YIP RUBE GOLDBERG 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 Rube Goldberg Machines

The Young Inventors' Program includes an option to take a more structured and defined approach to invention and design. Through the Rube Goldberg Machines track, you may choose to work on Rube Goldberg Machines (formerly referred to as Chain Reaction Machines) as an alternative to developing an original invention. The Rube Goldberg Machines ("RGM") 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—RGM inventions are meant to complicate an easy task! The resulting inventions are collections of everyday objects, 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.

While YIP RGMs 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 RGM. The culmination of the invention project may take the form of presentation at a school fair event, Regional Invention Convention, or even the National Rube Goldberg Machine Contest.

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 RGM, 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 everyday machines and mechanisms everyone encounters daily 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 elevators and window blinds
- **Screw:** mechanism that converts rotational motion to linear motion, such as a corkscrew or faucet
- **Wedge:** portable inclined plane used to separate two objects; axes, saws, and scissors 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 in vehicles

Lesson 2 of the YIP RGM 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 Rube Goldberg Machine

Rube Goldberg Machines are different from the everyday inventions people are used to seeing. A good RGM incorporates everyday devices and objects in an interconnected device that works in ways that may seem idiotic, ingenious, or creative. The students' machine must use everyday objects in a creative way, in order to complete the assigned annual task. For some inventors, it may take some time to put together and may undergo weeks 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 freestanding individual pieces. The less work to reassemble 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. There is no right or wrong way; in fact it's often the best way 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 pantry, borrow kitchen cooking utensils. Everyday common objects are often the best items, rather than having to create an item from scratch. Anything goes when you are building a RGM! 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 RGM learning 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.

Specific curriculum teaching 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.

Zach Umperovitch, the World's Leading Authority in Rube Goldberg Machines, has worked closely with YIP for nearly a decade, serving as a YIP Head Judge, performing educational outreach, as well as helping to develop our RGM curriculum. He is a three-time Guinness World Records breaker, Professional RGM builder (including OkGo, Disney, Sonic, RedBull, and many others), National Contest Director at the Rube Goldberg Institute, and the Creator and Co-Host of "*Contraption Masters"* on Discovery Channel. Through partnership with YIP, his Youtube channel: Zach's Contraptions, features video resources for students and educators specifically designed to provide simple to follow guidance, examples, and advice for building RGMs.

Zach is based in New England and is available for in classroom STEM Educational Workshops (K-12), Presentations, Hands-On learning programs, and more. For scheduling, visiting his website, or send an email to Zach@RubeGoldberg.org

YIP's RGM curriculum requires minimal supplies and many of the materials used are those that can be found at home or in school. Inventing 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 RGM 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.

The National Rube Goldberg Machine Contest *(held separately from the Invention Convention U.S. Nationals)* takes place in late March/early April, with Regional Results due in late February. Students and Teams who receive first place for their respective age Division at Regionals will be invited to present their machine at the National RGMC. Students and Teams' machines MUST solve the designated annual task in order to qualify.

Rube Goldberg 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 to be in the same grade (they will compete in respective age divisions - **Apprentice Level:** Grades K - 5, **Division I:** Grades 6 - 8. **Division II:** Grades 9 -12). All team members must participate in the development of the invention and should keep their own YIP RGM Inventor's Journal or invention logbook.

Please read more about Teams under the Rules of Competition.
**Please note that team participation for Rube Goldberg Machine projects is slightly different than for our invention track. While inventions only allow teams of two (2) to present in competition, RGMs allow for larger teams of up to five (5) students to present their 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 Rube Goldberg Machine contained within their Division's size limitation

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, Invention Convention US Nationals, and the National Rube Goldberg Machine Contest. Individual YIP sites may adjust and revise these rules as appropriate. **Advisory note**: adjusting or revising site rules may disqualify students from advancing to Regional or National level contests.

Teams:

- Only two students are allowed per Invention Team and up to five students are allowed per Rube Goldberg 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 Rube Goldberg 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 Rube Goldberg machine project for up to 3 minutes during the invention convention and then will have 2 attempts 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 process they took to design and build their RGM, their tests and results, changes made to the design and challenges they faced throughout the process. Inventors may show drawings and reference their RGM as a visual prop as they speak. Young inventors (grades K-2) may use notecards or be prompted by nearby adults; 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
- Rube Goldberg 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 RGM and how they uniquely solved the assigned task. They should also show the various simple machines used and how they work together. Finally, students must show the RGM 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 shown 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
- Rube Goldberg Machine name

- **Working Rube Goldberg Machine – Must Complete Assigned Task**

Students must have a working model of their Rube Goldberg machine to solve the assigned task which will be communicated each year on the YIP website and in news and announcements posted to the YIP community and beyond. The given task must be the final step of the machine, which students are encouraged to solve in as unique a manner as possible. For example, if the given task is PUT TOOTHPASTE ONTO A TOOTHBRUSH, then students must think of novel ways to do this. Ideas could be things like*" if you happen to brush your teeth with peanut butter - weird, but cool! What if your toothbrush is a toilet plunger with a mop head for bristles? - I'm not using that on my teeth, but that still counts!"* Students are allowed to physically pick up the toothbrush and brush your own teeth after the machine completes the task. Just be sure it's clear, either in the student's presentation or physically, that some form of toothpaste ends up on some form of brush that could brush teeth. The emphasis of Rube Goldberg machines are their creativity and humor.

- **Specifications & Rules**

	Apprentice Level: Grades K - 5	**Division I: Grades 6 - 8**	**Division II: Grades 9 -12**
Maximum Physical Size	6ft (W) x 6ft (L) x 6ft (H)	8ft (W) x 8ft (L) x 8ft (H)	10ft (W) x 10ft (L) x 10ft (H)
Minimum Number of Steps (Transfers of Energy)	10 Steps	15 Steps	20 Steps
Maximum Number of Steps (Transfers of Energy)	None		
Theatrical / Verbal Presentation	Two (2) Minutes or Less		
Single Run Time	Maximum Three (3) Minutes		
Guaranteed Number of Machine Runs	Two (2) Runs		
Hazardous Materials, Explosives, Flames, Electrical Arcing	Not Permitted		
Incorporation of Live (or Previously Alive) Animals	Not Permitted - Including Taxidermied Animals		

Political References	Not Permitted
Objects Flying Beyond Machine Boundaries	Allowed with **PRIOR** Safety Approval
Rube Goldberg Machine Steps vs Chain Reaction Device Interactions	Standard domino topples & simple marble run style steps are **DISCOURAGED - BE CREATIVE!!!**

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

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 Rube Goldberg Machine education guide consists of 4 lesson plans which include content and activities to support students as they develop and complete 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? (40 - 50 minutes)	Introduction to Rube Goldberg Machines, Rube & his cartoons, video RGM examples. Design a Lunch Tray Labyrinth
Lesson #2.1: Simple Machines (Part 1) (90 - 120 minutes, split into 2 sessions)	Overview of the six simple machines. Activity stations for the simple machines.
Lesson #2.2: Simple Machines (Part 2) (Continued from previous Lesson)	Simple machines continued from the previous lesson. Activity stations for remaining simple machines

Lesson #3: Designing a Rube Goldberg Machine (45 - 60 minutes)	Investigation of combining simple machines to create a complex one. Brainstorming ideas; developing a design plan
Lesson #4.1: My Rube Goldberg Machine (Part 1) (120+ minutes, split into at least 2 sessions)	Building the RGM. Testing and receiving feedback to inform modifications to the original design plan.
Lesson #4.2+: My Rube Goldberg Machine (Part 2, 3, etc.) (Continued from previous Lesson)	Building, testing, and re-designing the RGM (continued from previous lesson). Use testing to inform re-designs and modify machines as needed. Complete at least two iterations of testing and re-design

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.

Leading an Effective Brainstorming Session

Before starting 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 Rube Goldberg 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.
Sign and date all entries at the time they are made and have them witnessed at least once a week.
Begin your journal with all your problem ideas and the results of your survey.
Record your RGM ideas and describe how you got them. Also, record all changes as time goes by.
Explain what your RGM does and the simple machines used to complete the assigned 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.

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 educational experience. Just like the iterative invention process, it should take different forms with each group you lead. We count on the help of the community of users and inventors (past and present) to provide feedback and share their best practices. Please let us know how these tools spark your interest in inventing.