museum of discovery

chain reaction contest

presented by

SPP Southwest Power Pool

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Chain Reaction Tips

What is a Chain Reaction?

A chain reaction is defined as a series of events that are each caused by the previous event. If a trash can falls over and this scares a cat who then jumps and knocks over a glass of water, that's a chain reaction. The trash can fall is the initial event, and the end result is the glass getting knocked over.

A chain reaction machine uses a series of events to complete a simple task, such as switching on a light bulb. You could easily complete the task, but it's a fun challenge to try and accomplish it by using a series of simple machines instead!

Building a Chain Reaction Machine

How do you get started building a chain reaction machine?

Anytime you are developing a system or machine, there are a series of engineering steps you follow to get from the idea to the final product. Whether you're designing a bridge or a whole power supply system these same steps apply.

Researching Chain Reactions

Before you begin working on your own chain reaction machine, it's a good idea to look at what others have done before. You can get ideas and see which materials others have used for their machines.

Video examples (copy and paste in browser):

- Amazing Chain Reaction Videos: https://www.youtube.com/watch?v=CGUvMJ6cbXA
- 50 Chain Reaction Ideas: https://www.youtube.com/watch?v=BGq4W93TYQg
- The Incredible Mouthwash Machine:

https://www.youtube.com/watch?v=4Mn3nGJKuPw

- Garver Chain Reaction Videos:

https://garverusa.com/news/5/2019/garver-chain-reaction-challenge-winners-announced

  - Butterfield Trail Middle School:

    https://garverusa.com/about/centennial-celebration/butterfield-trail-middle

  - Azle Texas Junior High:

    https://garverusa.com/about/centennial-celebration/azle-junior-high

Brainstorming and Design

As you learn about chain reactions, you can begin to move into the design phase of building your chain reaction machine. This stage in your build process is all about thinking through which elements we want to include in your chain reaction machine.

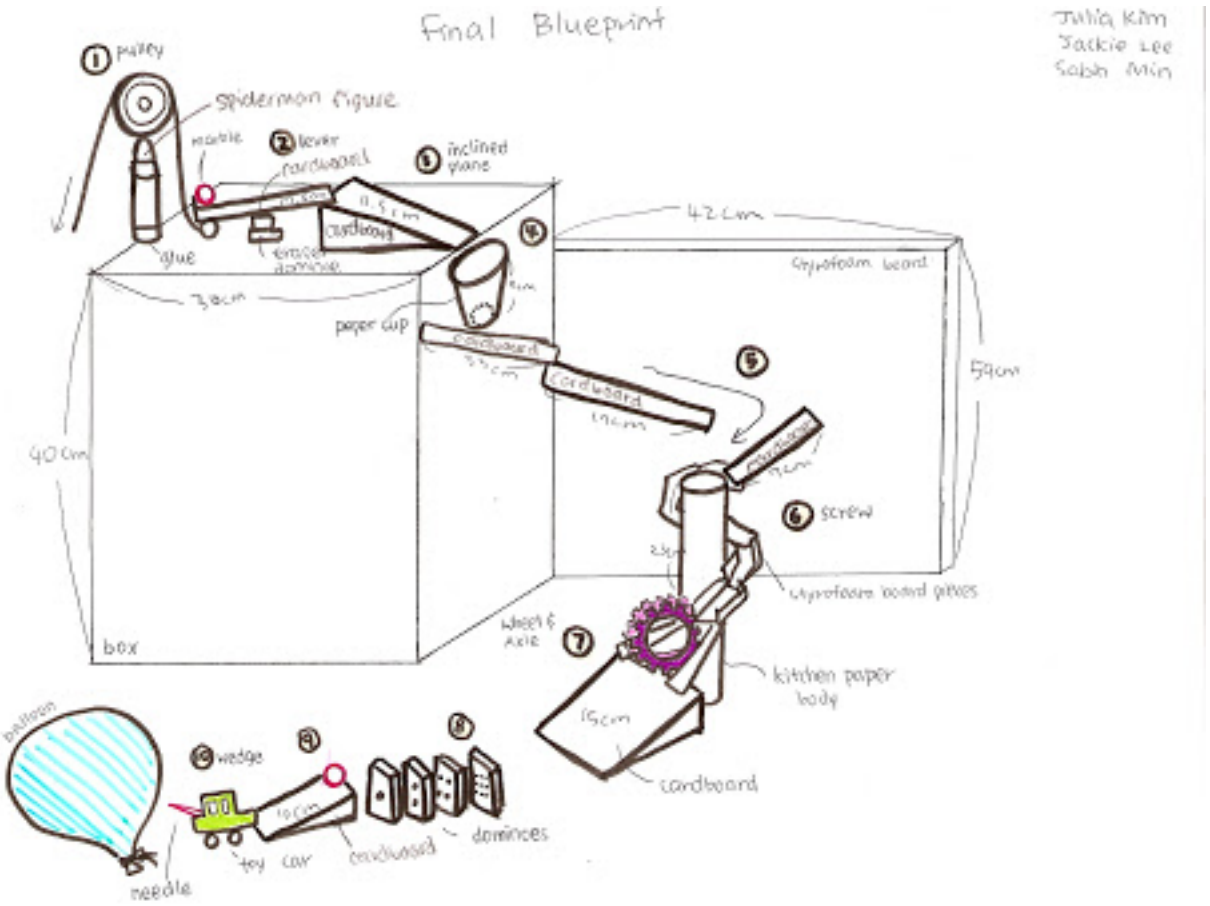
For this contest your chain reaction machine should complete a task such as flipping on a light (any kind of light). Now you can start thinking through some ways you want to go about completing that task. There are many different ways you can turn on a light. You can, for instance, complete a circuit, flip a switch, or turn a knob.

This piece of the process is critical. It helps you think through elements you might want to add to your design, as well as think through any potential pitfalls you might encounter along the way. Feel free to draw out your ideas. Write down your ideas, and draw out what you want the machine to look like.

Think through the materials you have available in your home that can be used as part of your design. Here is a list of some ideas for household items that can be used for a chain reaction machine.

- Vibrating phone down a ramp
- Dominoes
- Cardboard
- Pulley
- Fan / Sail combination
- Stretched rubber band
  - Skateboard
  - Marbles
  - Toy cars
- Fidget Spinner
- Ramps
  - Books
  - Trays
  - PVC pipe
  - Cardboard tubes
- Household items
  - Dustpan
  - Paper towel or toilet paper tube
  - Mesh strainer
  - Bowl
  - Funnel
  - Clothespins
  - Plastic cup
- Office supplies
  - Binder clips
- Building blocks
- Things that roll
  - Balls (golf ball, ping pong ball, tennis ball)
  - Roll of tape
  - Rubber bands
- Straws
- Yo-yo
- Items for turning on a bulb/fan
  - DC motor/alligator clips
  - Aluminum foil
  - 9-volt battery
- Ball bearing
- Service bell
- Mallet
- Big ring washer
- Eye hook, S hook, pulley
- Twine
- Jack-in-the-box
- Craft sticks
- Ruler
- Balloons
- Wood blocks

Gather materials you think might work as elements in your chain reaction. Look around your house and think of how everyday items can be used as simple machines in your design.



Construction and Test

Start simple. Put together and test sections of your design and observe the results. Test small sections before putting them all together into your design.

Start with something as simple as a ball rolling down a ramp to hit some dominoes. How far does the ball need to roll to make the dominoes fall over? How heavy does the ball need to be? As you gain confidence in each step you can add on and combine events.

Redesign and Retest

As you test each section of your chain reaction, make adjustments, keep the elements that work and make changes to those that don't. It is likely you will spend most of your time testing and making adjustments as you add and combine elements to your chain reaction.

Final results

Once you have a final design, it is now time to video your results. You may have to restart your video several times to get the full chain reaction, but it should be videoed start to end in one take. You can video with a phone or other device, but make sure to do so in landscape (horizontal) and with plenty of good lighting.

Science of Chain Reactions

Below are some of the concepts that govern the reactions and motions of a chain reaction:

- Simple and compound machines
- Potential and kinetic energy
- Newton's laws
- Conservation of motion
- Conservation of energy

What makes the chain reaction work? What science is at work? Let's explore the science that describes what makes a chain reaction work.

Vocabulary

Simple Machines

There are traditionally six simple machines. They are:

- Lever
- Wheel and axle
- Pulley
- Inclined plane
- Wedge
- Screw

Potential Energy
The amount of energy an object has within itself that is waiting to be released. An object holds this energy because of its location or because of some internal stressor.

Kinetic Energy
The energy released from an object when it is in motion.

Scientific Concepts

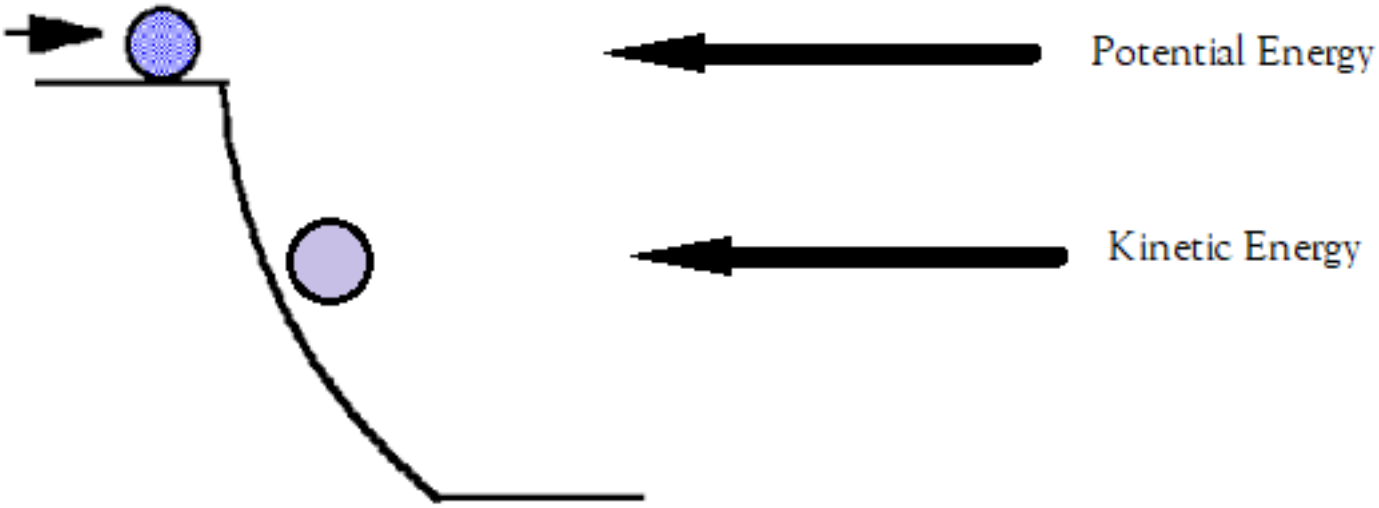
Simple Machine
A chain reaction is a series of simple machines. A simple machine is a device that allows you to change the direction and amount of force on an object. A lever, for example, allows you to exert more force on an object some distance away than you would normally be able to exert on your own (giving you a mechanical advantage). See how simple machines are utilized in chain reactions here: https://www.youtube.com/watch?v=nfo94faga5w&feature=emb_rel_end

Compound Machine
A compound machine is a machine that is built out of more than one simple machine. For example, a wheelbarrow is a compound machine made up of wheels and levers.

Mechanical Advantage
Something that gives you a mechanical advantage will make it easier to perform a task and exert more force on an object than you could by yourself. A pulley, for example, helps you lift heavy objects that you otherwise couldn't lift.

Potential and Kinetic Energy
A chain reaction machine (aka a Rube Goldberg Machine) is basically an energy chain converting potential energy into kinetic energy.

Imagine you have something as simple as a ball rolling down a hill. At first, when the ball is sitting still at the top of the hill, it is full of gravitational potential energy. Potential energy is the energy an object possesses by virtue of its location or internal stressors. The higher the hill, the more gravitational potential energy the ball has.



When something kicks the ball into motion, that potential energy is converted to kinetic energy, which is the energy of motion. When you set up a chain reaction you are building in a lot of potential energy waiting to be released. You build it such that once you input the initial energy of setting it off, there isn't any more energy input required. All the energy is already there waiting to be released.

For example, you send a ball rolling down a hill that sets off a line of dominoes. Your energy input was to set the ball in motion, wherein the potential energy of the ball is converted to kinetic energy that sets off the potential energy of the dominoes. You did not have to input any additional energy in to set off the dominoes; the ball did the work for you.

Newton's Laws of Motion

In addition to the principles of kinetic and potential energy discussed above, Newton's Laws of Motion also describe how objects move. In a chain reaction, you can observe these laws in action.

Newton's First Law of Motion

Newton's First Law, also called the Law of Inertia, states that an object at rest will stay at rest until another force acts on it. In other words, once you set up your chain reaction, it will stay in that state until you kick it off. The dominoes won't topple over until the ball rolls down the hill to hit them. They will stay at rest until a force acts on them.

Newton's Second Law of Motion

Newton's Second Law, also called the Law of Acceleration, creates the famous equation, F = ma. This equation states that the force is relative to the mass of the object times the acceleration of the object. For example, if you roll a ball down a hill toward some dominoes, the higher the hill, the more the ball will accelerate, and the greater the force will be that hits the dominoes. If you replace the dominoes with a book, the ball will need to exert more force on the book to knock it over than it needed for the dominoes. Therefore, you will need a longer ramp to make sure the ball has enough force to knock the book over.

Newton's Third Law of Motion

Newton's Third Law of Motion, also called the Law of Action/Reaction, states that for every action there is an equal and opposite reaction. In simple terms, this means that any force you exert on an object, like pushing on it, exerts a force back. Take the relationship between you and the ground, for example. The Earth is pulling you down via gravity (exerting a force). You are also exerting a force back on the Earth to keep you upright. These two forces are equal and opposite, keeping you in place on the ground.

Conservation of Motion

From these laws we also get the Conservation of Motion. This law states that the amount of momentum in a system stays the same, so long as there are no external forces acting on the system. So for your chain reactions, for instance, the amount of work you put into the system initially (pushing the ball to roll down the hill or toppling the first domino) stays the same throughout the system from beginning to end. You transfer that momentum from object to object.

However, your chain reactions don't happen in a vacuum. There are external forces acting on the system that you can take advantage of. Gravity puts more energy into your system, but friction also takes energy out.

Conversation of Energy

Similar to the conversation of momentum is the Law of the Conservation of Energy. This law states that energy is neither created nor destroyed, it merely changes form. For example, if you decided to utilize a chemical reaction in your chain reaction. In this example you topple a cup of baking soda into a vial of vinegar. The resulting reaction creates gas that blows up a balloon that pushes on a lever. The energy in that system remains the same from one step to the next, but it changes form from the kinetic energy of the baking soda toppling into the vinegar to the chemical energy of the reaction, to the heat energy of the air being produced, and ultimately back to kinetic energy used to push the lever.

Other topics

These are the basic laws of motion and energy that govern how objects move and behave within the chain reaction. This is, however, not a complete list. There are additional concepts that you can explore in further detail.

- Projectile Motion
- Fixed Axis Rotation
- Relative Motion
- General Planar Motion
- Impulsive Motion
- Instantaneous Center of Rotation
- Vibration and Damped Vibration

Have fun engineering!

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