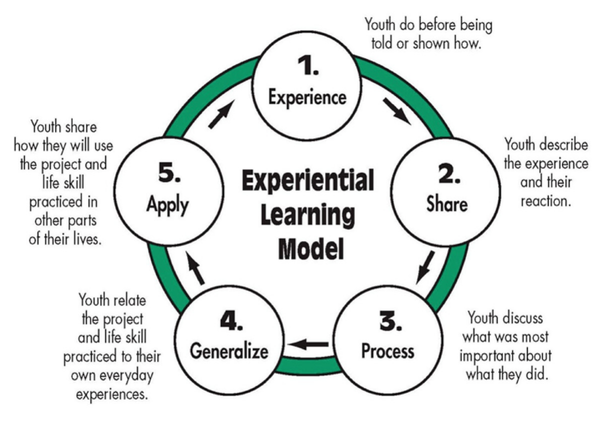
Adult and teen presenters don't give step-by-step instructions; there are hundreds of solutions to the challenges, and youth have creativity in meeting these challenges. All the while, youth participants are learning about robotic concepts, improving their engineering and technology process skills, and developing life skills, including teamwork, communication, critical thinking, sharing, and planning.

But why should you use this style of teaching and how do you put this into action?
Nonformal 4-H activities are strong at sparking interest and improving attitudes and confidence of young people. 4-H activities improve life skills (such as public speaking, teamwork, and leadership), in addition to increasing content knowledge and improving science process skills.

Research on nonformal science, engineering, and technology education backs the anecdotal evidence from 4-H staff and volunteers.

Nonformal education can increase content knowledge, and improve youth attitudes and confidence in science, engineering, and technology. The power of nonformal education is in engaging youth in hands-on activities that promote exploration and discovery of concepts. Adult and teen presenters do not teach but rather facilitate the creation of an atmosphere for learning. There should be few lectures in *4-H Junk Drawer Robotics*; instead, put your hands in your pockets and let the kids explore! As an adult or teen presenter, you don't need to know all the answers or have all of the information. You can explore and learn right beside the youth participants!

Many activities begin with opening questions to both help youth start to think about the big ideas in the activity and allow the adult or teen presenter to better gauge youth participants' prior knowledge. The experiencing section contains instructions to the presenter on how to deliver the activity. After the experiencing is complete, the critical component is to have youth reflect and apply. The activity guide contains sample questions for the presenter; however, the presenter has freedom to follow a line of thought formed by the youth participants and ask new open-ended questions.



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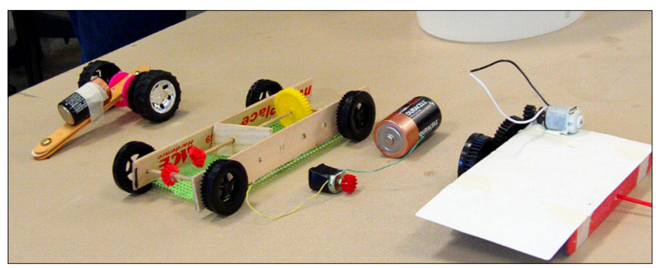
Experiential and Inquiry Learning

Facilitating an open discussion is crucial in promoting inquiry and not just providing the answers to the youth. This skill takes time and practice to develop. You are encouraged to practice with each other before delivering activities to youth participants. Try not to ask closed -ended questions that are fact-based, limit discussion, or have a clearly right or wrong answer. Ask open-ended questions that promote discussion, sharing, and may not have a single right answer. These types of questions should stimulate thinking and encourage speculation.

Here are a few tips and tricks in facilitating an open discussion:

- Prepare a **list of questions** in advance and review it with co-presenters. Ask yourself, "is there a single right or wrong answer to this question? Could this be a multiple choice test question?" If yes, think about ways to modify the question so that it uses the terms *discuss, interpret, explain, compare, evaluate* instead of *what, when, who, where*.
- **Don't ask too many questions**. One or two powerful open-ended questions may be enough to promote discussion. You will know you are successful in promoting inquiry when youth participants start to formulate their own questions about robotic concepts.



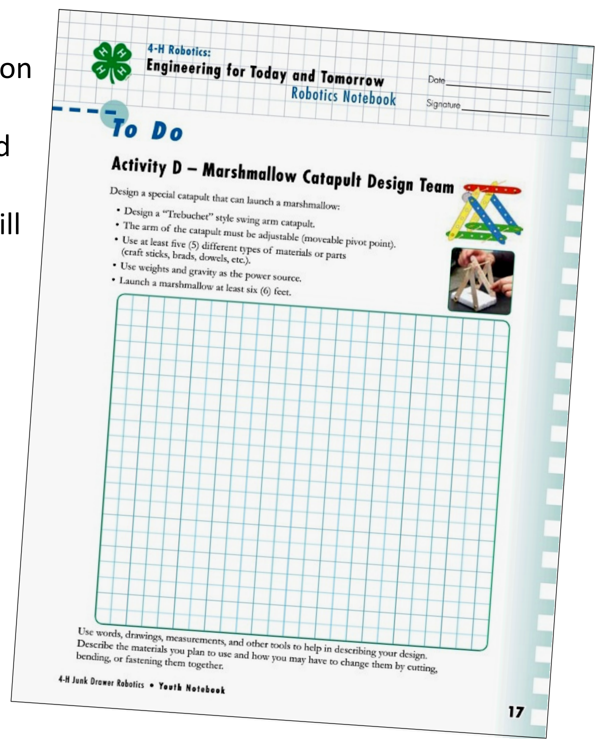
- Provide enough **wait time after asking a question**. Youth participants need time to think about the question before answering. Uncomfortable silence can be a good thing.
- Everyone needs an **opportunity to participate** in discussions. In large groups (10 or more youth), a few will be more vocal than the rest. To help ensure that all youth can participate, think about dividing youth into smaller groups of three or four. Ask a question and allow these smaller groups time to discuss amongst themselves, then ask groups to share out to everyone.

Experiential and Inquiry Learning

Robotics Notebook

The *Junk Drawer Robotics* curriculum also includes a youth notebook component. One Robotics Notebook covers all three levels of the *Junk Drawer Robotics* curriculum. In practice, scientists and engineers use notebooks to record observations, make predictions, and record results of their plans, constructions, and experiments. Using the notebook encourages members to think like scientists and engineers.

In their notebook, youth will record their ideas and predictions, collect data, draw designs, and reflect on their experiences. It also provides specific information for the challenges. Each student should have a Robotics Notebook. If this is not possible, a blank notebook can be substituted. Graph paper will work best. Students will have to record both the questions and their responses in a blank notebook. Leaders will have to make copies of supporting material.


4-H Robotics:
Engineering for Today and Tomorrow
Robotics Notebook
Date__________
Signature__________

To Do

Activity D – Marshmallow Catapult Design Team

Design a special catapult that can launch a marshmallow:

- Design a "Trebuchet" style swing arm catapult.
- The arm of the catapult must be adjustable (moveable pivot point).
- Use at least five (5) different types of materials or parts (craft sticks, brads, dowels, etc.).
- Use weights and gravity as the power source.
- Launch a marshmallow at least six (6) feet.

Use words, drawings, measurements, and other tools to help in describing your design. Describe the materials you plan to use and how you may have to change them by cutting, bending, or fastening them together.

4-H Junk Drawer Robotics • Youth Notebook

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While group discussions after an activity allow for group reflection, the Robotics Notebook encourages both group and independent processing and reflection. As an adult or teen facilitator, you can use the notebooks to view youth understanding of the concepts and measure growth as youth participate in multiple modules and levels.

For information and preparation on experiential and inquiry-based learning, please visit:

- UC Experiential Learning Modules
  http://www.experientiallearning.ucdavis.edu/
  These three modules are designed to improve adult and teen understanding of experiential and inquiry-based learning.
- Tools of the Trade II: Inspiring Young Minds to be Science, Engineering, and Technology Ready for Life!
  Available for order at http://www.ca4h.org/Projects/SET/Initiative/ToTII/.

Working with Teen Presenters

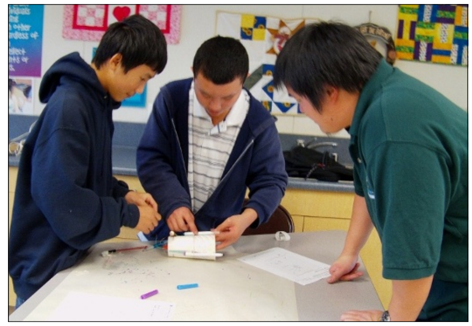
4-H emphasizes youth-adult partnerships. These partnerships take place when youth and adults plan, learn, and work together, with both groups sharing equally in the decision-making process. Building on the strengths of each group, the final program or activity is stronger than one delivered individually by either group.

Junk Drawer Robotics is an experiential and inquiry-based curriculum that can be greatly enhanced by such teamwork. Research has shown that children respond well to teen leaders, and teens often become positive role models for these children. Teenagers benefit from being presenters as well, increasing their self-confidence and improving their attitudes toward school.

Preparation before *Junk Drawer Robotics* sessions

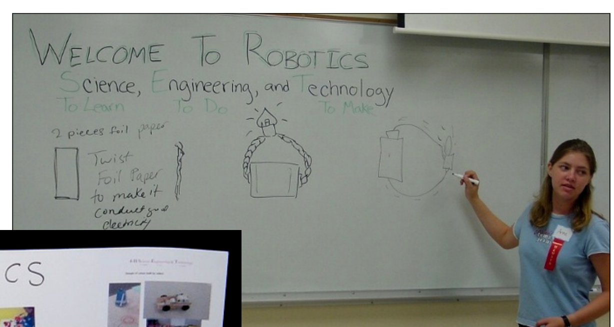
- Involve teenagers in **program planning** from the beginning, establishing your role as a supportive mentor early in the partnership process. Teens should be the central facilitators, planners, and evaluators. You should view your role as creating an environment in which teens will be successful, allowing them to assume new responsibilities in a safe and comfortable environment. Teens will be more successful when they make some of the decisions about planning the program.
- You should include an **initial training** for teen presenters on the *Junk Drawer Robotics* curriculum. The training should be fun and interactive and allow teens to try the activities they will later facilitate with younger youth.
- **Share the purpose** and philosophy of *Junk Drawer Robotics* with the teens, and explain that they will be assuming a primary role of facilitating, leading, and mentoring the youth participants. Then introduce them to the curriculum. You should have a general working **knowledge of the activities** before this training, and guide the teens as you work through the curriculum. Point out the "Note to Leader" sections.
- A critical piece is to increase the teens' **abilities in facilitating** the experiential learning cycle, including questioning strategies. Resources about promoting inquiry and open questions are available in this facilitator's guide. Model desired strategies and then have teens role play, practicing with their peers. Experienced teen leaders can be a great asset when training new presenters in *Junk Drawer Robotics.*
- Preparation and attention to detail is key when working with teen presenters. Maintain effective communication channels. Factor the basic needs of teens (such as food, transportation, and rest) into the decision making. Make the safety precautions in the curriculum a primary concern, and ensure the teen leaders understand proper safety procedures before presenting.

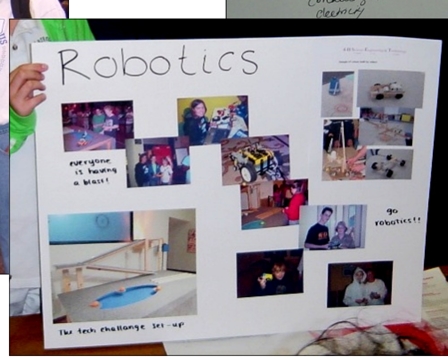
Working with Teen Presenters



During a *Junk Drawer Robotics* session

- Work with gusto and demonstrate your enthusiasm for your teaching, as teens will follow your example.
- Be a positive force and continually express your confidence in your teenage leaders.
- Prime teenagers for success by setting incrementally higher expectations.
- Encourage teens to work with each other to give two-way feedback. All teens should have equal jobs with an opportunity to try everything.
- While you may have designated roles, teens should have time to lead without adult interruptions.
- While teens are mentoring, give yourself a job, such as taking pictures or cleaning up, so that you won't be tempted to interfere.
- Although you won't always assume the central role, you should continually monitor the current situation:
- Identify potential problems, but encourage teens to propose solutions.
- Pay attention to the teen-child ratio; too many children (10-15)per teen can be overwhelming, while too few (2-3) can flatten the energy level.
- Provide prompts, such as printed lesson plans, verbal cues, or butcher paper with bullets, so teens can teach without worrying about forgetting the material.





Working with Teen Presenters

After a *Junk Drawer Robotics* session:

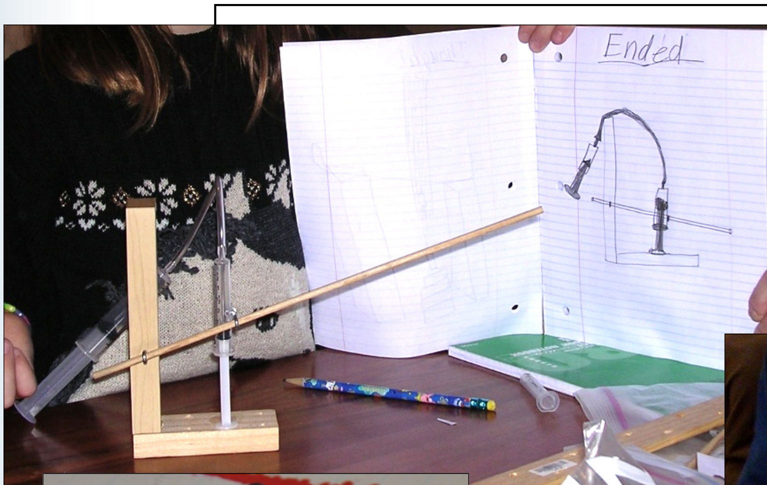
- Meet with teenagers at the end of each session to have them debrief their experience.
- Encourage the teens to reflect on their experiences, and offer both general and individual feedback. These meetings will improve the teens' abilities as communicators and educators.
- Everyone should be recognized for their hard work, and teen leaders are no exception.
- Teens need to know that their efforts are valued and appreciated.
- Provide recognition opportunities to publicly thank and congratulate teen leaders. Letters from participants or fun field trips can serve as a thank-you.
- Start planning for the next session.

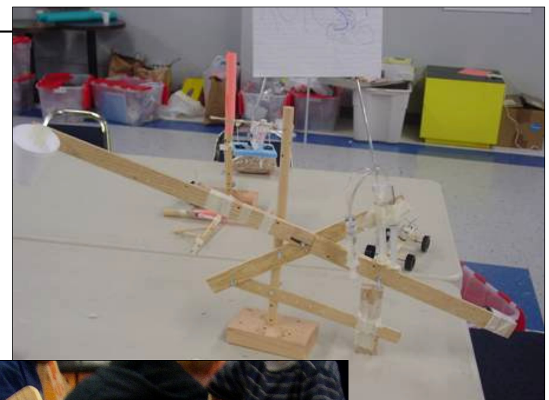
For more information about teen leaders, please visit:

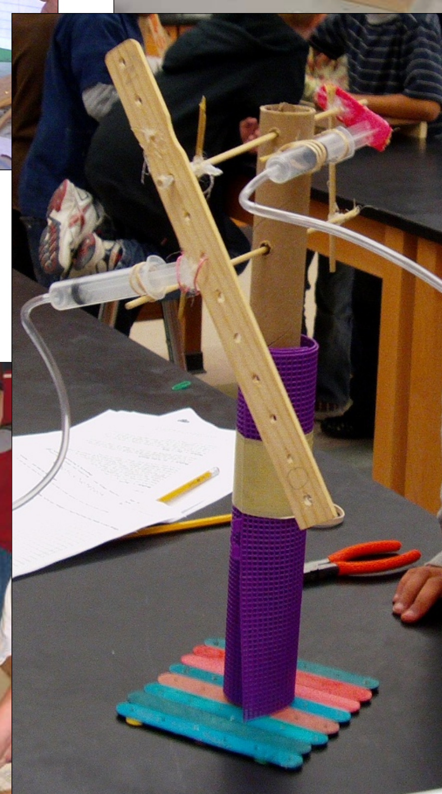
- Junge, S. (2005). *Teens as volunteer leaders: Recruiting and training teens to work with younger youth in after-school programs*.
  Available at http://4-h.org/b/Pages/Afterschool/Assets/AS_TeenVolunteers.pdf.
- Lee, F., Murdock, S. (2001). *Teens as teachers programs: Ten essential elements.*
  Available at http://www.ca4h.org/files/24256.pdf.

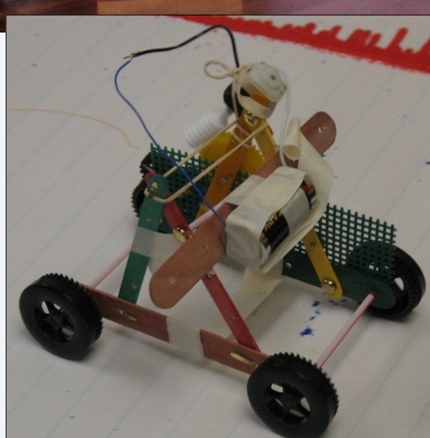
Sample Robots

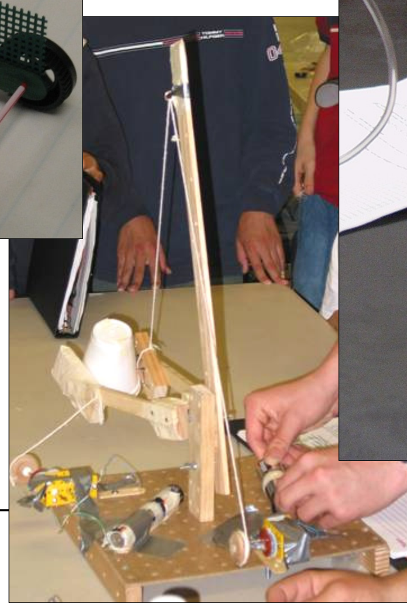
Use these as ideas but not as exact copies; the idea is to have the youth explore and design from their own ideas and build something they designed and created. These examples are good for the leader, helper, or coach to know some of the possibilities but it is even greater when the youth come up with designs that we never even imagined.



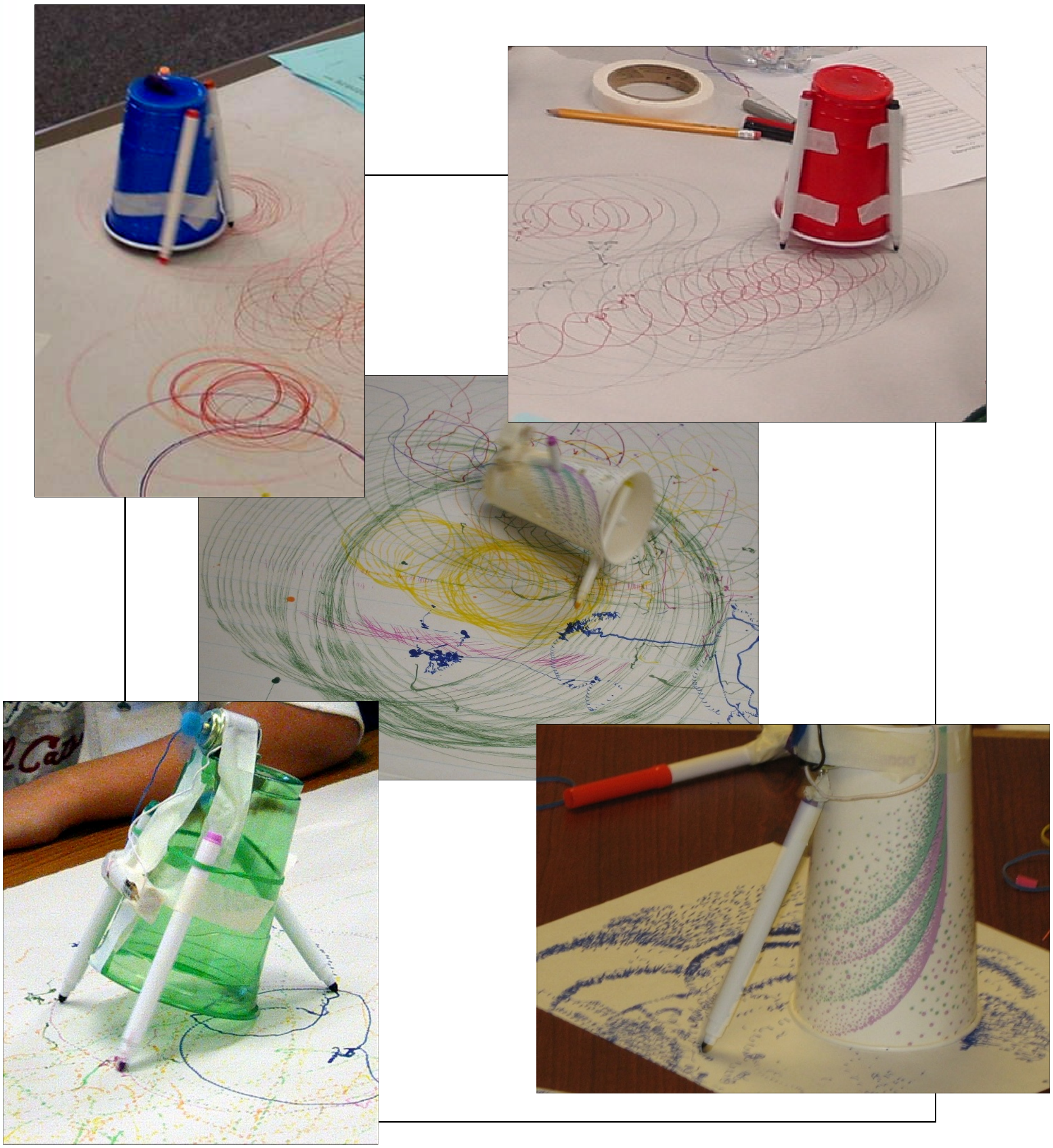




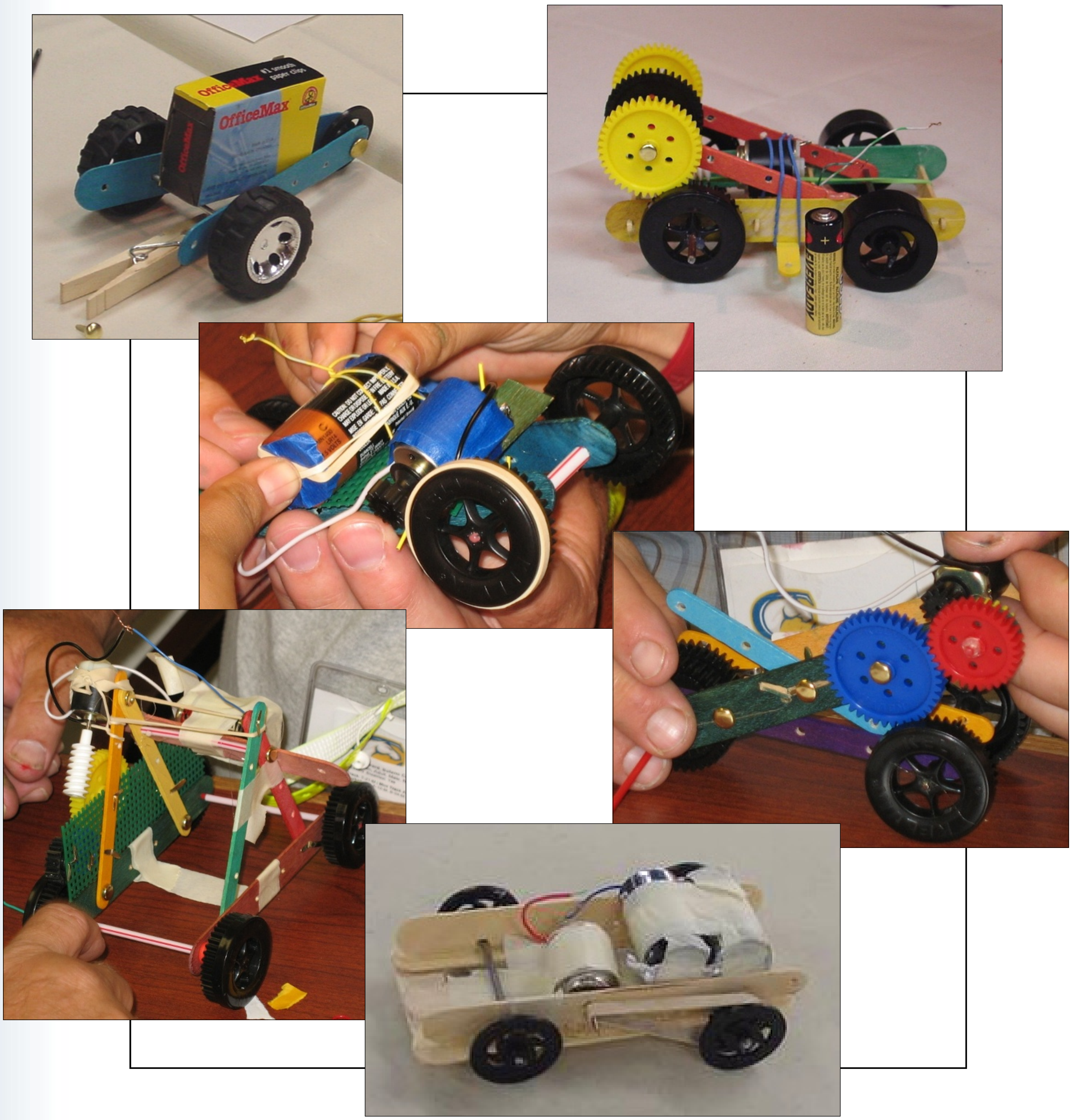




Sample Robots



Sample Robots



The Standards Matrix

The National 4-H Science initiative addresses America's critical need for more scientists and engineers by engaging young people in non-formal science education. 4-H Science activities and projects combine non-formal education with hands-on, inquiry-based learning in a positive youth development setting to improve youth's knowledge, skills, and abilities in science, engineering, and technology. 4-H Robotics activities are based on the following areas including national standards as listed on the next few pages. Educators can use these references to help identify local and state standards if needed.

Definitions of headings on charts to follow:

Activities

List of activities for each Level grouped by Module and identified as a To Learn, To Do, or To Make activity.

Big Ideas

Listed by Module, the main concepts and ideas that will be addressed by the Activities.

Performance Tasks

Performance tasks are listed for each activity.

National Science Education Standards (NSES)

The National Research Council developed the NSES to outlined what students should know, understand, and be able to do as they progress through their science education. The main standards covered in each of the Modules are listed. The standards present a vision of a scientifically literate person and cover not only content but also how students learn and how the content is presented.

Standards for Technological Literacy (STL)

The International Technology and Engineering Education Association (ITEEA) developed the STL to advance technological literacy for all.

Science Engineering and Technology Abilities Developed

The 4-H Science Program outlined 30 important science, engineering, and technology processes and refers to them as 4-H Science Engineering and Technology abilities.

4-H Life Skills Practiced

4-H programming strives to give youth developmentally appropriate opportunities to experience life skills, to practice them till they are mastered, and use these skills throughout a lifetime. This section lists the targeted life skills for the activities in the Module.

Connected Ideas

Junk Drawer Robotics is one of three tracks in the 4-H Robotics curriculum. This column lists similar content being addressed in other activities and tracks.

(***T**rack*:***L**evel*:***A**ctivity or **M**odule*)

Track 1-Virtual Robotics; Track 2-JunkDrawer Robotics; Track 3-Robotics Platforms

Level 1: Table of Standards - part 1

	Activities	Big Ideas	Performance Tasks
Module 1 Parts is Parts	A. Think Like a Scientist [To Learn] B. Communicate Like an Engineer [To Learn] C. Build Like a Technician [To Learn] D. Marshmallow Catapult Design Team [To Do] E. Marshmallow Catapult Build Team [To Make]	Scientific habits of mind (observation, computation, communication, evaluation) are an important element of science literacy. Form and function are essential considerations of quality design. Engineering Design is a purposeful process of generating and evaluating ideas that seeks to develop and implement the best possible solution to a given problem.	You will learn the importance of identification as you make observations and sort materials based on selected attributes. You also will record data into charts and graphs. You will describe an object by drawing and writing a description of it. You also will have to determine items that others have described. You will use the engineering design process to complete a building challenge that involves using manufacturing processes and design shapes. You will plan and design a swinging arm trebuchet-style catapult to launch marshmallows. You will assemble parts, use simple tools, make modifications, and record information in your Robotics Notebook as you build a catapult.
Module 2 In Arms Reach	F. Sense of Balance [To Learn] G. ABC…XYZ [To Learn] H. Arm in Arm Design Team [To Do] I. Arm in Arm Build Team [To Make] J. Pumped Up [To Learn] K. Just Add Air Design Team [To Do] L. Just Add Air Build Team [To Make]	Robots often use simple machines (such as levers) as tools to accomplish their intended function. The physical design (form) of a robot is based on its intended function, and it is often necessary to choose certain design elements (e.g., pneumatics, levers, etc.) or otherwise constrain the design in order to achieve the goal. Understanding three-dimensional space is important to movement of robotics arms.	You will experiment in balancing unequal weights on a balance beam while also moving the pivot point to different locations on the beam. This activity will help you understand the three axes of a cube, X, Y, Z, and locations in 3-D space. You will design and draw a robot arm that you will build, using levers to pick up and move a weight from one spot to another location. The arm will have at least two of the three axes of movement, X, Y, Z. You will build a robot arm from your design in Activity H. You will explore moving objects with balloons, plastic bottles, and syringes. You will design a power source to move the arm you built in Activity I. You will use your plans from Activity K and add a power source to move the arm built in Activity I.
Module 3 Get a Grip	M. Chopsticks [To Learn] N. Just a Pinch [To Learn] O. Hold On [To Learn] P. One for the Gripper Design Team [To Do] Q. One for the Gripper Build Team [To Make] R. Twist of the Wrist Design Team [To Do] S. Twist of the Wrist Build Team [To Make]	Robots often use simple machines (such as levers) as tools to accomplish their intended function. The physical design (form) of a robot is based on its intended function, and it is often necessary to choose certain design elements (e.g., joints, linkages, etc.) or otherwise constrain the design in order to achieve the goal. Understanding of underlying physical science and mathematics concepts (such as geometry) is necessary in understanding mechanical movements.	You will learn about joints and linkage by exploring with chopsticks. You will link (use) two chopsticks together to form a gripper and lift small objects. You will learn about joints and linkage by exploring various types of end effectors (grippers, tools, etc.). These devices may lift, hold, cut, or squeeze objects and vary in design, depending on the type of object and task to be done. You will learn about joints and linkage by exploring with chopsticks, pliers, and tongs. You will select a gripper best suited to lift the object. You will explore how end effectors (grippers) can be assembled and how to build or make more complex things. You will plan and design a gripper using the parts set out for this activity, basing the design on the objective of picking up selected items. You will build a gripper using the design from Activity P and various parts and supplies. You will design a way to attach the gripper to your robot arm. You will fasten the gripper to the robot arm and try it out by grabbing an item and moving it with the air-powered arm.

Level 1: Table of Standards - part 2

National Science Education Standards	Technological Literacy Standards	SET Abilities Developed	4-H Life Skills Practiced	Connected Ideas
Unifying Concepts and Processes: Systems, order, and organization Unifying Concepts and Processes: Form and function	Core Concepts of technology Relationships and connections Attributes of design Manufacturing technologies	Categorize/Order/Classify Compare/Contrast Communicate/Demonstrate Draw/Design Build/Construct	Keeping Records Critical Thinking Communication	Engineering Design T1:L1:A1 T1:L2:A1 T2:L1:M1 T3:L1:A1
Unifying Concepts and Processes: Systems, order, and organization Science and Technology: Abilities of technological design	Core concepts of technology Relationships of connections Attributes of design Manufacturing technologies	Compare/Contrast Communicate/Demonstrate Draw/Design Build/Construct	Keeping Records Planning/Organizing Critical Thinking Problem Solving Communication Contribution to Group Effort Teamwork	Robot Mechanics/ Simple Machines T1:L1:A2 T1:L1:A4 T2:L1:M2 T2:L1:M3 T2:L2:M3 T3:L1:A3
Science and Technology: Abilities of technological design—implementing a proposed design History and Nature of Science: Science as a human endeavor	Engineering design Problem solving Apply the design process Manufacturing Technologies	Invent/Implement Solutions Draw/Design Build/Construct	Problem solving Cooperation Teamwork	Robot Mechanics/ Simple Machines T1:L1:A2 T1:L1:A4 T2:L1:M2 T2:L1:M3 T2:L2:M3 T3:L1:A3

Level 2: Table of Standards - part 1

	Activities	Big Ideas	Performance Tasks
Module 1 Get Things Rolling	A. Slip N Slide [To Learn] B. Rolling Along [To Learn] C. Clipmobile Design Team [To Do] D. Clipmobile Build Team [To Make]	Friction can slow down or limit the movement of objects, but friction is also a useful tool when we need traction or gripping power. Understanding of underlying physical science and mathematics concepts is necessary in making engineering design decisions. Engineering design is a purposeful process of generating and evaluating ideas that seeks to develop and implement the best possible solution to a given problem.	You will explore movement and friction by testing a small box on a number of surfaces, looking at static friction and sliding friction. You will test rolling friction by adding wheels (cylinders) or rollers as a way to overcome the overall friction of an item. You will plan and design a vehicle to maximize its ability to coast based on considering the effects of friction. You will also consider constraints of capacity, efficiency, complexity, and costs in the design. You will build or assemble a complex Clipmobile, considering and addressing effects of friction and design constraints.
Module 2 Watts Up	E. Light Up My Life [To Learn] F. Magnetic North [To Learn] G. Can-Can Robot Design Team [To Do] H. Can-Can Robot Build Team [To Make]	Scientific habits of mind (observation, computation, communication, evaluation) are an important element of science literacy. An electrical circuit is a closed path through which an electric charge can flow – typically consisting of a power source (battery), conductors (wire), a load (bulb), and control (on/off switch). Engineering design is a purposeful process of generating and evaluating ideas that seeks to develop and implement the best possible solution to a given problem.	You will learn about electrical circuits by creating a circuit, causing a light to glow. You will concentrate the electromagnetic field to deflect a compass needle. You will design and sketch an electric-motor powered robot made from a cup. The robot will be able to draw or make marks on a piece of paper. Based on your design and using a cup, you will build a robot that will draw on paper.
Module 3 Get a Move On	I. Gear We Go Again [To Learn] J. Gears and More Gears [To Learn] K. Gear Train Design Team [To Do] L. Gear Train Build Team [To Make] M. Es-Car-Go– Design Team [To Do] N. Es-Car-Go – Build Team [To Make]	A drive train directs the motion, speed, and direction of the movements from a motor. Gears, levers, and cams are components of a drive train. Robots often use simple machines (such as levers, gears, or wheels and axles) as tools to accomplish their intended function.	You will work with a multispeed bicycle to understand gear ratios. You will assemble and test gear sets to determine the direction of rotation and gear ratios. You also will explore compound gear ratios. You will design a gear train that will have a gear ratio reduction. You will build a gear train using compound gears. You will plan and design a rover with a gear train to make it go really slow and climb a ramp. You will build a rover that can go as slow as an "Es-Car-Go" (snail) and is able to climb a ramp.
Module 4 Underwater ROV	O. Pennies in a Boat [To Learn] P. Sink or Float [To Learn] Q. Sea Hunt – Design Team [To Do] R. Sea Hunt – Build Team [To Make] S. To Make the Best Better Design and Build Team	Buoyancy is the force that causes an object to float in a fluid. An underwater ROV needs to be near neutral buoyancy so it can operate under water. Engineering design is a purposeful process of generating and evaluating ideas that seeks to develop and implement the best possible solution to a given problem. Scientific habits of mind (observation, computation, communication, evaluation) are an important element of science literacy.	You will learn about weight distribution, surface area, and buoyancy by floating an aluminum foil boat on water and adding pennies as weights. You will explore the concept of buoyancy, predicting what will float or sink. You will try to float something that normally sinks, and sink something that normally floats. You will use your knowledge of neutral buoyancy to design an underwater ROV that can be powered to go up and down in a tank of water. You will build an underwater ROV based on your design. You will redesign and rebuild your ROV design, making modifications as necessary, based on feedback from testing.

Level 2: Table of Standards - part 2

National Science Education Standards	Technological Literacy Standards	SET Abilities Developed	4-H Life Skills Practiced	Connected Ideas
Unifying Concepts and Processes: Systems, order, and organization. Form and function Physical Science Standards: Motion and forces Science and Technology: Abilities of technological design	Apply the design process Use of technology Core concepts Transportation technologies Manufacturing technologies	Collect Data Draw/Design Hypothesize Observe Predict	Critical Thinking Keeping Records Sharing	Robot Mobility T1:L1:A4 T2:L2:M1 T2:L2:M3 T3:L1:A2 T3:L1:A4
Physical Science Standards: Light, heat, electricity, and magnetism Science and Technology: Abilities of technological design Science and Technology: Understanding about science and technology	Relationships among technologies Influence of technology on history Use technological systems Problem solving Energy and power technologies	Collect Data Draw/Design Hypothesize Observe Predict	Communication Contributions to Group Effort Critical Thinking Keeping Records Sharing	Electronic Systems/Circuits T1:L1:A3 T2:L2:M2 T2:L2:M4 T2:L3:M2
Unifying Concepts and Processes: Form and function Physical Science Standards: Motion and forces Science and Technology: Abilities of technological design	Engineering design Core concepts Energy and power technologies Characteristics of technology Problem solving	Build/Construct Collect Data Draw/Design Hypothesize Observe	Critical Thinking Keeping Records Sharing	Robot Mechanics/ Simple Machines T1:L1:A2 T1:L1:A4 T2:L1:M2 T2:L1:M3 T2:L2:M3 T3:L1:A3 Robot Mobility T1:L1:A4 T2:L2:M1 T2:L2:M3 T3:L1:A2 T3:L1:A4
Science as Inquiry: Abilities necessary to do scientific inquiry Physical Science Standards: Motion and forces Science and Technology: Abilities of technological design	Apply the design process Relationships among technologies Attributes of design Energy and power technologies Problem solving	Build/Construct Communicate/ Demonstrate Design Solutions Draw/Design Redesign Test Use Tools	Critical Thinking Problem Solving Sharing Teamwork	

Junk Drawer Robotics

Facilitator's Guide

Level 3: Table of Standards - part 1

	Activities	Big Ideas	Performance Tasks
Module 1 Circuit Training	A. Series/Parallel [To Learn] B. Off and On [To Learn] C. Direction of Flow [To Learn] D. Forward and Reverse Design Team [To Do] E. Forward and Reverse Build Team [To Build]	An electronic circuit is a closed path through which an electric charge can flow. It typically consists of a power source (battery), conductors (wire), a load (bulb), and a control (on/off switch). The interaction between the "sense," "think," and "act" components of what a robot does can be accomplished using electric signals.	You will learn about the differences between series and parallel electric circuits. You will create an on/off switch for a basic circuit. You will experiment with circuits and control the direction of electrical flow. You will plan and design a double pole double throw (DPDT) switch to change the circuit's polarity. You will use your DPDT design and build a working switch that you can attach to a simple circuit.
Module 2 Come to Your Senses	F. Line Follower [To Learn] G. Keep in Touch [To Learn] H. Don't Buzz Me! [To Learn] I. Get in Touch Design Team [To Do] J. Get in Touch Build Team [To Build]	Simple sensors can help control robot behavior. Many different types of sensors are available to provide information to the robot. Sensors can enable robots to work autonomously (without human control).	You will follow a given line and learn how a visual sensor works on a robot. You will use the sense of touch to read Braille code. You will navigate two different size loops through a wire course to determine sensitivity and accuracy. You will plan and design a robot around the given wire diagram that will follow a wall. You will build a robot that will travel around an object or wall using a sensor for control.
Module 3 It's Logical	K. It's About Time [To Learn] L. Logic: AND, OR, NOT! [To Learn] M. Analog versus Digital [To Learn] N. Components [To Learn] O. Breadboard Build Team [To Build]	While humans typically use a base 10 number system, digital systems with a base 2 system (on/off) are more efficient for computers. Logical operators, used in Boolean logic, form the basis of all modern digital electronics. Basic electronic circuit design, including components of batteries, wires, conductors, resistors, lights, capacitors, diodes, transistors, and switches.	You will learn about base 2 binary counting and timing as related to electronic circuits. You will learn about logical operators, including AND, OR, and NOT. You will apply logical circuits in three real-world settings. You will learn about electrical components, including batteries, wire conductors, resistors, and capacitors. You will rebuild electronic circuits you've built in previous activities.
Module 4 Do What I Say	P. Cash Register [To Learn] Q. Walk the Walk [To Learn] R. Say What? Design Team [To Do] S. Say What? Build Team [To Build]	Programming allows us to control robot behavior. Basic logic elements in programming allow us to predict outcomes. Flowcharts are often used in programming to help design and clarify instructions. Input, output, if-then-else, loops, goto, and other commands are core components of simple programs.	You will illustrate the concepts of input, processes, and output through an activity simulation. You will follow simple flowchart instructions to act out the role of processor in a simple computer program. You will plan and design a program using the flowchart format involving basic commands like loops, goto, and if-then-else so the program can be acted out on a grid. You will follow the program designed by another group and offer suggestions for improvement.
Module 5 Ready, SET Go!	T. Build Your Robot Design Team [To Do] U. Build Your Robot Build Team [To Build]	Robots can sense, plan (think), and act. Generally, they are designed to perform a specific job better than it could be done by a person or another machine. How a robot behaves or acts is a product of its design. The robot's structure, components, and programming determine its function. Engineering design is a purposeful process of generating and evaluating ideas that seek to develop and implement the best possible solution to a given problem.	You will design an original robot that can perform a specific task. You will take your robot design and build a working model.

Junk Drawer Robotics
Facilitator's Guide

Level 3: Table of Standards - part 2

National Science Education Standards	Technological Literacy Standards	SET Abilities Developed	4-H Life Skills Practiced	Connected Ideas
Unifying Concepts and Processes: Constancy, change, and measurement Physical Science Standards: Light, heat, electricity, and magnetism Science and Technology: Abilities of technological design Science and Technology: Understanding about science and technology	Relationship among technologies Energy and power technologies Apply the design process	Build/Construct Compare/Contrast Draw/Design	Communication Critical Thinking Keeping Records Planning/Organizing	
Unifying Concepts and Processes: Systems, order, and organization Science and Technology: Abilities of technological design Science and Technology: Understanding about science and technology	Relationship among technologies Role of society in development and use of technology Apply the design process Energy and power	Communicate/ Demonstrate Draw/Design Build/Construct Observation	Keeping Records Cooperation Teamwork	Sensors T1:L2:A1 T1:L3:A1 T2:L3:A1 T3:L2:A1 T3:L2:A2
Unifying Concepts and Processes: Systems, order, and organization Science and Technology: Abilities of technological design Science and Technology: Understanding about science and technology	Core concepts of technology Development and use of technology Information and communication technologies	Design Solutions Build/Construct Invent/Implement Solutions	Keeping Records Problem Solving Sharing	
Unifying Concepts and Processes: Constancy, change, and measurement Science and Technology: Abilities of technological design Science and Technology: Understanding about science and technology	Relationships and connections Attributes of design Problem-Solving Information and communication technologies	Decision Making Sequencing Communicate/ Demonstrate	Keeping Records Self-discipline Teamwork	Programming T1:L2:A2 T1:L2:A3 T2:L3:M3 T2:L3:M4 T3:L1:A2
Science as Inquiry: Abilities necessary to do scientific inquiry Unifying Concepts and Processes: Evidence, models, and explanation Science and Technology: Abilities of technological design Science and Technology: Understanding about science and technology	Engineering design Problem solving Apply the design process	State a Problem Invent/Implement Solutions Redesign	Contribution to Group Effort Problem Solving Keeping Records	