YIP CHAIN REACTION MACHINE EDUCATOR GUIDE

Welcome to the Robert H. Rines Young Inventors' Program at the UNH Leitzel Center. The Young Inventors' Program (YIP), is a cutting-edge, K-12 project-based learning experience that provides hands-on STEM enrichment opportunities. Through the YIP, you will set your students on a course to shape an innovative future. Our resources help you guide students through the invention process to solve problems while applying STEM learning and gaining 21st century skills. The program takes learners on a path to showcase their original inventions that runs from their school/local invention fair all the way to national and international competitions. More than 5,000 K-12 inventors across Northern New England participate in YIP annually.

Our Mission

The mission of the Young Inventors' Program is to provide programs, pathways, and information to develop the intellectual capacity, critical thinking, creativity, and problem-solving abilities of all students so that they may become contributing, and forward-thinking members of the science, technology, engineering, mathematics (STEM), and the invention community.

Young Inventors' Program & Invention Education

Students are at the center of the Young Inventors' Program. We are unique among similar programs in that students pick the problem that they wish to solve. While we offer challenges and special categories, the heart of our program is imagination — the spark of creativity and innovation in every young person.

Invention education develops important 21st century learning skills through the process of identifying real problems and applying empathy, creativity, and design to create new solutions. Thinking skills are important in all fields of endeavor. In the invention process, they are essential. Creative thinking allows an inventor to generate new insights, strategies, and solutions. Critical thinking allows an inventor to sort through a potentially overwhelming collection of ideas and identify those that have promise. Problem solving encourages students to ask open-ended questions, categorize and classify information, find patterns, and make decisions. Collaboration requires students to work together toward a common goal. All are essential tools in life, and all are addressed by YIP.

YIP Chain Reaction Machines

The Young Inventors' Program includes an option to take a more structured and defined approach to invention and design. Through the Chain Reaction Machines track, you may choose to work on Chain Reaction Machines (formerly referred to as Rube Goldberg ® Machines) as an alternative to developing an original invention. The Chain Reaction Machines track of the Young Inventors' Program directs students away from traditional ways of looking at problems and sends them spinning into the intuitive, chaotic realm

of imagination. Unlike a conventional invention that helps solve a problem—chain reaction inventions are meant to complicate an easy task! The resulting inventions are collections of bits and parts of now useless machines, pieced together to achieve an innovative, imaginative, yet somehow logical contraption to conquer the job at hand. This approach to problem solving shows us all the need for simplicity and the pitfalls of complexity. Please see page XXX for the Chain Reaction Machines Curriculum.

While YIP Chain Reaction Machines includes a fully developed curriculum designed by experienced educators and STEM professionals, it is flexible and adaptable to meet each site's specific needs. Educators are encouraged to add or substitute activities and content that will best serve the group. The curriculum is organized into a framework that introduces students to the simple machines and then guides them through the invention design process using hands-on activities that allow them to design and develop their own chain reaction machines. The culmination of the invention project may take the form of presentation at a showcase or invention fair event.

Who Was Rube Goldberg?

Reuben Lucius Goldberg (Rube Goldberg®) was born in San Francisco in 1883. His father, a practical man, insisted he go to college to become an engineer. After graduating from the University of California, Rube did a short stay with the City of San Francisco Water and Sewers Department. He continued drawing and soon got a job as a sports cartoonist for a San Francisco newspaper. An outstanding success, he soon moved to New York, drawing daily cartoons for the Evening Mail. Through his inventions, Rube discovered harder ways to achieve easy results. His cartoons compressed time and were as he said, "Symbols of man's capacity for exerting maximum effort to accomplish minimal results." Rube believed that there are two ways to do things, the simple way and the hard way, and that a surprisingly large number of people preferred doing things the hard way. Rube Goldberg's work will endure because he gave priority to simple human needs and treasured basic human values. He was sometimes skeptical about advanced technology and big science. While most machines work to make difficult tasks simple, his inventions made simple tasks amazingly complex. Dozens of arms, wheels, gears, handles, cups, and rods were put in motion by balls, canary cages, pails, boots, bathtubs, and paddles. Rube's drawings of absurdly-connected machines accomplishing a simple task in an extremely roundabout way, has meant that his name, Rube Goldberg®, has become associated with any convoluted solution to perform a simple task.

Simple Machines

In order to build a chain reaction machine, students must first understand the fundamental concepts behind basic simple machines that can be strung together in a series to construct a more complicated mechanism. Most machines and mechanisms are comprised of at least one of the six basic simple machines:

- **Inclined Plane:** also known as a ramp; a flat surface tilted at an angle that aids in raising or lowering a load; examples are wheelchair ramps and slides
- **Lever:** consists of a beam or rod at a fixed hinge, such as a seesaw or bottle opener
- **Pulley:** wheel on an axle or shaft that supports movement and transfers power to a cable or belt, as seen in machines that use hoists
- **Screw:** mechanism that converts rotational motion to linear motion, such as a corkscrew
- **Wedge:** portable inclined plane used to separate two objects; axes, saws, and chisels as well as the blade of a knife all serve this purpose
- **Wheel and Axle:** two parts rotate together with force transferring from one machine to another, such as a doorknob or waterwheel

Lesson 2 of the YIP Chain Reaction Machine curriculum will introduce these six simple machines as students understand what they are and how they work and then are given the opportunity to explore how they work though hands-on activity stations.

How to Build a Chain Reaction Machine

Chain Reaction Machines are different from the machines people are used to seeing. A good Chain Reaction incorporates everyday devices and objects in an interconnected device that works in ways that may seem idiotic, ingenious, or creative. The machine must use at least 6 steps to complete an assigned task. It may take some time to put together and may undergo months of strategy and planning; others are put together in a few days. The machines that have worked the best seem to be those that are built in sections as opposed to pieces. The less work to assemble the machine, the better. A platform for the machine, with a simple and secure way to fasten it together, works well. Typical platforms are made of strong cardboard, foam core or plywood. Each machine is designed in its own way. Some machines are planned before the building takes place; others are assembled spontaneously. Maybe the best way is to use a little of both approaches. In the end, a numbered, detailed description of each step is needed. The materials that are used are the most important components of the machine. Encourage your students to use what you can find around school or around the house - raid old toy chests, use recycled items from home, dig into the craft closet. Anything goes when you are building a Chain Reaction Machine! Rube Goldberg knew no bounds when he created his machines, and that same attitude still applies. Follow the adage nothing is impossible if you try. Your imagination is your only limit!

Resources and Materials

YIP Chain Reaction Machines materials are adaptable to all learning environments. The program is easy to implement, flexible enough to meet diverse student needs, applicable to a broad range of disciplines and most important, accessible to anyone. Educators and group leaders with and without STEM expertise can use the modules to introduce fun activities and teachable units at all K-12 grade levels.

YIP Chain Reaction Machines require few supplies and many of the materials used are those that can be found at home or in school. Specific curriculum resources are provided and are accessible on the YIP website (https://www.unh.edu/leitzel-center/young-inventors-program), and may be ordered in a YIP Pack which is delivered to your site. Each activity plan includes a list of the materials needed to complete the lesson and any included activities.

Invention is about creativity and resourcefulness. Our young inventors are not only creative in their invention ideas, but also in the materials they use to build their prototypes. They are encouraged to build models that are “materials neutral”, meaning they can be made of reused and recycled materials and the overall product should not require money. If a student or their program site would like to purchase materials, they may, but the total cost of a project may not exceed $50. YIP provides limited funds to support program supplies.

In addition to the curriculum and supporting content, YIP provides sites with:

- YIP CRM Inventors’ Journals (hardcopies or electronic format to be downloaded)
- Awards Medals
- Participation and Awards Certificates (hardcopies or electronic format to be downloaded)
- Professional development and networking opportunities
- Engaging events at local, regional and national levels

Competitions

The Young Inventors' Program celebrates all inventors wherever they are inventing. In Northern New England, we offer opportunities for students to showcase their projects, meet other young inventors, and celebrate each other's accomplishments. These local, regional, national and international events allow students to progress to higher levels of competition.

Schools and organizations are encouraged to host their own showcase event which may be competitive or not. These fairs allow students to show off their achievements and display their unique inventions with peers, families and the community. In the process, students continue to develop valuable communication and presentation skills and more importantly, self-confidence. In order to be eligible for regional and national competitions, students must be nominated by their lead educator for an invitation to participate. School/Local Fairs are a way to assist with this nomination process. Nominations for the Northern New England Invention Convention are usually due in late February, so it is recommended that school/local fairs take place before then.

The capstone event for the Young Inventors' Program is the Northern New England Invention Convention (NNE-IC). Students from New Hampshire, Massachusetts, Vermont and beyond showcase their projects and celebrate together with the UNH partners, board, and volunteers. The NNE-IC typically takes place in late March/early April, and nominations are due in late February.

**Please note that Chain Rection Machines are not eligible to compete at the Invention Convention U.S. Nationals as they do not sponsor this category.*

Chain Reaction Machine Projects

Teams

Many project-based learning opportunities emphasize the development of 21st Century skills including collaboration, communication, social skills, and teamwork. Educators may choose to allow team projects or not. YIP encourages collaboration and welcomes teams to invent. Students may work in pairs or groups and students in a group do not have be in the same grade (they will compete in the grade level of the highest grade). All team members must participate in the development of the invention and should keep their own YIP CRM Inventor's Journal or invention logbook.

Please read more about Teams under the Rules of Competition.
**Please note that team participation for Chain Reaction Machine projects is slightly different than for our invention track. While inventions only allow teams of two (2) to present in competition, Chain Reaction Machines allow for larger teams of up to five (5) students to present their chain reaction machines.*

Participation Requirements:

All YIP students are encouraged to produce the following materials to complete an invention project, however each site may establish their own expectations and requirements as needed. If students would like to be eligible to present their inventions at the Northern New England Invention Convention, they must have:

- Inventor's Journal or logbook
- A 3-6 minute project presentation in which they present their project

- A 3-6 minute video of their presentation for review for originality
- A working model of the chain reaction machine

Please read more about the expectations for each of the above materials under Rules of Competition.

Rules of Competition

The following rules have been established for the Northern New England Invention Convention and the Invention Convention US Nationals. (**Please note that Chain Rection Machines are not eligible to compete at the Invention Convention U.S. Nationals as they do not sponsor this category.)* Individual YIP site may adjust and revise these rules as appropriate.

Teams:

- Only two students are allowed per Invention Team and up to five students are allowed per Chain Reaction Machine Team. Students do not have to be from the same grade.
- All team members must take part in the team presentation.
- All team members should keep their own YIP Inventor's Journal or invention logbook. *Note: logbooks are required materials for the regional and national competitions.*
- Each student can enter only one project for the School/Local Invention Fair, the Northern New England Regional Invention Convention, and the Invention Convention US Nationals. No student can enter both an individual and a team project, nor can they enter an invention and a chain reaction machine.
- Teams will compete against individuals and vice versa.
- The judging process for individuals and teams is exactly the same at all levels.

Project Requirements

All projects must have the following components:

- **YIP Inventor's Journal or invention logbook**

The journal documents the student's journey and all aspects of the invention process. Journals should be used throughout the development of the project and should not be a report completed after the fact.

- **Project Presentation**

YIP inventors are asked to speak about their chain reaction machine project for 2-3 minutes during the invention convention and then will have 3-4 minutes to put their machine into action to perform the task successfully. Inventors should share their idea and how it was developed as they talk about the steps they took to design and build their chain reaction machine, their tests and results, changes made to the design and challenges they faced throughout the process. Inventors may show drawings and their chain reaction machine as a visual prop as they speak. Young inventors (grades K-2) may use notecards or be prompted by nearby adult; inventors in grades 3-4 may use notecards; and inventors in grades 5-12 may not use notecards. All presentations should include the following:

Presentations must include:

- Name of inventor(s)
- Grade(s)
- School
- City & State
- Chain Reaction Machine name

- **Video Presentation**

A video presentation is **required in addition** to the in-person presentation. The video must be 3-6 minutes in length and must be recorded in a continuous take and unedited. The student should talk about their chain reaction machine and the task it completes. They should also show the various simple machines used and how they work together. Finally, students must show the chain reaction machine working from start to finish to complete the task successfully in one run (if possible. Powerpoint and other presentation software is not allowed, and students may not rely on videos show within their presentation. They should be the primary speaker, as if they were presenting in person. K-2 students may use interview style prompts from adults in the background. Grades 3-4 may use notecards, but no prompts. Grades 5-12 may not use any notecards or prompts. The video is similar to the oral presentation in which the student describes their machine and how it was developed.

Videos must include:

- Name of inventor(s)
- Grade(s)
- School
- City & State
- Chain Reaction Machine name

- **Working Chain Reaction Machine**

Students must have a working model of their chain reaction machine. If possible, the machine should be able to run continuously to complete the task successfully. Students are allowed several tries to achieve success if needed.

Project Restrictions

The following items are not allowed on your person or in your project:

- Electric stun guns, martial arts weapons or devices
- Guns, replica guns, ammunition, and fireworks
- Knives of any size
- Mace and pepper spray
- Razors and box cutters
- Live animals
- No balloons, glitter, or confetti are allowed in any form

If a project requires batteries, these must be provided by the inventor. The Northern New England Invention Convention will have access to electrical outlets if needed.

Pacing Guide

YIP Chain Reaction Machines consists of 4 lesson plans which include content and activities to support students as they develop and compete an invention project. Lesson 2 and Lesson 4 are developed to spread across at least two class sessions. Each session is designed to fill a 45-60 minute period but may be adjusted as needed. More time is always encouraged.

LESSON	FOCUS/ACTIVITY
LESSON 1: Who Was Rube Goldberg? (30-50 minutes)	Introduction to Chain Reaction Machines, Rube Goldberg and his crazy cartoons; Mouse Trap Game (optional, allow for more time); Desgin a Lunch Tray Labrynth
LESSON 2: Problem Solving (Part 1) (90-120 minutes total, split into 2 sessions of 45-60 minutes each)	Overview of the six simple machines; Activity stations for 2-3 of the 6 simple machines
LESSON 2: Problem Solving (Part 2) (Continued from previous session, 45-60 minutes)	Simple Machines continued from previous lesson; Activity stations for remaining 3-4 of the 6 simple machines
LESSON 3: Desgining a Chain Reaction Machine (45-60 minutes)	Investigation of combining simple machines to create a complex one; Brainstorming ideas; Developing a desgin plan for a chain reaction machine
LESSON 4: My Chain Reaction Machine (Part 1) (90-120 minutes total, split into 2 sessions of 45-60 minutes each)	Building the chain reaction machine; Testing and Receiving feedback to inform modifciations to original design plan
LESSON 4: My Chain Reaction Machine (Part 2) (Continued from previous session, 45-60 minutes)	Building, testing and re-designing the Chain Reaction Machine continued from previous lesson. Use testing to inform re-designs and modify machine as needed; Complete at least two iterations of desgin to create a machine that successfully completes a simple task

Tips For Success

Thanks to our YIP leaders and years of experience, we have collected best practices and lessons learned. These tips may help you frame lessons and conversations with students as you prepare them for success in their invention project.

Examples of Past Student Inventions

"*I can't think of a machine to make!"* is a complaint teachers sometimes hear when students begin the design process. You can encourage students by discussing some of these student inventions:

- Lunch box alarm that indicates its contents are being stolen
- Dog/cat food feeder
- Water bottler filler
- Door bell ringer
- Halloween candy hand out (for social distancing)
- Device to take out the trash/recycling

Leading an Effective Brainstorming Session

Before starting the any brainstorming sessions either as a class or in small groups, establish the ground rules with the class. A list of recommended rules is below, but certainly add to them with your students.

Post these rules so everyone can see them, and review them before each brainstorming session. Rules should be simple and positive. Be sure to save this list of rules for future YIP activities.

Suggested Brainstorming Ground Rules:

- Defer Judgement: accept all ideas without comment at this initial stage
- Work for Quantity: all ideas should be recorded and allow ample time for everyone to think and contribute to the list
- Piggy-Back: encourage students to combine or improve ideas already on the list.
- Freewheel: Encourage wild ideas. They may be dismissed but should be considered.
- Everyone Participates: all students should be involved in the brainstorming process.

Using the YIP Chain Reaction Machine Inventor's Journal

A journal helps students learn valuable communication, writing and recording skills. Proper record keeping is an important part of any research project. And, if a student ever wants to patent their invention or publish research, a journal is essential to protect their rights. An Inventor's Journal is "an official record of the process of invention…[It] is an ongoing record of all the events, actions, experiments, and observations during the entire development of the invention." (*Steven Caney's Invention Book*) Neatness is not the priority as creativity is messy!

Suggestions to follow:

- Write in ink and do not erase.
- Leave no empty spaces.
- Use a bound notebook.
- Date your notes.
- Begin your journal with all your problem ideas and the results of your survey.
- Record your chain reaction machine ideas and describe how you got them. Also, record all changes as time goes by.
- Explain what your chain reaction machine does and the simple machines used to complete the task.
- Write about the challenges you faced while developing the machine and how you overcame them.
- Make a diagram of your ideas whenever possible.
- Tell what you changed and why.
- Describe all materials and parts you use. List your costs if you have any.
- Diagram and describe the tests you run. Include the results of each test.
- Describe your search for a catchy name.
- Sign and date all entries at the time they are made and have them witnessed at least once a week.

Presentation Tips

Help your students prepare for their presentation experience. The following tips are great reminders and preparation tools to get your students ready and excited for their big day.

Inventors need good ideas and good communications skills. Part of YIP is to present your invention to your peers at your school or program and present to judges at showcases and competitions. We have a few tips to prepare for your invention presentation:*

- Practice Out Loud: Practice your presentation in front of a friend or family member at least 5 times so you are more familiar with your speech and are comfortable speaking in front of someone.
- Take a Deep Breath: If you lose your place or get nervous, take a deep breath, pause and restart. There is no rush when speaking and the audience appreciates time to think about what you are saying as well.
- Practice in Front of a Mirror: Stand in front of a mirror and give your presentation. Be careful not to wiggle, twitch, or shift. Practice how you will stand, sit, move or point as you present.
- Time Yourself: Time yourself as you give your entire speech from start to finish. Speak at a normal pace, which will probably seem slower than you think it should.
- Make Eye Contact: Look up at your audience at least 3 times when you present.
- Expect the Unexpected: It is okay if things do not go as planned. Stay positive and follow through.
- Summarize & Restate: At the end of your presentation, repeat your most important points to summarize your project.
- SMILE!: When you smile, your whole body relaxes. And smiling is contagious- if you smile, your audience will too.

** Adapted from Science Buddies, "Science Fair Project Presentation Speech Tips".*

Please see the Rules of Competition section for a full list of display requirements.

Final Thoughts

As you embark on your own YIP journey, we hope that you will embrace discomfort and challenge yourself and your students to think differently and to innovate in the face of adversity. While we hope you will find our resources valuable, we want you to add your own personality and bring your own interests as well as those of your students into each program. This Educator Guide is exactly that- a guide. All of the information and resources in this guide are recommendations and are not requirements as you design your own YIP experience. Just like the iterative invention des process, it should take different forms with each group you lead. We count on the help of community of users and inventors (past and present) to provide feedback and share their best practices. Please let us know how you these tools spark your interest in inventing.